

FlyBox Assembly

Fly Box Materials and Items

https://docs.google.com/spreadsheets/d/1IHYI5jYujjvnLfjMplQ0Q5b2qjvNmh8gb_7PU2YNHrg/edit#gid=1894107250 to ensure that you have all required parts.

Have the following tools and supplies on hand:

- Electric screwdriver with M2, M3, M4, small flathead bits
- Vise-grip or slip joint pliers
- Wire cutters or scissors
- Wire strippers
- Paper towels
- Tape
- Sandpaper (about 40 grit) or a small hand file
- Soldering iron and supplies
- Boxcutter knife
- Allen wrench size 3
- 4 toothpicks (or 4 wooden sticks the size of toothpicks)

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Laser Cutting Instructions

The FlyBox laser-cut files can be found at

<https://github.com/Rosbash-Lab-FlyBox/FlyBox/tree/main/fabrication-files/laser-cut-files>.

The FlyBox frame is assembled from 17 laser-cut panels, of which 15 are cut from opaque $\frac{1}{4}$ " black acrylic and 2 are cut from translucent $\frac{1}{8}$ " diffuser acrylic. There are 7 cutsheets, each needing a 12"x24" panel. In addition, a light proofing curtain is cut from an 18"x18" felt sheet and a 1" radius IR filter is cut from IR filtering acrylic.

Material (cutsheets)	Part name (Cutsheet #)
Opaque $\frac{1}{4}$ " Black Acrylic (Six 12"x24" cutsheets)	Bottom Panel (1) Back Wall (1) Outer Top (2) Inner Top (2) Top Hatch (2) Electronics Panel (2) Outer Front (3) Inner Front (3) Front Door (3) IR Alignment Panel (4) Fly Tray Holder (4) Lower Floor (4) Upper Floor (5) Left Wall (5) Right Wall (6) Curtain Clamp (6)
Translucent $\frac{1}{8}$ " White Acrylic (One 12"x24" cutsheet)	LED Diffuser Panel (7) IR Diffuser Panel (7)
Opaque Black Felt (One 18"x18" cutsheet)	Lightproofing curtain (8)
IR Filtering Acrylic (One 12"x12" cutsheet)	Camera IR filter

Suggested Laser Settings

The provided cutting files are color-mapped: black lines (#000000) should be completely cut through the material, blue lines (#0000ff) should be lightly vectored and rastered to engrave the part, and red lines (#ff0000) should not be cut at all. The suggested settings listed below apply to an Epilog Helix 60-watt laser cutter and should be verified before being used on other laser cutters.

There is a small (1" x 12") test cut file included with this file set that can be used to test that your laser settings are correct. To avoid wasting material, on the black acrylic this should be cut out from cutsheets 3, 4, or 6 that will have excess material on the right side of the sheet.

Opaque 1/4" Black Acrylic

	Black lines	Blue lines
Raster	Speed: 100% Power: 30%	Speed: 100% Power: 30%
Vector	Speed: 9% Power: 100% Freq: 5000	Speed: 100% Power: 30% Freq: 5000

Translucent 1/8" White Acrylic

	Black lines	Blue lines
Raster	Speed: 100% Power: 30%	Speed: 100% Power: 30%
Vector	Speed: 20% Power: 100% Freq: 5000	Speed: 100% Power: 30% Freq: 5000

Opaque Black Felt

	Black lines
Vector	Speed: 20% Power: 100% Freq: 5000

3D Printing Instructions

The FlyBox also has a few 3D printed components. 3D-printable STL files are available at <https://github.com/Rosbash-Lab-FlyBox/FlyBox/tree/main/fabrication-files/3d-print-files>

These are the parts that need to be printed:

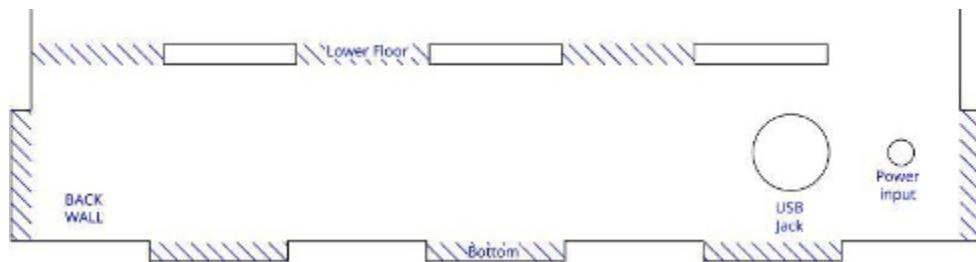
Part Name	Qty	Image	Print Settings
Camera Mount	1		Print with side facing away from camera face down No supports necessary
SD Card & Rotary Encoder Mount	1		Print with side facing away from camera face down No supports necessary except possibly in the channel for rotary encoder. Either print with supports or verify the channel is clean after printing.
Fan Baffle	2		Print with side facing camera face down Print with supports
Spacer	14		Print as shown No supports necessary

Optional: If building multiple flyboxes, consider 3D printing several pieces at once if space permits.

FlyBox Frame Assembly Instructions

The laser-cut parts of the FlyBox are labeled with their names and the names of connecting parts. On most parts, the engraved labels face inward to the center of the box, such that they will be hidden when assembly is complete. The name of the part is on the main body of the part in ALL CAPS; lowercase letters indicate where connecting parts attach.

For example, below is a portion of the Back Wall, as is labeled at left. The finger joints of the Lower Floor and Bottom panels fit to the slots and dashed tabs. The USB Jack and Power Input are attached in the holes at the right.



Hardware Attachment

Generally, when attaching hardware, the screw heads should be on the outer, unengraved side of panels and the nuts should be on the inside. This will make it easier to replace parts if any component breaks.

Fly Box Assembly Instructions

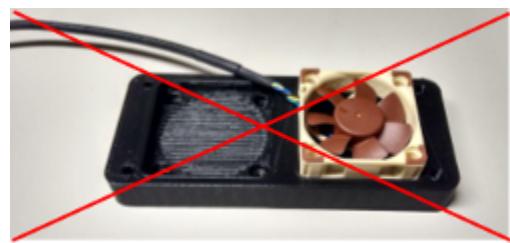
1-1 Right and Left Walls

Take the four Fans and two Fan Baffles. On each Fan Baffle, attach two Fans to the flat faces of the baffle with eight M3x20 screws and M3 nuts (sixteen total).

Fans on each baffle should face the same direction, so they push air in one direction. The fans attached to one baffle should point in the opposite direction to the fans on the other baffle, so that one baffle is pushing air in and one is pulling air out.

Rotate the fans so the cables on each baffle are pointing the same direction. This will make wiring easier later.

It helps to hold 1 nut in place while tightening the screw with the other hand



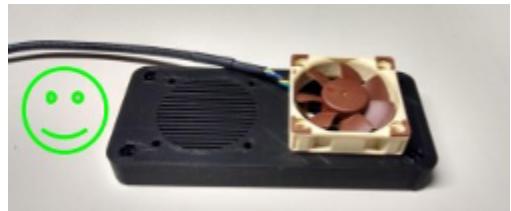
Incorrect attachment: Fan is placed inside square recess.

1-2 Right and Left Walls

The cords of each fan should point towards the back wall.

Now is a good time to peel off the paper coating on all the acrylic pieces. Using a box cutter blade (or something sharp) helps.

Put the fans in the flat side of the Fan Baffle Assembly



Correct attachment: Fan is on flat face



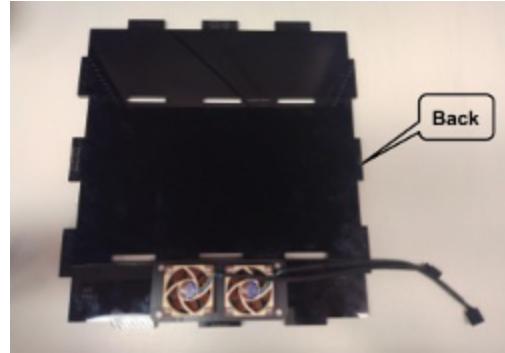
Nuts set into recesses on underside

1-3 Right and Left Walls

Using eight M3x20 screws and M3 nuts, attach one Fan Baffle Assembly to the engraved side of the Right Wall, and one to the Left Wall.

The cables of the fans should point toward the Back Wall, as marked on the engraved tabs.

Clean out holes from the Fan Baffle Assembly if needed – there may be 3d printed residue



2-1 Bottom Panel (IR and Fans)

Using four M3x16 screws and M3 nuts, and four Spacers attach the IR and Fans Board to the Bottom in the orientation shown by the engraving

It can be tricky tightening the nuts and screws - you'll have to carefully push the spacers under the board as you tighten



It's easier to attach the bolts and spacers if you put each one on loosely first before tightening them

IR LEDs connect to the front 3 terminal buttons. Screw in the M3x16 screws from the bottom. M3 nuts should be “inside”

2-2 Bottom Panel (IR and Fans)

Cut about 24 inches of 4 strand wire and 24 inches of 2 strand wire. Connect the 4-strand wire to the terminals labeled Fans from above and the 2-strand wire to the terminals labeled IR from above. Leave the other ends of the wire loose, they will be routed up the corner channel to the main board later.



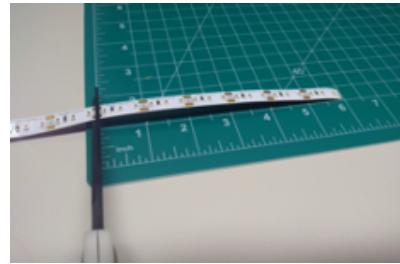
Keep note of which wire connects with which screw terminal – this will be needed afterwards

Use different colors of wire for each of these – it will make it easier to wire correctly later

2-3 Bottom Panel (IR and Fans)

Cut three 6-inch sections of IR LED strip. Cut on the indicated cut lines with contacts.

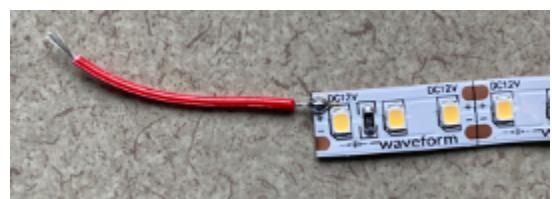
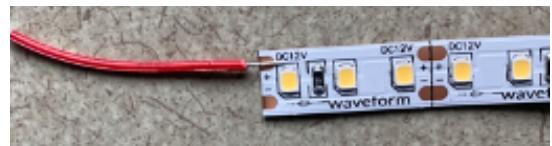
When cutting the pieces, make sure you cut evenly down the middle of the copper areas as you'll need space for soldering later



2-4 Bottom Panel (IR and Fans)

Carefully solder 1.5" wire onto LED strips with the following instructions:

1. Cut 1.5" of red and black electrical wire and remove the sheath on both ends
2. Twist the ends of the wire so it is condensed and not hairy
3. Flatten the LED strip horizontally with the (+) metal end away from you and the (-) metal end towards you
4. Solder onto the left side with (+) being red and (-) being down
5. Orientation matters! If you incorrectly solder the wrong ends, you'll have to solder again. Make sure the copper (+) and (-) ends of the LED strip you solder match up with the (+) and (-) inputs of the screw terminals on the board!!
6. Do one wire at a time. Place the red exposed wire end on top of the copper (+) end of the LED strip as shown in the image and solder
7. A helpful tip in soldering this way is to hold the soldering gun tip and wire closely above and quickly melt the wire to create a droplet, then gently push down the droplet, engulfing the wire and contacting the copper (+) end of the LED strip
8. Pull both wires to see if it falls out. If it falls out, simply re-solder.



STOP

Check to make sure the orientation is correct. Hover the LED strip next to the screw terminal and see that the (+) and (-) ends match up

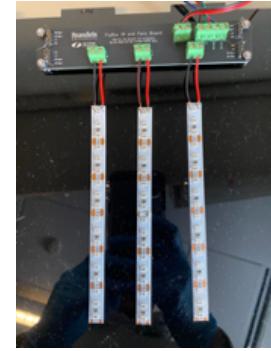
Because this is IR light, we cannot test it until after the box is built.

2-5 Bottom Panel (IR and Fans)

Remove the paper backing and apply the three 6" IR Light Strips in the marked rectangular spaces on the Bottom.

Connect the wire end of the LED strip connectors to the corresponding screw terminals on the IR Fans Board.

Place the outer two strips further apart than is marked on the board and shown in the picture. This is to accommodate a 2-tray setup



2-6 Bottom Panel (IR and Fans)

Attach the 4 Feet to the unengraved side of the Bottom using four M3x16 screws and M3 nuts



The wider part of the Feet should contact the board. The slightly smaller part will contact the ground. The nuts should be tightened inside the box.

3-1 Front Wall

If the Rotary Encoder came with a knob attached, remove it by gently pulling it until detaches. Set aside the knob and any hardware

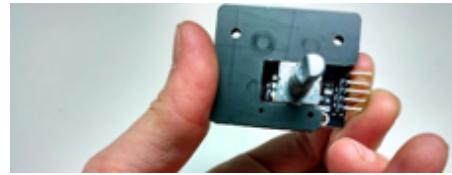


3-2 Front Wall

If the SD Card & Rotary Mount was printed with supports, make sure the small channel on the backside is completely clear of support material.

Slide the square, silver base of the Rotary Encoder into the large slot on the SD Card & Rotary Mount, with the stem of the encoder extending through the flat face of the mount. It should fit into the slot snugly. Make sure the Rotary Encoder is pressed into the slot as far as it can go. Flip over the assembly and attach using 2 M2x6 screws.

You may need to apply more pressure than expected. This is intentionally a very tight fit.



3-3 Front Wall

Using two M2x6 screws, attach the SD Card Reader to the top square bump out of the SD Card & Rotary Encoder Mount. It should be positioned such that the board sits flat, and the SD card slot is pointing in the same direction as the rotary knob.



3-4 Front Wall

Attach the SD Card & Rotary Encoder Mount to the engraved side of the Outer Front using two M3x16 screws and M#3 nuts. The stem of the encoder should protrude through the unengraved face.

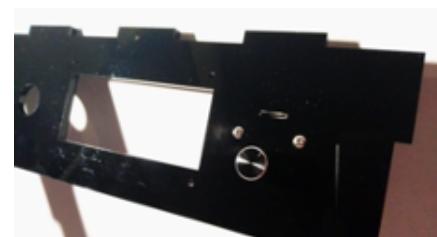


Replace the knob of the Rotary Encoder.

Attach a five-strand female-to-male jumper cable to the Rotary Knob pins and a six strand female-to-male jumper cable to the SD Card Reader pins.



Once the rotary encoder is attached to the front panel, you can put the washers and knob back on



3-5 Front Wall

Attach the Display Screen to the Outer Front using four M3x16 screws and M3 nuts and four Spacers.

The spacers are placed between the LCD screen and the outer front panel. They ensure that the display screen is flush to the front. The pins should point toward the space for the Power Switch.

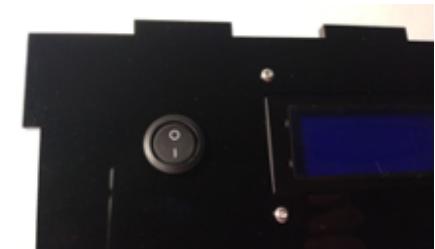
Attach a 4-strand male-to-female jumper cable to the pins.



3-6 Front Wall

Press the Power Switch through from the unengraved face of the Outer Front.

Connect the included quick connect wires to the Power Switch by pressing them into the tabs. It does not matter which wire is connected to which tab.



4-1 Removing the Camera IR Filter

Remove the Camera IR filter and base by carefully following this video below:

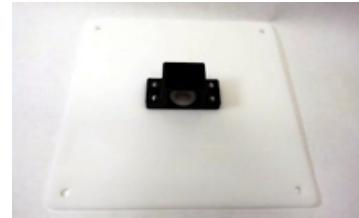
https://www.youtube.com/watch?v=eoMUJxUo4d8&ab_channel=KinseyLab

Important notes:

- Disregard 18:08-19:00, this step is unnecessary
- Do not replace the webcam's base, as shown at 19:00 as the base does not fit into the FlyBox

5-1 LED Diffuser Panel

On the LED Diffuser Panel, attach the Camera Mount using four M3x12 screws and M3 nuts.



5-2 LED Diffuser Panel

Place the IR Filter into the round space in the Camera Mount.
Hold the filter by the edges to avoid smudges that could interfere with the camera's view.

Not to be confused – this filter will filter everything else out except for IR light. The filter removed from the camera filters out IR light but takes everything else in.



5-3 LED Diffuser Panel

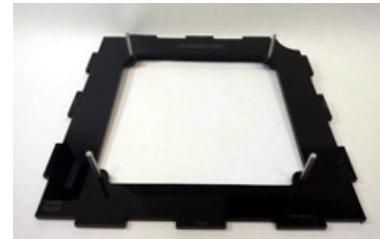
Slot the Camera into the Camera Mount, such that the lens is pointing through the hole in the diffuser panel.

Sometimes putting the camera into the mount can be tight – it should work.



6-1 Upper Floor

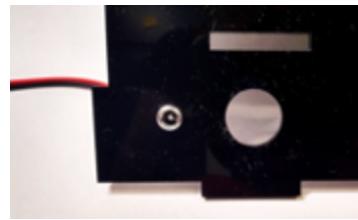
Add four M3x35 standoffs extending upward from the engraved side of the Upper Floor using four M3x12 screws



7-1 Back Wall

On the Back Wall, attach the Power Input by pressing it in from the unengraved side.

The Power Input is also known as the DC in Power Jack



7-2 Back Wall

Unscrew the collar from the USB Jack, press it through from the unengraved side, and screw the collar back on to hold it in place.



8-1 Bottom Side of Electronics Panel

On the engraved side of the Electronics Panel, attach the RGW Board in the orientation shown by the engraving using two M3x16 screws and M3 nuts, and two Spacers.



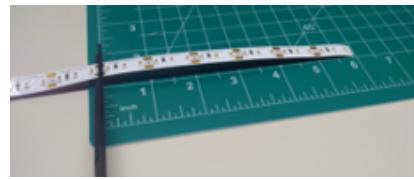
8-2 Bottom Side of Electronics Panel

For the R from above, W from above, and G from above screw terminals, cut about 5 inches of wire (6 pieces total). Connect one end of the wire to the screw terminals on this board and leave the other ends loose for now.



8-3 Bottom Side of Electronics Panel

Cut four 6-inch sections of red LED strip, four 6-inch sections of green LED strip, and two 6-inch sections of white LED strip.
Cut on the indicated cut lines with contacts.



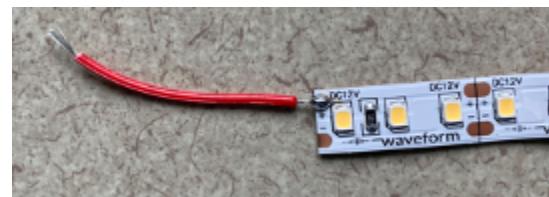
Because the red and green strips look identical when unlit, you may want to mark them to avoid confusion.

When cutting the pieces, make sure you cut evenly down the middle of the copper areas as you'll need space for soldering later

8-4 Bottom Side of Electronics Panel

Carefully solder 1.5" wire onto LED strips with the following instructions:

1. Cut 1.5" of red and black electrical wire and remove the sheath on both ends
2. Twist the ends of the wire so it is condensed and not hairy
3. Flatten the LED strip horizontally with the (+) metal end away from you and the (-) metal end towards you
4. Solder onto the left side with (+) being red and (-) being down
5. Orientation matters! If you incorrectly solder the wrong ends, you'll have to solder again. Make sure the copper (+) and (-) ends of the LED strip you solder match up with the (+) and (-) inputs of the screw terminals on the board!!
6. Do one wire at a time. Place the red exposed wire end on top of the copper (+) end of the LED strip as shown in the image and solder
7. A helpful tip in soldering this way is to hold the soldering gun tip and wire closely above and quickly melt the wire to create a droplet, then gently push down the droplet, engulfing the wire and contacting the copper (+) end of the LED strip
9. Pull both wires to see if it falls out. If it falls out, simply re-solder.



STOP

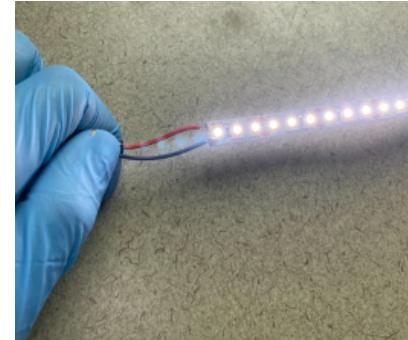
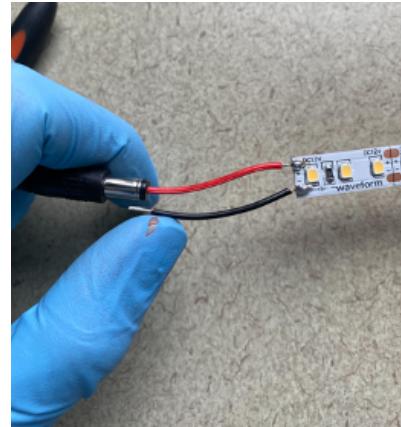
Check to make sure the orientation is correct. Hover the LED strip next to the screw terminal and see that the (+) and (-) ends match up

8-5 Bottom Side of Electronics Panel

Test the LED strip with an AC power cord. Plug the AC power cord and put the red (+) end of the wire inside and touch the black (-) end on the outside.

The light should turn on

The image on the right is just for white light. The red LED strip should emit red light, green LED strip will emit green light.

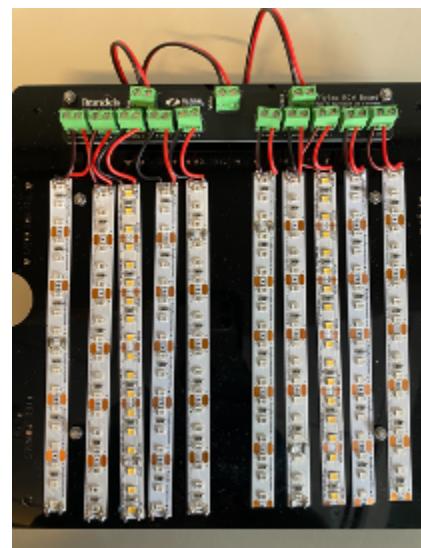


8-6 Bottom Side of Electronics Panel

Insert the ends of the LED strip connector into the corresponding screw terminal on the LED board making sure to connect the positive wire to the positive side of the screw terminal and vice-versa for the negatives. Remove the tape backing on the LED Strips and press them down into position, as indicated by the engraving.

These are a tight fit! It is recommended to start on the outside edges and work your way to the center.

Make sure you do not cover the holes around the ends of the board.



9-1 Top Side of Electronics Panel

On the un-engraved side of the Electronics Panel, attach the Main Board using four M3x16 screws and nuts, and four Spacers. The main text on the board should face the front door.

Orientation matters! Make sure the Red, White and Green screw terminals on the RGW Board are on the same side as the Red, White and Green screw terminals on the Main Board.

If the orientation is incorrect, you'll have to flip it.



9-2 Top Side of Electronics Panel

Insert the ESP-WROOM-32 component into the corresponding area on the Main Board (lower left), plugging the male pins on the component into the female pins on the main board, with the micro-USB slot facing upward.

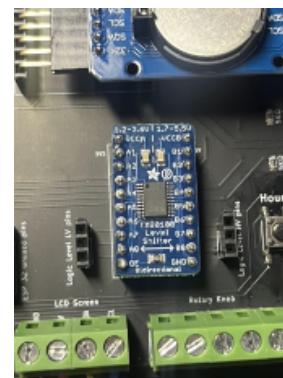
Sometimes the pins can be tricky to insert as all the pins must go in at the same time.



9-3 Top Side of Electronics Panel

Solder the Logic Level component and insert the Logic Level component into the corresponding area on the Main Board (lower middle), plugging the male pins on the component into the female pins on the main board. Make sure the 3V3 and 5V labels on the main board match up with their corresponding labels on the Logic Level component.

When soldering, keep one extra metal thing so the metal ends do not fall out and push in the metal ends onto a soft material, so it does not move.



9-4 Top Side of Electronics Panel

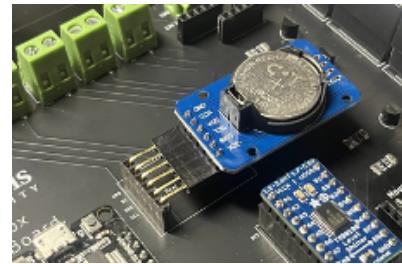
Insert each of the four BuckPuck components into the corresponding area on the Main Board (right side), plugging the male pins on the component into the female pins on the main board.

If you find yourself using the last BuckPucks, order more immediately as these parts have a long lead time to order



9-5 Top Side of Electronics Panel

First, insert the Button Cell Battery into the Real Time Controller component. Then, insert the Real Time Controller male pins into the female end of the 90 Degree Header Pins, and connect the male pins into the Real Time Controller area indicated on the Main Board (middle left).



9-6 Top Side of Electronics Panel

Insert the Audio Potentiometer component into the corresponding area on the Main Board (lower right), plugging the male pins on the component into the female pins on the main board. The pins will be to the left of the knob, as indicated in the photo.

This step is difficult, and you will not be able to fit the metal ends inside completely. This is okay.



This piece does not fit very tightly or securely. You may want to wait until the box is assembled and the board is in place to attach it as it will likely fall out.

If it is significantly difficult, the flybox will still work without it, but the IR intensity may not be adjustable

9-7 Top Side of Electronics Panel

Place the Buck Converter above the Main Board. Terminals are labeled on the back of the buck converter

Connect the VIN+ screw terminal on the Buck Converter to the 12V in on the Main Board

Connect the VIN- screw terminal on the Buck Converter to the GND on the Main Board

Connect the 5V screw terminal on the Buck Converter to the 5V in on the Main Board

Connect the GND screw terminal on the Buck Converter to the GND on the Main Board



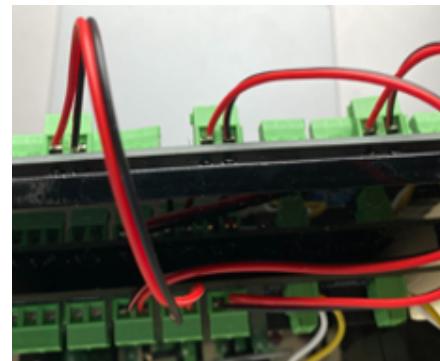
NOTE: Be very careful when wiring this component. Wiring this component incorrectly may cause significant damage to the box and to any laptop connected to it. Make sure the 12V and the 5V sides are facing the correct direction.

9-8 Top Side of Electronics Panel

Connect the Red screw terminal in the top left corner to the corresponding wires from the LED Board.

Connect the Green screw terminal in the top left corner to the corresponding wires from the LED Board.

Connect the White screw terminal in the top left corner to the corresponding wires from the LED Board.



Box Structure Assembly

As noted above, the laser-cut FlyBox panels are marked with the name of the part in ALL CAPS, and attaching parts in lower case. On most panels, the engraved side faces into the inside of the box.

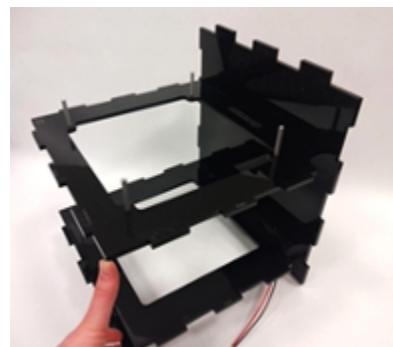
Striped hatching patterns indicate areas where glue should be applied when joining panels. A row of striped finger-joint tabs or a striped panel face will have the name of the attaching panel in lower case. A “dry fit” without glue can be done first to understand how the box is assembled without permanently fixing the pieces.

Pieces should fit securely, but you should not have to wiggle them or use a lot of force to fit them together. If pieces are too tight, use a file to shave down the tabs until the pieces fit together easily. File a little at a time and check the fit until they are at the correct tightness.

10-1 Box Structure Assembly

Insert Upper Floor and Lower Floor into the Back Wall panel, referring to markings on each panel for alignment. The rounded corner cut-outs in the Upper and Lower Floor should be facing toward the right side of the Back Wall.

Do not glue anything to the back. Keeping it removable makes troubleshooting and repairing the flybox a much easier and less frustrating experience. It will be secured in place with gaff tape once the box is checked over after assembly.



Before gluing on the acrylic pieces, fit them in together without glue first to make sure they connect smoothly without squeaky noises

Please wear gloves – acrylic glove is very strong and can burn your skin. You may want to put covering (newspaper, old paper, etc.) down as the glue can be messy

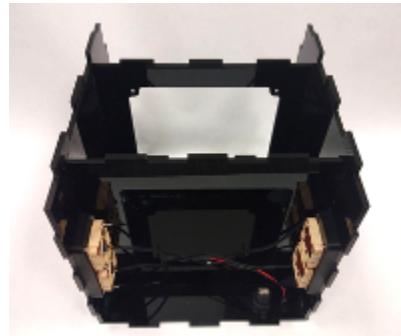
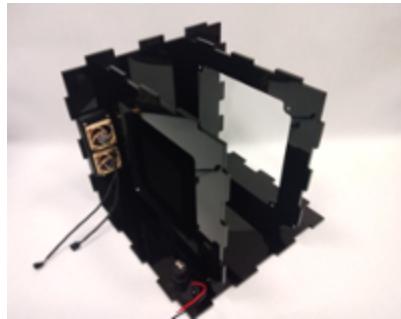
10-2 Box Structure Assembly

Glue on the Left Wall and Right Wall, with the fans facing in.

To avoid getting glue on the back panel, do not put any glue on the last cm or so of the walls/floor closest to the back panel.

Sometimes the boards may not fit in completely – you may have to grind or shave down the connecting ends or try using different pieces

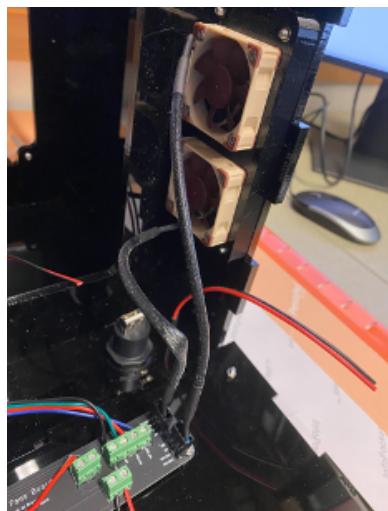
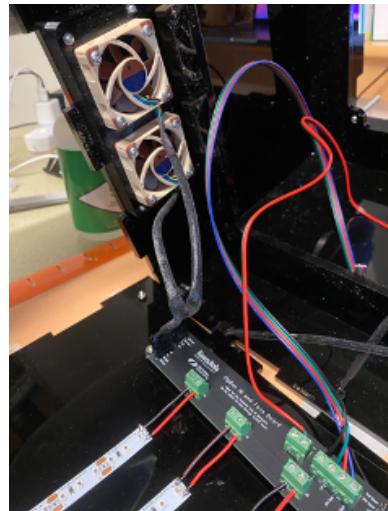
If you need to shave down any pieces, do so bit by bit. Shave then try, shave then try, etc.



10-3 Box Structure Assembly

Take the Bottom, plug in each Fan to the male header pins on the board. The orientation matters for each fan! Please look carefully at the images on the right to see which fan goes to which male header pins.

Please see below to see the orientation of the fan female receptor. If the wires are not connected properly the fans will not work.



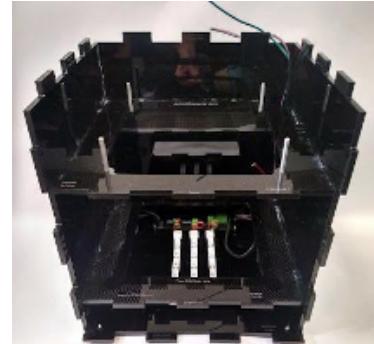
You can see the colored wires on the fans right before they go into the plug. Plug the blue side into the pin that says PVW signal, and the black side into the pin that says GND.

10-4 Box Structure Assembly

Glue on the Bottom, with the IR lights and board facing in. The 20-inch wires of the Fans from above and IR from above screw terminals can be routed upward through the round channel in the back right corner.

Remember not to glue anything to the back panel

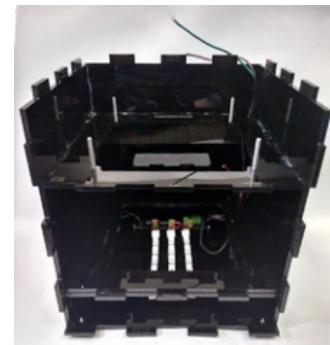
Before gluing down the Bottom, push the wires (the 4-strand wire and 2-strand wire) behind the fan wiring. Not the end of the world if you do not, will make it a lot easier after the Bottom is glued in.



10-5 Box Structure Assembly

Apply glue to the striped surface of the Lower Floor. Glue on the IR Alignment Panel, striped face to striped face. The round corner cutouts on the back right of each panel should align.

The pieces no longer have stripes. Glue text side down.

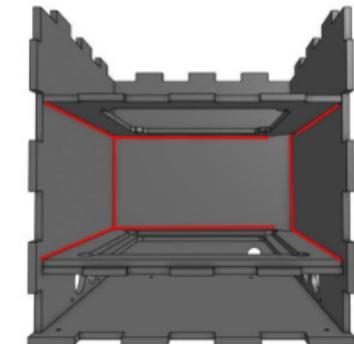


10-6 Box Structure Assembly

Silicone can be applied to the inside corners of the central chamber, as shown by the highlighted edges to the right. Corners can be tested for light-tightness by shining a flashlight over them and checking that light doesn't go through.

The silicone tube can be hard to press, expect some resistance and a forearm workout

Instead of silicone, you can also apply gaff tape over the joints on the outside of the flybox. It is easier to get a light proof seal, and you don't have to deal with the sticky, smelly silicone.



10-7 Box Structure Assembly

Glue on the Inner Top and Inner Front. These panels should have the striped sides facing outward.

Tape applied on the inside and outside can be used instead of silicone

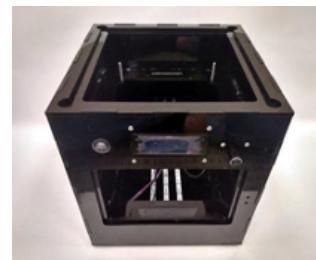


10-8 Box Structure Assembly

Glue on the Outer Top and Outer Front

The order doesn't really matter

When gluing in the Outer Front, be careful with guiding the exposed wires into the box as they may get unplugged. If they get unplugged, a long skinny nose plier helps to re-plug connections.



10-9 Box Structure Assembly

Reaching in from the top, tape the corners of the center chamber where the Inner Front meets the Left Wall and Right Wall, as shown by the highlighted edges to the right.

(The Upper Floor in the image on the right has been hidden in this image for clarity)



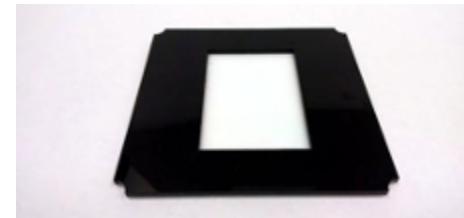
10-10 Box Structure Assembly

Glue the Fly Tray Holder to the IR Diffuser Panel and sandwich it together tightly.

Let glue dry! Blue tape can be used to secure parts in place as they dry.



Doing a drizzle pattern with the glue helps with adhesion



10-11 Box Structure Assembly

Using 2 M4x12 screws and nuts, screw in the larger latch piece on the unengraved side of the Front Door, such that the side with the spring mechanism is closer to the edge.

For this you will need a slightly larger sized Allen wrench as the electric screwdriver's adapter is too small

Watch the orientation of the latches!

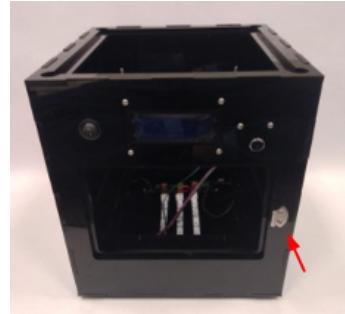
Use a size 3 Allen wrench



10-12 Box Structure Assembly

Using 2 M4x20 screws and nuts, screw in the smaller latch piece on the right side of the Outer Front, such that the hook-shaped side is nearest the front door opening.

Watch the orientation to make sure it is correct



10-13 Box Structure Assembly

Optional: Rough up the inner faces of both hinges using sandpaper to increase adhesion surface area.



10-14 Box Structure Assembly

Gently press the Front Door into place on the front of the box with the latch on the right side. Ensuring each hinge is vertical and aligned over the gap, glue them to the left side of the Front Door and Outer Front.

Let glue dry! Blue tape can be used to secure parts in place as they dry. Do not open the Front Door until the glue has had time to set fully.



11-1 Final Wiring

Attach a WAGO inline wire connector to each end of the Power input.

Attach a WAGO inline wire connector to each end of the Power Switch wires.

Cut a 24-inch length of red wire. Connect it to the red wires of the Power Input and Power Switch using the WAGO inline wire connectors.

Cut a 14-inch length of yellow wire. Connect one end to the black wire of the Power Switch using the WAGO inline wire connector. Connect the other end to the + side of the Male Barrel Adapter.

Cut a 14-inch length of black wire. Connect one end to the - side of the Male Barrel Adapter.

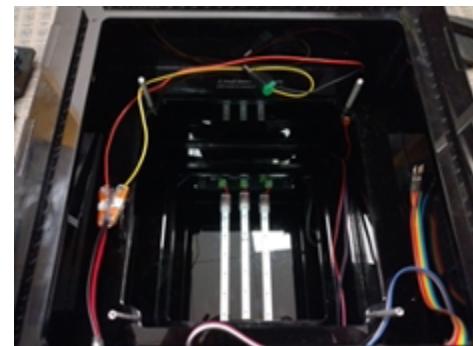
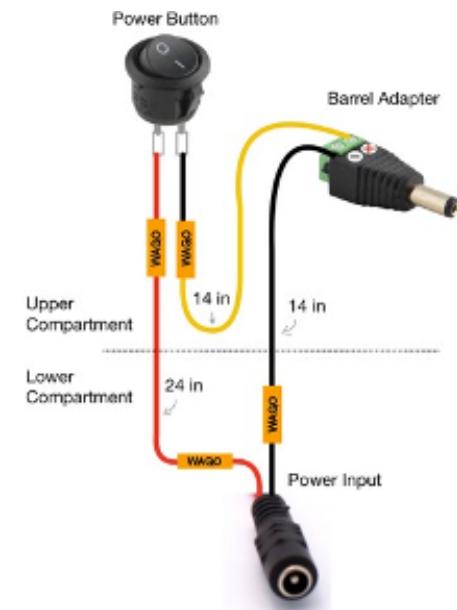
Connect the other side to the black wire of the Power Input using the WAGO inline wire connector

Add an extra 6 inches to the red and black wires so that the removable back panel can be set down without pulling on the wires.

Do not forget to weave the wires through the opening on the far-right corner and upward

It may be dark and hard to see inside the fly box at this stage – you can grab lights used for microscopes or any other light source

Tape any hanging wires to the side



Top view showing WAGO connectors attached to the Power Switch and Male Barrel Adaptor

11-2 Final Wiring

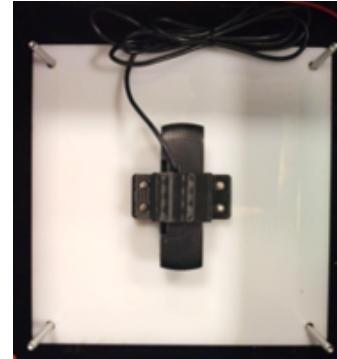
Take the LED Diffuser Panel and attached Camera. Run the camera cable down the back right corner channel and plug it into the inside side (USB A port) of the USB Jack.



11-3 Final Wiring

Slot the LED Diffuser Panel and attached Camera over the standoffs on the Upper Floor. The Camera lens should point into the center chamber and the cable of the Camera should extend toward the Back Wall.

There will be a lot of wires sticking outward from all places – make sure the LED Diffuser Panel does not hit or sit on any of them when placing downward through the standoffs. Carefully move the wires out of the way. Use nose head pliers or tape.



11-4 Final Wiring

Place the felt Light proofing Curtain on top of the Electronics Panel and the Curtain Clamp on top of that. The wires from the LED Board should run through the slit in the Light proofing Curtain and the gap in the Curtain Clamp.

Insert each wooden stick Completely through the Curtain Clamp, Light proofing Curtain and Electronics Panel. It helps to hold it sideways

Once all 4 wooden sticks are through, you should be able to hold the amalgamation of the 3 parts like a sandwich.



Alternatively, you could do 1 layer at a time directly in the flybox if that is easier. e.g. put the electronics board in, then the 4 sticks in each hole, then the curtain, and then the clamp.

11-5 Final Wiring

Carefully place the Electronic Panel “sandwich” on top of the 4 standoffs and insert each wooden stick completely into the standoff hole. It may take a while to connect the wooden stick with the standoff hole, but you should feel it go in.

Do this one at a time: Take out a wooden stick and connect a M3x16 screw through all the holes.

Repeat until all 4 holes are connected.

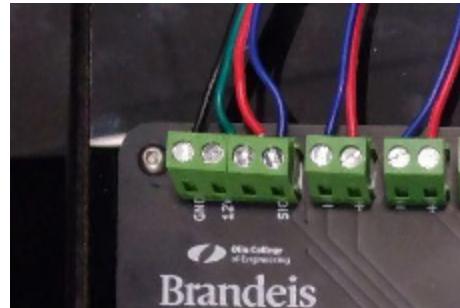


Orientation matters! Everything should be positioned such that the screw terminals in the Main Board for the SD Card Reader, LCD Screen, and Rotary Knob are at the front.

11-6 Final Wiring

The Fans and IR wires (pulled through the corner channel earlier) can be connected to the IR and Fans screw terminals on the Main Board. Take care to connect the correct wires

Sometimes if the IR lights do not at the end, you can swap the wires on the main board and it should work. Very unlikely that all 3 IR LED lights were improperly soldered on)



11-7 Final Wiring

Plug the Male Barrel Adapter into the Buck Converter.

Barrel Adapter plugged into the Buck Converter in the image on the right



11-8 Final Wiring

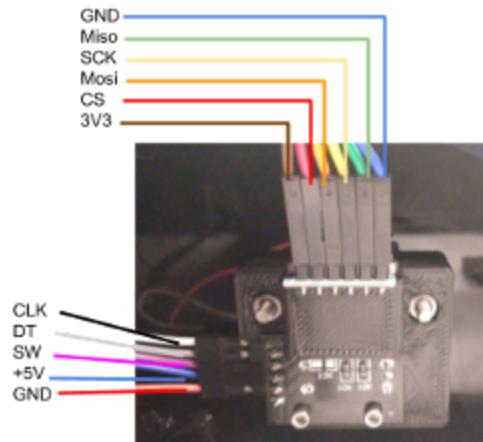
Connect the pins from the Display component in the front panel to the display screw terminal portion on the main electronics board, matching the labels on the board to the display, using the male-to-female jumper wires.



11-9 Final Wiring

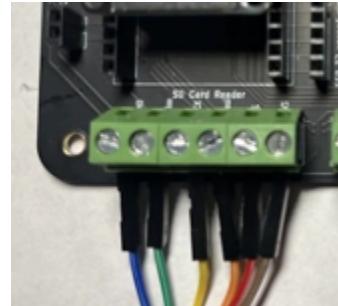
Using male-to-female jumper wires attached earlier, connect the SD Card Reader pins to the SD card screw terminals on the Main Board, matching the labels on the board to the display.

Using male-to-female jumper wires attached earlier, connect the Rotary Encoder pins to the Rotary Knob screw terminals on the Main Board, matching the labels on the board to the display.



SD card reader and rotary encoder pins with label

Remove any protective film from the Display Screen. The IR Diffuser Panel (with the Fly Tray Holder glued on top) can be set inside the box short edge to the front, loosely fitting in the Alignment Panel. Tuck the Light proofing Curtain down around the edges of the

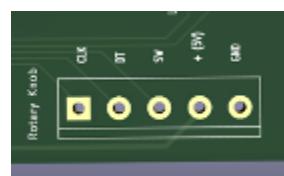


SD card reader terminal on main board

Electronics Panel. The Top Hatch can be placed in the space on top of the box, flush with the Outer Top panel.



Rotary knob terminal on main electronics board

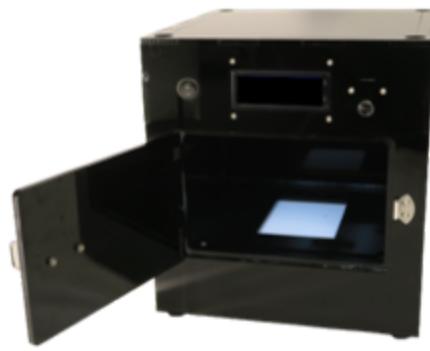


Labeled pins for rotary knob on main electronics board

Congratulations! You have completed assembly of the FlyBox. Now on to loading firmware!

Firmware Loading

Before you can use the box, you will need to install its firmware. You should only ever need to install the firmware on the box once, unless further updates are made.



Setting up the Arduino IDE

You will need to set up an Arduino IDE. You can download and install the Arduino IDE by following the following setup guide:
<https://docs.arduino.cc/software/ide-v2/tutorials/getting-started/ide-v2-downloading-and-installing>

Setting up the Arduino IDE for ESP32 Microcontroller

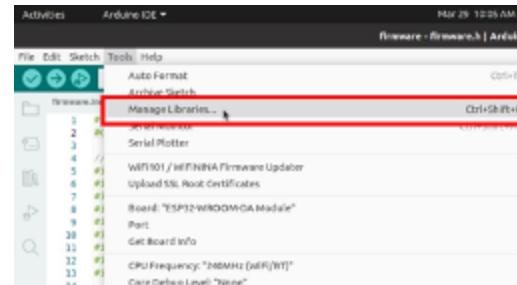
By default, the Arduino IDE doesn't support the microcontroller in the FlyBox. To add compatibility with the FlyBox, follow the following guide:
<https://randomnerdtutorials.com/installing-the-esp32-board-in-arduino-ide-windows-instructions/>

Installing the necessary libraries in Arduino

There are a few external libraries that you will need to install in Arduino.

12-1 Arduino Installation

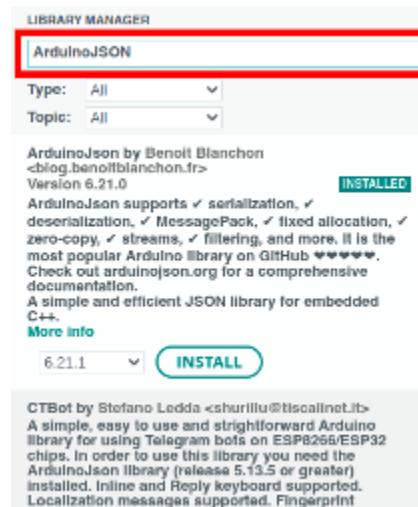
Go to “Tools” in the top menu bar, then under the drop down menu, select “Manage Libraries...”



12-2 Arduino Installation

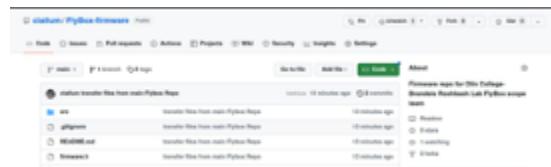
To add a library to the Arduino IDE, Search and install the following libraries

- ArduinoJson by Benoit Blanchon
- RTClib by Adafruit (May require additional downloads, complete these)
- LiquidCrystal I2C by Frank de Brabander
- ESP32Encoder by Kevin Harrington
- Adafruit_BusIO by Adafruit



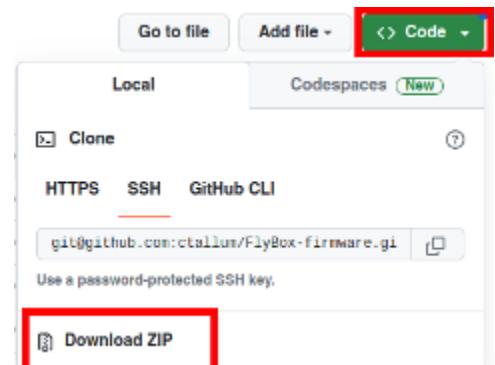
13-1 Firmware Download

Go to <https://github.com/Rosbash-Lab-FlyBox/FlyBox-firmware>



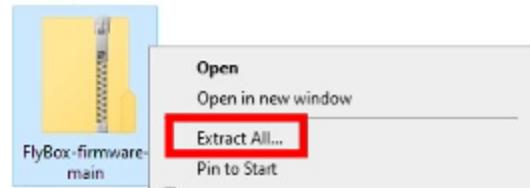
13-2 Firmware Download

Click on the green button labeled “Code” then choose “Download ZIP”



13-3 Firmware Download

Unzip the downloaded folder. It should be titled “FlyBox-firmware-main”



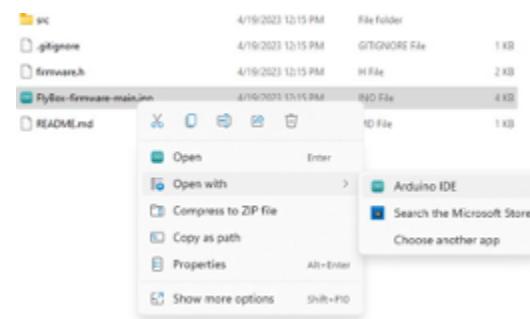
13-4 Firmware Download

Within the “FlyBox-firmware-main” folder, open the “FlyBox-firmware-main.ino” file in the Arduino IDE

It will ask if you want to create a new folder, click yes.

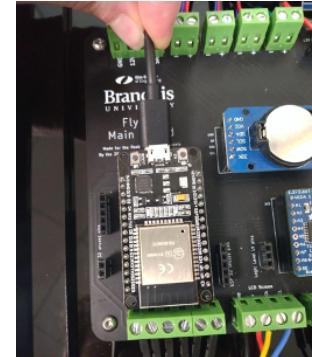
Make sure the FlyBox-firmware-main folder has the following files inside:

- firmware.h
- FlyBox-firmware-main.ino
- src folder (which has “screens” and “utils” folders inside)



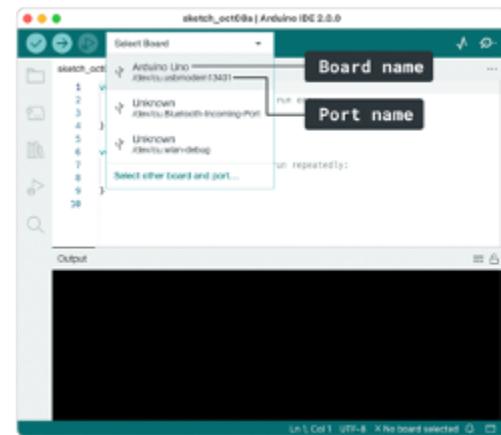
13-5 Firmware Download

Connect the ESP32 to your computer using a micro USB to USB A cable



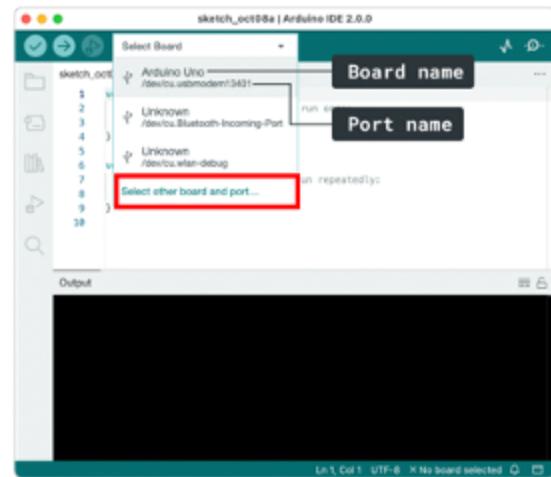
13-6 Firmware Download

Open up the board selection menu



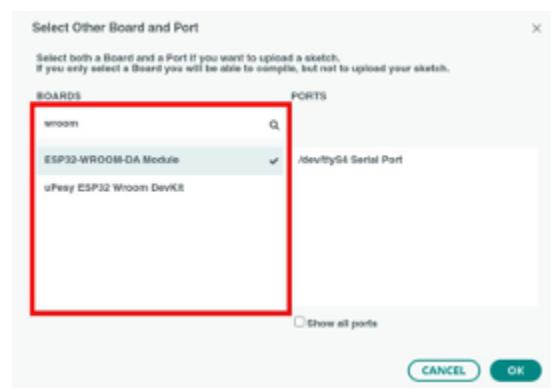
13-7 Firmware Download

Click “Select Other Board and Port”



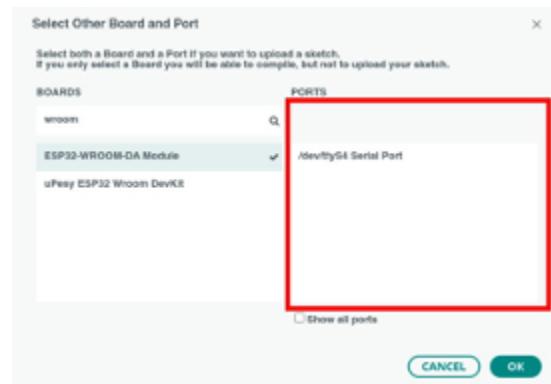
13-8 Firmware Download

Search and select “ESP32-WROOM-DA Module”



13-9 Firmware Download

On the right half of the menu, select the port your ESP32 is connected to, and click “OK” to close the menu



13-10 Firmware Download

Click to upload the file



Common Errors

If you see a “library error,” search /users/”your name”/documents/Arudino/Libraries and delete any library you are not using or delete everything and start over

If you see a “src/utils/lights.h” not found, you have to move the src folder into the FlyBox-firmware-main folder

If you ever see a “Adafruit_I2CDevice.h” not found, it’s because this library is no longer used. The new library used is now “Adafruit_BusIO”

Selecting the Board is relatively simple. However, 2 ports may appear after connecting the ESP32. Select the port that contains “USB to UART serial port” instead of a port that may have 4 digit numbers, such as “0001”

Removing back wall for repairs

Removing the backwall provides access to:

- IR and Fans Board
- Fans
- IR LED lights
- USB A to USB Jack B
- Power outlet wiring

However, before removing the backwall, disconnect

- WAGO inline connectors from the red and black power input
- Camera USB A cord from the USB Jack B

Keep in mind that when the backwall is installed, the friction between the backwall and the left and right walls can be very tight, so expect some resistance. If helpful, you can use a rubber hammer/stick to gently hit and push the backwall out from the front door.

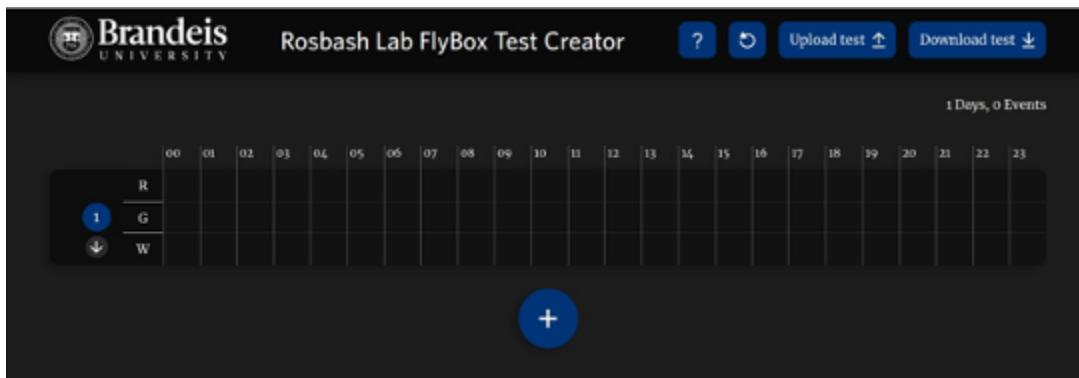
Problems we encountered when removing the backwall were:

- The flybox screen would stop working. After trial and error of switching out electronics boards and re-wiring, replacing the rotary encoder + SD card reader resolved the issue. It is possible that the impact of hitting the backwall caused damage to these boards as they’re all connected (physically).
- The backwall acrylic may crack or break during removal or while being put back in. If so, depending on the damage, a new backwall may have to be lasercut.

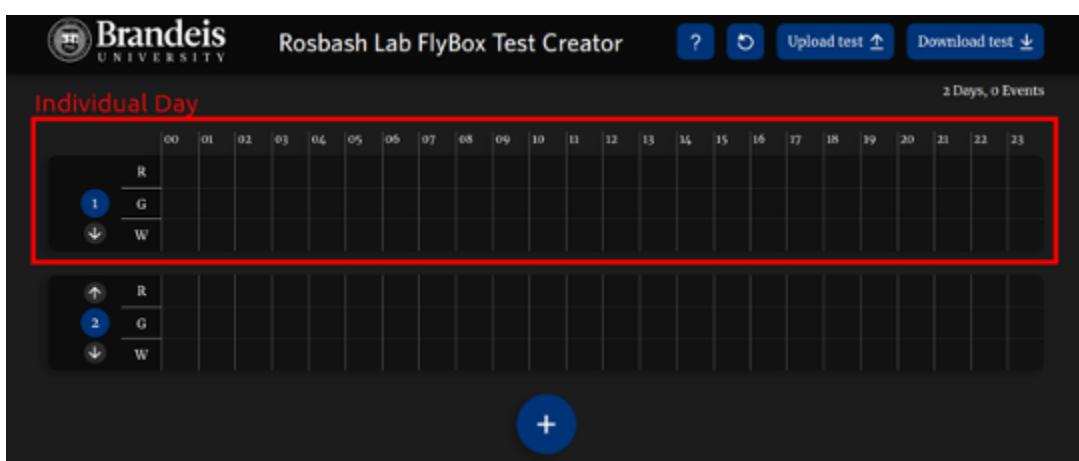
Running a Test

To run a test, first design a test using <https://rosbash-lab-flybox.github.io/FlyBox/>. You can then download the test and upload it to the box. On the box, you can then select and run the file.

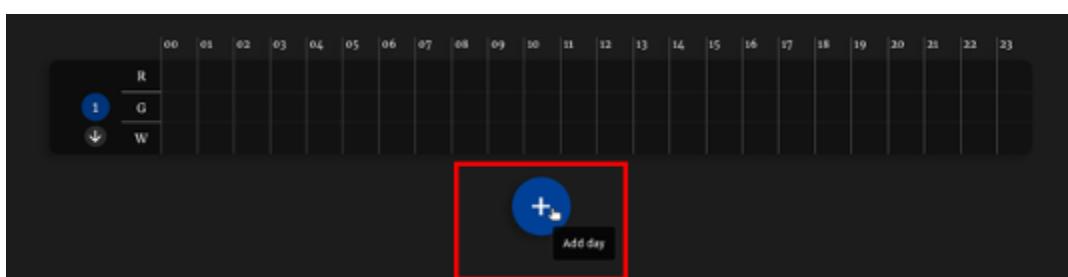
Using the Rosbash Lab FlyBox Test Creator



Above is an image of the test creator website. You can use this website to generate and modify test files. To create a test file, you can click and drag to create an event.



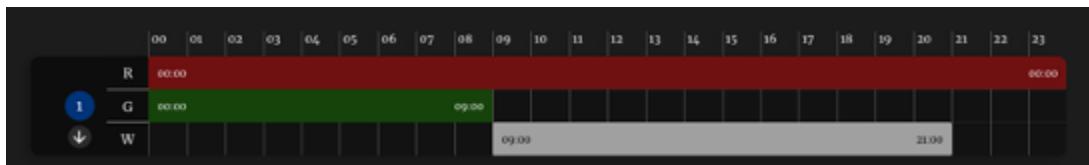
Each individual day of the test is grouped together as seen in the image above. The 24 hours of the day are displayed at the top of the day.



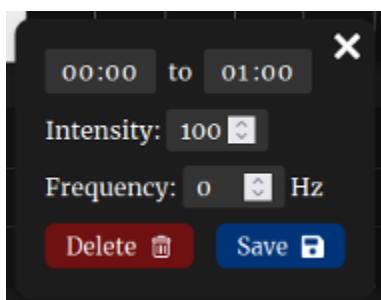
You can add more days to the test by clicking the large circular plus button at the bottom of the screen.



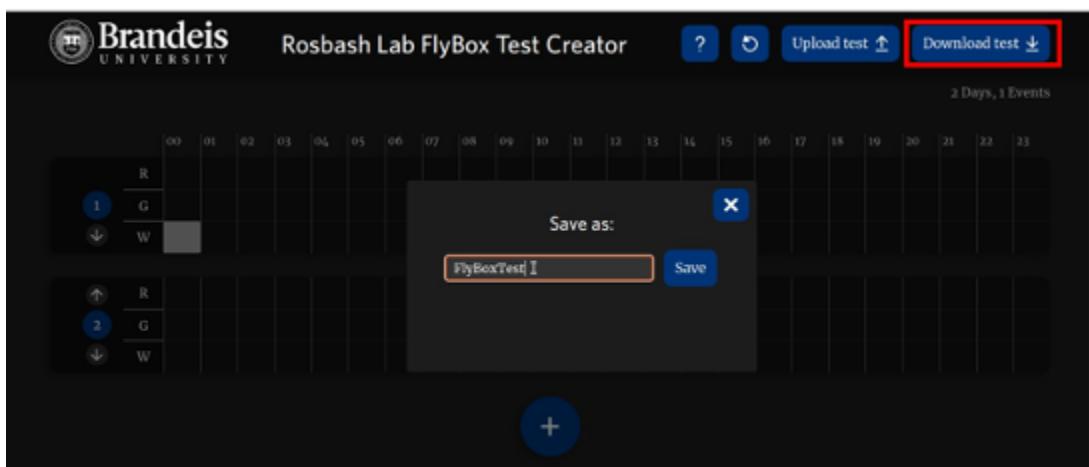
You can delete a day by hovering over the day indicator on the left.



Horizontally, across each day, you can add discrete lighting events. As shown in the image above, the top row is red light events, the middle row is green light events, and bottom is white light events.



If you click on any event, there is an info panel that appears. In this modal, you can modify the start and stop time, the intensity of the light (from 0-100) and change the frequency of the lights (0 Hz is solid).



Once you are satisfied with your test, you can download the test file locally to your computer using the “Download test” button.

Running a test file on the FlyBox

After downloading your test file from the FlyBox test creator website, load the file onto an SD card, and insert into the SD card reader slot on the right side of the FlyBox. The FlyBox camera can be connected to your computer using a USB B to USB A cable from the USB output on the back of the FlyBox.

14-1 Test Run

This is the intro screen for the box. Click the knob to enter the main menu screen.



14-2 Test Run

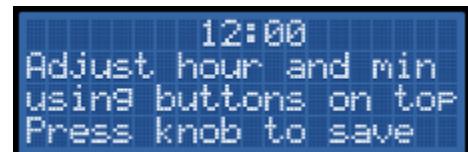
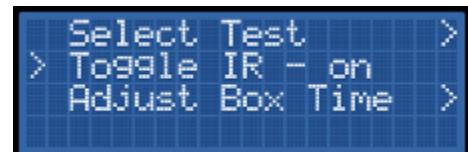
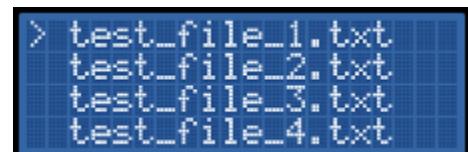
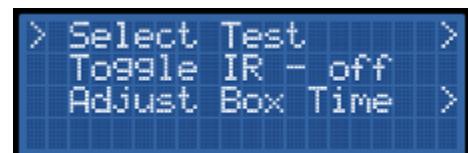
This is the main menu screen. You have three options here: select a test file, toggle the IR on and off, and change the time on the box.

You can scroll between the options using the rotary knob.

If you click Select Test, you will be brought to a screen where you can select your test file. You can scroll between the files using the rotary knob.

If you click Toggle IR, you can turn the IR light on and off. The main menu screen will display the current status of the IR light.

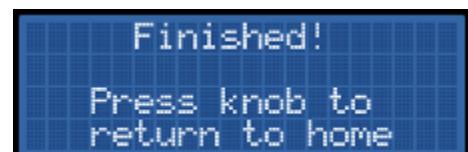
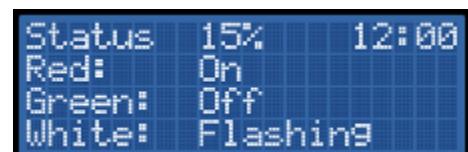
If you click Adjust Box Time, you will be brought to a screen where you can adjust the hour and minute on the box. You can change the hour and minute by clicking the hour and minute button on the main electronics panel. Clicking each button will increment the hour/minute by one minute.



14-3 Test Run

As you run a file, it has a live display indicating percent through the test, which lights are on/off, and the current time

When the test is over, you have the option to return to the main menu by pressing the knob.



Appendix

Calibrating IR

The toggle IR option in the main menu will turn on the IR lights. While connected to the camera, you can twist the potentiometer (shown on the right) on the Main Electronics Board to decrease or increase the brightness.



Camera focus

We have noticed issues with the camera sometimes not being able to focus on the tray of flies. This results in a pulsing sort of effect as the camera repeatedly shifts focal length, trying to find an object to focus on. When we ran into this issue, we found that the solution was to simply replace the camera with a different one. This resolved the issue.

If switching to a different camera does not work, another solution is to lock the focus of the camera. To do this, you can use the Logitech Capture software

(<https://www.logitech.com/en-us/software/capture.html>). Using the Logitech Capture software, it is possible to turn off auto-focus and have a fixed focal length. We found some success with this software in it being able to fix the pulsing focus issue.

Another solution is to shift the fly tray up by a small amount. Sometimes, just moving the tray up by a slight amount allows the camera to focus.

Buying the PCBs from PCBway

<https://wwwpcbway.com/>

Each of the manufactured boards should be available through PCBway's "Share and Sell Program." The links for each board are as follows:

FlyBox Main Board:

https://wwwpcbway.com/project/shareproject/W547848AS1D13_MainBoardGerber3_5fe985dc.html

FlyBox IR Board:

https://wwwpcbway.com/project/shareproject/FlyBox_IR_Board_50aa739c.html

FlyBox RGW Board:

https://wwwpcbway.com/project/shareproject/FlyBox_RGW_Board_fc0900b7.html

Be sure to order it as PCB+Assembly if you are looking for the PCBs to arrive ready to use (around 4-5 weeks) or just PCB if you have the ability to solder yourself.

General troubleshooting

If the box isn't turning on correctly, most likely something is wired incorrectly. Common issues are incorrectly wiring the display or the SD card reader. Check that these components have wires connected firmly and in the right place

Strange clock readings

- It is possible that the coin battery in the RTC component has died. If so, replace battery and update the time using the build in time modification screen
- If the RTC is broken, replace component

Strange display artifacts

- If the display is broken, there are a few symptoms. It might not turn on, it may stream random characters, or it may show incorrect text.

Cleaning

- The FlyBox can be dusted with a microfiber cloth or canned air
- Use water and mild soap (such as dish soap) to clean the FlyBox. Be sure not to get electronic components wet.
- Don't use alcohol to clean the box, it can degrade the acrylic panels.
- Don't use abrasive cleaners, they will scratch the surface of the FlyBox

FlyBox on a Budget

To lower the cost of the FlyBox, a couple changes can be made:

PCBs

If you have the ability to solder, you can order unassembled PCBs from PCBway and assemble them yourself. The components of the PCBs are listed in the PCB BOM on PCBway and will need to be ordered separately; they are not included in the FlyBox BOM.

Fans

The suggested Noctua fans are expensive. Cheaper brands of fans will have two wires, red and black. Put the black wire in the ground position, and the red wire in the power position on the IR/Fans board.

MDF

Instead of black opaque acrylic, medium density fiberboard can be used for the wall panels (cutsheets 1-6)

Kitting

There are a number of small pieces of hardware (nuts, bolts, standoffs, etc.) that are easy to miscount or confuse for one another. This may not be an issue in the Rosbash lab. However, if kits are someday made to be sent to another lab or organization, a large bag of unsorted hardware won't be ideal. Instead, we recommend kitting the hardware, which means putting the proper quantity of each type of hardware into an individual bag. There are many companies that offer this service. Here are a few that we found:

- <https://www.associatedfastening.com/products-services/hardware-polybagging/>
- <https://www.mudgefasteners.com/custom-kitting-packaging>
- <https://www.autobag.com/markets-served/hardware-fasteners>
- <https://www.foremostfastener.com/kitting-custom-bagging-services.html>