Caveatron Rev B Assembly Instructions

Version: 2020-04-10

Overview

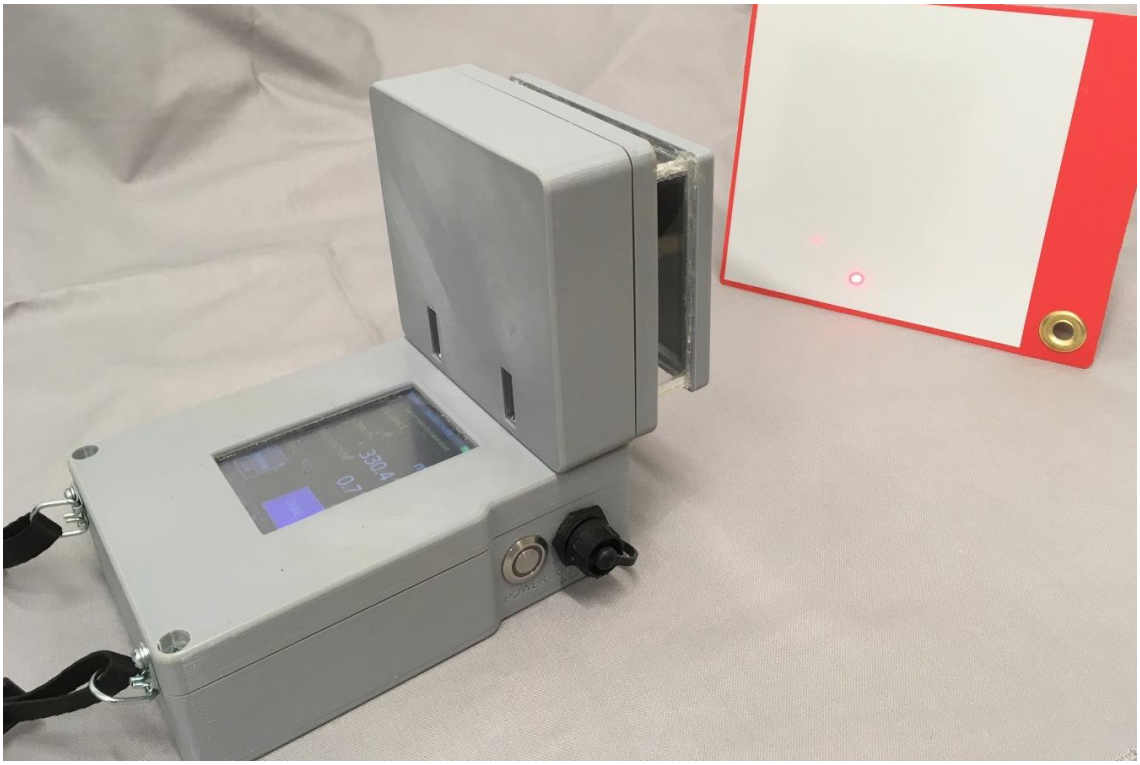
This document provides instructions on how to assemble the Rev B (Teensy-based) version of the Caveatron assembly. In contrast to the Rev A version, the Rev B version has a 3D printed enclosure and a custom printed circuit board that greatly reduces the machining and wiring required. If you do not have access to these capabilities, you can either perform your own wiring or make your own enclosure in the style of the Rev A design.

Some Tools Required:

- Band Saw (or other tool for cutting plastic)
- Soldering Iron
- Screw drivers
- Pliers
- Tweezers

Assembly Materials Required:

- Flexible adhesive such as marine grade adhesive
- Silicone sealant
- O-ring epoxy
- O-ring lubricant (synthetic grease)
- Soldering supplies including heat shrink tubing
- Adhesive-backed foam
- Tape (Kapton or electrical)



Enclosure

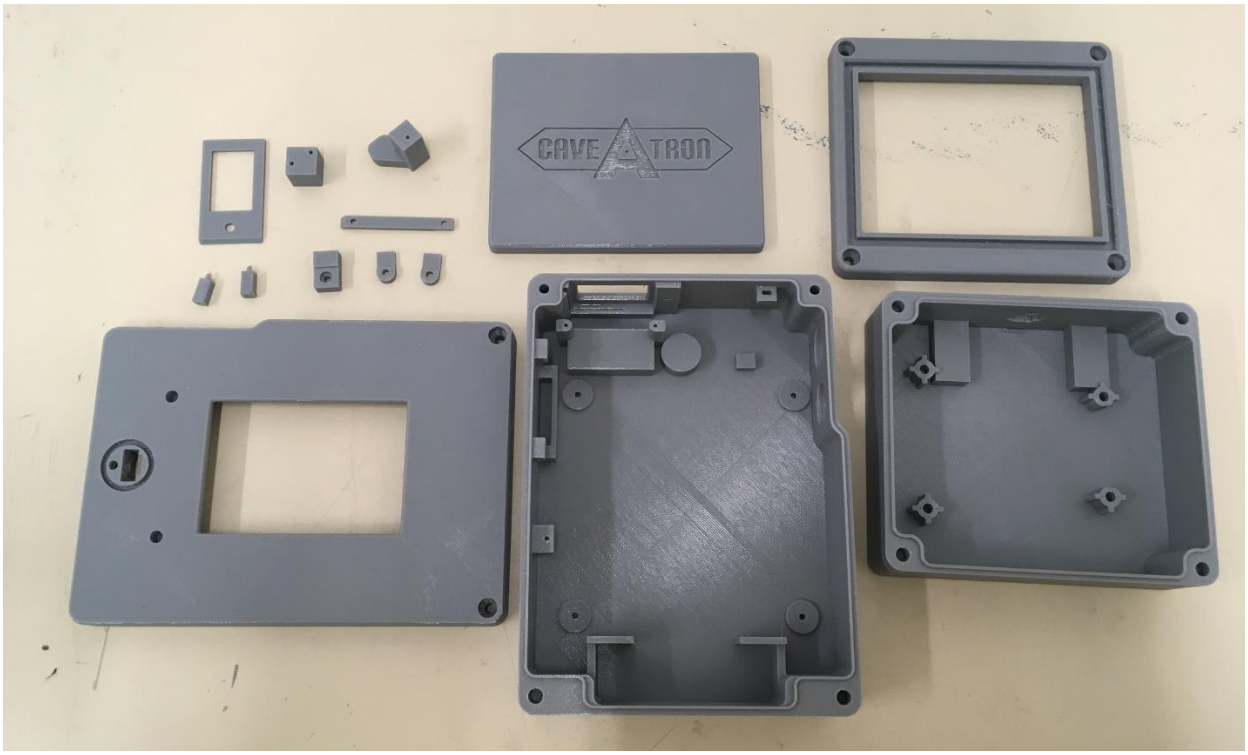
3D Printed Parts

The enclosure parts are 3D printed. Detailed information about the parts and printing them can be found in the separate "3D Printed Parts Description" document. The material I used is PETG which is much more durable than PLA, but more flexible and easier to print than ABS. The goal is to be durable and ABS would probably be fine, but I would not recommend PLA.

The designs provided assume you are using the UT390B LRF and the Coldtears 3.5" IPS display. If you are using a JRT LRF or the Coldtears 4" display, portions of the design will need to be modified.

There are 13 printed parts needed (11 unique parts) as summarized below and shown in the photo:

- Main Enclosure Base
- Main Enclosure Lid
- RPLIDAR Enclosure Base
- RPLIDAR Enclosure Lid (Bottom)
- RPLIDAR Enclosure Lid (Top)
- LRF Window Frame
- LRF Support Bracket
- LRF Mounting Post
- AltIMU Bracket
- LCD Clamp (2 pieces)
- Battery Charging Board Support Posts (2 pieces)



3D Printed Parts

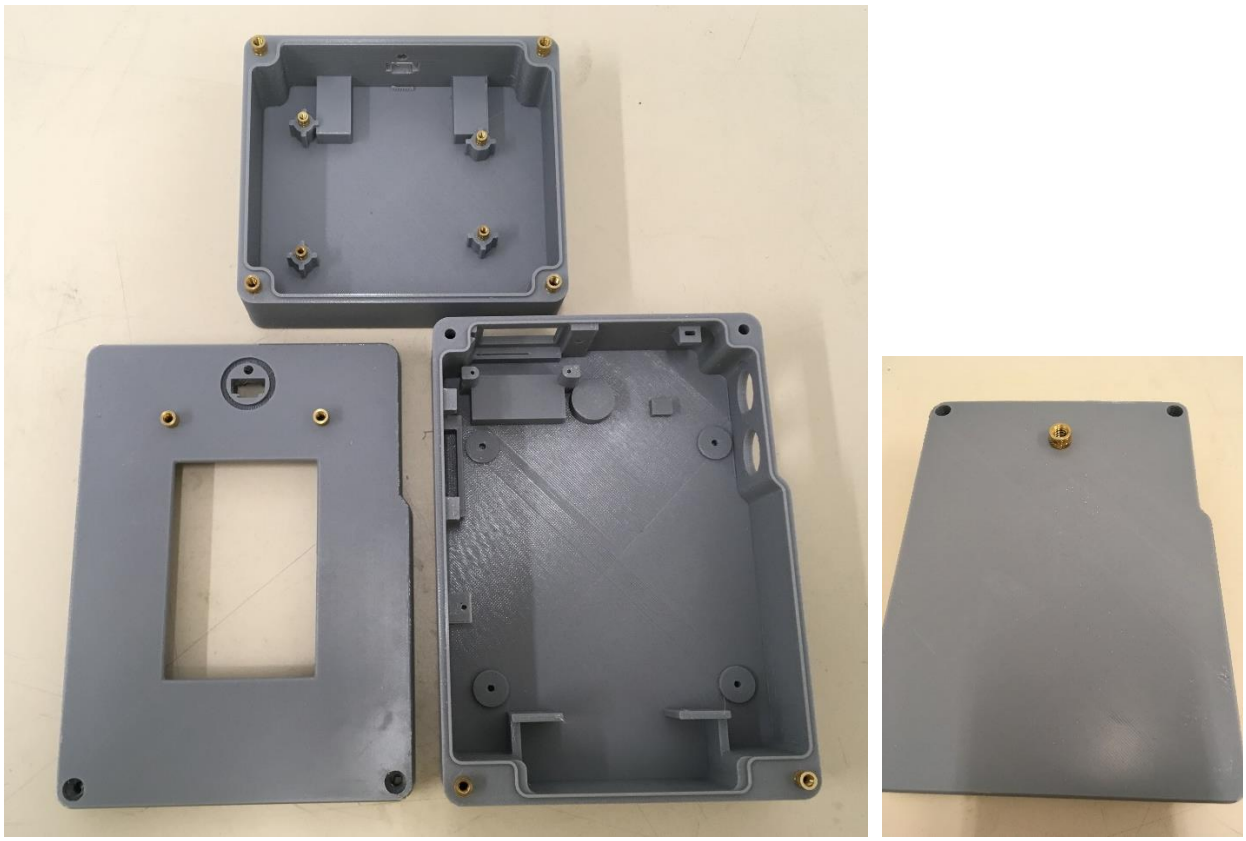
Preparing the Parts

After printing the parts and removing support material, a small amount of sanding with a fine grit sanding sponge or sandpaper may be needed to clean up the edges – especially on the main enclosure to give the edges a little more of a rounded edge for more comfort while holding it.

Installing the Threaded Inserts

The parts have holes for either thread-rolling screws, for mounting smaller components, or for threaded inserts, where a more durable connection is required. Heat-set threaded inserts are used which can be installed using a soldering iron. Three sizes are used and their locations are shown in the photo below:

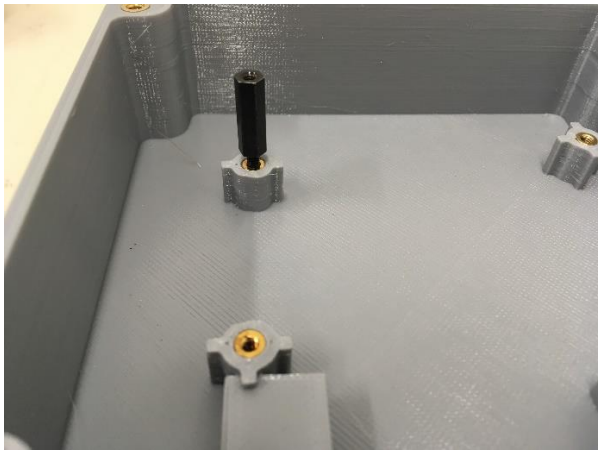
- #6-32
    - 2 in the Main Enclosure Base top side rear corners
    - 2 in the Main Enclosure Lid top side
    - 2 in the Main Enclosure Lid underside front corners
    - 4 in the RPLIDAR Enclosure Base corners
- M2.5-0.4
    - 4 in the RPLIDAR Enclosure Base interior for mounting the LIDAR
- ¼-20 (optional - for tripod mounting)
    - 1 on the underside of the Main Enclosure Base



Locations for installing the threaded inserts

Before installing the inserts, have a matching screw ready to check that the insert if vertical. To install them, hand press them as far as you can into the hole and give them a few light taps with a tool. Press the soldering iron onto the top of the insert for a few moments to allow it to heat up the part and then start gently pressing and slightly wiggling the insert to encourage it to move deeper into the hole. Be careful not to the let the soldering iron slip and damage the 3D part surface. Keep pressing and wiggling until the insert is level with the top surface of the part as shown below. Remove the soldering iron and quickly thread in the matching screw a short distance and look to confirm that the screw sticks straight up from the surface. Be careful since the inserts are very hot! If it is angled by any significant amount, try to use the screw to straighten it out before the plastic cools and re-hardens. Otherwise leave in the screw and use the soldering iron to warm it back up to correct it (use gloves to avoid getting burned).

Use a large tip soldering iron to install the inserts. As shown In the photo at left, tilt the soldering iron along the edge of the insert or use a wide tip to be sure to not get the tip stuck inside the insert or it will pull out the insert once you have pressed it in. Be sure that the inserts are installed level with the surface. In the image at right, the left hand insert has not been installed deep enough and sticks up slightly whereas the one on the right has been installed to the correct depth.



Use a matching screw (or the RPLIDAR standoffs) to quickly confirm that the inserts are installed vertically and not tilted. If you are fast enough you can use them to correct any tilt before the plastic cools down. Be careful as the inserts are very hot!

Acrylic Windows

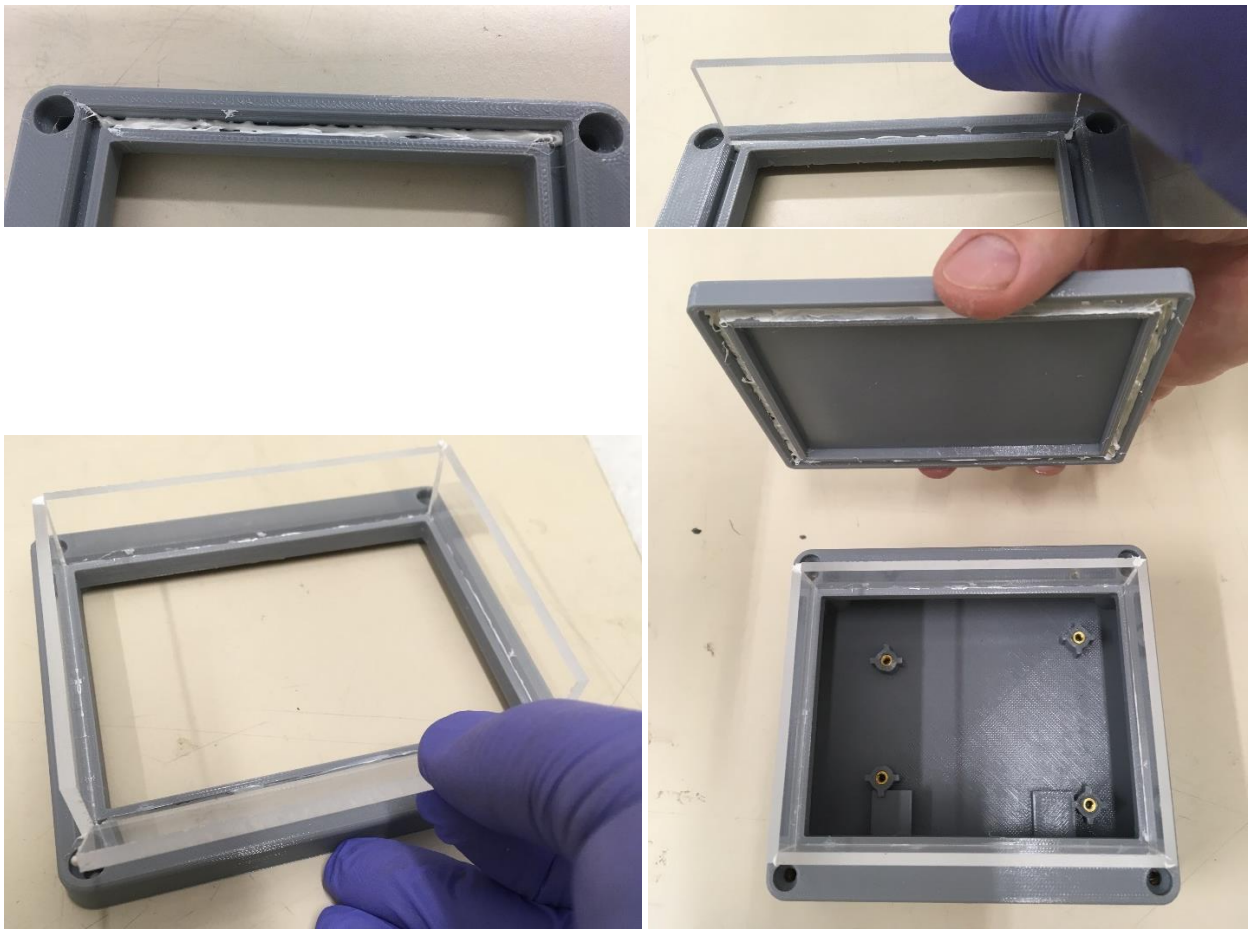
There are 5 clear acrylic windows that must be cut out and installed. Four form the LIDAR module windows while one is the LRF window. The thicker 0.118" material is used for the LIDAR windows while the thinner 0.090" material is used for the LRF window.

There are two lengths for the LIDAR module windows with the longer pieces forming the top and bottom while the shorter pieces form the sides. These pieces also form the mechanical connection between the two halves of the LIDAR module lid. When cutting them out, cut the lengths as precisely and as squared on the ends as possible since they must join together at the corners. Test the cut pieces by installing them in the slots in the RPLIDAR Module Base. The shorter pieces fill the full length of their slots, while the longer pieces go inside the shorter pieces.

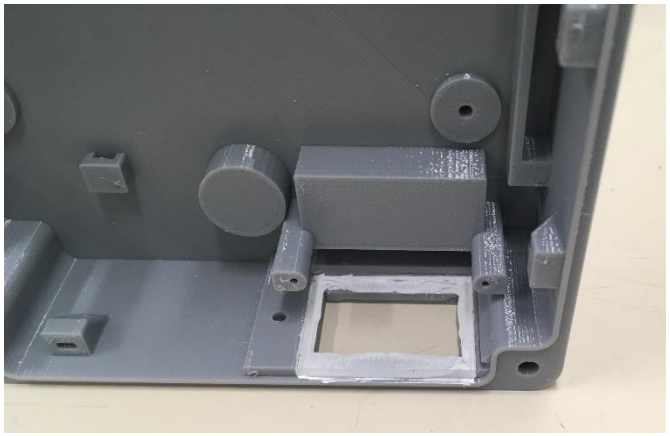
Once you are satisfied with the fit of the pieces, it is time to glue them into place. Use a marine grade or other semi-flexible, waterproof adhesive. If you use a rigid adhesive, it will warp the windows, causing errors, and not result in a good seal. One method to dispense the epoxy is to use a blunt tip syringe. I use a 16 gauge syringe for the epoxy. Place the epoxy on the inside walls and base of the groove in the LIDAR module lid. Put in just enough to get continuous coverage but not too much or it will ooze out when you insert the window. Note the angled lip on the outside perimeter of the groove. That will be used later to add silicone sealant, so try not to get epoxy on that part. Use gloves to handle the windows so that you don't leave fingerprints on the inside. Be extra careful not to get any epoxy on the central portion of the windows.

Install the shorter windows first. Line the windows up with the groove and press them in, checking that they go in all the way and are level. For the longer windows, before installing them carefully place a bead of epoxy on the ends of these windows (the short edges). This will form the joint between the windows so it especially important to get a seal. Press these in at a slightly angled manner as shown in the photo below so that the epoxy on the ends does not smear too much. Once the windows are in, it will look like the photo below. Now add epoxy to the groove in the top of the lid. Note that the module lid base does have a preferred orientation, though it is hard to tell by looking. The best way to check is to set it on the RPLIDAR module base and run your finger along the top or bottom. If it is NOT oriented correctly there will be a small step at the joint between the base and the lid. Check both ways for where this joint aligns the best. The top orientation of the LIDAR module base is shown in the photo. For the lid top piece, you want the Caveatron logo to be upright in this orientation. Once you are sure you have the orientation correct, press the lid top onto the windows. You may have to wiggle it a bit to get it to set the windows into the grooves correctly. Be sure everything is level and that the lid top is not at an angle to the base. Allow the epoxy to cure for 24 hours.

The LRF window is relatively simple. First check the fit– it should fit pretty tightly so you may have to press it slightly to snap it into place. Place a bead of the epoxy around the inside of the window. Be careful that none goes into the thin slot just below the window where the neutral density filter will be installed later. Again, using gloves press the window into place being careful that no epoxy gets on the center part of the window. Press it tightly for several minutes to allow the epoxy to set up or clamp it. Allow it to cure for 24 hours.



LIDAR Windows: Place epoxy in the LIDAR window groove (upper left). Using gloves, press the windows into the grooves, doing the shorter windows first (upper right). Place epoxy on the ends of the longer pieces and press them into place being sure to get them square (bottom left). Add epoxy to the grooves in the lid and press it onto the windows (bottom right). Be sure not to get epoxy on the exposed part of the windows.



LRF Window: Place epoxy around the perimeter of the window opening. Using gloves Press the window into place being sure not to get any on the open part of the window. Continue to press until the epoxy starts to set up.

If you have gotten a good bead on the epoxy, you may not need to do the next step, but I have found that to be difficult to ensure. If you are not planning to use the Caveatron in a stream passage, its fine at this point and will provide sufficient protection against mud, dampness, and water on its surface. However, if submerged, water might force its way inside, so for extra protection, its best to add silicone sealant around the outside window joints. After the epoxy is cured, complete the sealing of the windows by using syringe (I used 20 gauge) to place the sealant into the angled edge of the groove around the outside of the LIDAR windows (both top and bottom sides) as shown. For good measure, you can add some across the corner joints as well. Try to get a nice continuous bead and be sure not to get any on the window. You can use a pointed toothpick to push it in further or spread out any blobs you might get if necessary.

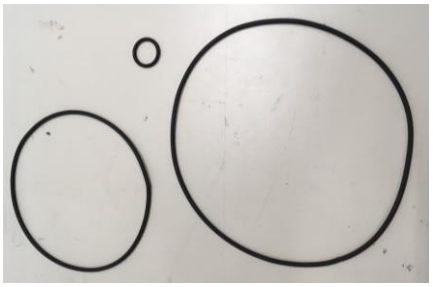
Repeat this around the LRF window. You may want to spread some along the lip of the top inside of the window cutout, as sometimes the print does not have a clean edge at that location and you don't want water getting inside the print interior.

Adding silicone sealant to the LIDAR windows (left) and the LRF window (right).

O-Ring Gaskets

Two custom cut O-ring gaskets are needed. These are cut from gasket cord and glued into an O-ring using O-Ring epoxy. Cut two lengths for cord as follows:
Main Enclosure: 19.25" (49 .0 cm)
LIDAR Module: 14.75" (37.5 cm)
When epoxying the ends together, be sure to get an aligned joint.

A third O-ring is used at the connection between the Main Enclosure and the LIDAR module. This is a standard sized 5/8" ID, 13/16" OD, 3/32" section (metric equivalent: 15.8 mm ID, 20.6 mm OD, 2.4 mm section).



The three O-rings used with the enclosure

After the epoxy has cured for a few hours, smear a bit of lubricant along the length so that it will go in more easily and improve the seal. Press the O-ring into the slot starting at one location and working around the perimeter. Work it in so that it is consistent and not sticking out or pressed too far in at any location.

Wire Harnesses

Detailed instructions for preparing the wiring harnesses can be found in the separate "Wiring Harness Assembly" document. There are 5 key wiring harnesses:

- Laser Rangefinder
- LIDAR
- Power Switch
- Piezo Buzzer
- Battery

There is also one optional wiring harness if you use the waterproof USB connector with solder terminals. Otherwise use a short USB Micro to Mini cable to directly plug the Teensy into the connector.

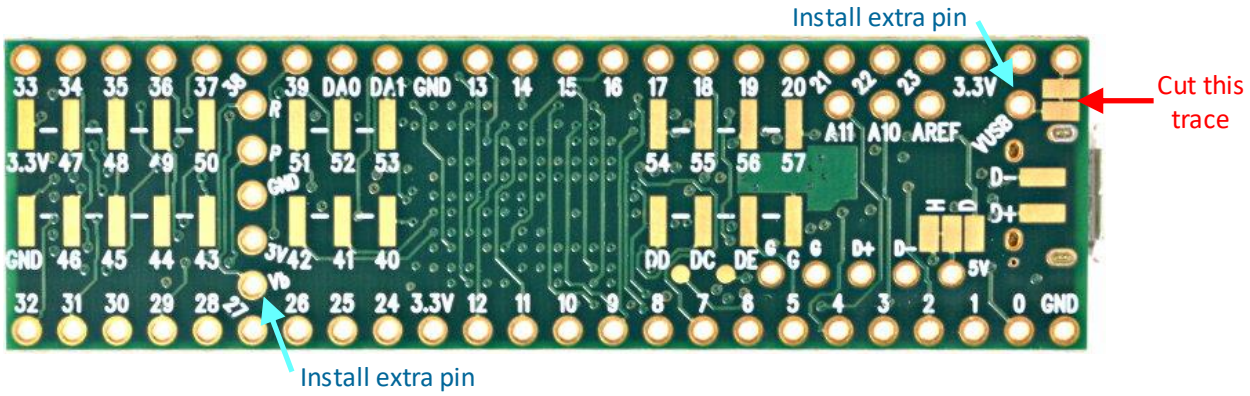
Electronics

Some electronics modules are intended to be attached to the printed circuit board (PCB) by plugging them into a female header while others are to be directly soldered onto the board. All of the components will need male header pins soldered onto them as well, though for some components, only selected pin locations are populated. This is described below.

Teensy 3.6

If you ordered it with pins pre-soldered, you still need to add single 1x1 male header pins as indicated in the photo at VUSB and also at Vb. If you ordered it without pins, then you will also need to solder both full edge rows with a 1x24 set of pins. On the PCB, two 1x24 rows of female header sockets are soldered to the board along with two 1x1 female header sockets under VUSB and Vb.

You also need to cut the trace between the two pads next to VUSB to isolate USB power from internal battery power. Use an Exacto knife to cut the thin trace at the location marked.



Teensy 3.6 Board. In addition to all of the 24 pin along both sides, the two pins marked with blue arrows must be populated with male headers. Also, the trace between the two pads indicated with the red arrow must be cut.

Voltage Regulators (3x)

All pins on all three of these boards are populated (two 1x4 and one 1x3) and is soldered directly to the main PCB. Pay special attention to the small 3 pin regulator to be sure to get its orientation correct.

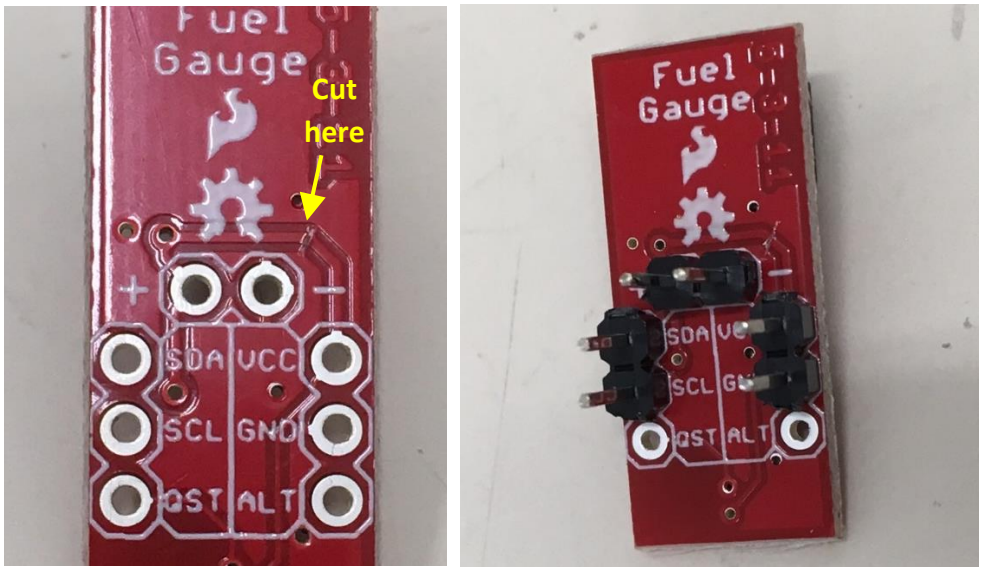
Font/Graphics Module
All pins on this board are populated (1x6) and it is soldered directly to the main PCB.

AltIMU
All 5 pins along one edge of the board are populated with a 1x5 male header and it is plugged into a 1x5 female header socket that is soldered to the PCB. This component is additionally attached to the PCB with the IMU bracket. Since the positioning of this component is more important than the others (to get the compass orientation correct), the following procedure should be followed. First solder the female headers to the PCB. Insert the male headers into the socket without soldering them to the IMU. Attach the IMU board to the IMU bracket with two 2-28 x 1/4" long thread rolling screws. Place the IMU and bracket onto the main PCB (with the tops of the pins through the IMU board pin holes) and attach the IMU bracket to the PCB with two more 2-28 x 1/4" screws from the underside. Finally, solder the pins to the IMU board.

Power Switch Board
For this board, the CTRL and ON pins are NOT populated but all the others are. The easiest way to do this is to solder 1x6 male headers on both sides (omitting the CTRL pin hole) and cut off the ON pin at the base. This component is soldered directly to the main PCB. Be sure to get the orientation correct.

Fuel Gauge
Before attaching pins to this board, it needs to be modified by cutting a trace. In the design, the board uses 3.3V from the Teensy rather than the battery input voltage (to isolate the rest of the electronics for safety). You need to cut the trace on the board that joins the Battery Input positive to the 3.3V VCC. When looking at the back of the board, with the "Fuel Gauge" text at the top, the track to cut is the one that runs around (from 12 o'clock to 3 o'clock) the CELL V+ pad in the center of the board and attaches to the VCC pad on the right side. You can use an Exacto knife to make the cut.

After the trace is cut, attach three 1x2 male header pins. One goes on the +/- pins, one on the SDA/SCL pins and one on the VCC/GND pins. This component is soldered directly to the main PCB.



Fuel Gauge Module. A trace on the backside of the board needs to be cut as shown in the image at left. The pins shown at right are populated with header pins.

Other Parts & Connectors

The coin cell battery holder is soldered directly to the PCB in the marked location.

A 2x20 female header socket is soldered to the PCB at the location marked Touchscreen LCD.

Three 5-pin JST connector sockets are soldered at the locations marked LRF Connector (J2), LIDAR Connector (J3) and Power Switch (J4). One 2-pin JST connector socket is soldered at the location marked Buzzer Connector (J5). Be sure to the note the socket key orientation as shown on the PCB.

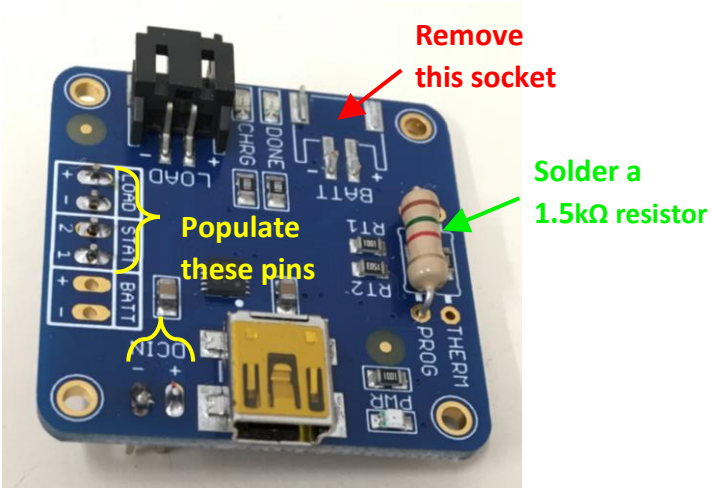
The remaining locations on the board are present for possible future use but are not used at this time.

Li-Ion Charger Board

The component sits above the power switch board and fuel gauge board. It should be installed last. Solder a 1x2 and 1x4 female header socket to the main PCB. Solder matching male header pins to the Li-Ion charger board. Only the DCIN +/-, LOAD +/-, and STAT 1/2 have pins attached. The JST socket for BATT also needs to be removed. Do NOT remove the JST socket labeled LOAD, the battery will plug in here (it is connected to the same points on the board as the BATT connector.) The easiest way to remove the BATT JST is to use diagonal cutters to cut off the two solder points on each side and then cut the connector points in the back. Be careful not to damage the board while doing this.

The default charge rate for this board is 500 mA. This can be increased by adding a resistor across the PROG pads. Although Adafruit does clearly document this, the charge rate can be safely increased to a maximum of 1.2 A. To do this, solder a 1.5 kΩ resistor across PROG (in parallel to the built-in resistor, the combined resistance becomes 850 Ω).

Now screw the Charger Board Support Posts to the main PCB using one 2-28 x 1/4” screw each through the backside of the main PCB. Finally push the Li-Ion Charger Board into the female header sockets and onto the support post protrusions so they go through two corner mounting holes. Gently mash down or slightly bend the support post protrusions (don’t break them) so they secure the board into place.

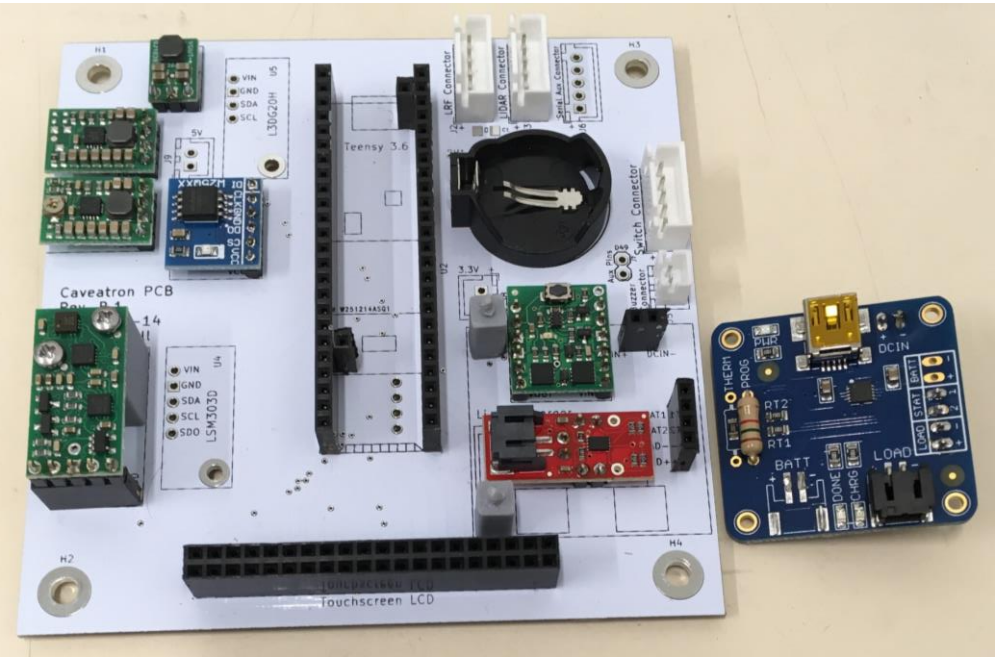


Li-ion Charger Module. Only the 6 indicated pin holes are populated, the BATT JST socket is removed, and a 1.5 kΩ resistor is added to PROG.

Alternate to the AltIMU

As an alternative to the AltIMU, an LSM303D accelerometer/magnetometer module can be used in combination with a L3DG30H gyroscope module. These are place at the designated locations on the PCB

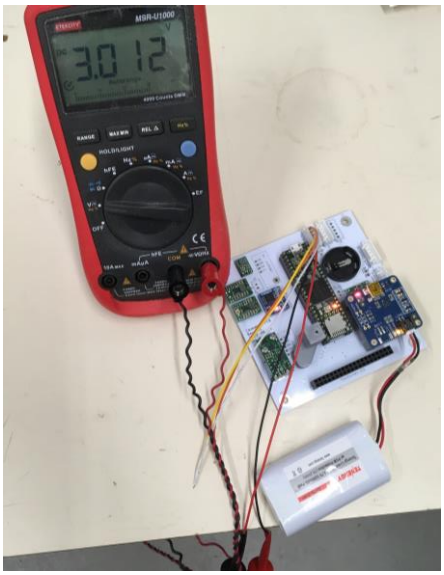
(in that case the AltIMU is not used.). The LSM303D can be attached with a 1x5 set of male header pins soldered to the LSM303D VIN, GND, SDA, SCL, and SDO pins and plugged into a 1x5 pin female header socket soldered to the PCB. A mounting bracket would need to be printed (design not provided) similar to the AltIMU mounting bracket (or make a custom standoff) that has a single hole straight through in the position of the provided mounting hole under the LSM303D. The main point is that the LSM303D be well secured to the PCB and exactly level and square to it. The L3DG20H must be directly soldered to the main PCB or it would interfere with the LRF module directly above it. You will need to create a custom washer or standoff and probably use a #2 through-hole machine screw and nut to secure it.



PCB with all components soldered on. The Teensy and Battery Charger board are not installed for clarity.

Set the LRF Regulator Voltage

Before installing the circuit board, the output voltage of the adjustable regulator (for the LRF) needs to be set. Assuming you have not yet loaded any code onto the Teensy, you should be able to do this by plugging in the battery and connecting a voltmeter to the two most interior pins on the LRF JRT connector (J2) - the plus voltage pin (marked on the PCB with a "+", right next to the J2 label) and the minus pin right next to it. Press the small button on the Power Switch Board to turn the system on or off. Use a screwdriver to adjust the pot on the voltage regulator (the one closest to the IMU) until the voltage reads 3.0 volts.



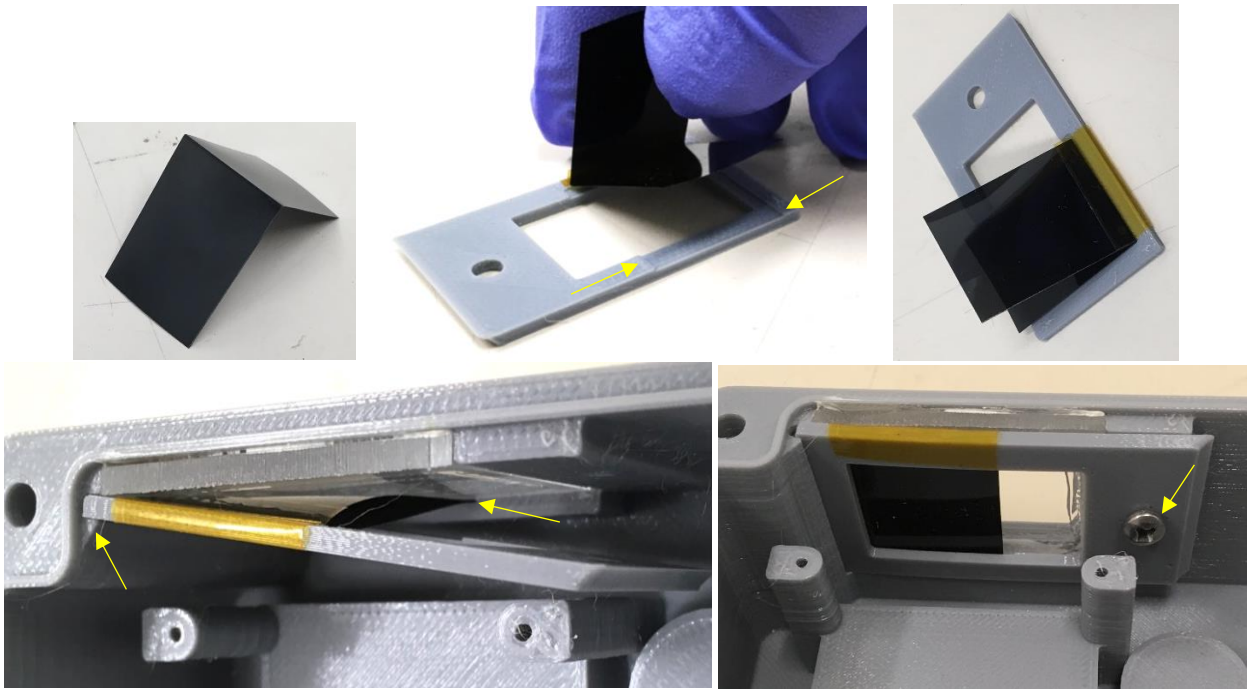
Setting the LRF voltage regulator.

Main Enclosure Base Assembly

General note: When installing the thread rolling screws, it can be helpful to start the holes a little bit with the screw first before trying to install the part.

LRF Filter and Window Frame

Cut a piece of the neutral density filter material to 2” x 0.75”. Fold it in half to make a 1” x 0.75” piece and make a sharp crease. (Doubling the filter material is needed for sufficient optical density to avoid false detections.) The open ends of the filter will get inserted into the slit just below the LRF window, while the creased end gets taped to the top of the LRF Window Frame part (the long axis of the filter is up.) The filter sits within the shallow cutout in the LRF Window Frame. This also serves as a position guide since it is intended to only block the receiver side of the LRF, and not block the laser. A small piece of tape across the top of the filter (creased end) is useful to hold the filter in place while it is being inserted and prevent it from possibly sliding around in the future. I used Kapton tape since it provides reliable adhesion. Do not allow the tape to extend much beyond the frame to avoid blocking the optical path.



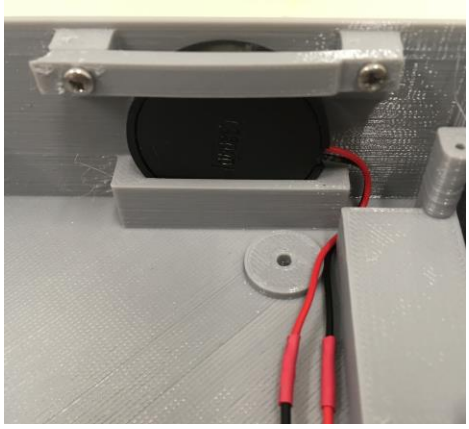
Steps for preparing the LRF window frame and filter. Cut the filter to size and fold in half (top left). Tape it onto the frame so the folded end is at top and it will rest inside the slight cutout (top center and top right). Insert the filter into the narrow slot right behind the LRF window and slide the frame into the cutout on the left (bottom left). Finally screw the frame into place (bottom right).

Before the next step, be sure the filter and inside of the window are clean and fingerprint-free by wiping them and/or blowing off any dust. The use of a glove is preferred for the next step to avoid introducing new fingerprints. Grab the filter piece and tip it forward slightly from the window frame holding the two halves together. Line it up with the slit under the LRF Window and slide it in – be sure both halves went it. Now slide the Window Frame into the slot on the left side of the LRF Window (as seen from inside the enclosure) and press it in as far as it goes. Be sure the filter stays in the slit and does not get creased. The screw hole on the right side of the Window Frame should now be lined up with the hole in the enclosure

wall and the filter should be square and flat against the LRF Window. Use a 4-20 x 1/4” long thread rolling screw in this hole to secure the Window Frame.

Buzzer

The piezoelectric buzzer is installed into the slot along the left wall of the enclosure (as seen from the rear). The buzzer opening faces toward the enclosure wall. Be sure the wires come out toward the front of the enclosure as shown. Press it into the slot and then install the buzzer clamp. Use two 2-28 x 1/4” thread rolling screws to attach it. The end with the slight inset cutout around the hole goes toward the front of the enclosure (it is inset to avoid the screw head interfering with the LRF).



Installed buzzer

Battery

The battery goes in the large slot in the rear of the enclosure. To be sure it is tightly held and cannot slide around, two pieces of adhesive backed foam are attached to the two vertical walls at the front of the battery slot as shown. Cut these to about 0.5’ x 0.75” and stick them on. Orient the battery so that the wire harness will come out of the front right side (as viewed from the rear of the enclosure. Press the battery into the slot and it should be held securely by the foam.

Foam adhesive backed pads to hold the battery (left) and the battery installed (right).

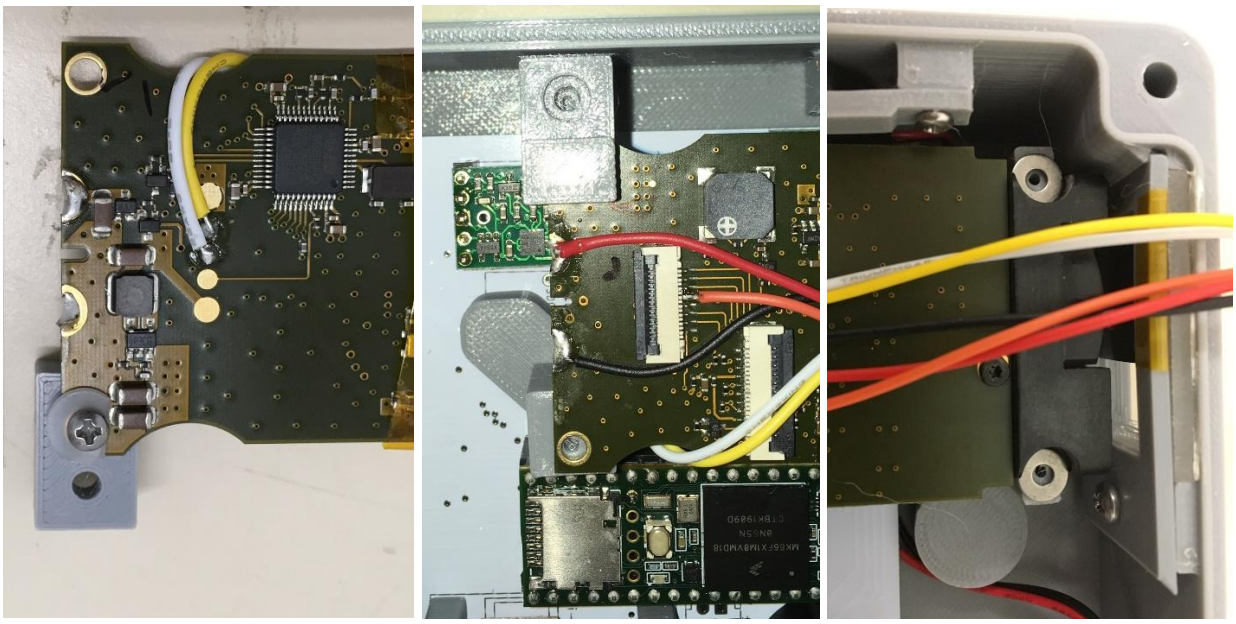
Circuit Board

The main circuit board is installed using four 4-20 x 1/4” thread rolling screws (one in each corner). Take care to route the Buzzer wire harness as shown so that it goes in front of the front left circuit board support and is slightly under the circuit board (this helps hold it in place). Place the board onto the supports and be sure it slides freely and the buzzer cable is not getting pinched between the board and the support. Attach it with the screws, being sure that it is square to the enclosure. One way to do this is insert each screw part way and then press back on the board from the front so that it is not skewed with respect to the walls.

Laser Rangefinder

The LRF is installed in an upside down orientation with its PCB on top. The first step is to attach the bracket to the LRF. Place the LRF in its upside down orientation as it will be installed. The bracket is oriented as

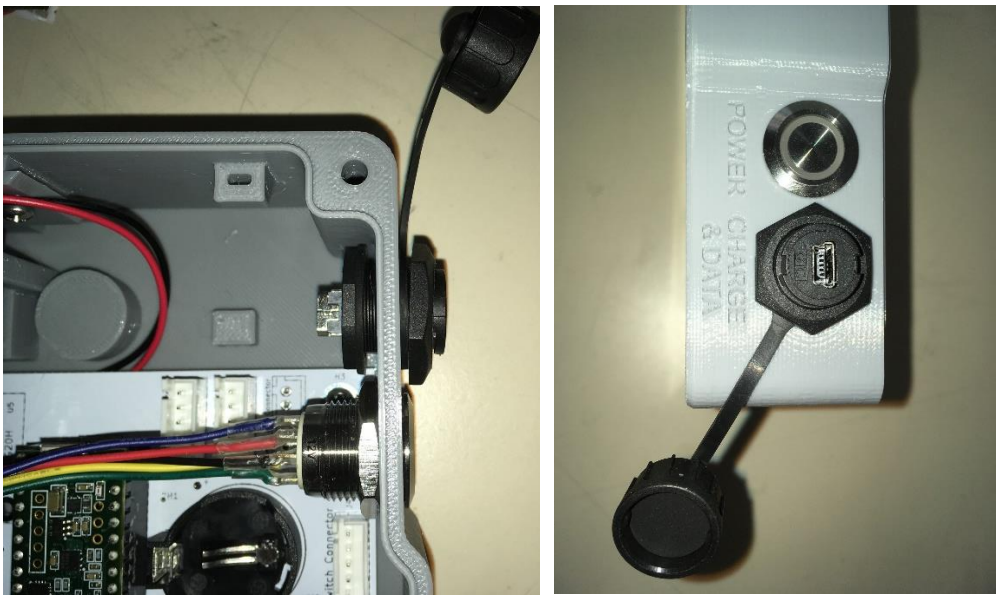
shown above the LRF PCB with the countersunk screw hole visible. The non-countersunk hole is the one onto which the LRF will attach, while the countersunk one is attached to the mount point on the side of the enclosure. Attach the bracket from below with a 2-28 x 1/4" thread rolling screw. If you have a small nylon washer, I recommend using it since there is a surface mount component very close to the hole and we don't want to risk something getting damaged or shorting out. I trimmed my washer slightly for a better fit. If you are careful you can probably get away without using one. Tighten the screw, being sure the bracket sticks straight off the side. Insert the LRF into the enclosure – the posts near the front should easily slide through the cutout slots on the front sides of the LRF module. Check that the countersunk hole in the bracket lines up with the hole in the enclosure wall mount point and that the other rear hole in the LRF PCB lines up with the LRF Support Post (already installed on the main circuit board.) You may need to twist one or both of the support bracket or post slightly to get them to line up. Attach the LRF using 2-28 x 1/4" screws. On the side that will be attached to the support post piece, you can use a #2 washer since the hole is not much smaller than the screw head. On the other side, the screw goes into the countersunk hole for attachment. At the front of the LRF, two 2-28 x 1/4" thread rolling screws are used to secure it to the posts. Two #2 washers are required to hold the LRF module. Use tweezers to set these washers in place on the top of the posts and position them so that the washer's edge is over the small lip around the slots on the LRF module. Insert the screws and tighten them down ensuring the washers stay in place.



Installing the LRF. Attach the LRF to the bracket from the underside with a screw (and preferably a nylon washer) (left), Slide the LRF into place in between the posts on the front (shown at right) and be sure the bracket and support holes line up with the holes in the rear of the board (center) and screw into place. Finally place #2 washers over the front support posts and screw into place (right).

Power Switch

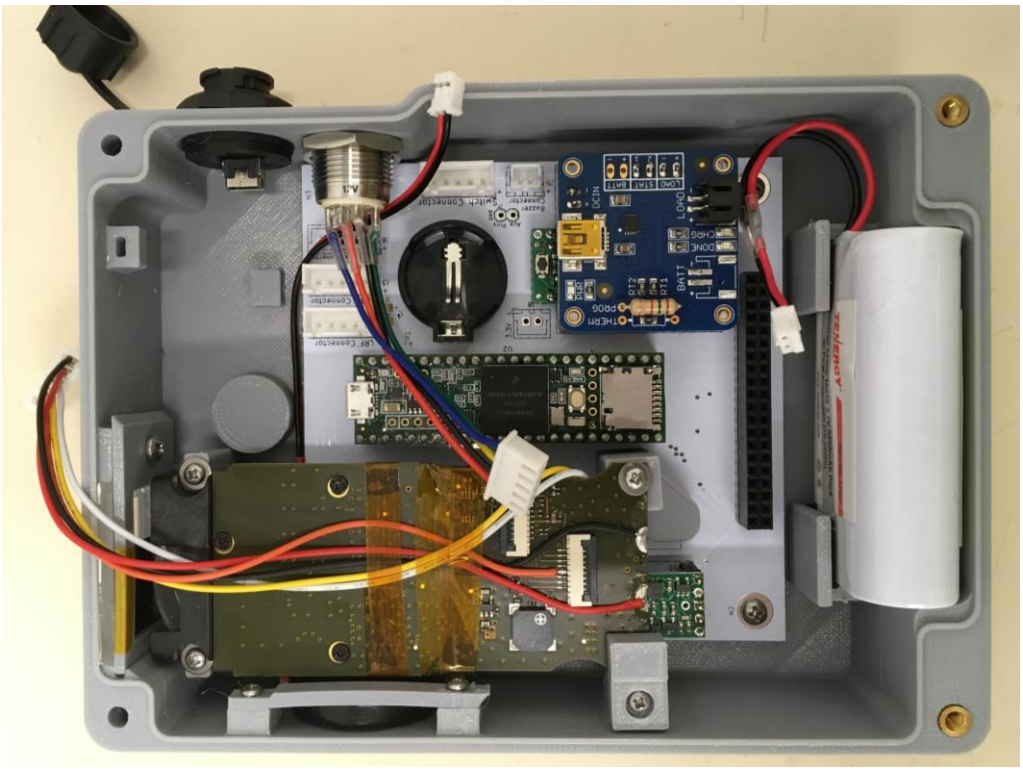
The power switch is inserted from the outside of the enclosure. Be sure the rubber gasket that comes with it is placed on the switch body before installing it. Once in place, slide the nut over the cable and thread it onto the rear of the switch and tighten it into place.



Power switch installed and USB connector partially installed (left) and fully installed (right).

USB Connector

The USB connector is inserted from the inside of the enclosure. It is keyed so it can only be inserted one way. Take the nut off first and be sure the gasket is in place on the connector. After sliding the connector into the enclosure hole, install the USB connector cover by sliding it over the threaded part of the connector from the outside. Be sure to position it, so the connecting piece is toward the bottom front as shown. Screw on the nut and tighten it down.



Main enclosure base with everything installed (but not yet plugged in).

Main Enclosure Lid Assembly

Touchscreen Display

The touchscreen LCD display goes in the lid of the Main Enclosure and connects to the main PCB by a 40-pin ribbon cable. Start preparing the display by removing the protective film and installing the screen protector. First cut the screen protector to size. For the 3.5” display, the screen protector in the Bill of Materials is the correct width and only needs to be cut to length:

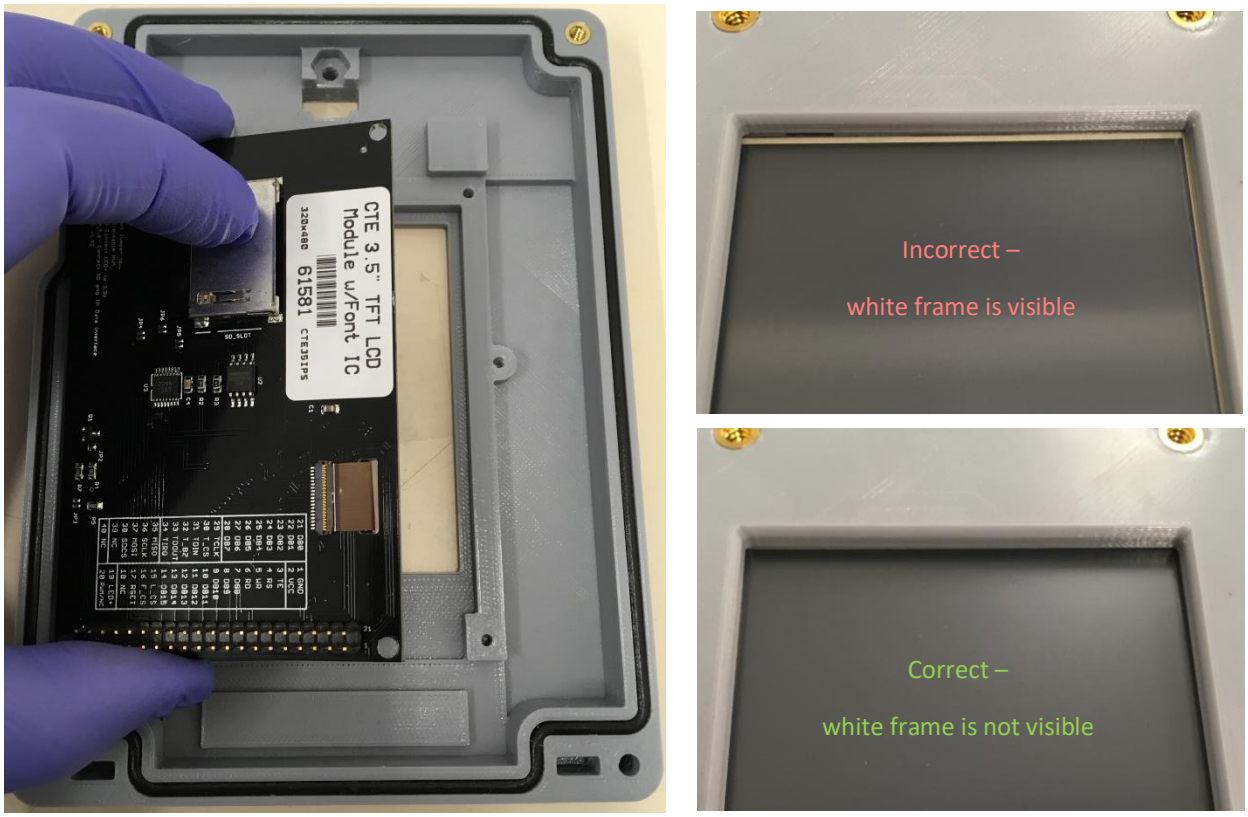
Screen Protector Length: 3 5/16”

Now remove the protective film on the display. This step is optional and leaving it on might give it a little more protection, but the display will look better if you remove it. Use your fingernail to pick at a corner of the display to get the film to come loose and gently peel it up toward the other corner. Be careful not to touch the display or get any dirt particles on the display until you get the screen protector installed. For the screen protector, peel the cover film off of screen side, being sure not to touch or get any dirt particles on the exposed part of the protector. Install the protector, lining it up with the top end of the LCD (the end opposite the pins). Be sure to line it up with the actual top end of the display module (covering the white frame part) which is slightly beyond the end of the actual screen – this gives it a bit more coverage for the silicone to seal to it. Slowly lower the protector across the length of the display, keeping it aligned to the edges and not getting bubbles in the middle of the screen. Once on, smooth out the edges and then peel off the top covering on the protector and smooth out again if you need to.

Preparing the Touchscreen Display. Removing the film (left), cutting the screen protector to length (center with cut piece on the bottom), and after placing the protector on the screen (right). Be sure that the top of the protector is aligned with the white frame at the top of the display and extends beyond the edge of the screen, not aligned with the screen itself.

Before installing the screen, check the fit. Place it in the cutout as shown and be sure the screw holes line up. For best fit, slide it as far toward the front as possible (the end with the slot for the LIDAR module cable). When viewed from the top, you should not see any of the white frame of the display module, as shown below. Pull out the display and prepare to place silicone sealant around the display perimeter. A syringe is recommended but you could use a toothpick or other method – just be sure to get a smooth bead all the way around the edge so that you get continuous coverage as shown. I prefer to apply a double

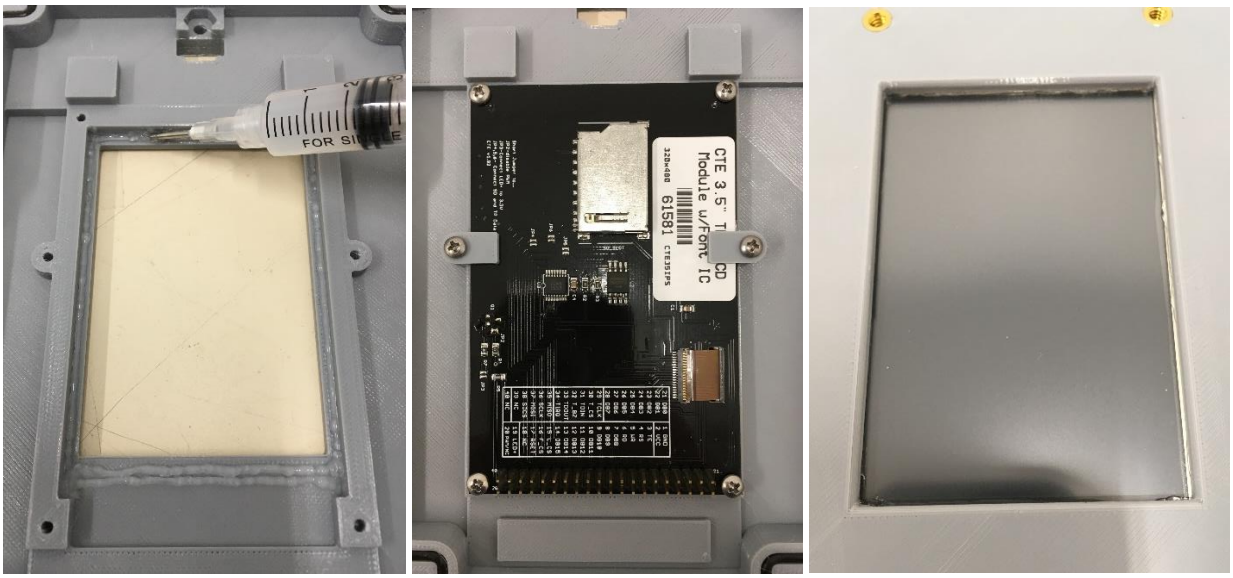
wide layer at the back end since there is more area to seal to. Don't put on too thick of a bead or it will ooze out from under the screen edges when you screw it down in the next step.



Positioning the touchscreen module – from the back when inserted into the cutout (left) and positioning with the white frame not visible from the front – incorrect (top right) or correct (bottom right).

Once the silicone bead is applied, line up the display at the front end so that you can tilt and press it down at the right spot in the cutout in a single movement (if you have to slide it, you might end up smearing silicone onto the visible part of the screen. Use four 4-20 x 1/4" thread rolling screws – one in each corner to secure it. Start, but don't tighten these down until you have all screws started. Tighten down only enough to be secure but not too tight to avoid damaging the display module. Now insert two more 4-20 x 1/4" screws into the touchscreen display clips, as shown, so that the lip on the clip will go over the display module PCB when inserted. Install and tighten the screws. Check the topside of the screen and clean up any excess silicone. Allow the silicone to cure overnight.

LCD clamp screw orientation



Add a silicone bead around the inside of the display cutout in the main enclosure lid (left). Screen installed from the backside (center) and from the front (right). Be sure not to put on too much silicone so it does not ooze out onto the screen and clean up any that does.

Neck Strap Rings

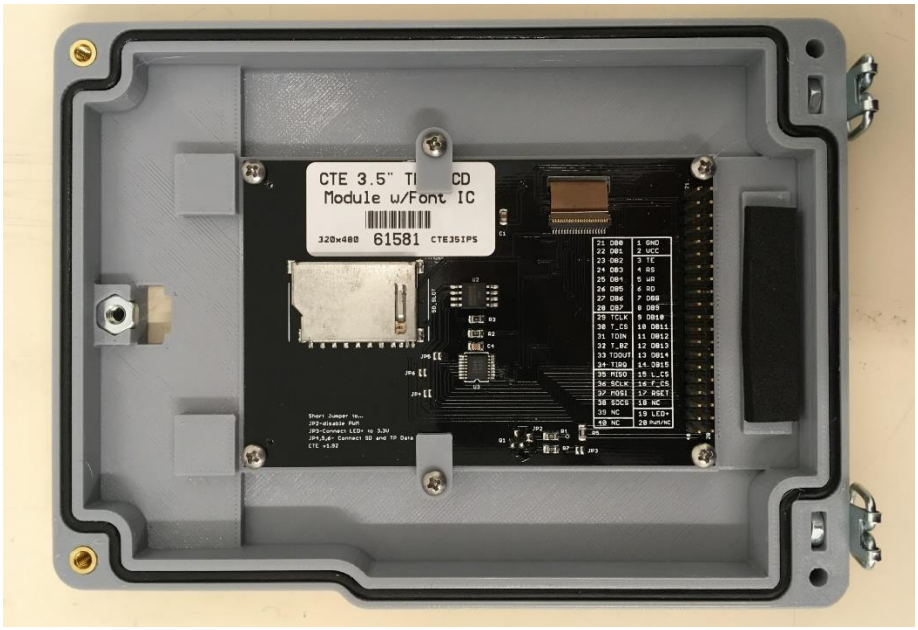
Two D-rings are installed at the rear of the lid onto which a neck strap can be installed. Two #6 nuts are inserted into the provided slots. Prepare the D-rings as shown in the photo with a 6-32 x 3/8” screw and a #6 lock washer placed between the D-ring and screw head as shown in the photo. Screw in the rings such that they will hang downward when the lid is placed on the rest of the enclosure and tighten.

Preparing to install the D-rings for the neck strap (left) and orientation after installed (right).

Other Components

A #6 nut is installed in the nut holder near the front of the enclosure lid for one of the LIDAR module screws.

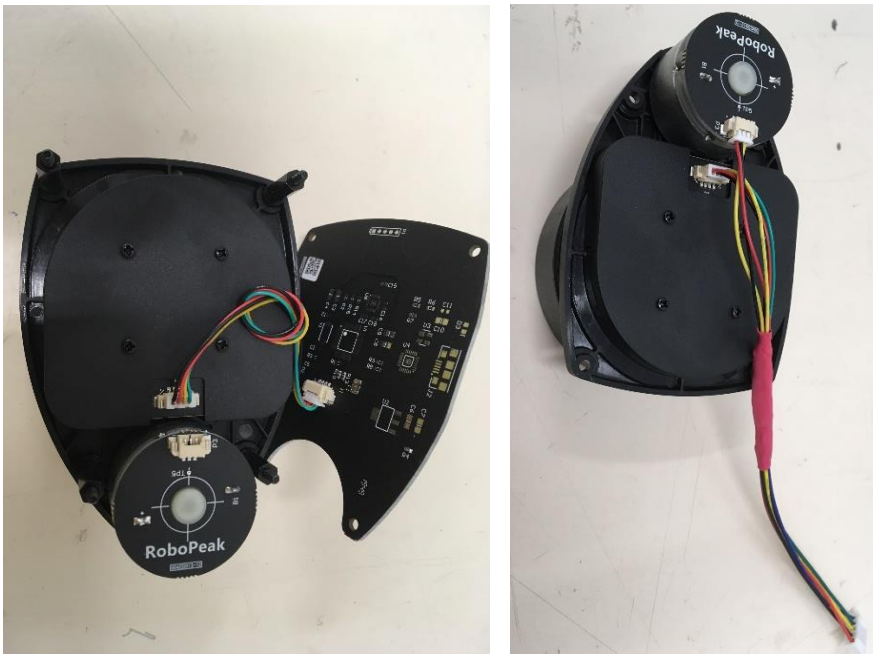
A piece of adhesive foam is placed on the flat raised area near the rear of the lid to help hold the battery in place. This piece of foam should be about 0.5” wide by about 1.75” long.



Main enclosure lid with everything installed and ready for final assembly.

LIDAR Module Assembly

Out of the box, the RPLIDAR has a second board attached underneath the main module body. Remove this by unscrewing the lower part of the threaded standoffs and gently removing the two connector cables. You will not need this board.



Partially removed lower PCB from the RPLIDAR showing the first of the two connectors disconnected (left). The LIDAR after installing the custom wire harness (center).

Unscrew the upper part of the threaded standoff from the main module by removing the screws on the top. Screw these four standoffs into the threaded inserts in the base of the Caveatron LIDAR module. Take the LIDAR cable assembly and plug it into the two connectors on the underside of the RPLIDAR. Set the LIDAR and mounting screws aside until the final assembly step.

Final Assembly

Main Enclosure Base

First install the CR2032 battery into the coin cell battery holder. Then, plug in the piezo buzzer wire harness. If this wire ends up being extra long or moves around, you can anchor it with a cable tie in the provided cable tie anchor point on the base of the enclosure just in front of main PCB. Now, plug in the Power Switch wire harness. Next, install the USB cable. Route the cable so that the cable tie anchor on the front wall of the enclosure can be used to provide strain relief to the USB Micro plug end that plugs into the Teensy. Since the USB Micro connector is less tolerant, it is important that the USB Micro connector come straight out from the front of the Teensy and not be able to move. If you are using an adapter cable to a USB Mini plug, loop this around and plug it into the USB Mini jack on the external connector (see the photo below). Secure it with the cable tie. Then, plug in the LRF wire harness.

Get the microSD card ready. Insert it into a computer and verify that it is formatted as FAT32. If not, reformat it. It is highly recommended to use the SD Association's official SD Formatter utility which can be downloaded here: https://www.sdcard.org/downloads/formatter/. Once formatted, copy the "cvfont32.bin" file to the microSD card so you don't have to remove the card later for the initial Caveatron software setup. Install the card in the Teensy's microSD slot.

Next, plug the 40-pin ribbon cable into the connector on the main PCB. Be careful that its centered, since it's possible to accidently offset it to the side while plugging it in and have the pins offset by one position in the connector. The ribbon portion should extend toward the front over the main PCB away from the battery. Fold the cable roughly in half so it folds back on itself with the connector on the other end pointing upward so that it can rest on top of the connector to the main PCB (see photo below).

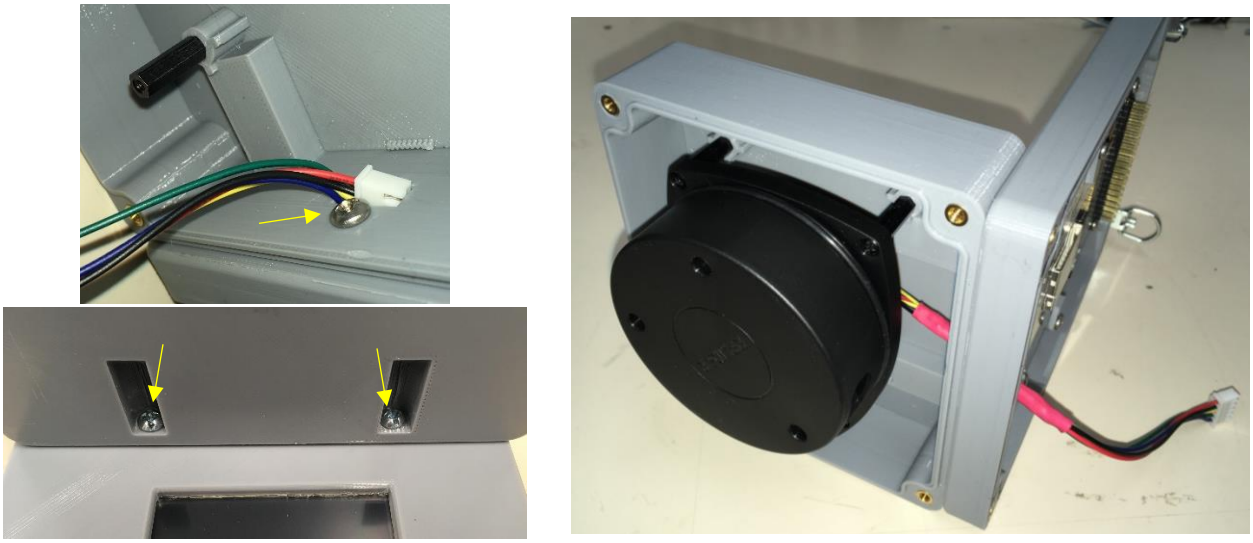
Main Enclosure base with all components and wiring harnesses installed.

Plug in the battery connector by looping the wire so it stays in the pocket to the right of the battery. Add a cable tie to keep it looped if necessary.

LIDAR Module and Main Enclosure Lid

Insert the small O-ring into the slot in the front of the top of the Main Enclosure lid. Line up the LIDAR module over the O-ring. Get a 6-32 x 9/16" long pan head screw (5/8" will work as well) and insert it into the hole in the interior of the LIDAR module. Screw it slightly into the nut in the Main Enclosure lid, but don't tighten it yet. Line up the LIDAR Enclosure base so that the holes on its back side align with the threaded inserts on the top of the Main Enclosure Lid. Attach with 6-32 x 3/8" pan head screws. Be sure the LIDAR Module is square to the Main Enclosure lid and tighten down all three screws.

Before installing the RPLIDAR, route its cable through the slot in the base of the LIDAR enclosure. Turn it sideways so the connector protrusions go through the wider part of the slot. Pull it all the way through the Main Enclosure lid. Now, install the RPLIDAR into the LIDAR Enclosure base using the screws that came with the RPLIDAR. Since the standoff posts may not be perfectly straight, its best to loosely install all the screws first before tightening them all down. Be sure the wire harness is not pinched and freely goes to the slot in the base.



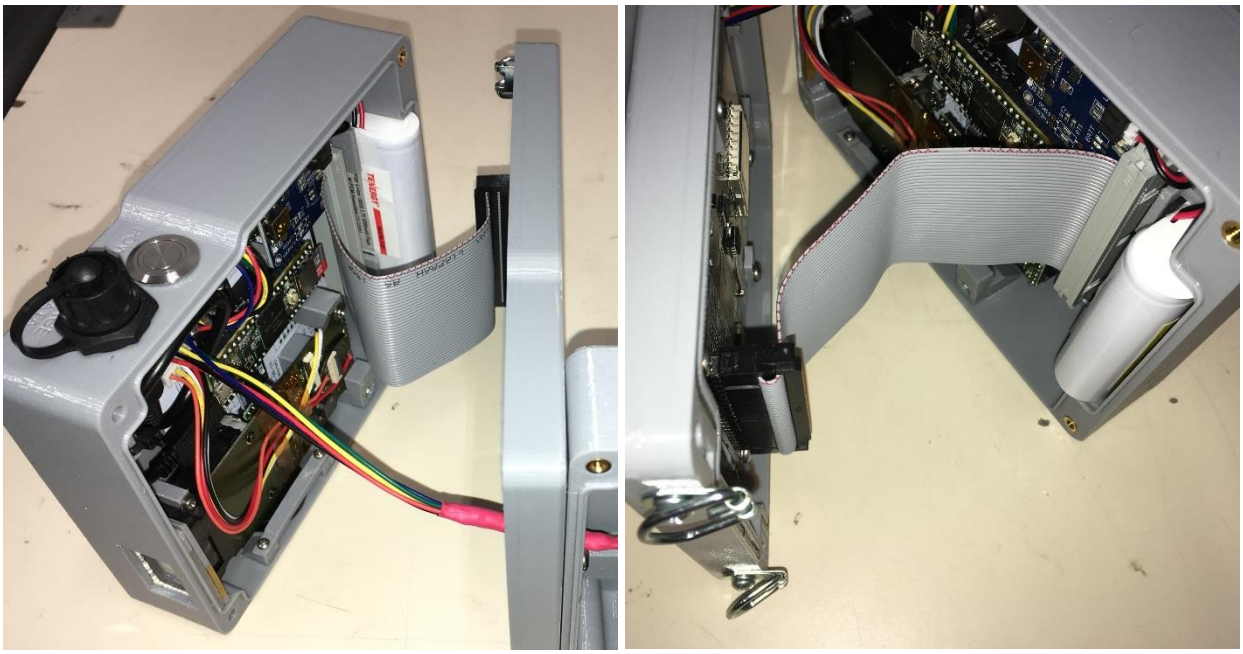
Connecting the LIDAR Enclosure Base to the Main Enclosure Lid. Location of interior 6-32 screw in the LIDAR Enclosure base and inserting the LIDAR wire harness connector through the slot to the Main Enclosure (upper left). Location of the two rear 6-32 screws on the exterior of the LIDAR Enclosure base (lower left), and after connecting the enclosure parts and mounting the RPLIDAR (right).

Before installing the LIDAR Enclosure lid, recheck the inside of the windows to be sure there are no smudges or dust. If so, blow them clean or wipe off the smudges. Add a bit more O-ring lubricant grease all around the O-ring on the lid to ensure a good seal (being sure not to get any on the windows) and place the lid on the enclosure base, verifying that the orientation is correct. Using four 6-32 x 1/2" long flat head screws, tighten down the lid. The LIDAR module is now complete.

Final Steps

Before attaching the lid, plug a USB Mini cable into the external connector and plug it into a USB power source. The ring LED around the power switch should illuminate red. Now press the power switch and you should see several LED lights come on inside the box.

Turn the enclosure sideways and plug the LIDAR wiring harness into its connector next the LRF connector on the front of the main PCB. Next, plug the 40 pin ribbon cable into the pins on the touchscreen LCD. Be sure that the pins are aligned since its easy to accidently offset it to one side.



Photos showing the Caveatron with the LIDAR and touchscreen cables installed before closing the lid.

Add a bit more O-ring grease to the O-ring in the Main Enclosure lid and place the lid on the Enclosure base. Use four 6-32 x 1/2” long flat head screws to attach it. The two on the rear are inserted from above the lid, but the two in the front are inserted from the underside of the base. Tighten these down.

Screw locations on the underside of the Caveatron for attaching the Main Enclosure base to the lid.

Finally, install the neck strap onto the D-rings. Adjust it so the straps are evenly distributed between the two D-rings and it is not twisted. Adjust the length for comfort.

Neck strap attachment.

The Caveatron assembly process is now complete!

Reflective Card

Cut out the plastic card material to make a 6.25” x 7.5” rectangle. Round the corners by cutting and sanding. Cut out adhesive-backed retroreflective sheets or strips to make a 6” x 6” square. Place the retroreflective material on one side of the card so that it has a 1/8” border on three sides. On the side with the 1 3/8” border, install a 3/8” grommet near one corner as shown in the photo. To do this, cut or drill out an appropriate sized hole in the plastic, insert the grommet pieces and use a grommet tool and hammer to tap on the grommet until the pieces are attached to each other and the plastic.

The reflective card.

Software Installation and Setup

There are several steps remaining to prepare the Caveatron for use. These are described in other documents but the steps are summarized below:

- Prepare to load code into the Caveatron. Read the “Loading Caveatron Rev B Firmware” instructions and download the TyTools software.
- Load the Caveatron_Setup firmware appropriate for the display on your Caveatron and run the setup process described in the “Caveatron Setup & Calibration Instructions” document.
- Load the Caveatron_v2xx firmware.
- Calibrate the Caveatron as described in the “Caveatron Setup & Calibration Instructions” document.

Your Caveatron is now ready to scan caves!

Fully assembled Caveatron.