EcoSoar Build

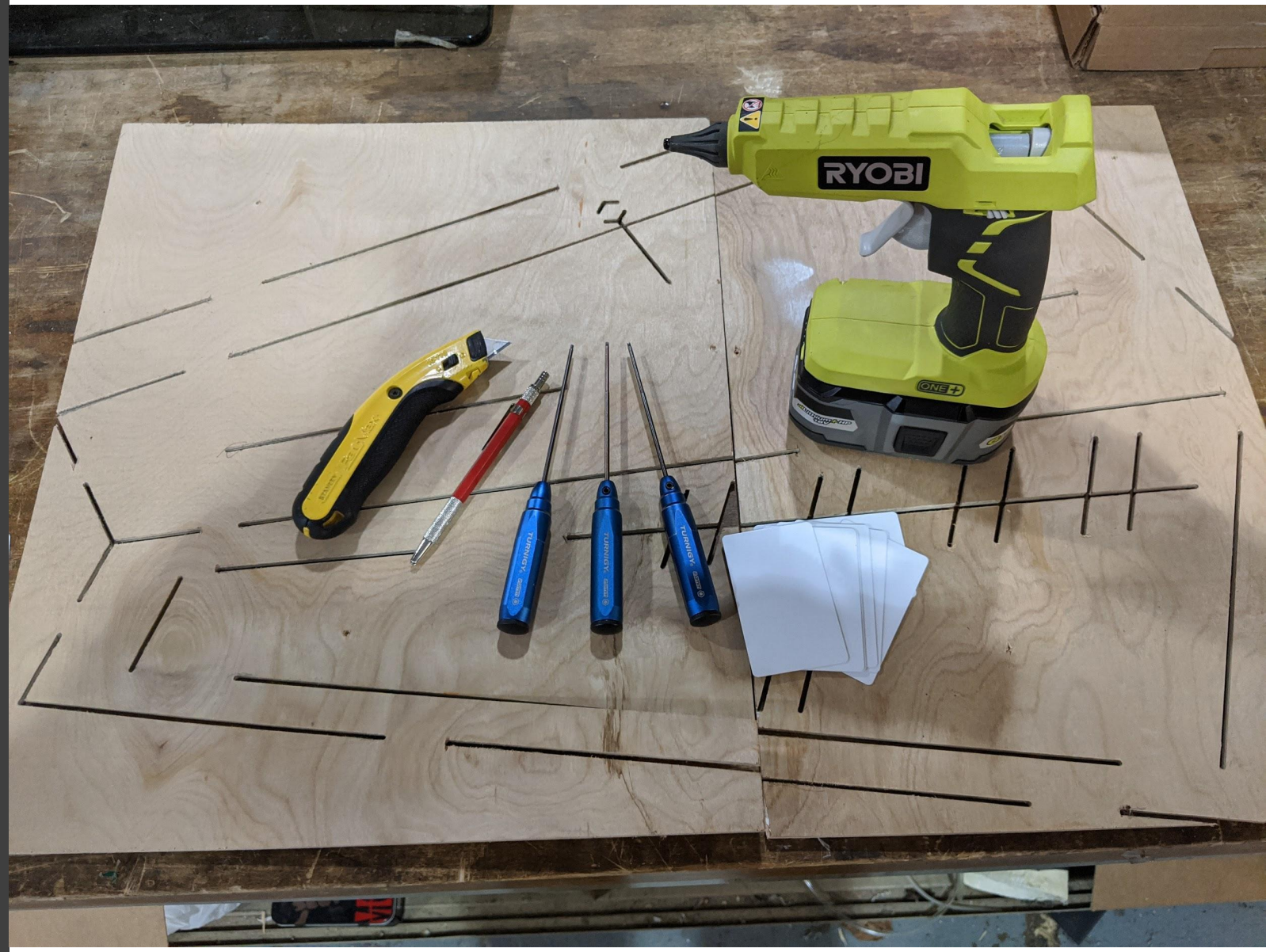
EcoSoar Workshop – ADDA

Introduction + Tools to Have on Hand

This lab fully explains the build process of the EcoSoar fixed-wing aircraft. Below you may find a list of the required tools needed throughout the lab.

Needed Tools:

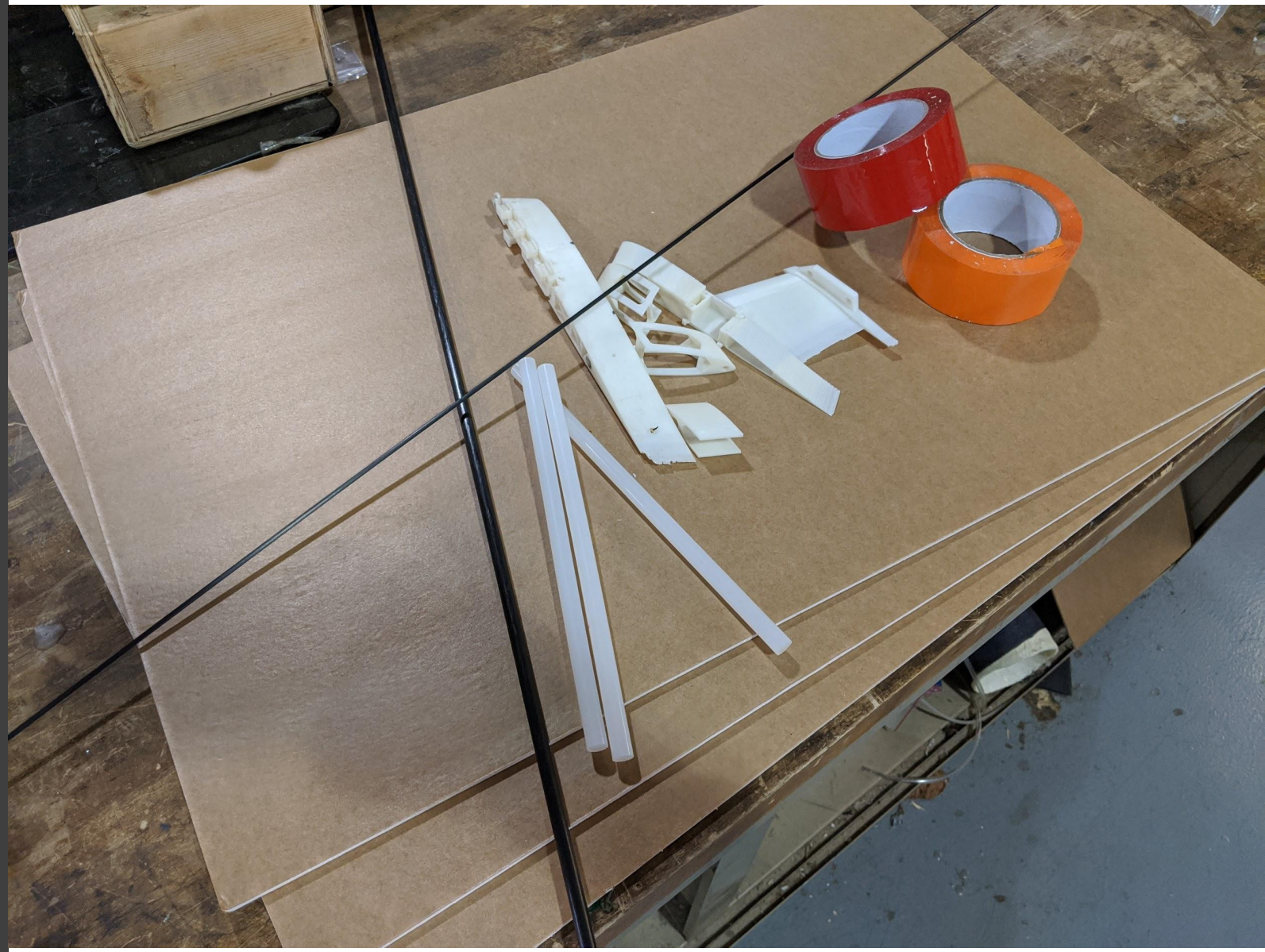
- M2.5, M2, and M1.5 Hex Drivers
- Hot Glue Gun (and glue)
- Box Cutter/ X-Acto Knife
- Lead Holder/ Pencil
- Plastic Card



Materials (Aircraft Structure)

Ensure that you have the following items required for building an EcoSoar:

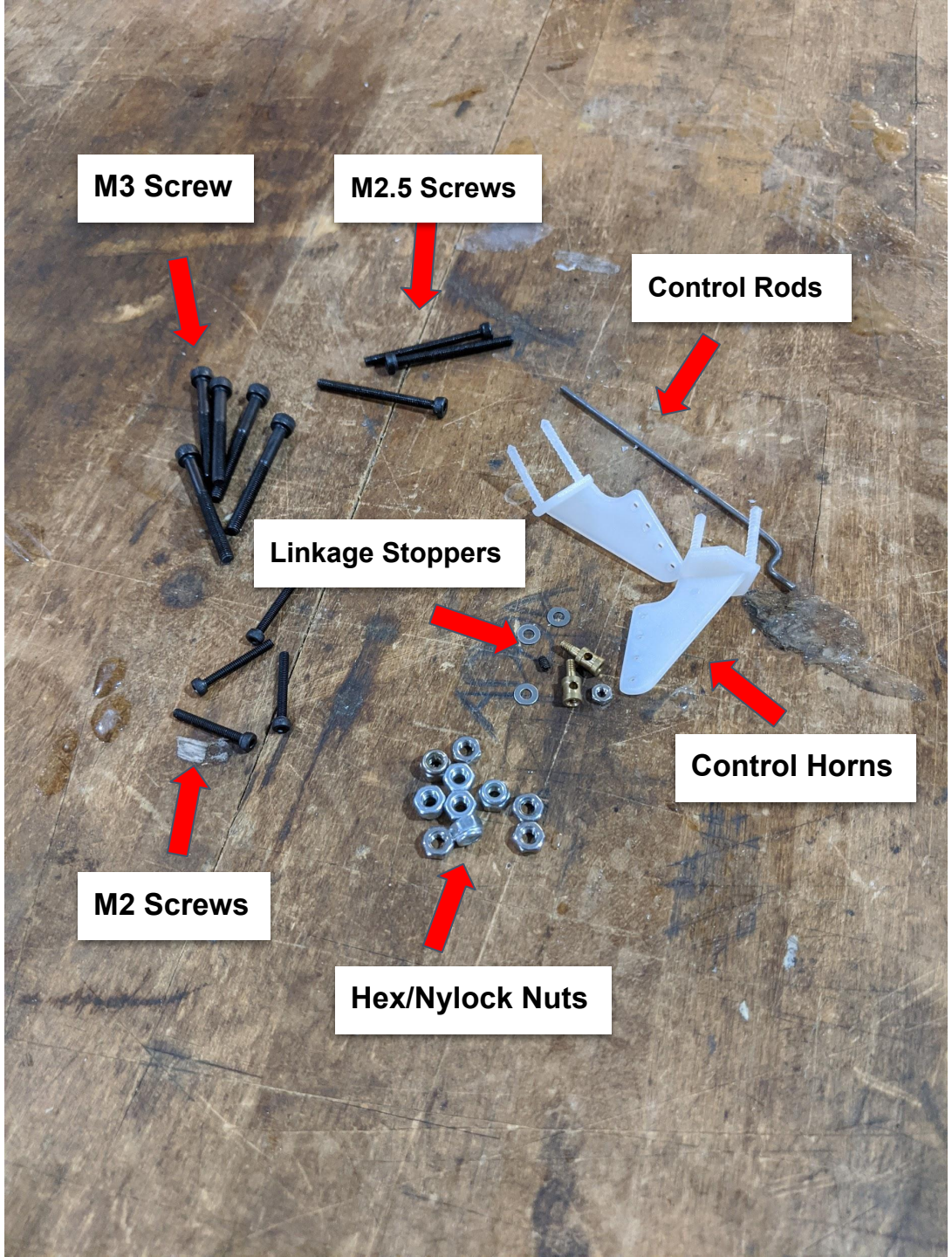
- Right and Left Posterboard wings (pre- cut and taped)
- 3D Printed Parts
- Carbon Fiber Rods (1 8mm OD rod cut to 762 mm length, and 2 4mm OD rods cut to 680 mm length)
- Hot Glue Sticks



Materials (Misc. Hardware)

Ensure that you have the following items required for building an EcoSoar:

- M3x30 (2x), M3x25 (2x), M3x20 (2x), M2.5x12 (2x), and M2x8 (2x) screws
- M3, M2.5, and M2 hex nuts and nylocks. (2x M2.5 hex nuts and the rest nylocks)
- Linkage Stoppers (2x), Control Horns (2x), and Control Rods (2x)



Materials (Avionics)

Ensure that you have the following avionics required for operating an EcoSoar:

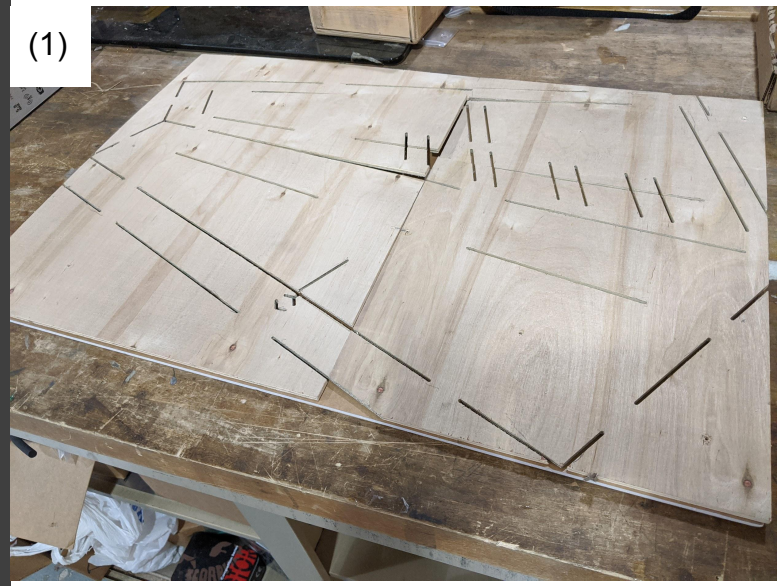
- Pixhawk 4 Mini
- GPS / Compass Module
- Radio Telemetry (2x)
- Servos (2x)
- Pitot Tube/ Airspeed Sensor
- ESC (Electronic Speed Controller)
- Motor
- Power Module
- Receiver
- Servo Wire Extensions

Beginning Aircraft Build

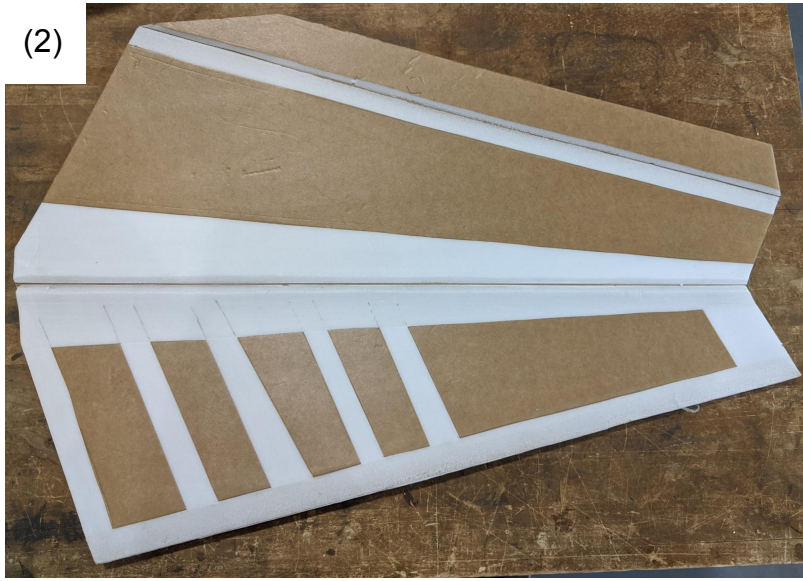
This lab begins the build process of the EcoSoar aircraft with the wings already created by instructors. This included:

(1) Using wooden templates to trace the wing outlines and determine cut locations
(2) Removing paper from the board at the rib locations, and sanding
(3) Taping over the outside of each wing
(4) Bending the wings to allow them to fold over ribs without pulling apart later

(1)

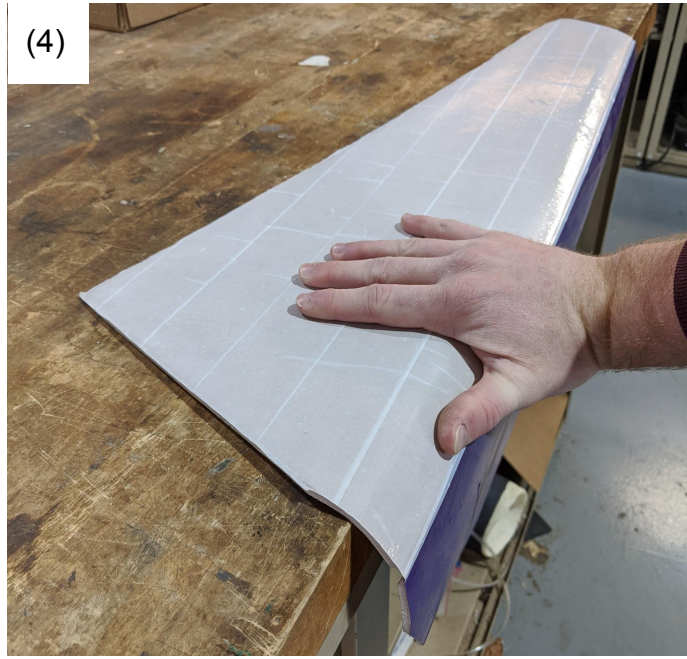


(2)



(3)

(4)



Gluing Parts Down

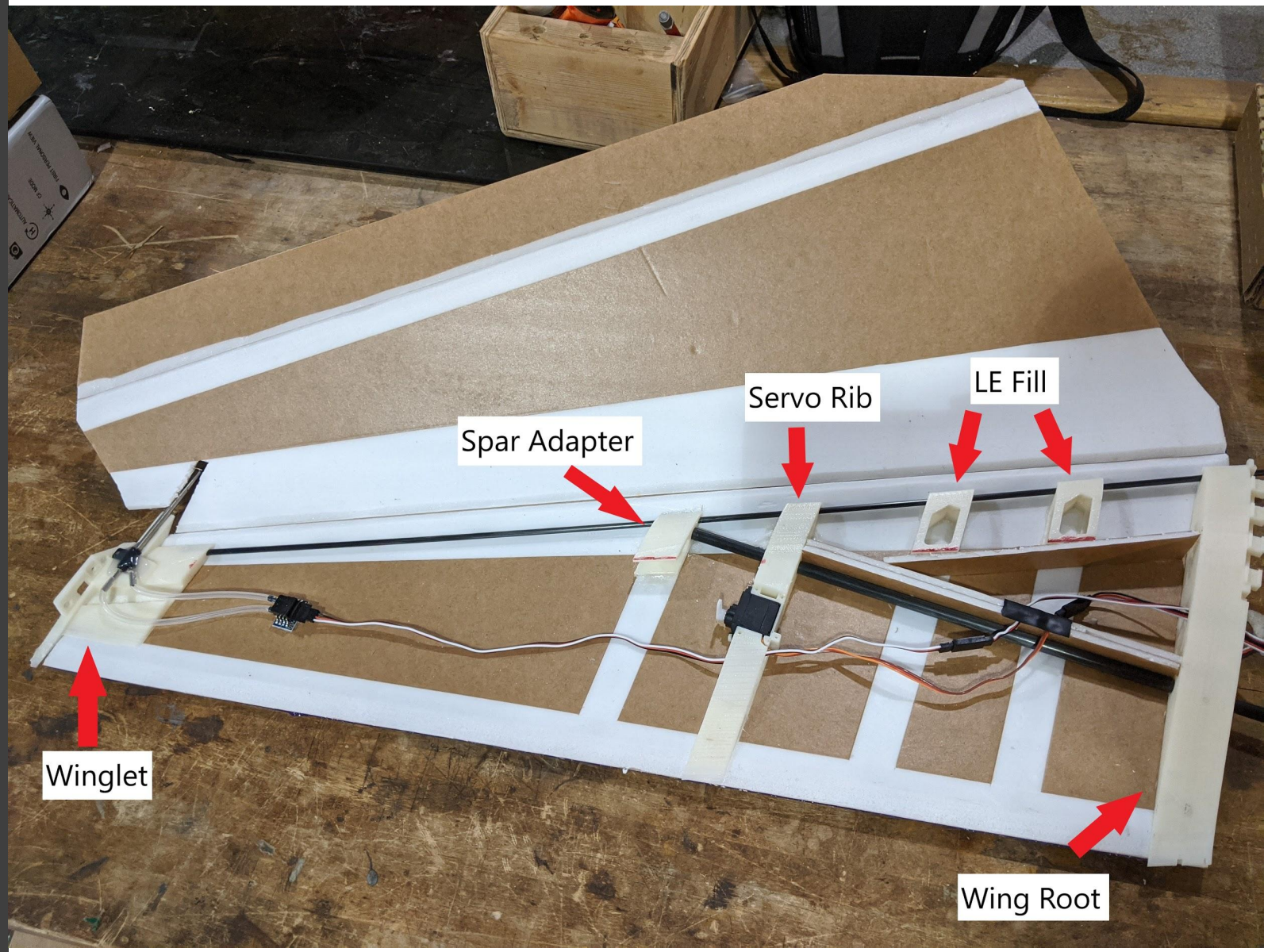
Gather all parts needed for left wing, shown in picture to right.

The ribs on the left wing and right wing can be differentiated by the position of the spar holes being closer to the posterboard when placed in the correct orientation.

Note that the LE Fill closer to the wing root is slightly larger than the other.

Taking the carbon fiber leading edge rod, place them all on the rod in the same order shown.

Carefully line all parts up over the exposed foam sections.



Gluing Parts Down (Cont.)

Beginning with the wing root, place glue in zig-zag pattern on bottom and press down.

Using the same pattern, glue down the rest of the parts working your way from the wing root to the winglet.

Gluing Parts Down (Cont.)

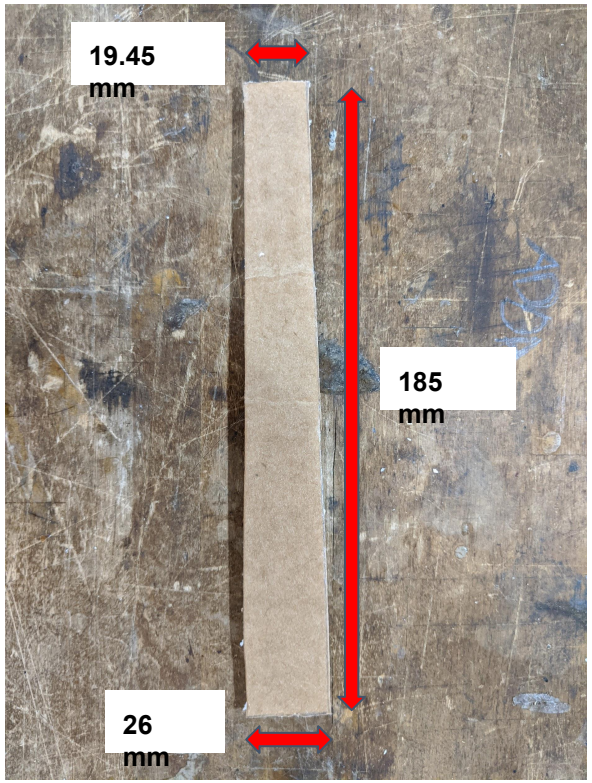
If there is another hot glue gun, both wings can attempt to be glued down at once

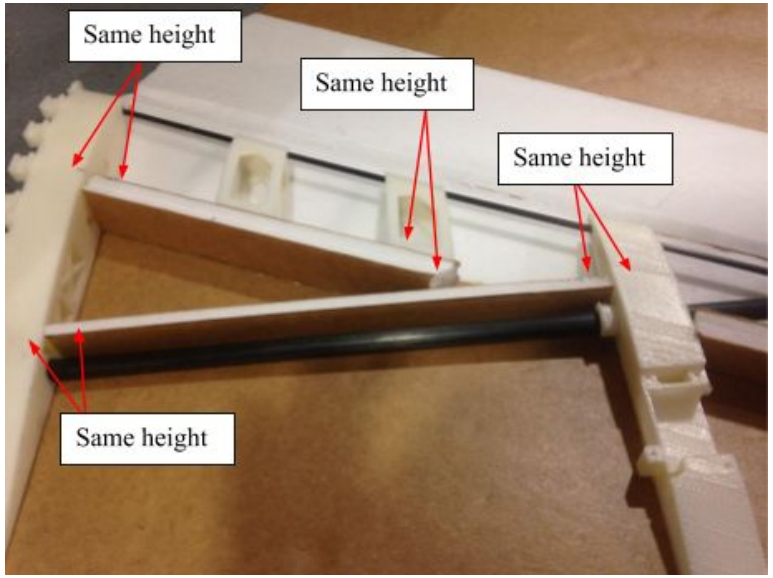
Placing Posterboard Ribs

Cut out two pieces of the poster board spar seen in the top left, and four pieces of the poster board in the top right.

Glue two of the posterboard strips in the top right together.

Glue them in the spots identified in the bottom picture for both wings.



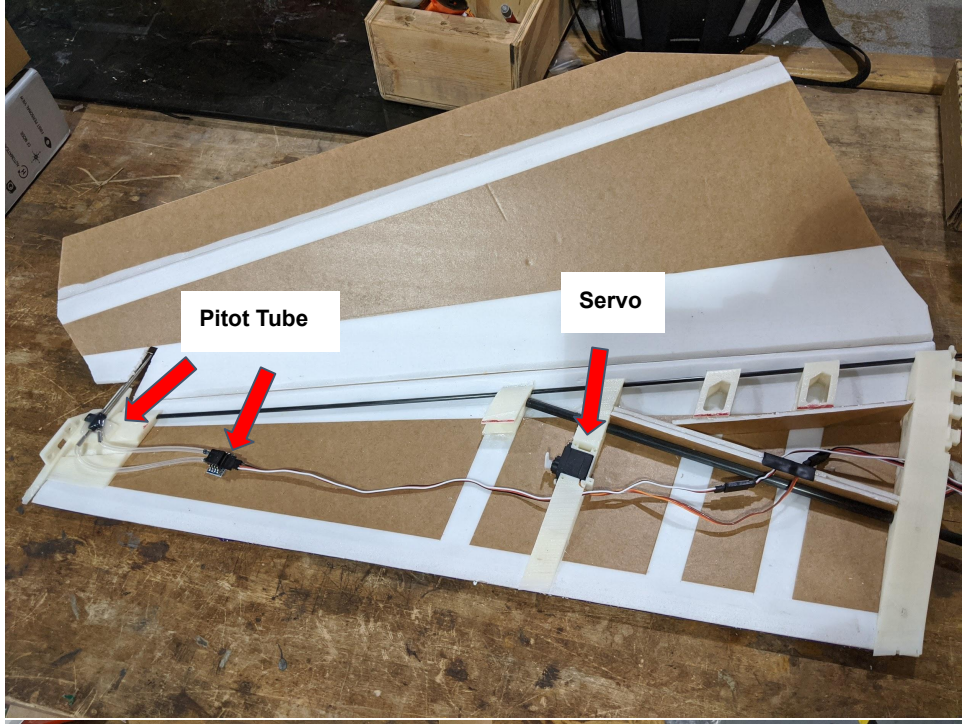


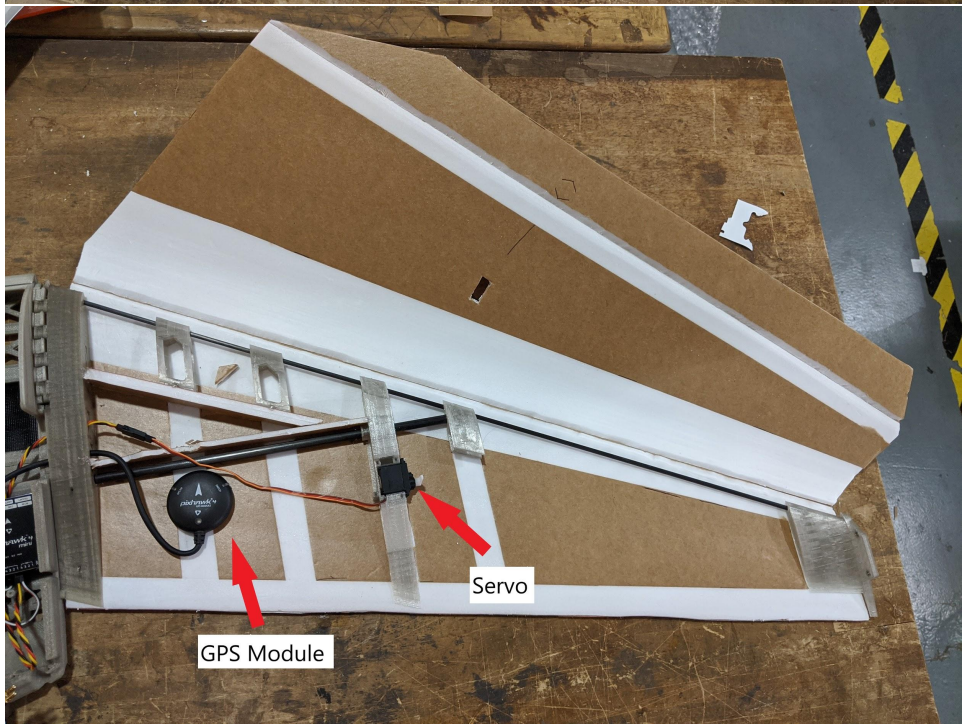
Insert Avionics into Wings

Glue down servos, the GPS module, and the pitot tube into the correct spots shown to the right.

For better adhesion when gluing, it's best to slightly score the bottoms of electronics. Do so for the servos and GPS module.

Place the servo rib cover over each of the servos once they're both glued down.





Inserting Avionics (Cont.)

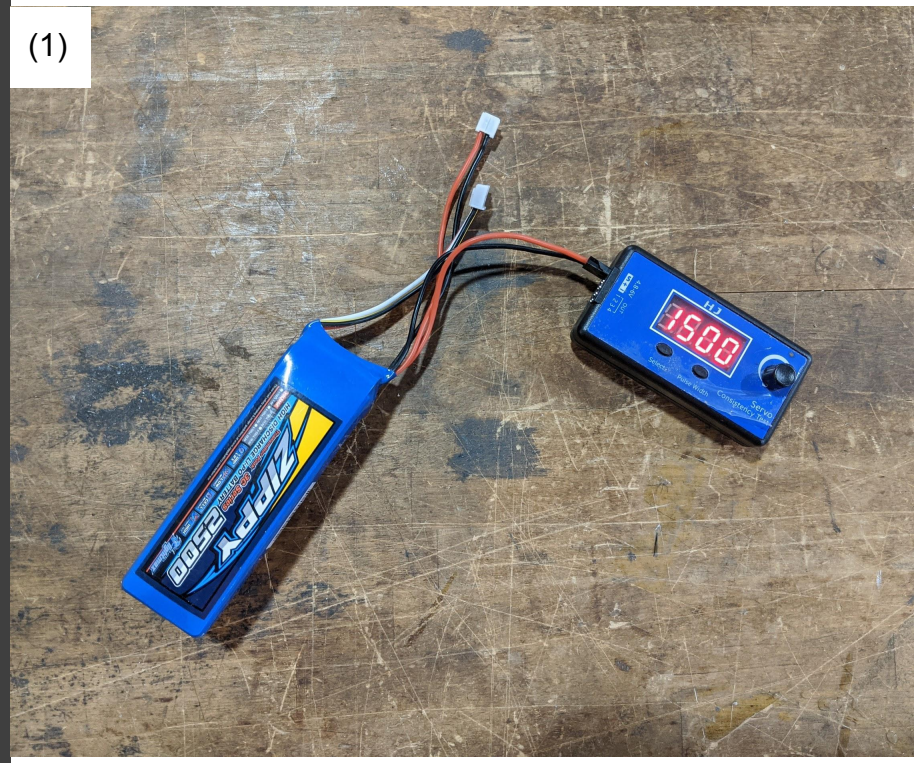
(1) Zero the servos by plugging them into the servo checker and setting the PWM signal to 1500.

(2) Cut a small section from the wing end to allow the pitot tube to fold through the wing. Ensure pitot tube is properly secured with glue.

(3) Attach largest servo arm provided with servos, screw in.

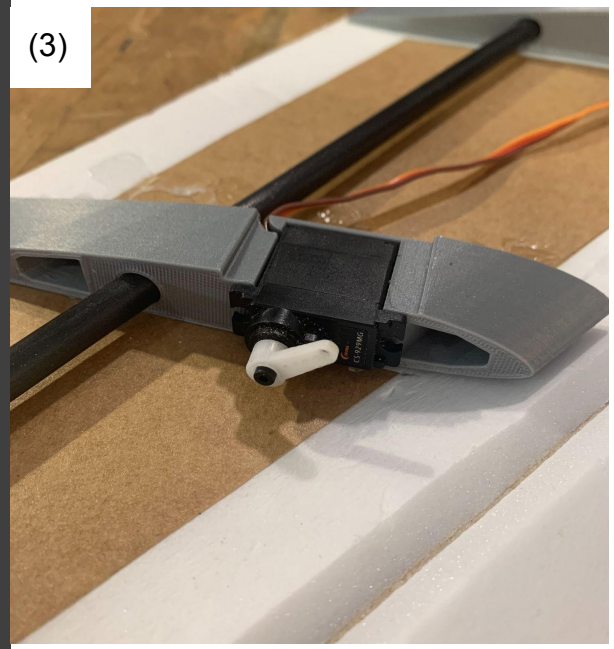
(4) Bend wing over onto arms and cut out rectangle around where you scored. This ensures room for servo arm to move through wing.

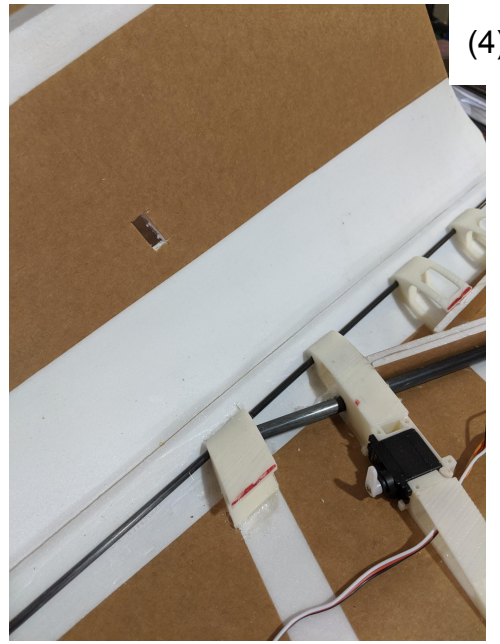
(1)



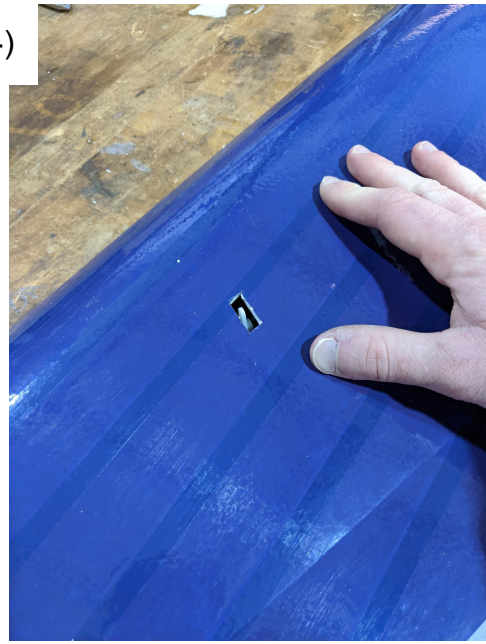
(2)

(3)





(4)



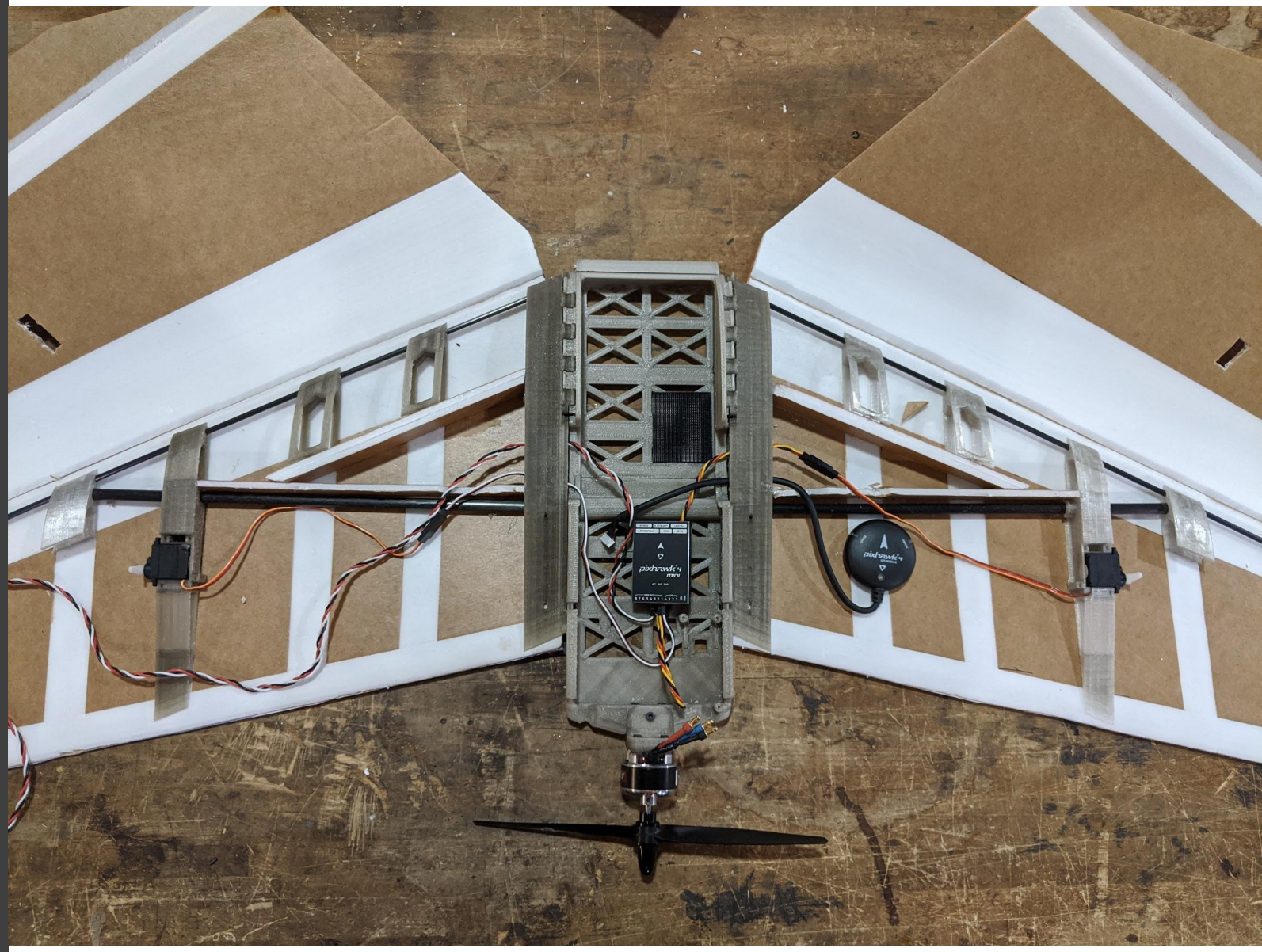
Connecting Wings and Fuselage Together

Glue the two fuselage halves together to form one part.

Remove the main spar from either the right or left wing.

Begin working the remaining spar through center of fuselage and back into the wing without the spar.

For example, if you removed the spar from the right wing, you will then work the left spar through the fuselage and into the right wing’s spar holes.



At this point, you've finished the 1st stage of the EcoSoar build! Call an instructor over to check your aircraft.

Avionics Introduction

Today you will connect the avionics in the wings to the avionics in the fuselage, and ensure that all are functioning properly.

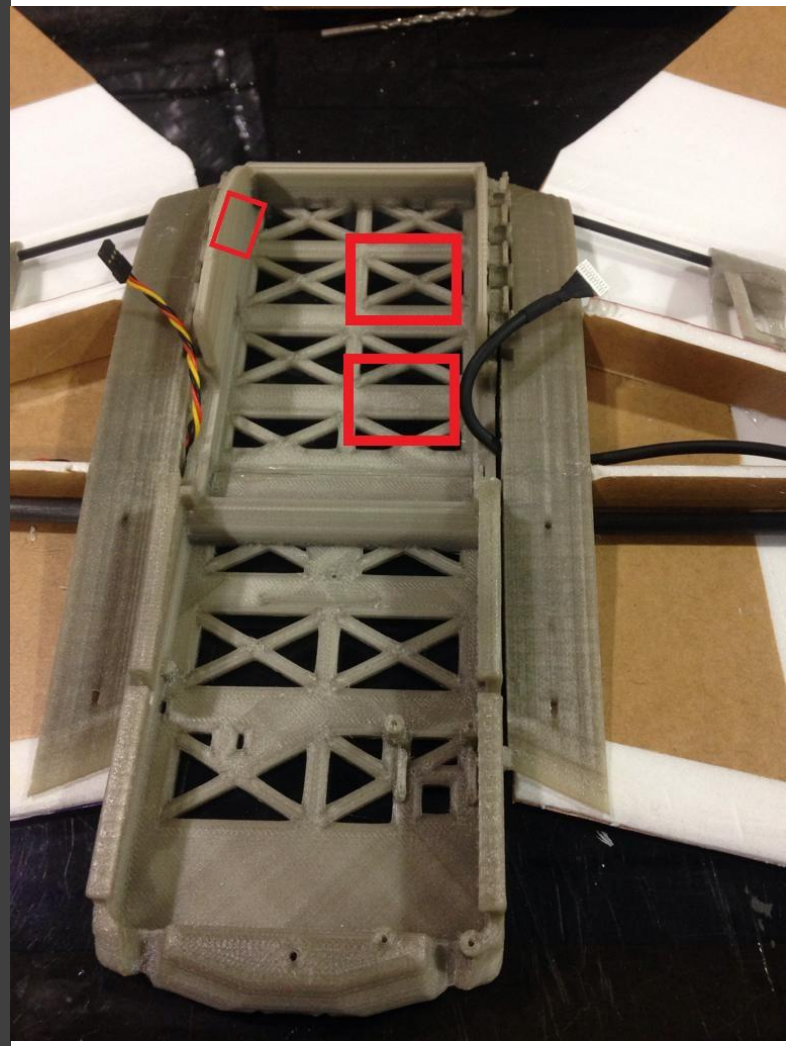
Placing Avionics onto Fuselage

Begin by placing velcro in approximately the same spots in the left image, boxed in red.

First, you will connect the motor and motor mount combo onto the back of the fuselage.

The motor mount uses M3 screws of lengths 12 mm, 25 mm, and 30 mm.

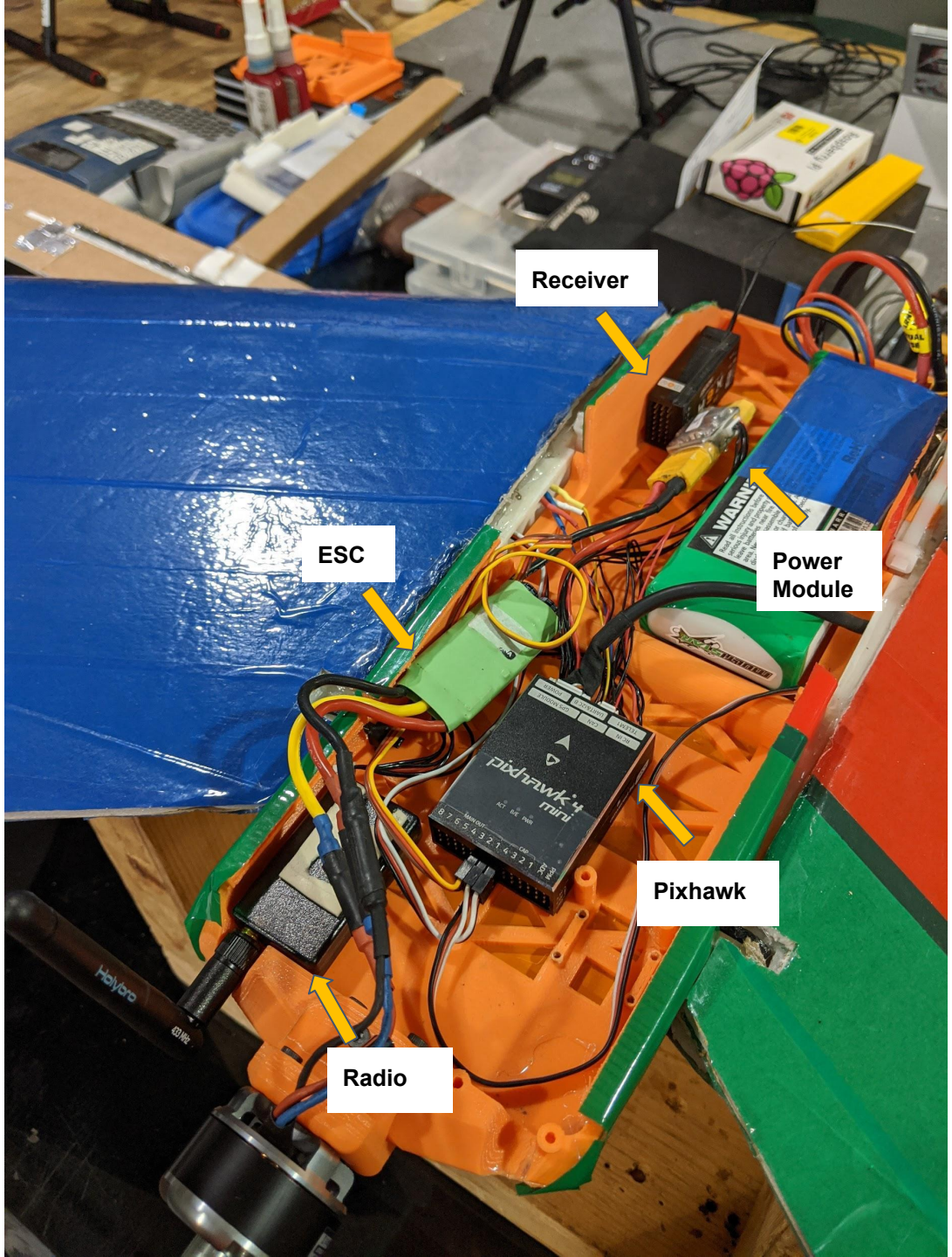
When inserting screws, be careful that they do not hit and score the windings on the insides of your motor.



Placing Avionics onto Fuselage (Cont.)

The pixhawk flight controller must now be placed in the same orientation and approximately the same location as shown to the right.

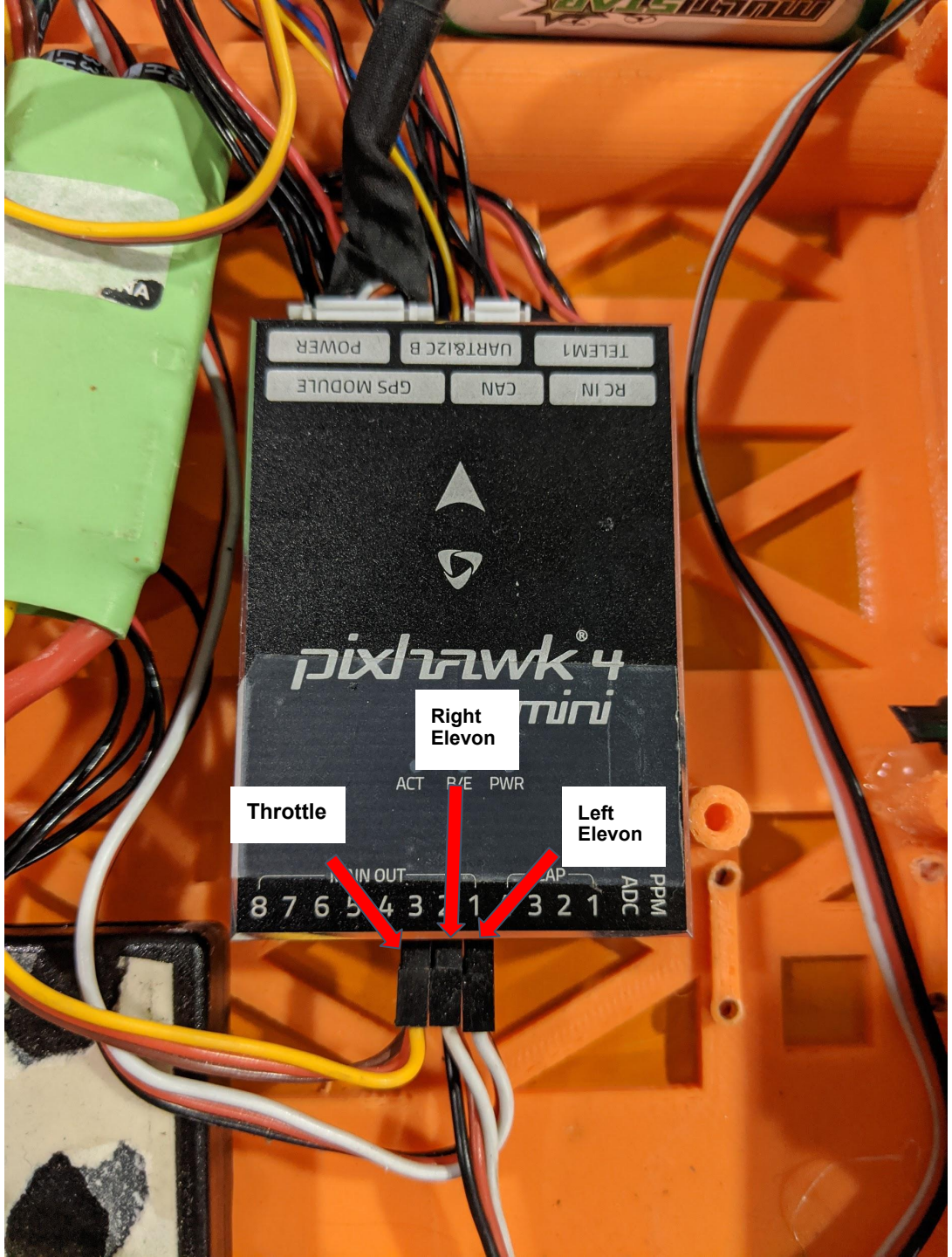
Place down ESC, radio, power module, and receiver in their relative locations.



Placing Avionics onto Fuselage (Cont.)

Connect the servos and ESC to the following ports:

- Main Out 1: Left Elevon
- Main Out 2: Right Elevon
- Main Out 3: Throttle

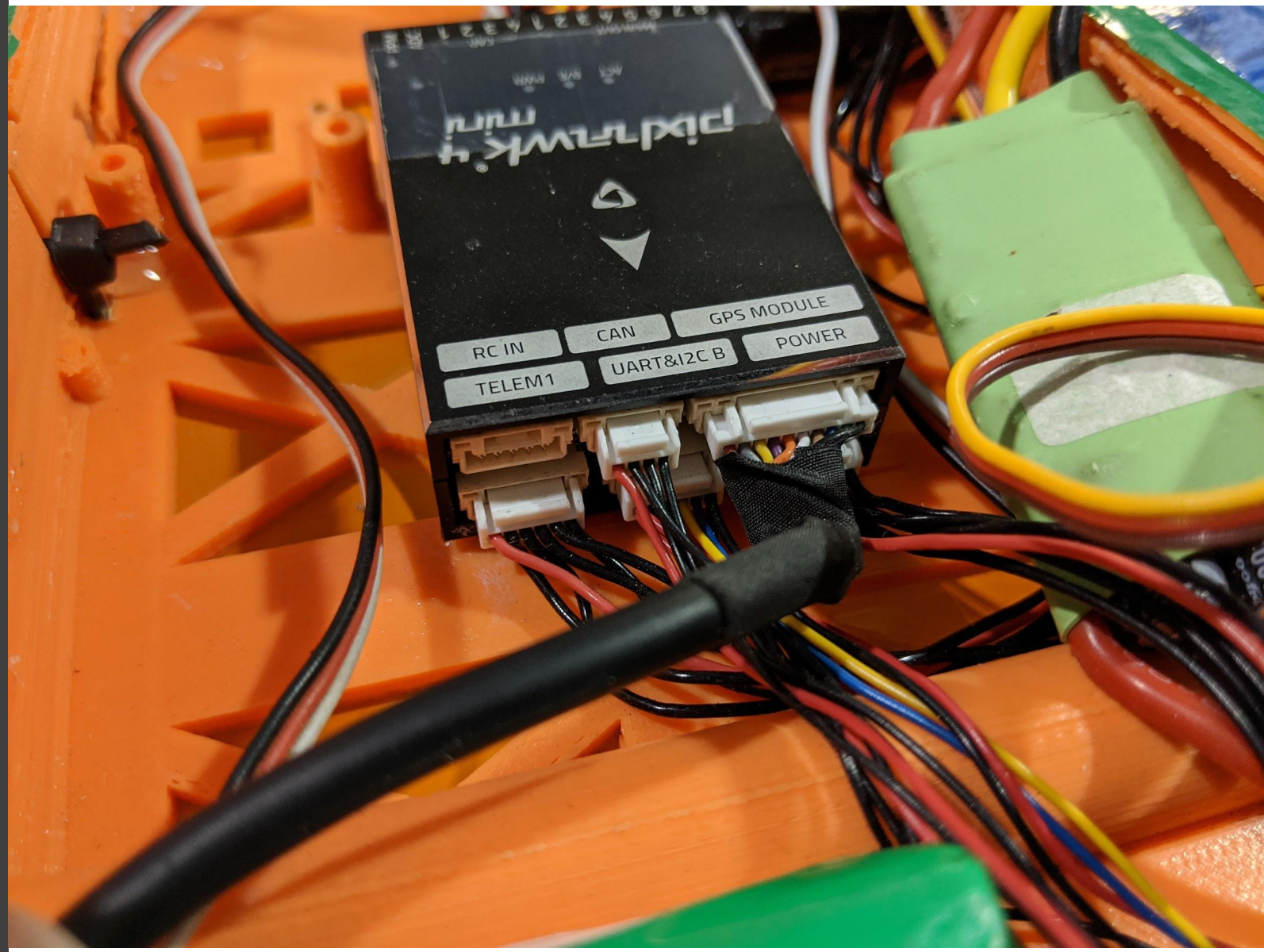


Placing Avionics onto Fuselage (Cont.)

Connect the telemetry wire to the TELEM1 port.

Connect the power cable from the power module into the POWER port.

Connect the GPS cable into the GPS MODULE port (above the POWER port).



Ensuring Avionics are Functioning

This step is essential in preventing any avoidable mistakes, which would require you to open the wing for maintenance!

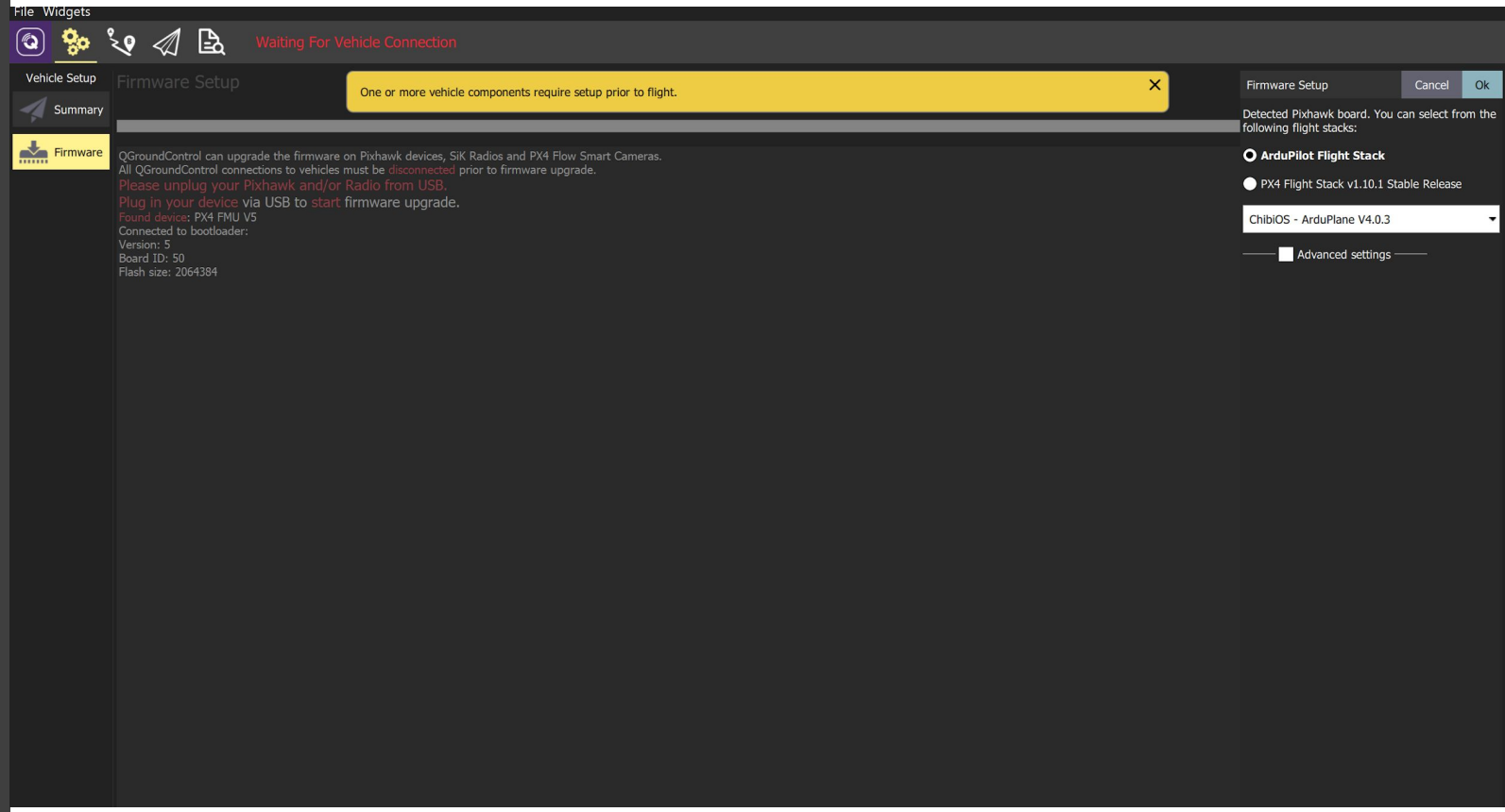
Once all avionics are properly connected to pixhawk, connect the pixhawk to your ground station (computer) and establish connection in QGC.

Loading Firmware

Since this is a new Pixhawk in a new aircraft, the correct firmware must be downloaded onto the Pixhawk.

To do this:

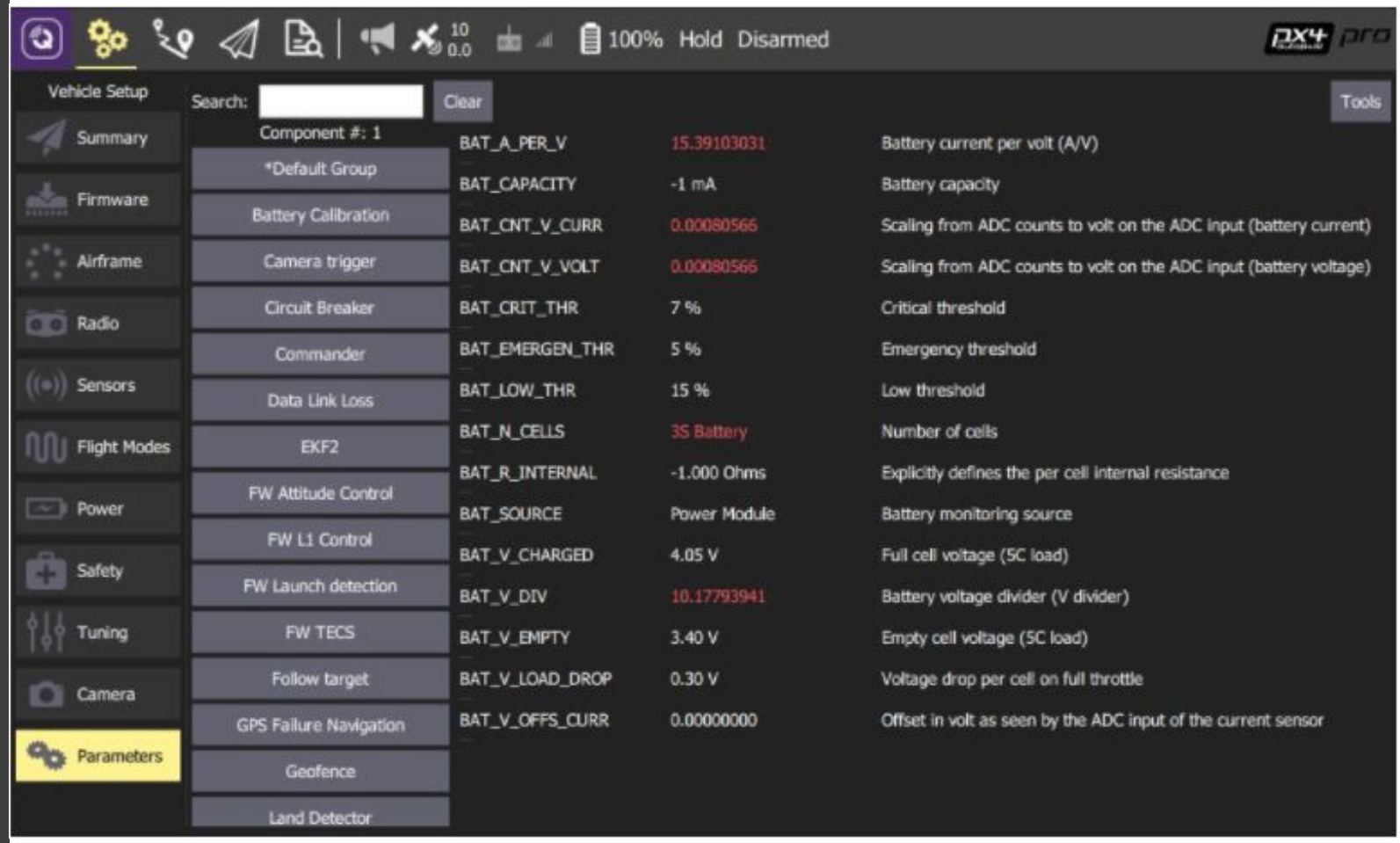
- Select the Gear icon (Vehicle Setup) in the top toolbar and then Firmware in the sidebar.
- Choose ArduPilot Flight Stack to download the current stable release.
- Then choose the ChiBiOS Arduplane option.



Loading Aircraft Parameters

With the aircraft firmware now flashed to your Pixhawks, it's time to upload the proper EcoSoar parameters that have been tuned for the aircraft.

On the Vehicle Setup, click the Parameters tab.

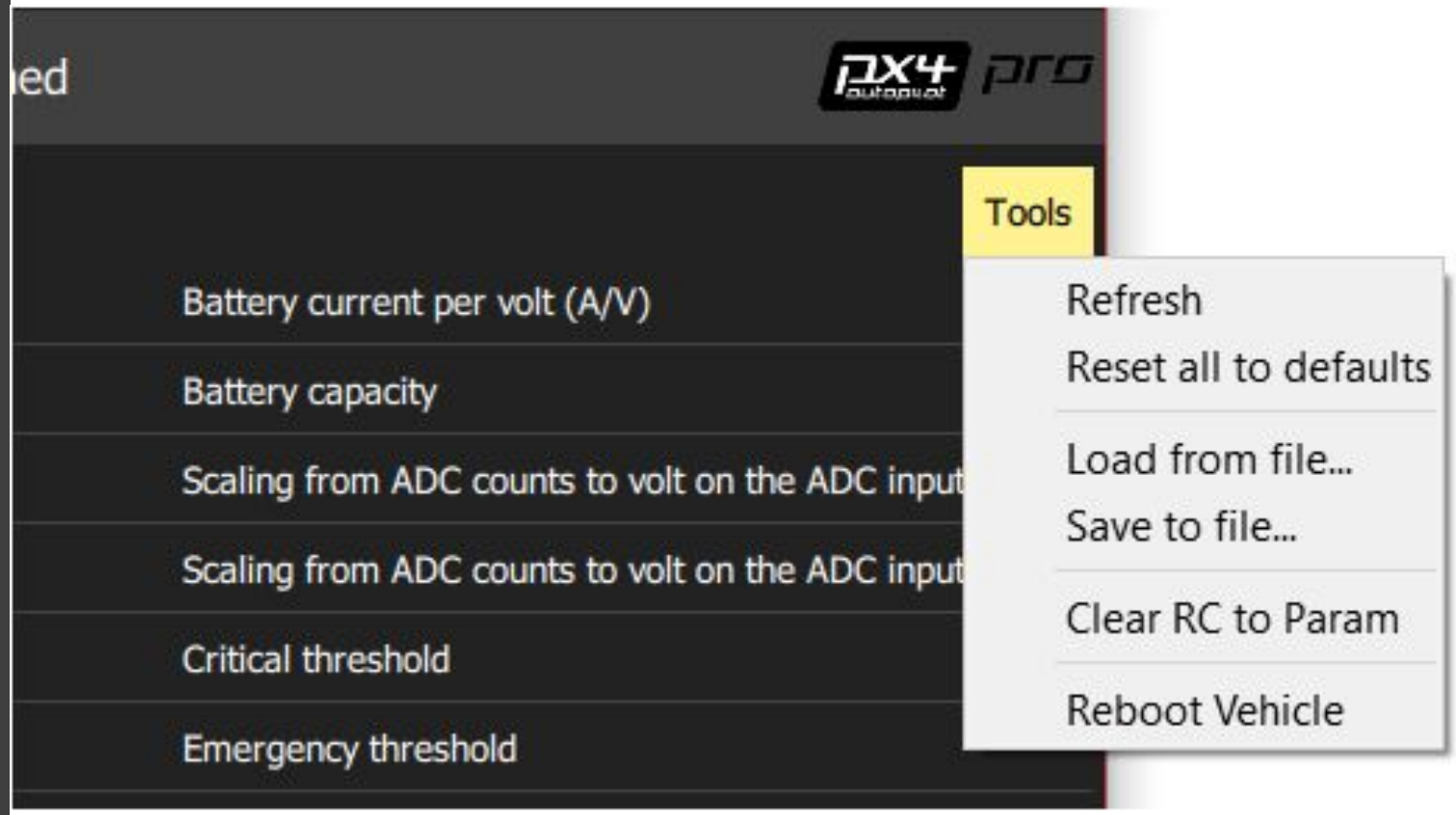


Loading Aircraft Parameters (Cont.)

From the ADDA Moodle site, download the parameter file “2020-07-06_EcoSoar.param”

Once the file is downloaded, click on “Tools” in the top right corner of the parameters tab and then “Load from file…”

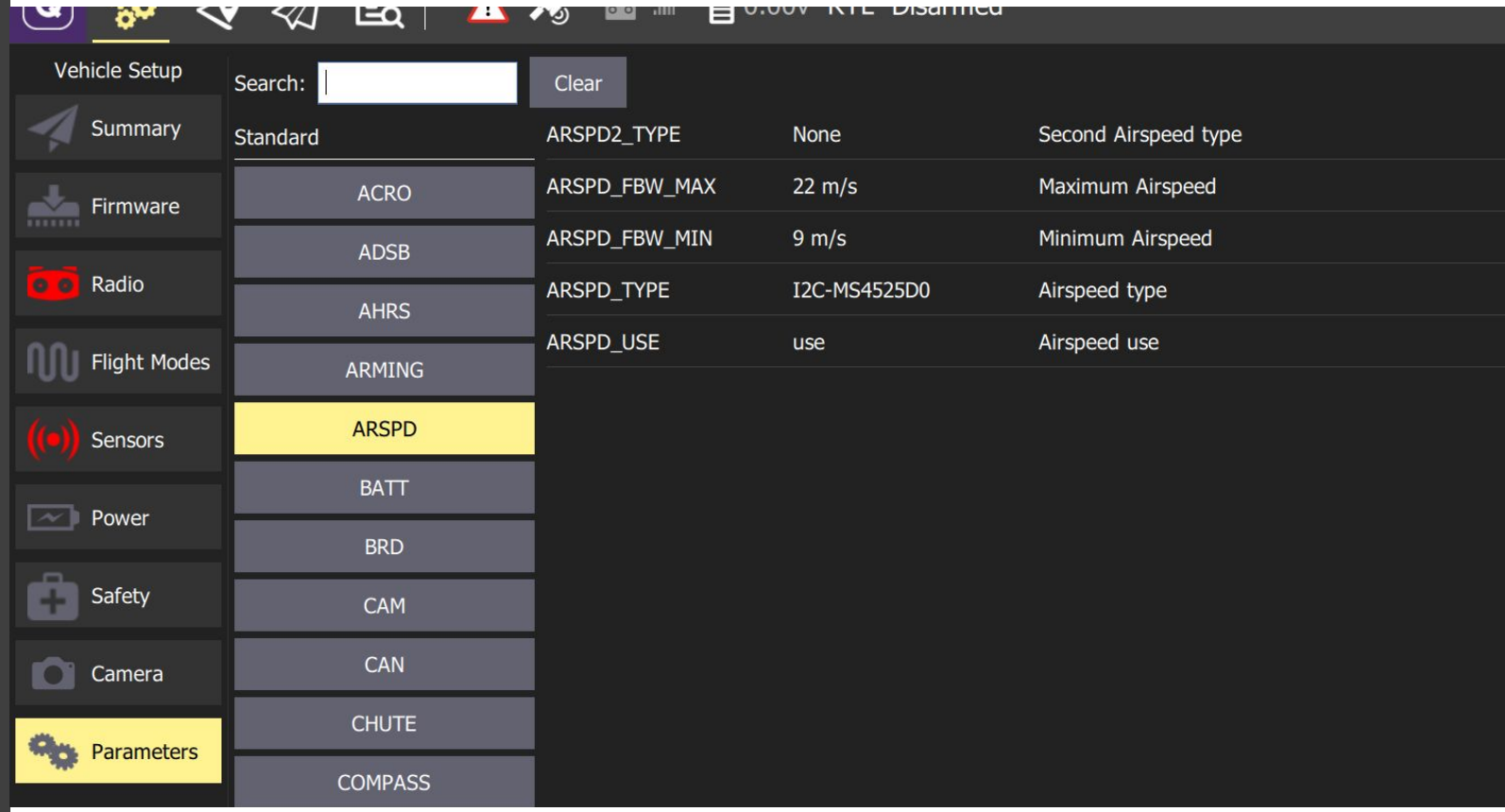
Select the EcoSoar parameter file that you just downloaded from Moodle.



Setting up the Airspeed Sensor

Once the firmware update is complete, proceed to the parameters tab.

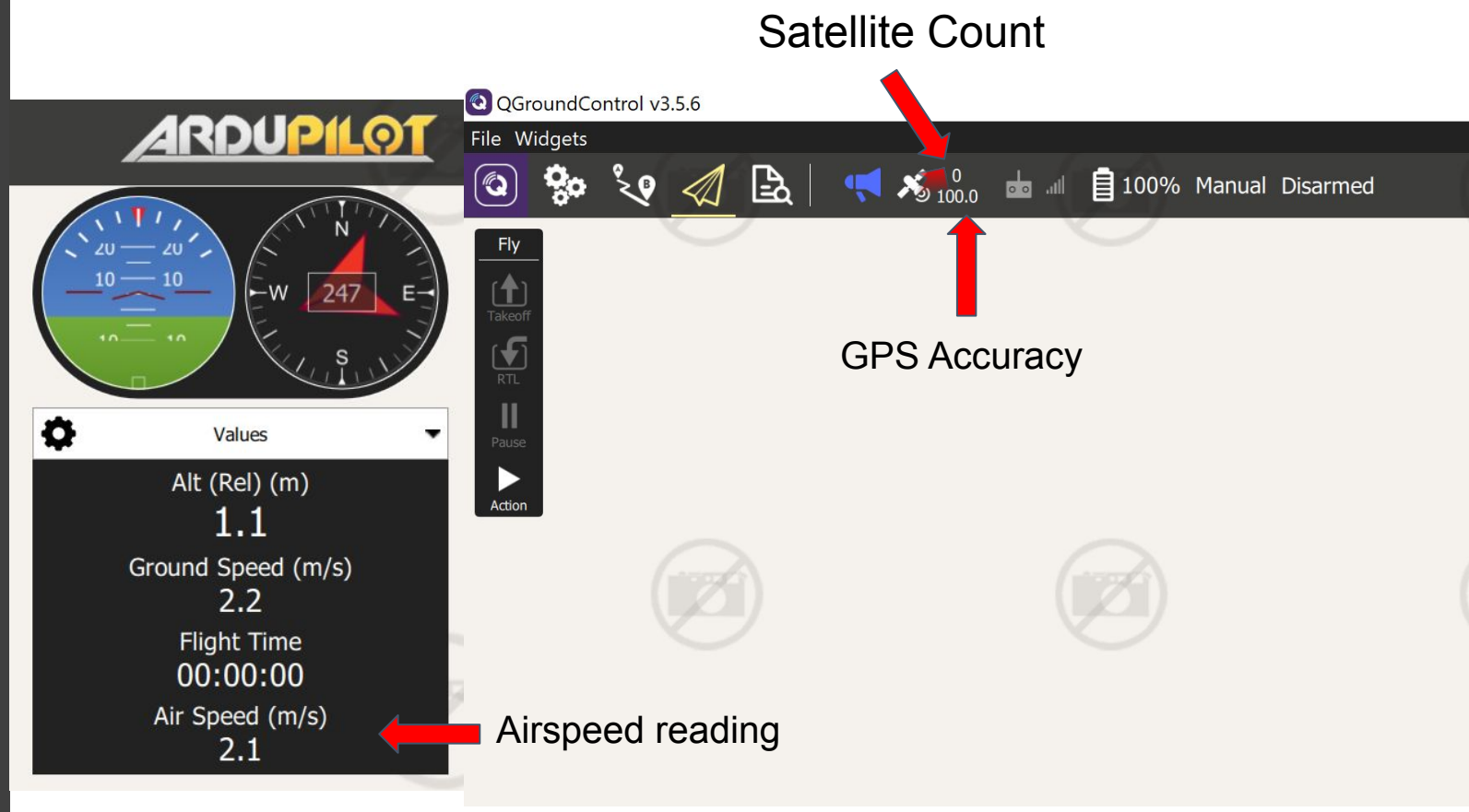
Click on ARSPD and ensure that the parameter ARSPD_USE is set to “use”



Ensuring Avionics are Functioning (Cont.)

Ensuring that the pitot tube, GPS module, and servos are functioning properly is the true goal at this time.

Check for fluctuating airspeed velocity in the QGC interface, when blowing into pitot tube. Also ensure that the accuracy of GPS module readings is 100%.



Ensuring Avionics are Functioning (Cont.)

Once the pitot tube and GPS module are working properly, pair transmitter and receiver on aircraft.

Once paired, check that the transmitter has control over servos when manipulating the pitch and roll control stick.

Closing the Wings Notice

Please read carefully all “Closing the Wings” slides before in fact closing the wings!

This is time-limited process so be sure you and your partner are both ready and aware of how to close the wing.

Closing the Wings

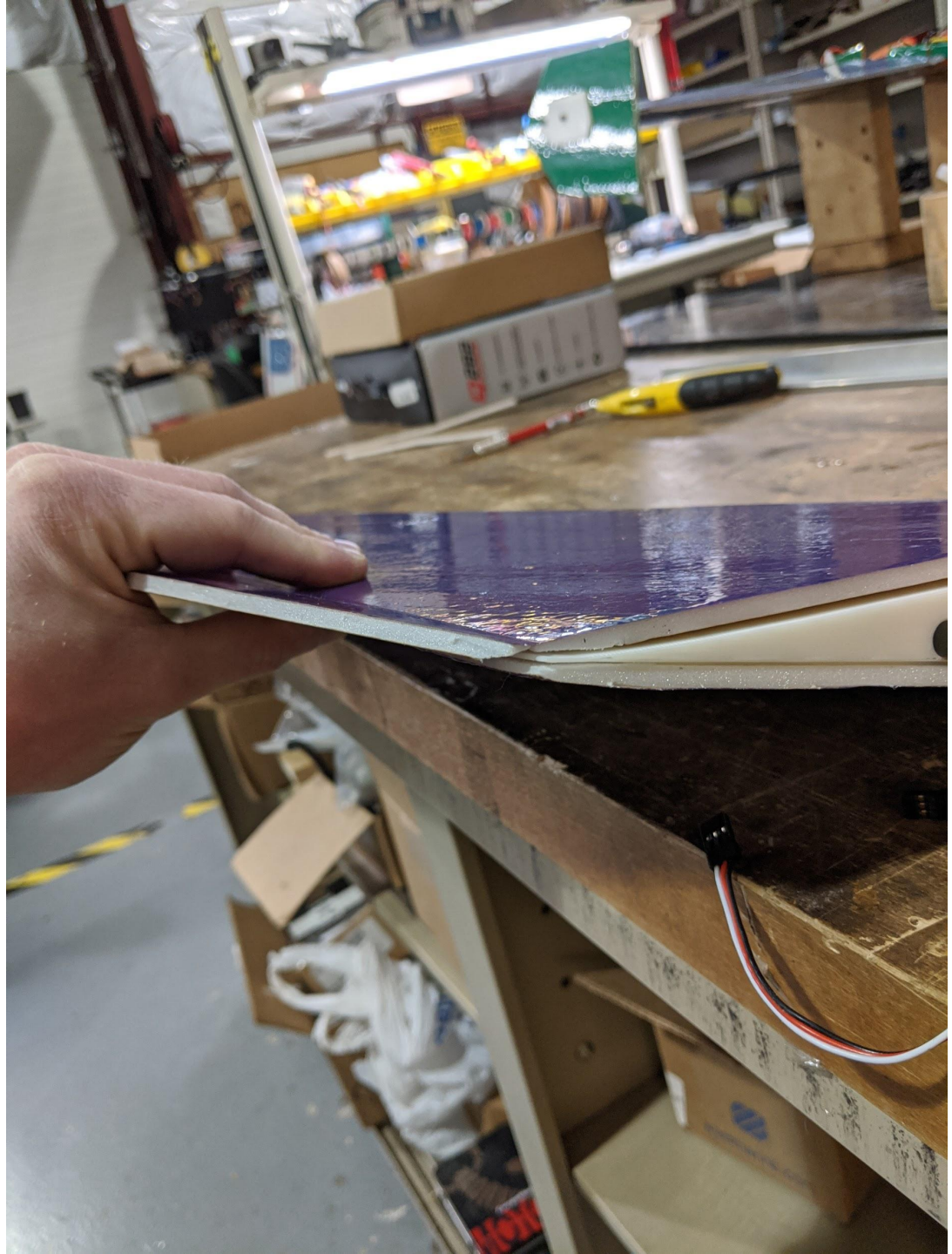
In order to identify the advantages of a closed cross-sectional area over that of an open one, one wing will be closed first and then the team will perform a twist test on both wings (one open and one closed) to identify which one is more structurally sound.

Each team member will grab both EcoSoar wings by their endplate mount parts and give a slight twist to both the closed and open wing. Be sure to note the differences in rotation and torque required to conclude which shape is strongest.

After determining the results of your test, your group may then close the other wing.

Closing the Wings (Cont.)

Once again, ensure that you can fully close the wing around the winglet and servo arm and have the two halves comfortably meet in the back.



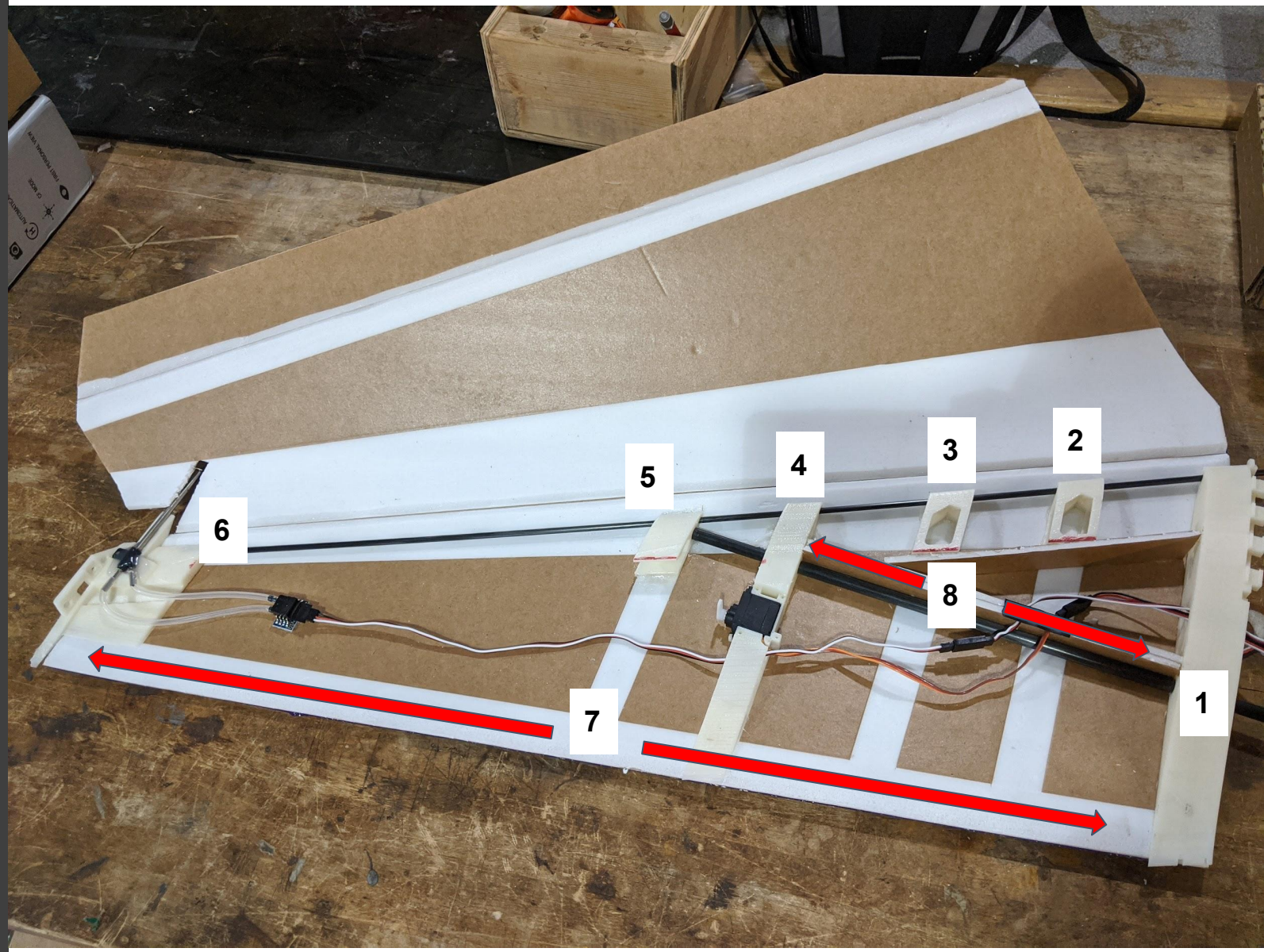
Closing the Wings (Cont.)

Begin applying hot glue in the order marked by number in the picture to the right.

Perform a slight zig-zag pattern when gluing.

Fold top half over onto the ribs and have both you and your partner hold it shut. Work your hands along the ribs over the posterboard to ensure good contact with the glue as it dries.

You should be able to remove your hands after approx. 5 minutes.

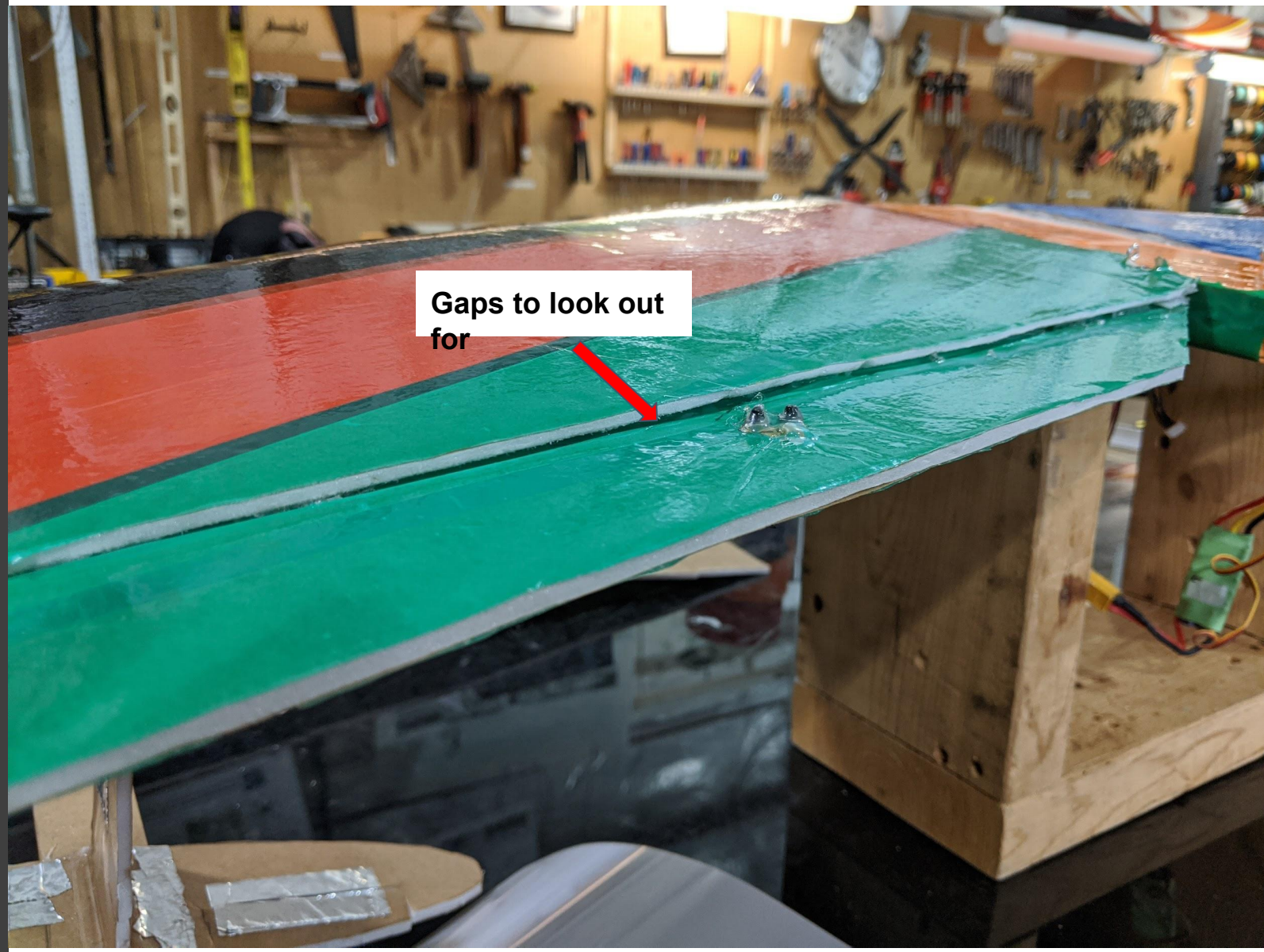


Closing the Wings (Cont.)

After the glue has dried, flip the wing over and check for gaps in between the top and bottom half of the wing.

Fill any gaps present with hot glue.

Place tape over exposed area on the left winglet from the pitot tube.



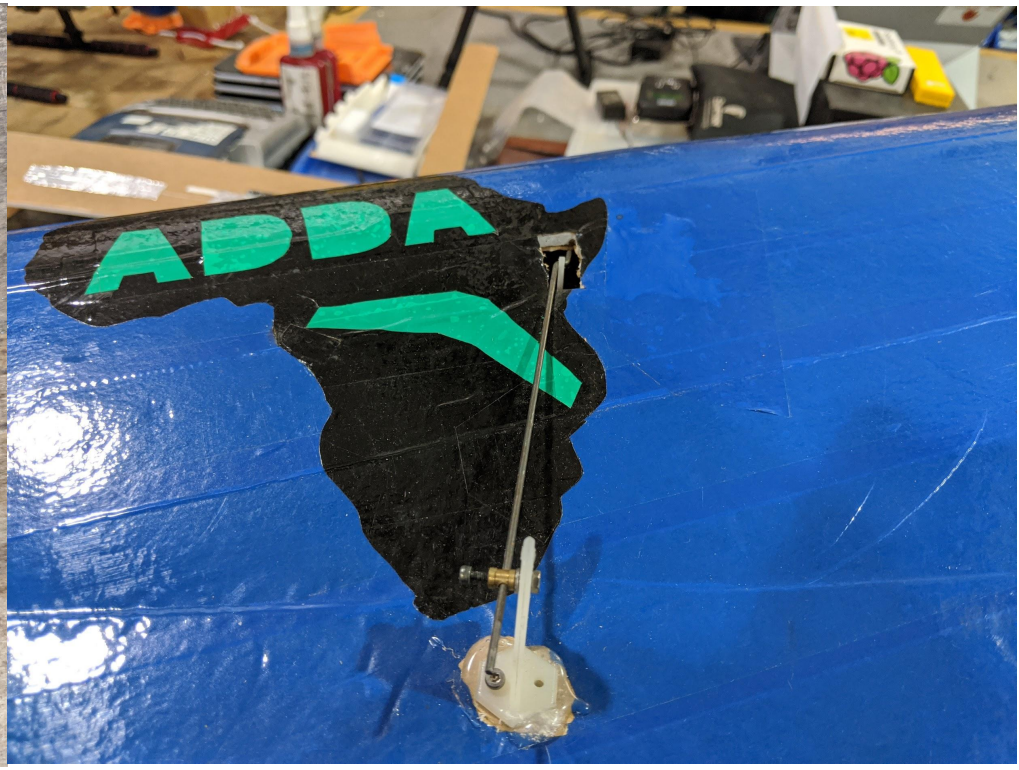
At this point, you've finished the 2nd stage of the EcoSoar build! Call an instructor over to check your aircraft.

Control Surfaces

Place a z-bend in the end of one of your control rods and loop through the servo arm.

Place a linkage stopper through the second from bottom hole on the control horn.

Line up the control rod through the linkage stopper.

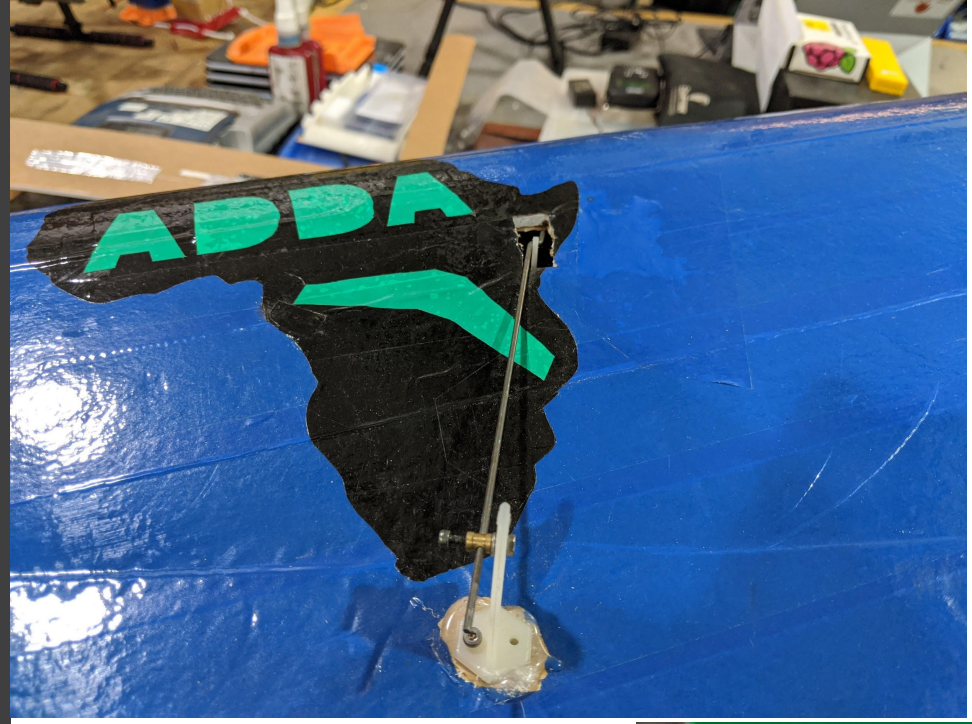


Control Surfaces (Cont.)

Line up control horn so that it moves straight in line with action of servo arm and control rod.

Also be sure that the holes of the control horn lie directly over the hinge of the control surface for maximum authority.

Firmly press down the control horn onto the control surface to mark location of placement.



Control Surfaces (Cont.)

Set aside a control horn. Using a drill with a drill bit smaller than the legs of the control horn, drill through the markings where the control horn will go.

Then cut a small amount of the tape and paper away from the location the control horn will go.

Hot glue the bottom of the control horn as you place it through the pre-drilled slots.

Control Surfaces (Cont.)

Once the hot glue has dried, flip the wing over and snip off the excess length of the control horn legs.

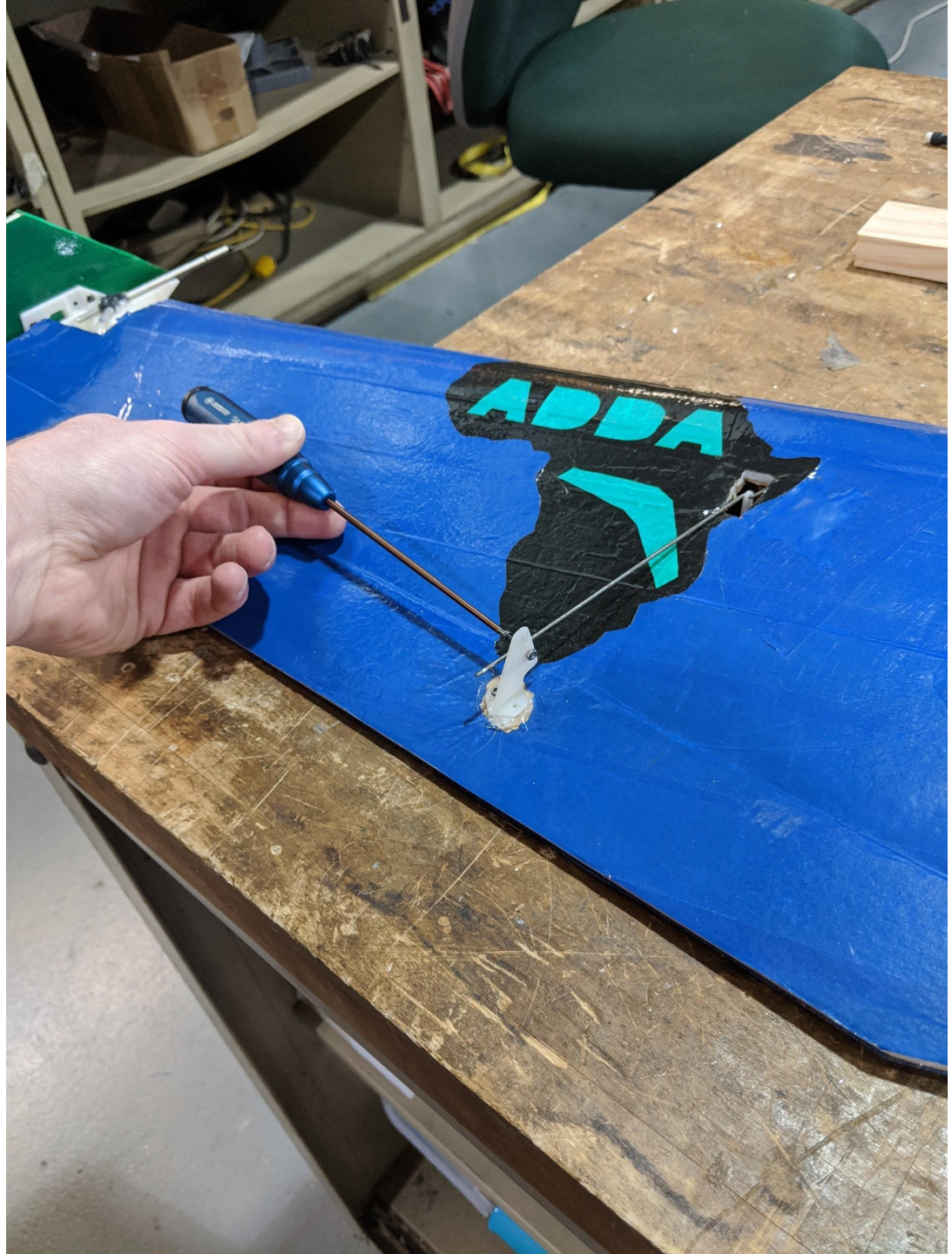
Place small dabs of glue over the remaining nubs of the legs to secure the control horn from the underside of the wing.

Control Surfaces (Cont.)

Flip the aircraft back to be to rightside up. Then, lay the EcoSoar flat on the table.

Adjust the control rod through the linkage stopper until the control surface is also laying flat on the table

This is a properly trimmed EcoSoar. Securely tighten the screw to lock the control rod in.

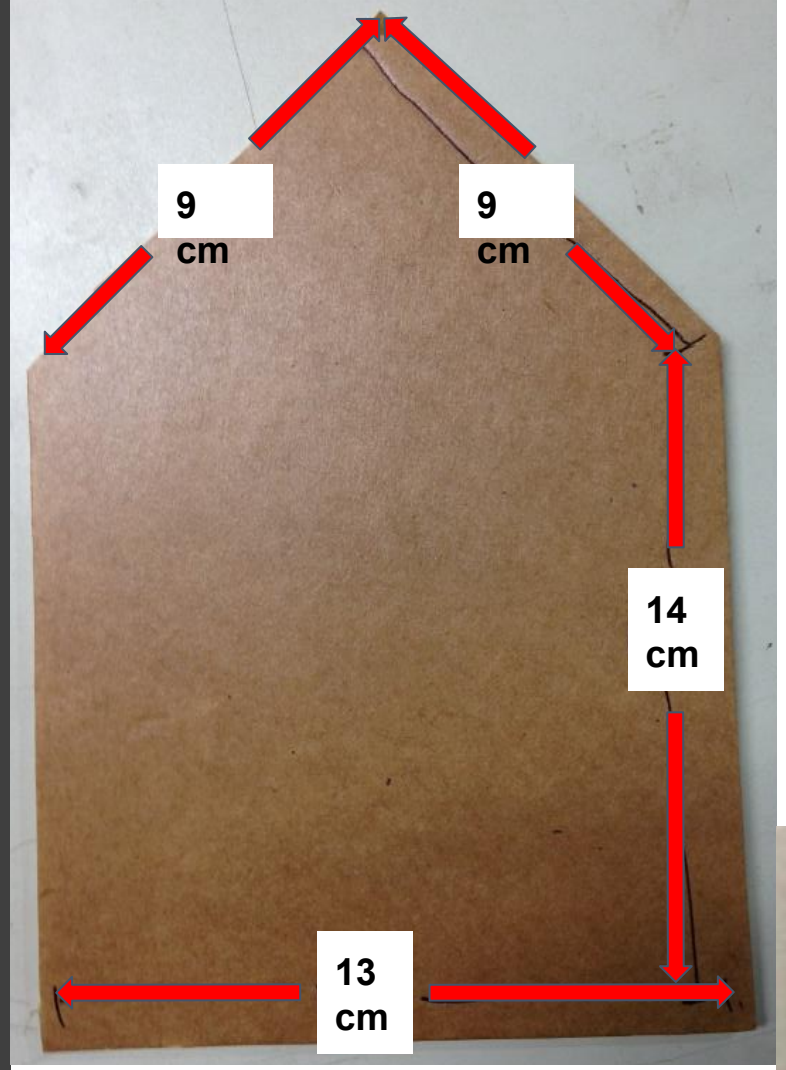


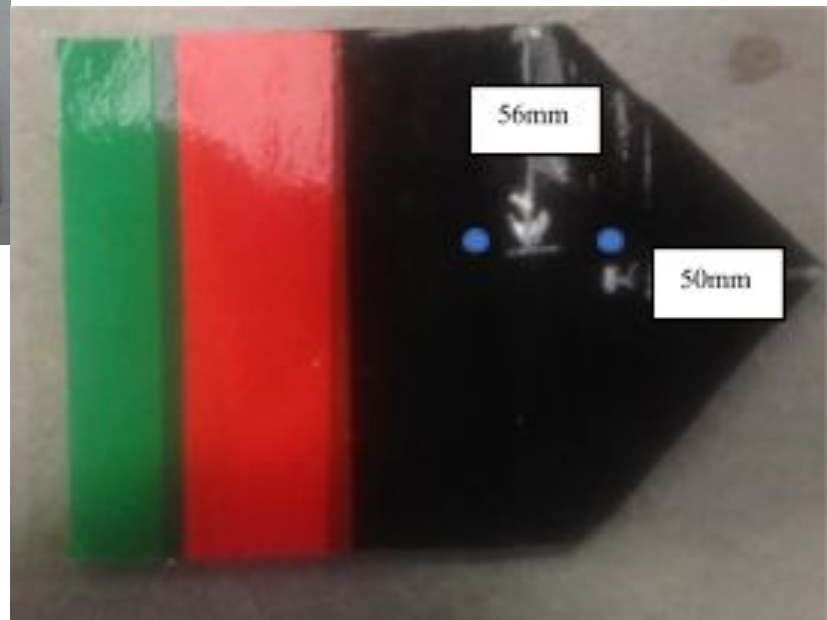
Winglets

Take your piece of spare posterboard and cut out two winglets with the dimensions shown to the right.

Tape over both sides of the winglets, with a similar effect as the wings.

Lay the winglet flat on the table. Moving from one side to another, place tape across the winglet. Press it flat using the plastic card. Keep approximately a 1 cm overlap between tape strips.

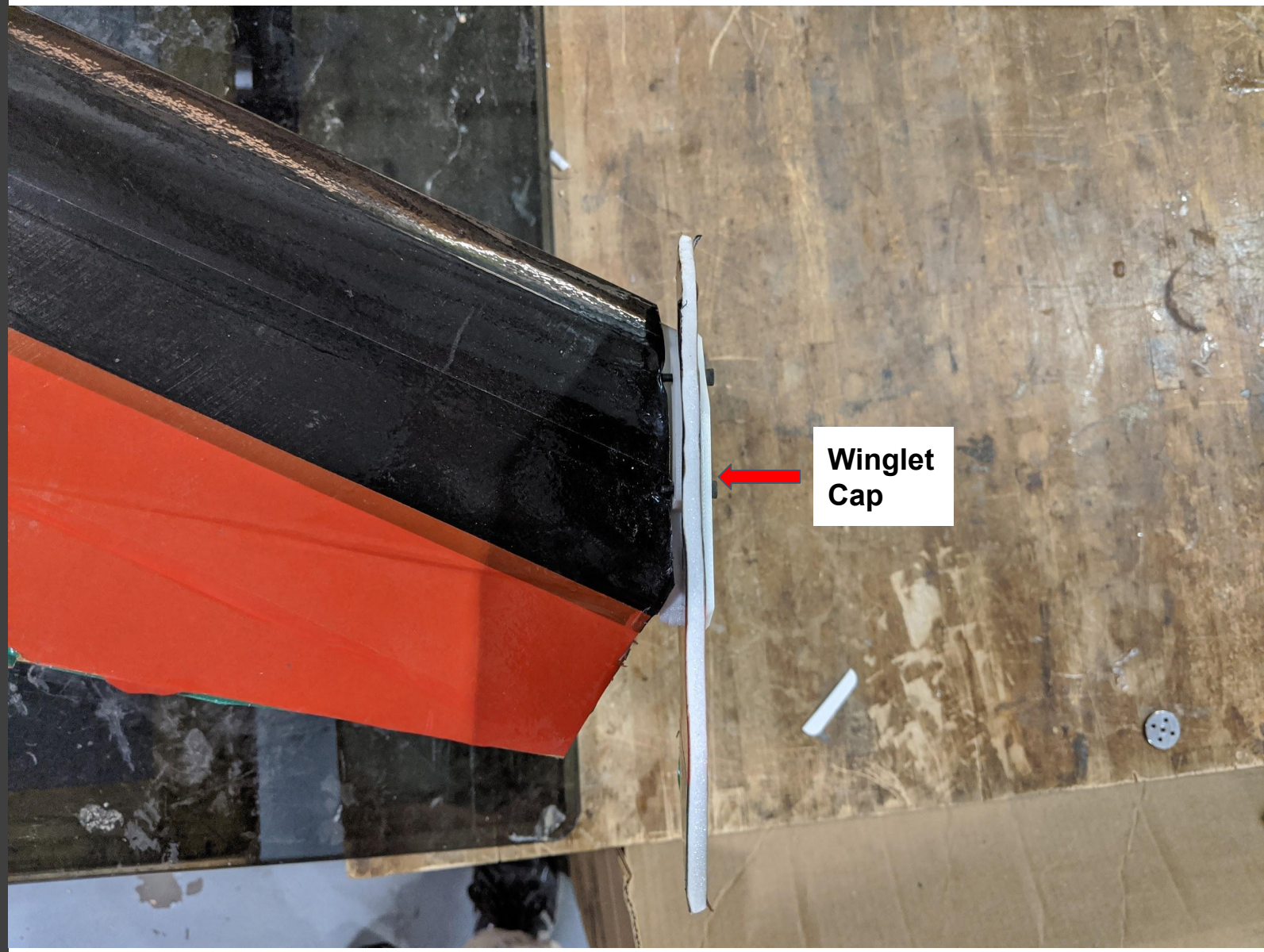




Winglets (Cont.)

Then, attach the winglets to the wing tip using the winglet cap piece.

Reference picture for clarification!



Call an Instructor Over to Clear Your Craft for Flight!

Calibrations

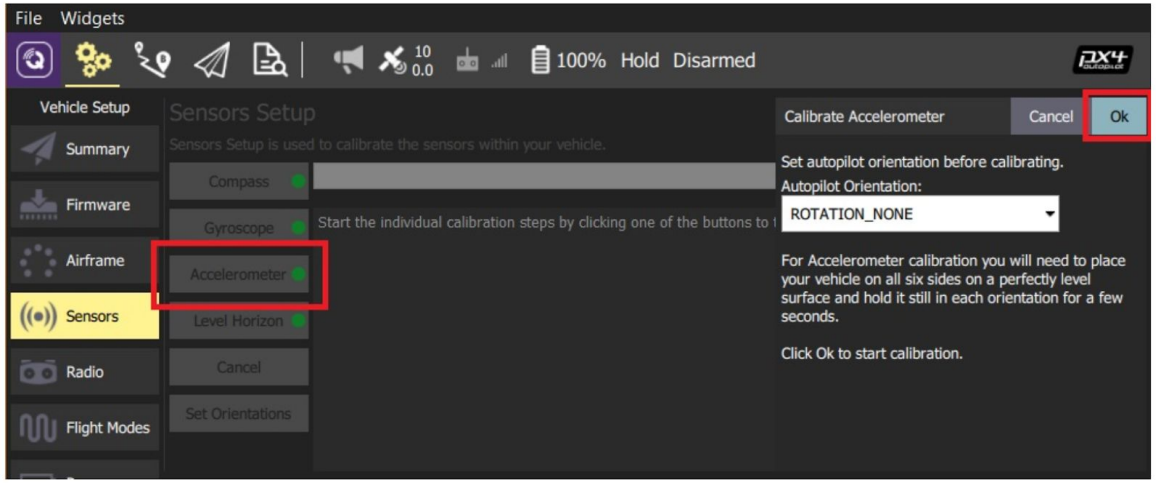
Now begin to perform the calibrations needed to fly!

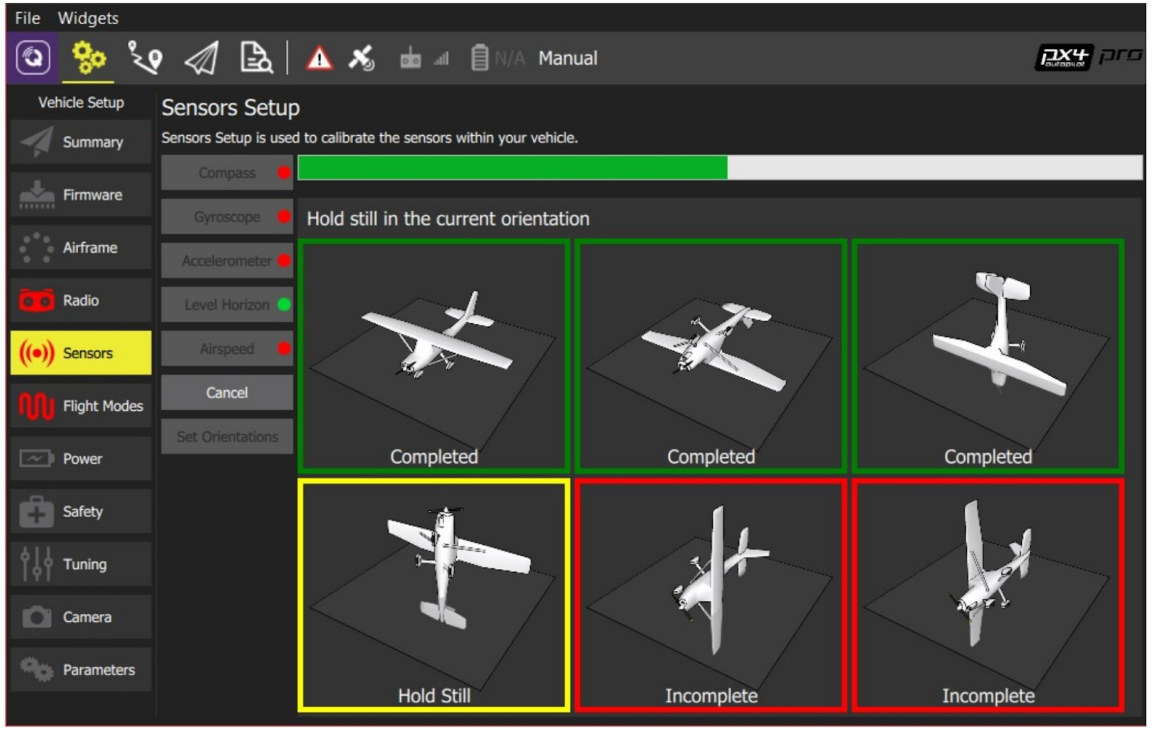
Accelerometer Calibration

Click the Accelerometer sensor button. Set Orientation to ROTATION_NONE and Click OK to start the calibration.

Position the vehicle as guided by the images on the screen. This is very similar to compass calibration.

Repeat the calibration process for all vehicle orientations.



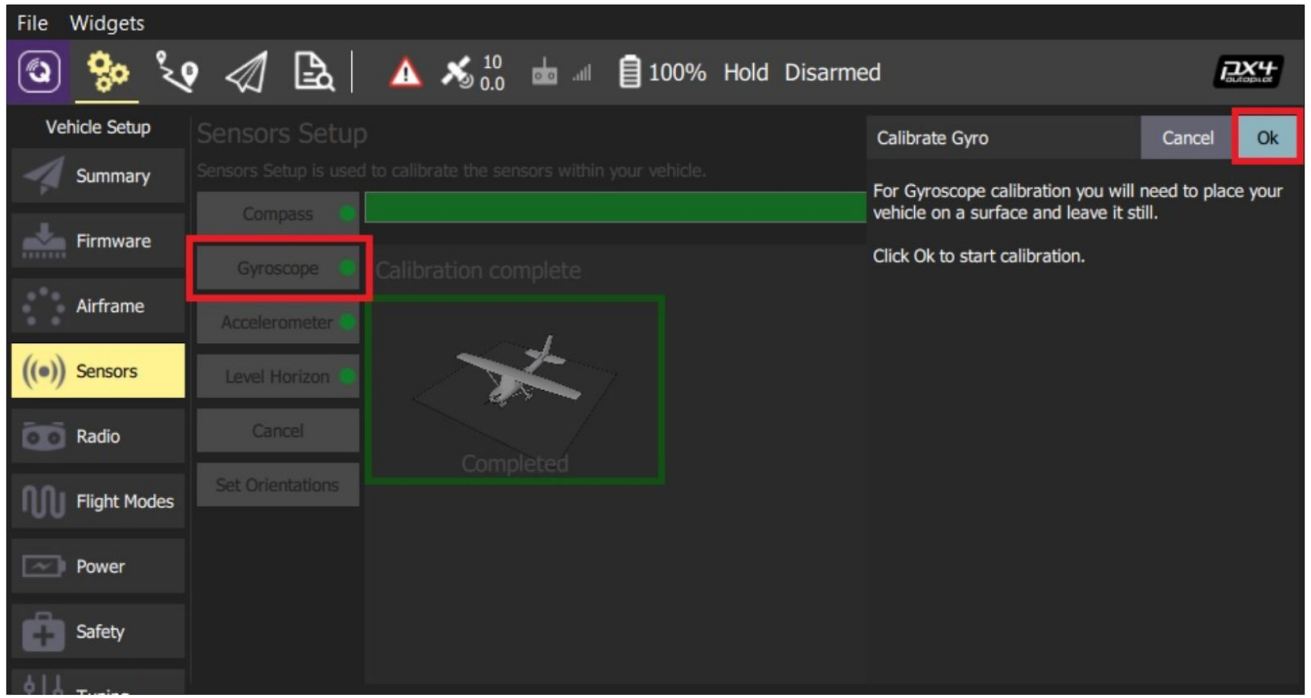


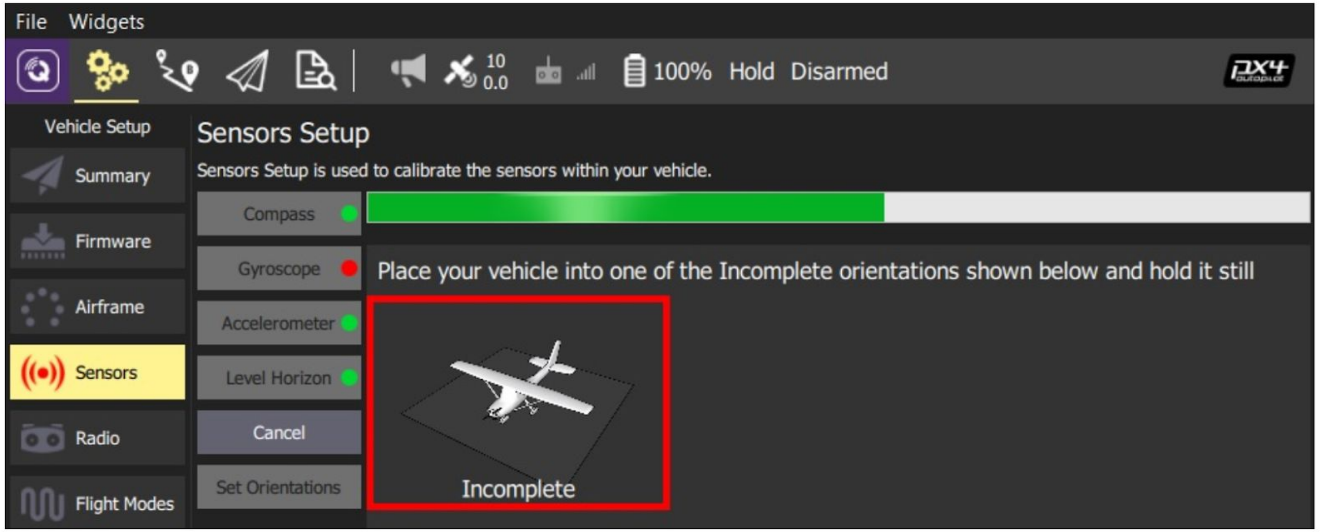
Gyroscope Calibration

Click the Gyroscope sensor button.

Place the vehicle on a surface and leave it still. Then, click “Ok” to start the calibration.

When finished, QGC will display a progress bar and “Calibration complete”.

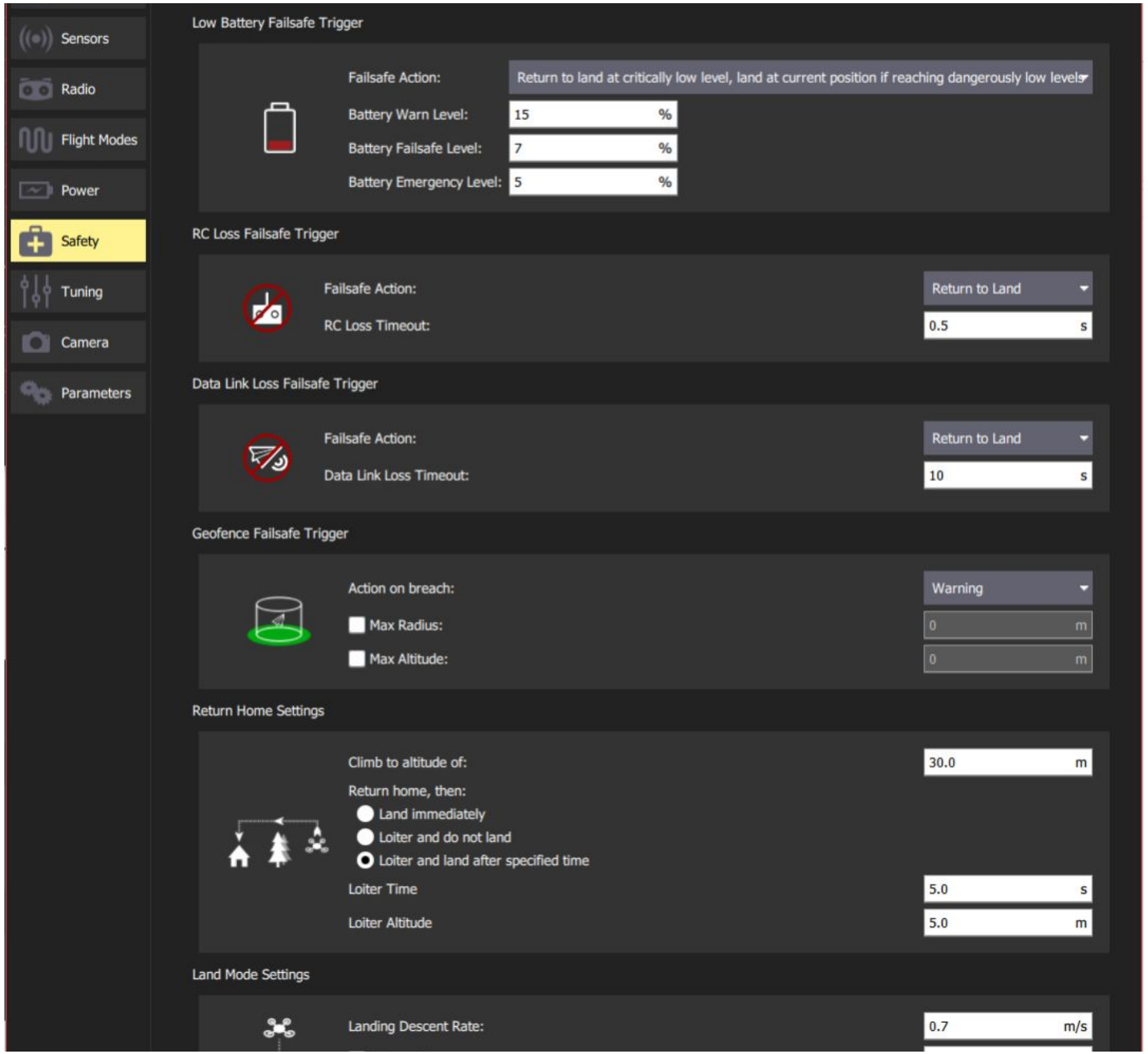




Failsafe Setups

Click to the “Safety” section on the Sidebar.

Setup Failsafe values so that they match the image to the right.



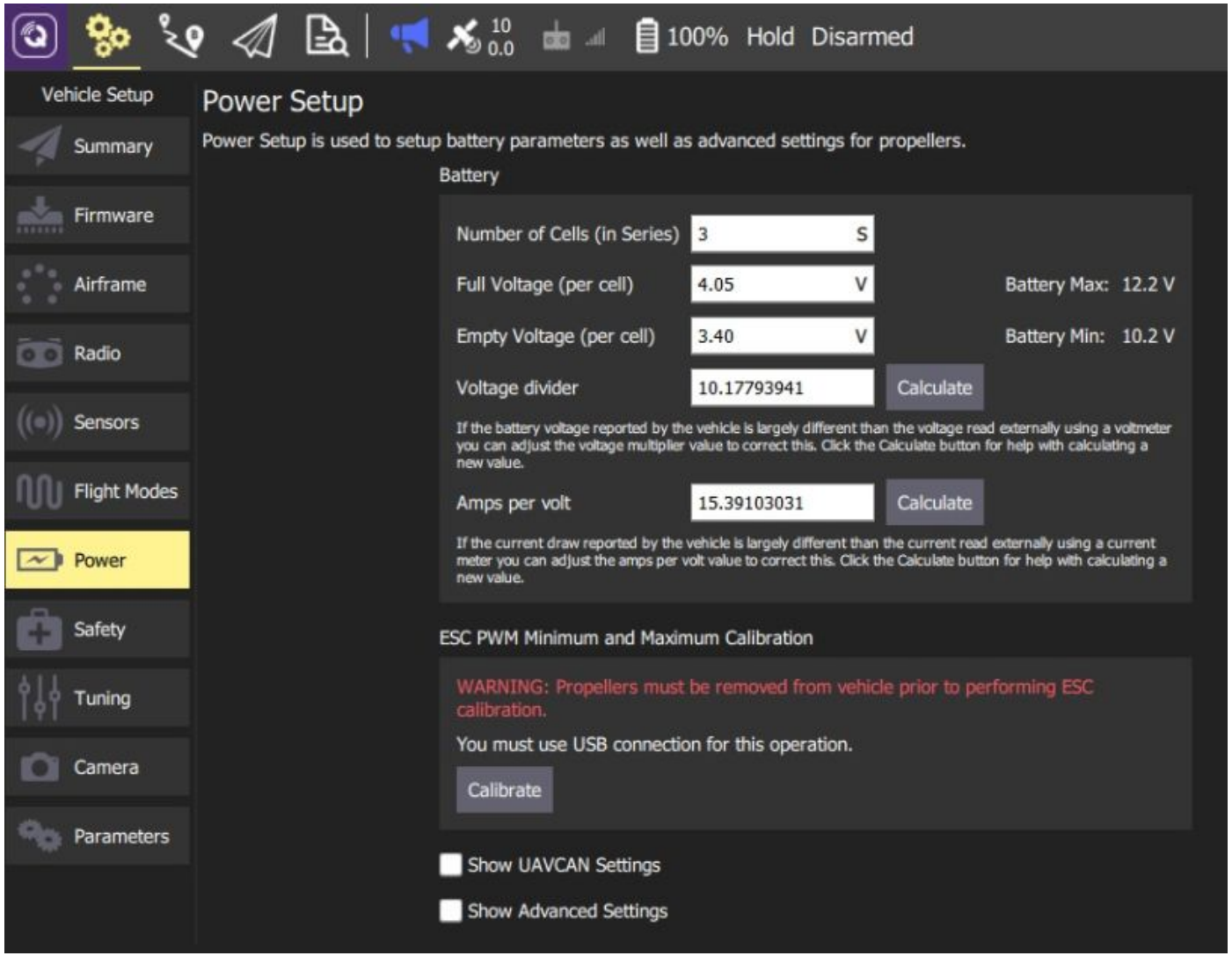
Current/Voltage Sensor Calibration

Set the following parameters:

- Number of Cells : 3s
- Full Voltage (per cell) : 4.2V
- Empty Voltage (per cell) : 3V

Click “Calculate” on voltage divider and follow the instructions in QGC.

No need to set Amps per volt!



Radio Calibration

Select the Gear icon (Vehicle Setup) in the top toolbar and then Radio in the sidebar.

Turn on your RC transmitter.

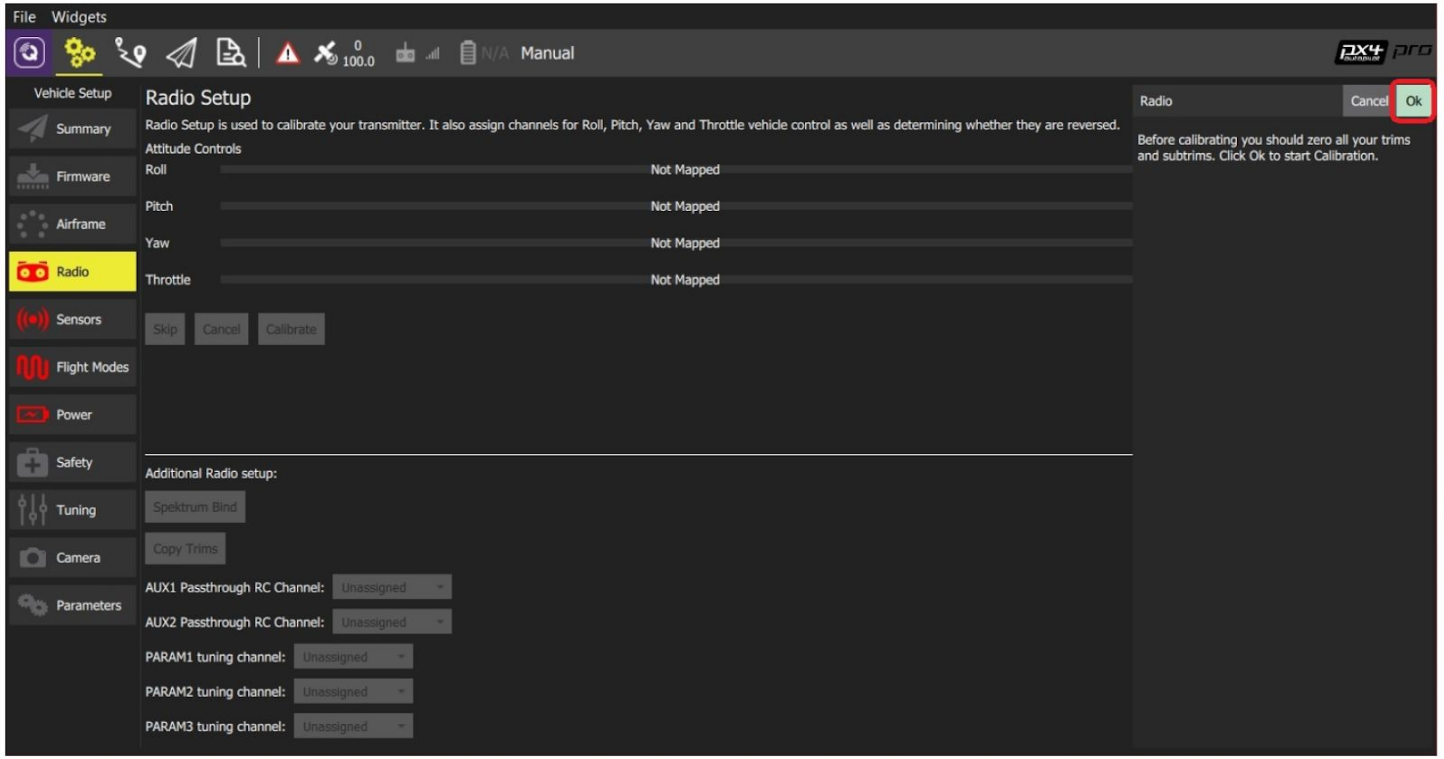
Press OK to start the calibration.

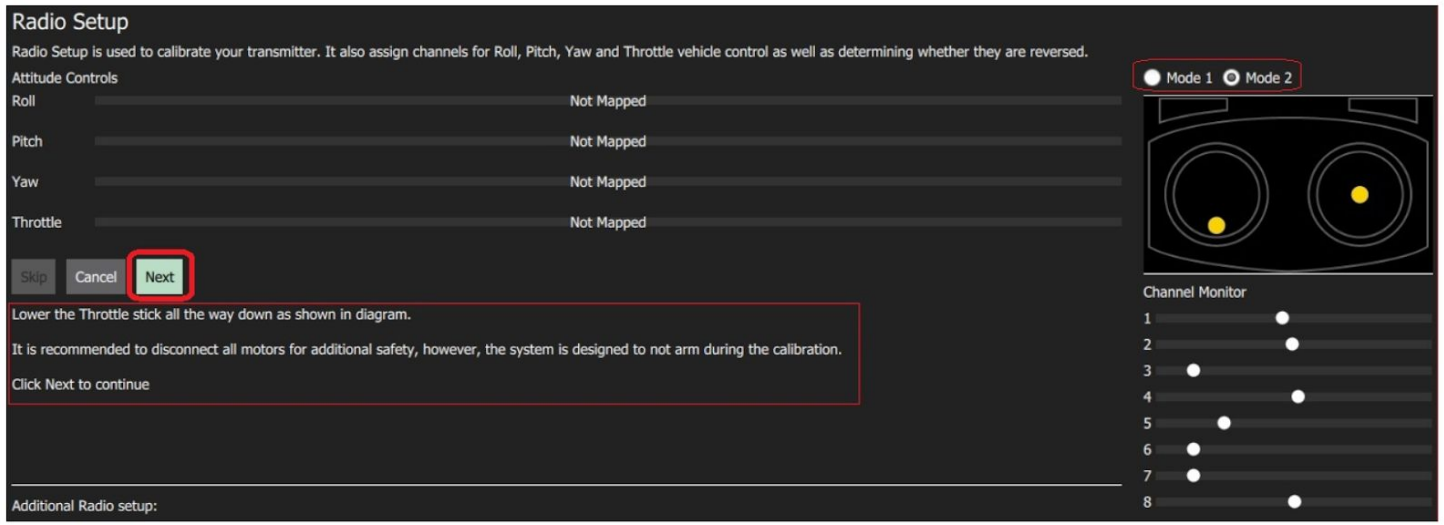
Set the transmitter mode radio button to Mode 2.

Move the sticks to the positions indicated in the text (and on the transmitter image). Press Next when the sticks are in position. Repeat for all positions.

When prompted, move all other switches and dials through their full range (you will be able to observe them moving on the Channel Monitor).

Press Next to save the settings.





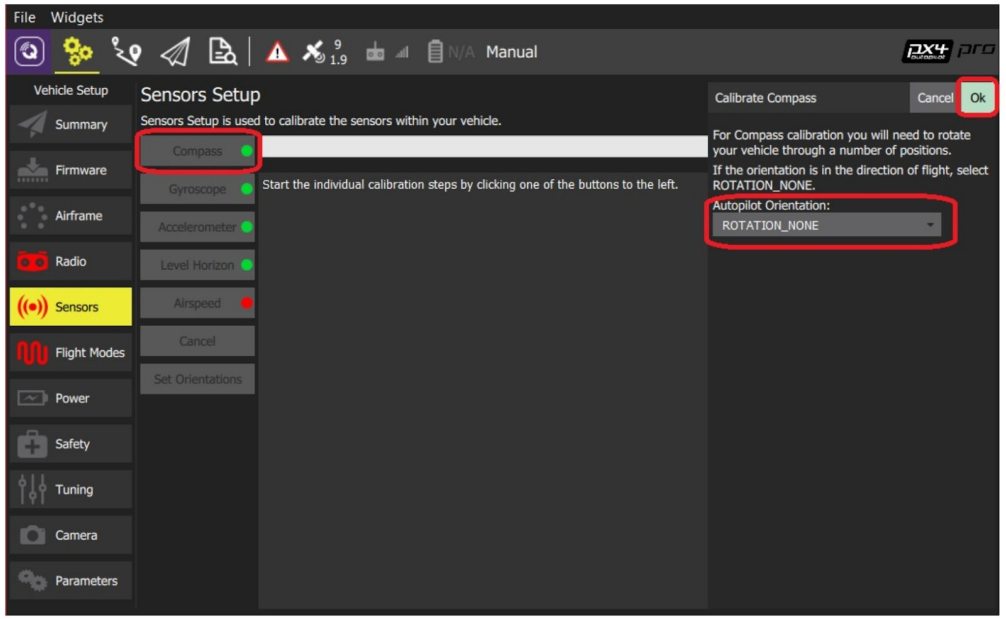
Compass Calibration

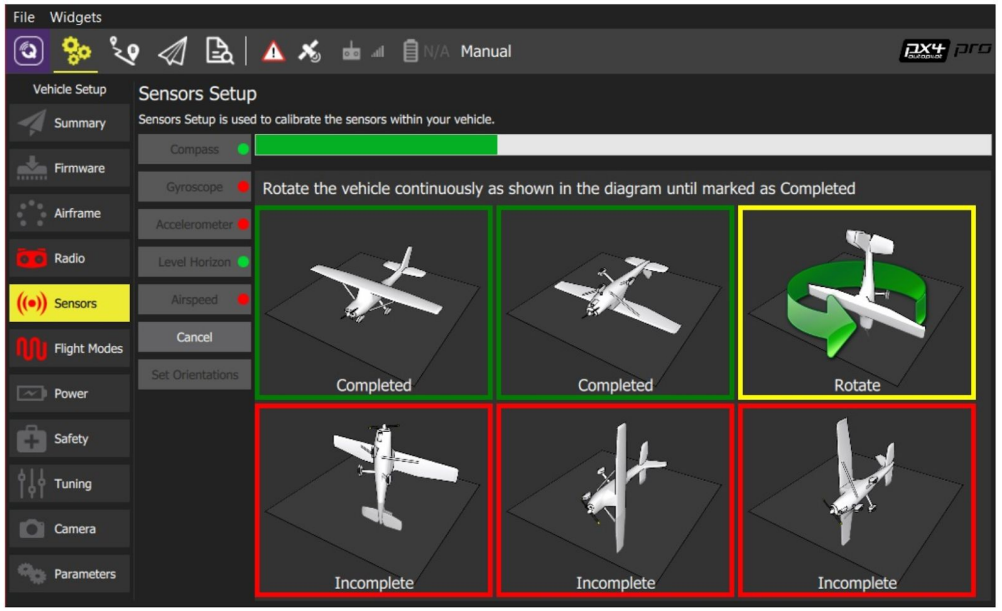
Please move outdoors to conduct this calibration!

Click the Compass sensor button.

Set Orientation to “Rotation_None” and Click OK to start the calibration.

Place the vehicle in any of the orientations shown in red (incomplete) and hold it still. Once prompted (the orientation-image turns yellow) rotate the vehicle around the specified axis in either/both directions. Once the calibration is complete in that orientation the associated image on the screen will turn green.





You’ve finished all steps in the EcoSoar build! Call an instructor over to check your work.

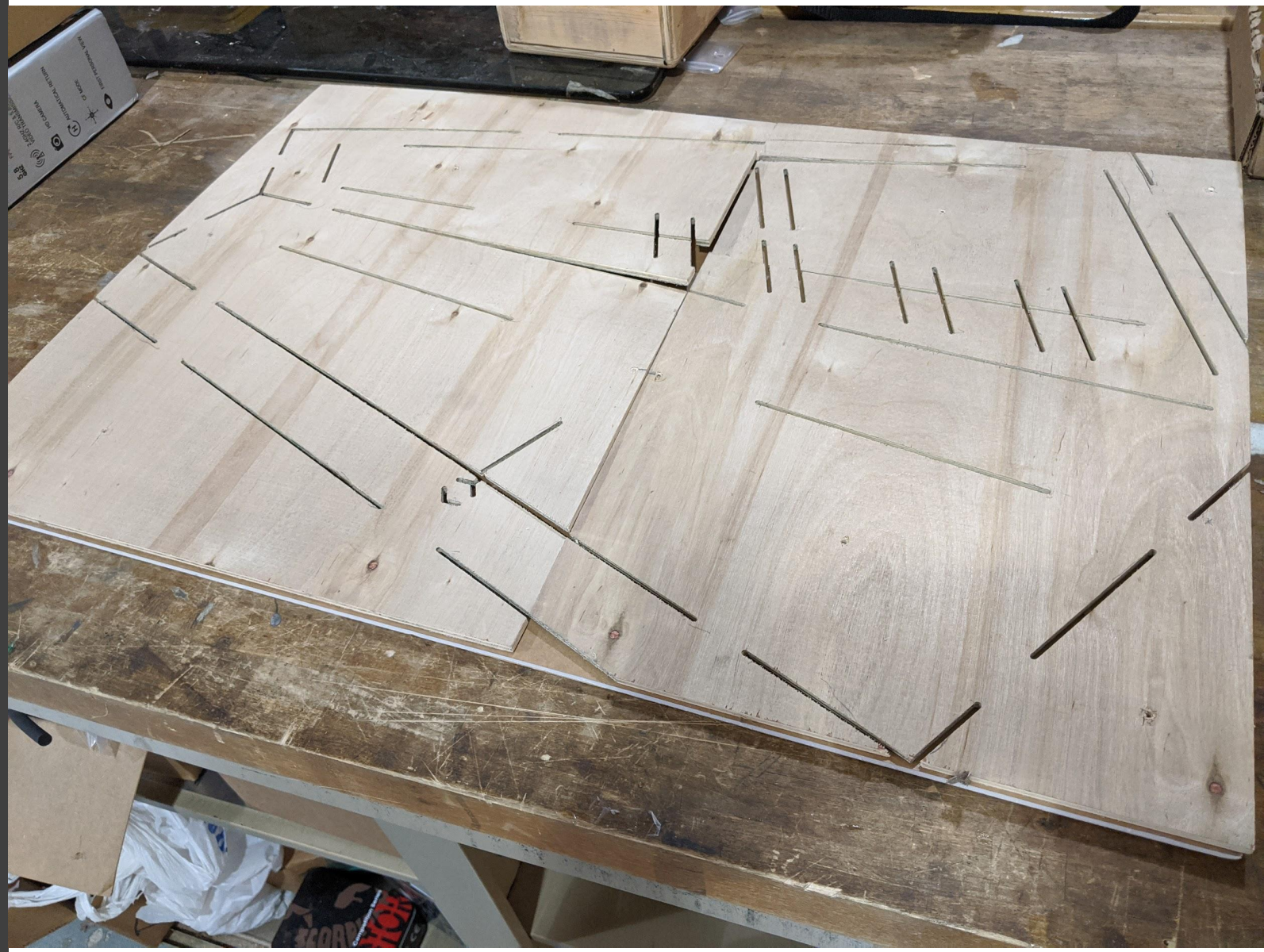
Extra Slides on how to build the wings

Marking out Wings

Place template over piece of posterboard, lining up edges

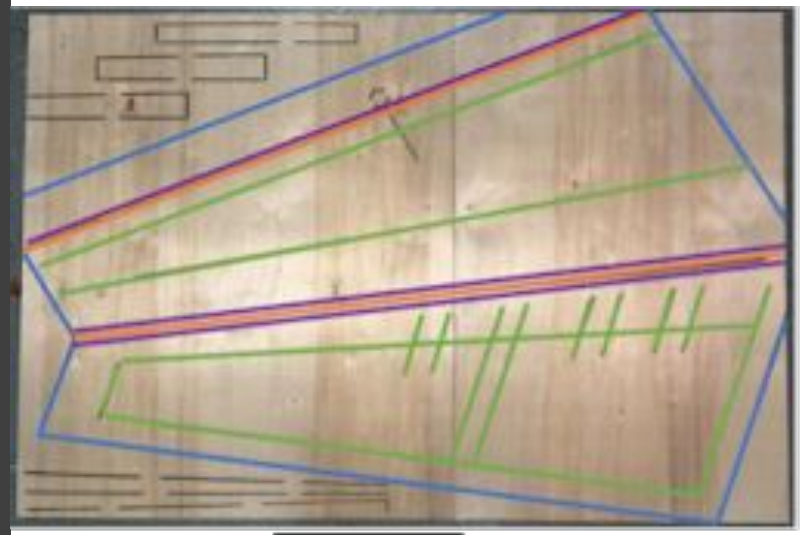
Mark all lines onto posterboard using lead holder/pencil

Ensure that template does not move relative to posterboard once you've begun marking

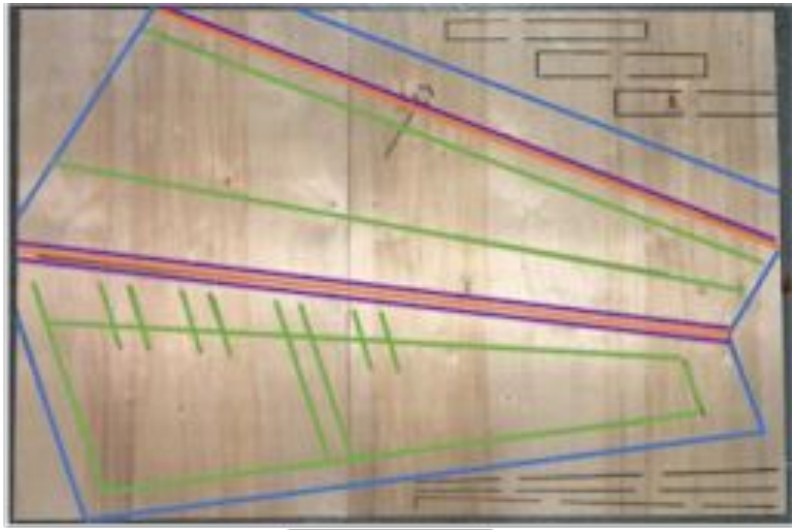


Cutting out Wings

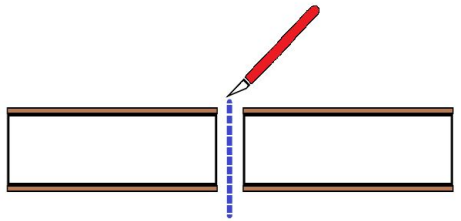
- Referencing the picture on top, begin cutting out the EcoSoar wings with a box cutter or X-Acto knife
- Refer to the diagram below for instructions on the types of cuts needed
- The colors in the second image correspond to the colors found in the image above
- NOTE: BE SURE TO MARK OUT BOTH LEFT AND RIGHT WINGS BY ORIENTING POSTERBOARD AS SEEN IN PICTURES ON THE TOP

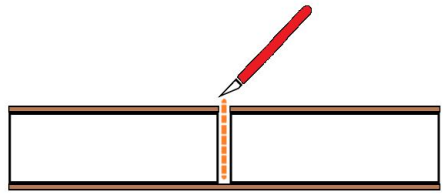


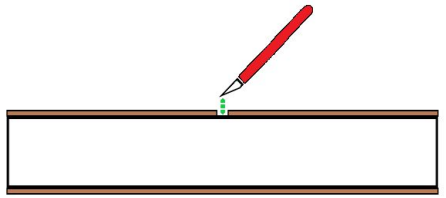
Left Wing

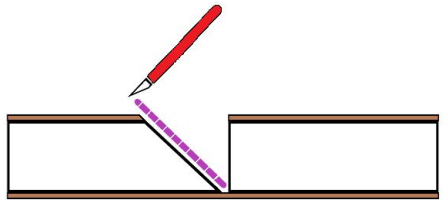


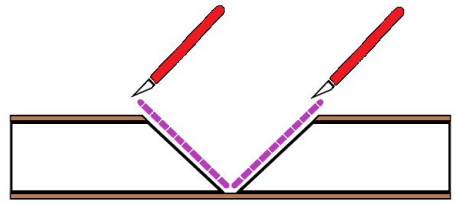
Right Wing





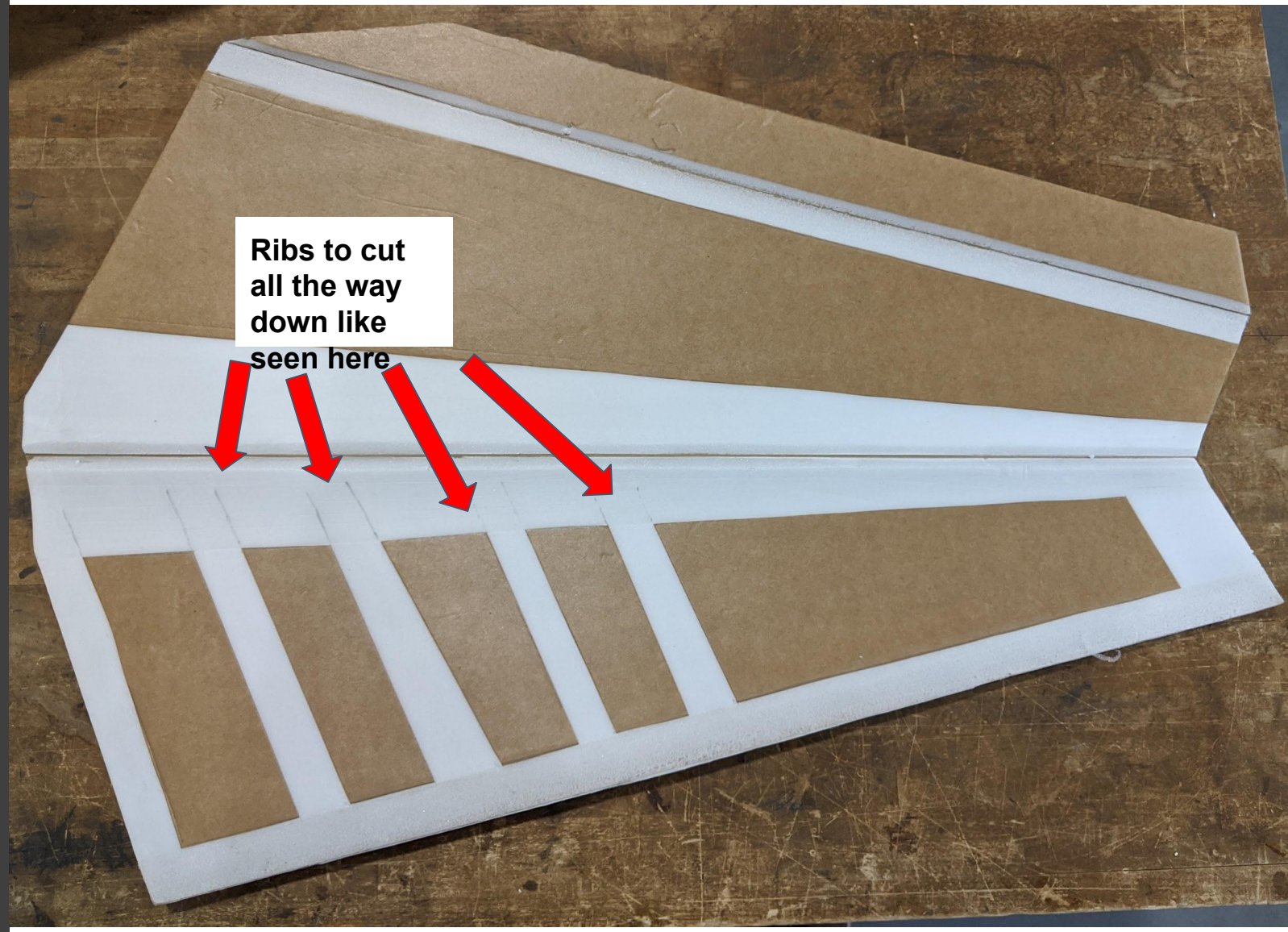






Removing Paper

- Next, the top layer of paper must be removed from the wing so that it resembles the image to the right
- Be sure to cut all the way down for the ribs even though template does not have these marked
- This allows for better adhesion between the posterboard and the 3D printed parts



Taping Wings

- Take out tape and plastic card
- Lay the EcoSoar wing flat on the table, uncut side facing up
- Moving left to right, begin taping EcoSoar
- Keep approximately a 1 cm overlap of tape when moving down
- Cut excess tape off the edges of the wings when fully taped

Bending Wings

- Place wing on edge of table as seen in picture
- Begin pulling wing down over edge and bending the posterboard toward the table with your palms
- This is to introduce bend to wings to allow them to fold over ribs without pulling apart

Sanding Wings

- Slightly sand the edges of the wings, as seen in the picture, so that when gluing wing shut, the two surfaces have sufficient contact