Caveatron Assembly Notes – Revision A

Version: 2019-03-19

Overview

This document is provides general information and tips on Caveatron assembly and is not intended to provide detailed step-by-step instructions. The Revision A hardware is a design to get a system working with minimal custom parts. For the next revision of the design (B), it is planned to develop a 3D printed enclosure and custom printed circuit board that will greatly reduce the machining and wiring required. As such, I do not want to spend a great deal of additional effort on the previous design. However, in the meantime, I wanted to provide at least minimal documentation to assist others in building their own system prior to the availability of a custom enclosure or for those who may not have 3D printer access.

Some Tools Required:

- Dremel Tool
- Drill
- Jig saw
- Soldering Iron
- Thread tap
- Screw drivers
- Pliers
- Tweezers

If you have access, these tools will simplify machining:

- Band saw
- Drill press
- Milling machine

Materials Required (beyond the Bill of Materials):

- Pan head machine screws of various sizes and lengths
  - 2-56 (or similar metric)
  - 4-40 (or similar metric)
  - 6-32 (or similar metric)
  - M3-05
- Matching nuts and lock washers for the 2-56, 4-40, and 6-32 (or equivalent) screws (Lock-washers are important to prevent nuts working loose. DO NOT USE LOCTITE - it will dissolve the ABS enclosure material! I found this out the hard way.)
- Nylon spacers
- Silicone adhesive
- Double sided adhesive foam tape
- Electrical wire
- 2-pin JST connectors or pre-wired JST connectors (you can find the latter on Ebay for relatively low cost)

Base Unit Component Electrical Notes

General wiring notes

You can purchase pre-wired JST connectors, which makes assembly much easier, but be very careful to check the polarity of the colors. Sometimes they are wired backwards with red ground and black positive and sometimes they are correct.

Arduino Due

The Due is the brains of the Caveatron. The DC input jack must be removed and the 9V input from the Power Board wired directly to the DC jack pads The Programming USB port must also be removed and the USB+ USB- and GND wired directly soldered to the appropriate pads. Do not wire anything to the +5V terminal on the USB jack. The 5V line from the external USB jack must be connected to the battery charger board instead. Items that plug into the Arduino connect via right angle headers that are inserted between the LCD adapter shield and the Arduino.

Remove red-circled component for direct soldering of wires

Laser Rangefinder (LRF) Module

This component is used to measure the station-to-station range and provide continual distance measurements during LIDAR scans. Two part options are available for this module. Regardless of which one you choose, soldering the wires to this board can be a little tricky since they must be soldered to pads rather than to through-holes. See the wiring diagram notes for detailed soldering locations. The power wires are soldered to the LRF and terminate in a JRT plug. The signal wires are soldered to the LRF and terminate in right angle header pins that plug into the Arduino.

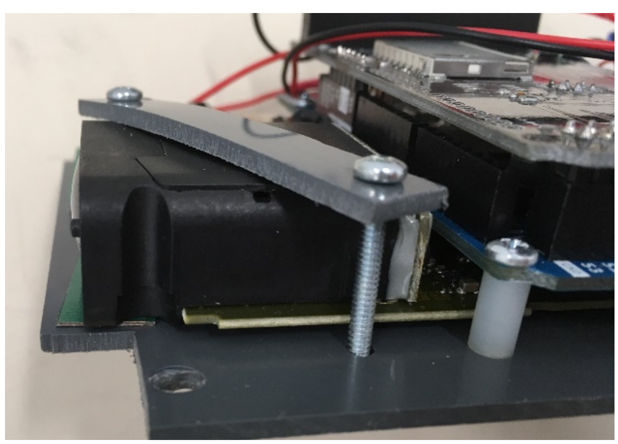


Photo of the clamp on the front of the UT390B and how the Arduino Due board is positioned above it.

Accessory Board

This board is user-fabricated and contains the Real Time Clock/EEPROM module and the Battery Fuel Gauge module. You can use any standard 0.1” protoboard to produce this and cut it to size. Add a JST socket to connect the I2C onward to the Compass Module. I2C input wires are soldered onto the Board and terminated in a right angle header to plug into the Arduino. The input power wires are soldered to this board and terminated with a JST plug that plugs into a 3.3V distribution socket on the Power Board. To make connections on the Board, solder wires between points or make solder traces between points on the protoboard.

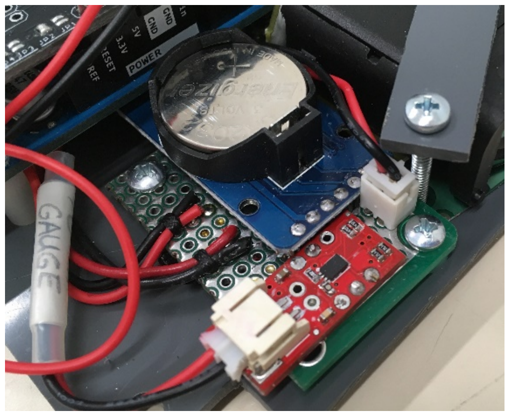


Photo of assembled Accessory Board (protoboard is green, Clock Module is blue, and Fuel Gauge is red)

Real Time Clock/EEPROM module

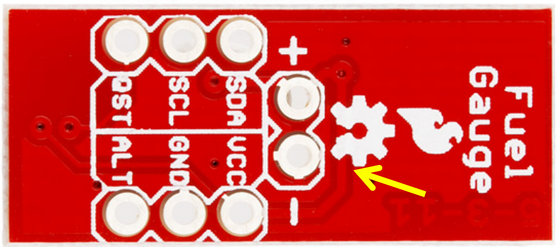
Located on the Accessory Board, the Clock module not only provides the time, but more importantly, contains the non-volatile EEPROM memory in which the system hardware parameters and calibration values are stored. You will need a CR2032 battery to keep the time when powered off (disconnecting the battery will NOT result in loss of EEPROM data). Do not use the batteries that come with some of these modules on Ebay. They have often caused me problems with this module – buy the battery separately from a name-brand source. The battery is removed by pressing on the vertical metal terminal and using a small flat tipped screwdriver pry it up. Insert the new battery with the label visible face up and pressing down until it snaps into place. After changing the battery, the clock time will have to be set via the Caveatron user interface.

The module is soldered directly onto the Accessory Board

Battery Fuel Gauge Module

This module is used to compute the remaining level of charge in the battery pack. These modules should be bought from Sparkfun, not off of Ebay. Most of the one’s I bought on Ebay don’t work and appear to have counterfeit ICs. In the design, it is setup to use 3.3V from the Arduino (to isolate it from the battery for safety). You need to cut a 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 much testing, I have concluded that the state of charge indication provided by these modules varies greatly and can be highly

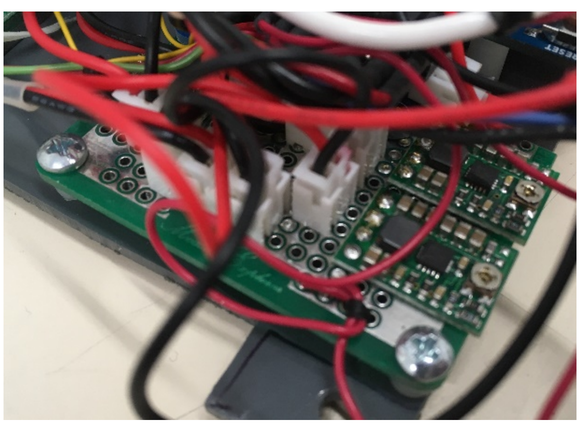
inaccurate. As such, I am now only using this as a voltage sensor and use my own algorithm to compute the state of charge. More Information about this Module can be found here:
https://www.sparkfun.com/products/10617
This module is soldered directly onto the Accessory Board, but a JST connector wired to the Battery plugs into this module's JST socket.

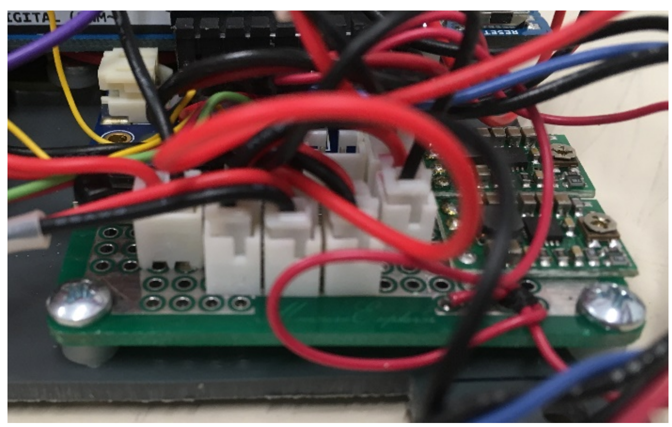


Cut trace where marked by yellow arrow

Power Supply Board

This board is user-fabricated contains the Battery Charger module, the 9V regulator, the 5V regulator, and the 3V (adjustable) regulator. There are 8 JST sockets on this this Board. This board also serves as distribution for 3.3V power which originates from the LCD interface shield that is plugged in on top of the Arduino board. There are two 3.3V outputs – one to the Compass board and one to the Accessory board. As with the Accessory Board, you can use any standard 0.1" protoboard to produce this and cut it to size. Depending on the protoboard you use, you will probably need to drill holes in one or two corners to provide a way to mount it to the baseplate. Exact position and orientation of this part is not critical. Besides the JST plugs, two wires are soldered to this Board with that control the shutdown lines on the 5V and adjustable (3V set) regulators. These are terminated to right angle header pins that plug into the Arduino.



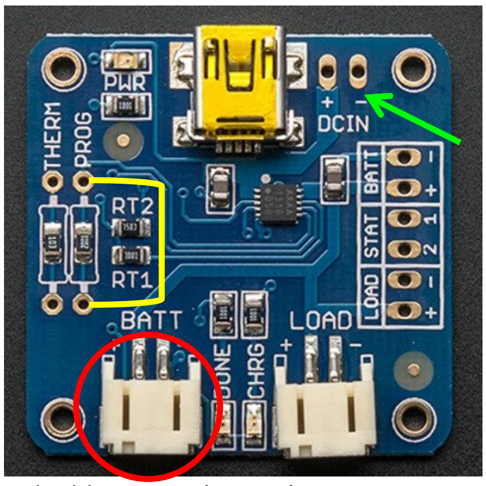


Two views of the Power Supply Board. It is difficult to see because of all the wires but the 5V and 3.0V voltage regulators are on the right (both were adjustables were in this build) and the Charger module - blue board faintly visible with the battery connector JST (battery unplugged) at rear in the right photo. In the foreground are the various JST connectors from this board.

Battery Charger Module

This module controls the charging of the battery pack and provides indication when charging is complete. Two options are available.

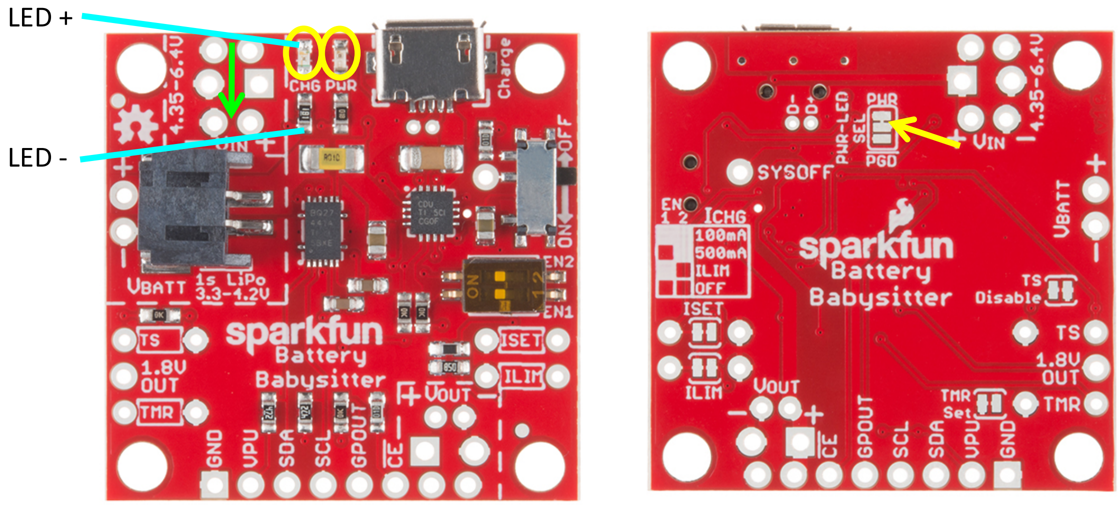
If using the Adafruit Lion/Lipo Charger, additional modification may be needed. The spacing between the Arduino Due board and this module is very tight. You may need to remove the JST connector labeled BATT if there is interference. When wiring this board, ignore the USB connector on it and attach a JST socket to the DCIN terminals that will connect to the external USB jack. The Lithium Ion battery pack can be should be plugged into the “LOAD” JST connector rather than “BATT” due to aforementioned spacing constrains (both terminals go to the same points, electrically.) I don’t recommend soldering it directly so you can easily disconnect it if something goes wrong. The default charge current for this board is 500 mA which makes for slow charging (8-10 hrs for a full charge). It can be modified to charge at 1A by adding a 2kΩ resistor across the terminals labeled “PROG” (parallel to the existing resistor for a combined resistance of 1kΩ). A tutorial with information about this board may be found here: https://learn.adafruit.com/li-ion-and-lipoly-batteries/proper-charging (Note that some of the information in the tutorial, specifically regarding terminal names, is incorrect or out of date for the current board revision)



Remove red-circled JST socket and add a JST socket to the DCIN pins marked by the green arrow. Add a 2k resistor across the terminals marked by the yellow bracket to have a 1 Amp charge current.

If you are using the Sparkfun Battery Babysitter, I have not tried mounting this board inside the Rev A enclosure, so this is currently an exercise left for the reader. However, in testing, I have found a few things that need to be considered when using this module. When wiring it, ignore the USB connector on it and wire directly from the USB jack that mounts on the Caveatron enclosure to the Vin terminals. The Lithium Ion battery pack can be should be plugged into the “VBatt” JST connector rather than soldering it directly to Vout so you can easily disconnect it if something goes wrong. In order for external power to charge the battery, the small Output Enable switch must always be in the ON position. If it’s set to OFF, the LEDs might illuminate when external power is connected, but the battery will not actually be charging. The downside to this is that the IC will always be drawing a small amount of power from the battery, even when the Caveatron is off. Worse, the PWR LED on this board will always be illuminated drawing considerably more power. You should minimize the “OFF” state power draw by disabling the PWR LED by cutting the PWR-LED trace on the back of the board between the PWR pad and the SEL pad. This will permanently disable that LED. The IC will still draw up to 200 uA in this case, but a fully charged battery will take a couple of years to discharge, which is not too bad. When you get the board, check that it is set to its maximum charge current of 1.5A by verifying the DIP switches are set to EN1 ON and EN2 OFF. A detailed tutorial about this board may be found here:

https://learn.sparkfun.com/tutorials/battery-babysitter-hookup-guide?_ga=2.160531773.1449206758.1519741257-995455524.1518817951



Remove the PWR and CHG LEDs (yellow-circled) and cut the trace marked by the yellow arrow. Connect wires from the green marked pads to the LED output JST socket on the Power Board. Add a JST socket to VIN where marked with the green arrow.

9V Regulator Module

This module powers the Arduino Due. No additional comments.

5V Regulator Module

This module powers the LIDAR module and is turned on and off via its Shutdown pin, controlled by the Arduino. No additional comments.

Adjustable Regulator Module

This module powers the LRF. The pot must be adjusted before hooking it up to the LRF and set to 3.0V (the LRF expects to be powered by 2 AAA alkaline batteries.) It is turned on and off via its Shutdown pin, controlled by the Arduino.

Compass Module

This module is used to measure the magnetic-based azimuth angle and the accelerometer-based inclination/roll angles to determine the Caveatron's orientation in space for station-to-station measurements and for LIDAR scans. You can either solder this to a piece of protoboard or solder wires directly to the Compass Module. If you do the former, solder wires to the protoboard. Mount it with two screws and use a plastic spacer or nylon washers to support it level. If you don't use protoboard, attach it with the single screw hole. The power wires that solder to this board are terminated with a JST plug that plugs into the 3.3V socket on the Power Board.

Battery

The distance to the charger board is a bit of a reach for the provided wire. If it needs to be longer, wire an extension with a JST plug on the end.

Piezoelectric Buzzer

You will need to wire this to right angle header pins that will plug into the Arduino board.

LCD Adapter Shield

The 3.3V supply originates from this board and gets routed through the distribution connectors on the power board. Solder power and ground to pin 1 (+3.3V) and pin 2 (GND) of the 32 pin header terminal in front of the 40 pin connector and terminate it on the other end with a JST plug. Plug the shield into the Arduino board.

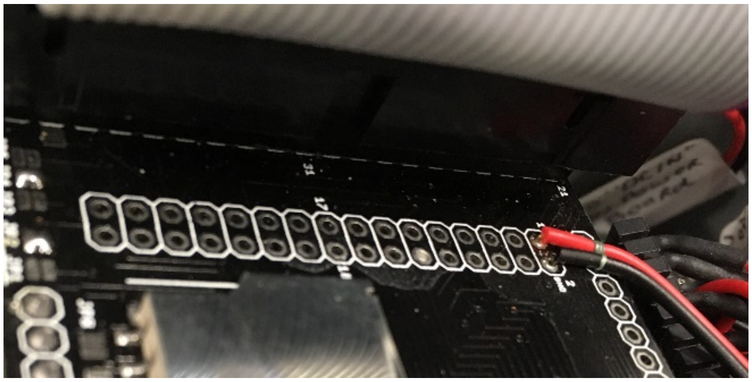


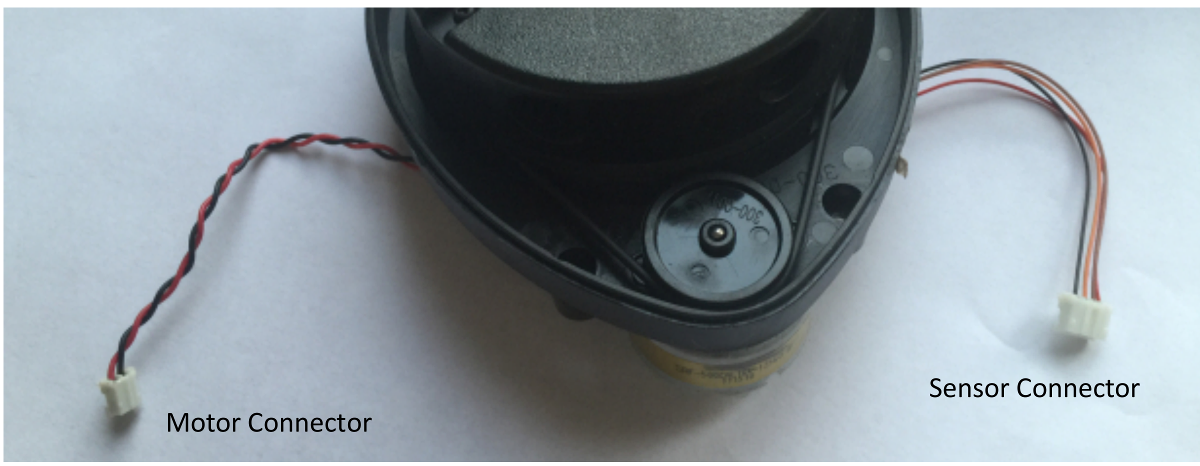
Photo showing the source of the 3.3V supply on top of the LCD Adapter Shield (red and black wires).

LIDAR Unit Component Electrical Notes

There are two separate LIDAR Modules that can be used with the Caveatron interchangeably: one with a 4 m-range based on the Neato XV LIDAR and one with a 25 m-range based on the Scance Sweep LIDAR. Some components are unique to one module or the other while others are used in either.

XV LIDAR (Only used in 4m LIDAR Module)

This LIDAR has separate wiring for the electronics and the motor, which require different voltages. The Caveatron main body provides +5V to the LIDAR over the interface cable, which is suitable to power the electronics. A separate voltage regulator is used to power the motor at a lower voltage. The motor must not rotate faster than 300 RPM (5 rot/sec) to avoid data loss, so the motor speed (via the voltage) must be carefully set to be below this rate – ideally around 4.75 rot/sec. On the electronics connector, only the power, ground and TX are used (this LIDAR transmits only). It might be worthwhile replacing the small 4-pin electronics connector on this LIDAR with a larger 4-pin JST connector that is easier to work with. The motor connector is a standard JST, so can be used as is.



Unmodified XV LIDAR Connectors

Motor Connector	
Red	PWR
Black	GND

Sensor Connector	
Red	+5V
Brown	RX (UART)
Orange	TX (UART)
Black	GND

Wire colors for XV LIDAR.

SWEEP LIDAR (Only used in 25m LIDAR Module)

Link to Scanse Sweep manual showing the wire colors and connections:
https://s3.amazonaws.com/scanse/Sweep_user_manual.pdf

RP LIDAR A1M8 (Only used in 12m LIDAR Module)

Link to RP LIDAR manual showing the connection details on page 8-9:
https://download.slamtec.com/api/download/rplidar-a1m8-datasheet/2.1?lang=en

Adjustable Regulator Module (Used in 4m and 12m LIDAR Modules)

This module powers the LIDAR motor. For the XV LIDAR, the pot must be adjusted to obtain a rotation speed of about 4.75 rot/sec. A voltage of about 2.8 V should be safe. The 12 m RP LIDAR is more flexible with the motor input voltage. A rotation speed of 5 rot/sec is recommended which is obtained by setting the regulator to 3.68 V. You fine-tune this if you have a photodetector to sense the laser pulses as it rotates and an oscilloscope available. The shutdown pin on the regulator board is not used. The appropriate JST socket should be soldered to the output side of this regulator module so that the LIDAR motor can plug in directly.

SWEEP LIDAR (Only used in 25m LIDAR Module)

This LIDAR has a single voltage input of 5V so no additional regulator is needed. A connector is provided with this LIDAR which can be wired to directly. Both RX and TX lines are used to communicate with this LIDAR but the Sync and Enable lines are not used.

LIDAR Module Connector

A short length of 4-conductor cable will be need to come out the back of the LIDAR module and go to the 6-pin LIDAR module connector plug. The four wires are +5V, GND, Serial TX, and Serial RX. These are soldered to the correct pins within the connector plug and enter the rear of the LIDAR module through a cable gland. Within the LIDAR module these are soldered directly the wire leads on the provided SWEEP connector (25m version) or to a 4 pin JST and the Adjustable Regulator Module (4m version). The two additional pins of the connector plug are used for sensing which LIDAR module is attached and the appropriate ones for the 4m, 12m, or 25m version are connected inside the plug to the GND pin.

LIDAR Module Connector plugged in

Base Unit Component Mechanical Notes

Note that numerous photos of the interior and exterior of the enclosure can be found at the end of this document.

There are two parts to the enclosure – the Base Unit with includes most of the components and the LIDAR Unit which is detachable. The Base Unit has the following openings in the enclosure that must be machined:

- **LRF Window** – Use a piece of clear acrylic glued onto the inside of the enclosure using silicone epoxy or other low stress sealing epoxy so the window is not deformed when the glue dries.
- **USB Jack** – Sealed with the jacks' included rubber o-ring.
- **Power Button Switch** – Sealed with the switch's included rubber o-ring.
- **LIDAR Jack** – Sealed with the jacks' included rubber o-ring.
- **LCD Display** – Sealed around the edges with a rubber or foam gasket that you must cut out or use a silicone sealant.
- **LCD screw mounting holes** – You can seal these with a dap of silicone sealant
- **LIDAR rail screw mounting holes** – You can seal these with a dap of silicone sealant
- **Neckstrack D-ring mounting holes** – These do not penetrate the enclosure seal

Most of the electronics in the Base unit are mounted on a plastic sheet that is cut to be secured in the base unit by the existing mounting bosses in the enclosure box.

The LIDAR is mechanically connected to the main body by two small clamps that tighten onto the LIDAR mounting rail that is attached to the top of the lid. The LIDAR electrical connections are through a cable to that connects to the LIDAR Jack, also on top of the main body lid.

Arduino Due

The Arduino gets mounted above the other components and sideways across the enclosure, so you will need to cut some Nylon spacers to at least 0.35" (8.8 mm) to be sure it sits high enough to clear all components beneath (but not so high that it runs into the LCD display when the lid is closed.) Exact position and orientation of this part is not terribly critical but if not positioned within a small area, it will mechanically interfere with other parts such as the LRF, the battery holder on the Clock/EEPROM module or the battery connector on the Battery Charger module.

Laser Rangefinder (LRF) Module

The orientation of this part is critical. It needs to be as parallel to the sides of the enclosure as possible and as level to the base as possible. Be sure to leave enough room between its front surface and the front of the enclosure for the LRF window and neutral density filter film. Two part options are available for this module. If you are using the UT390B LRF module, you will need to cut nylon spacers for the back screw mounts to support it above the components on the bottom, so it sits level. You will also need to fashion a clamp to secure the front. I cut a long thin piece of plastic, drilled a couple of holes near its ends and used a couple of long screws to attach it to the baseplate.This needs to be as parallel to the enclosure as possible. Be sure to leave enough room between its front surface and the front of the enclosure for the LRF window and neutral density filter film. If you are using the UT390B LRF, you will need to cut nylon spacers for the back screw mounts to support it above the components on the bottom. You will also need to fashion a clamp to secure the front. I cut a long thin piece of plastic, drilled a couple of holes near its ends and used a couple of long screws to attach it to the baseplate. If you are using the JRT LRF module, it is much easier to mount as mounting-holes are integrated into the module.

The optical filter material is needed to weaken the return signal to the LRF so that it doesn't see reflections from regular surfaces but only from the retroreflective card. You will need to use two pieces of filter film to get enough attenuation. I usually cut one long piece and fold it in half. Tape this on the inside of the front window on the right side, positioning it so as not to block the red laser output. Cover the entirety of the right side top to bottom. There should only be a small part of the window remaining uncovered on the left when done. I used Kapton tape as it sticks well to the plastic and will not be affected by heat/cold. Be sure that the tape does not block too much of the window and that the film is as flat as possible.

LIDAR rail
This attaches to the top with #6 flathead machine screws onto the top and lock-washers and nuts on the inside of the drilled holes.

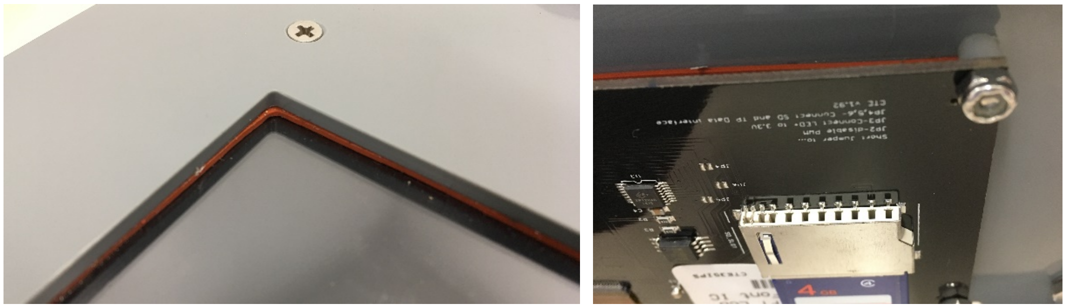
USB jack
This inserts from the inside with the nut on the outside. The cap holder goes on before installing.

Power Button Switch
This inserts from the outside with the nut on the inside. The o-ring goes on the outside. Be sure to slide this nut on before connecting the wires to the Power board. Orient the terminals upward so that they fit above the Accessory Board.

LIDAR jack
This inserts from below with the nut on the outside. Be sure to put the cap holder on before installing.

LCD display
Find some rubber or single sided adhesive foam material and cut out a gasket to go around the screen cutout so that it is flush with the edges of the screen cutout. When the screen is attached it will compress the gasket all the way around. This provides the water/dust seal for the screen. Alternatively, you could use silicone sealant but it will make removal difficult and you must be extra careful not to smear any on the display.

Before attaching the screen, cut a piece of the screen protector material to be the length of the screen (it is already the correct width). Sometimes these screens have a film on top of the display, which needs to be removed first. Carefully lay the screen protector down per the instructions, avoiding creating bubbles underneath. Cut four nylon spacers to match the thickness of the screen (about 0.153" or 3.9 mm). The mounting screws will go through the spacers so that when mounting it, the spacers will prevent the corners of the board from bending when the screws are tightened down. Proceed to mount the display with the 40-pin connector toward the back of the enclosure. Be careful not to damage the fragile ribbon cable at the back of the screen when handling it or to scratch the screen with tools. Use the 40-pin ribbon cable to attach the display board to the LCD Adapter Shield. Be sure to get the polarity right. When placed correctly, the cable will go forward from the display board, then fold at a right angle and plug into the shield adapter without any additional bends.



Photos of the gasket material around the edge of the LCD display from the top and inside of the lid. Also visible are the nylon spacers in the corner of the display on the inside of the lid.

Accessory and Power Boards

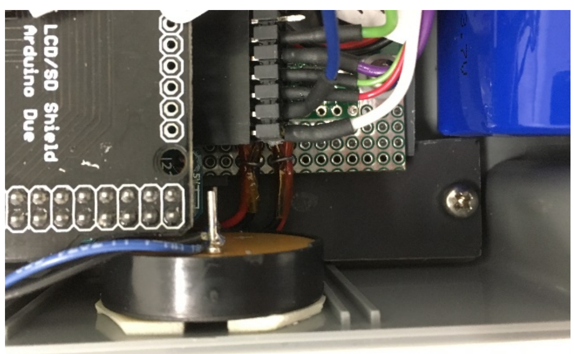
Since these are assembled onto protoboard, you will probably need to drill holes in one or two corners to provide a way to mount to the baseplate. Exact position and orientation of these parts are not critical but be careful not to create a mechanical interference with adjacent parts.

Battery

This goes in the back. Attach the battery with double-sided foam adhesive tape on the bottom and rear enclosure walls.

Piezoelectric Buzzer

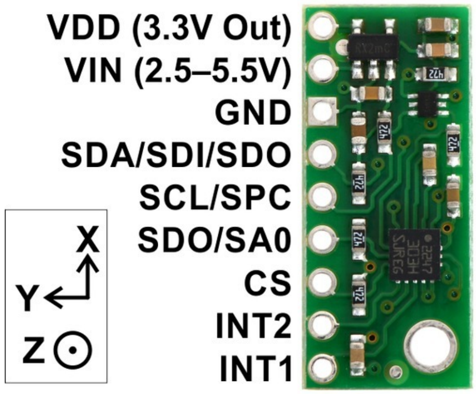
This can be mounted in any convenient location along the enclosure wall, facing outward. Just behind the Arduino board along the left wall seems to work well. Use two strips of double-sided foam adhesive tape placed on either side of the buzzer opening to stick it on.

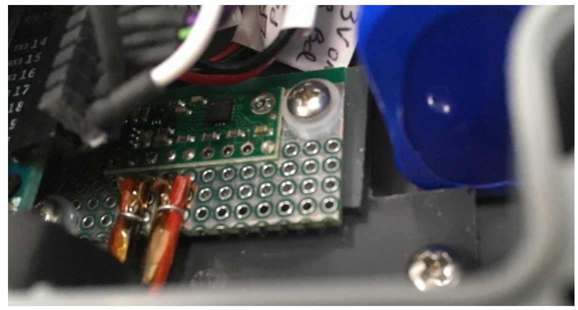


Suggested mounting location of the piezo buzzer next to the Due and LCD adapter shield.

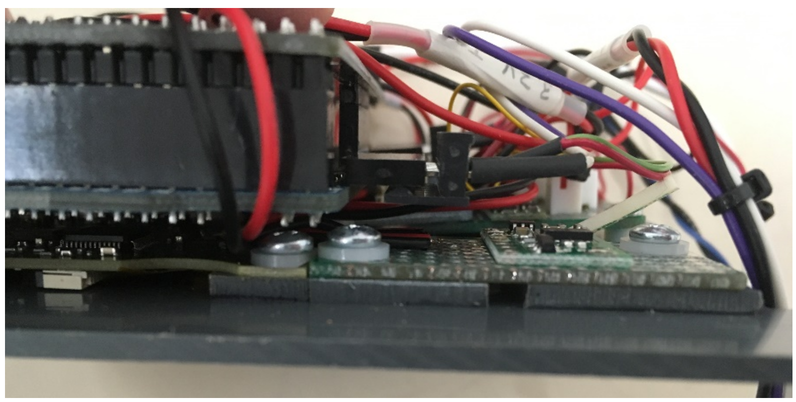
Compass Module

The orientation of this part is extremely critical. It needs to be carefully mounted to be parallel to both the enclosure wall and the LRF. Also, it is important it be flat and level with the base of the enclosure and not tilted by any amount. The other consideration is that it should be as far away as possible from the LIDAR module but not too close to the battery or other components that might generate a varying magnetic field. To mount this, I made its protoboard piece long enough to butt up against the rear of the LRF to ensure it was parallel. The X-axis must be oriented toward the front of the enclosure with the Y-axis oriented to the left when looking toward the front of the enclosure (as seen in the image in the section above). The components will be on the topside of the board when oriented correctly.





This is the orientation which the compass module should have when installed in the Caveatron as viewed from above with the X-axis pointed toward the front of the unit.



Rear of the LRF and the Compass module showing how it is mounted to a protoboard and raised up with additional spacer pieces and butted up against the rear of the LRF to ensure alignment. The LRF also has a spacer since it has large components that project from the bottom side of the board. These plastic spacers are cut from the same material as the baseplate. (Note that this is an earlier version of the Compass module and is oriented differently than the current version, which is shown above.)

LIDAR Unit Component Mechanical Notes

There are three versions of the LIDAR which are similar mechanically although they use different enclosures and have different window configurations. The LIDARs must be supported off of the base of the enclosure to clear the enclosure lip, have a cover with acrylic windows, have a rear opening for the connection cable feedthrough and have holes to attach the clamps that support it on top of the Base Unit.

- **LID with LIDAR Windows** – These vary depending on the LIDAR with 3D printable models existing for all designs. These are detailed further below.
- **Cable Gland** – Self-sealing feedthrough for the LIDAR connection cable. I suggest securing the exposed part of the cable to the back of the LIDAR enclosure with an adhesive backed cable tie mounting pad to reduce its chance of snagging.
- **Support clamp mounting holes** – You can seal these with a dap of silicone sealant

4m XV LIDAR Details

The LIDAR mounts to a plastic baseplate that is secured in to the existing mounting bosses in the enclosure box. The LIDAR itself must be raised off the plate to clear the lip of the enclosure and avoid mechanical interferences. For the XV LIDAR, use 3/8" long, ¼" diameter threaded round standoffs that can be pushed straight into the XV LIDAR mounting holes. You may need an extra washer or two underneath the standoffs to get a bit of extra height.

This LIDAR requires an adjustable regulator module to set the motor voltage. It can be mounted to the plastic baseplate in any convenient location (suggest upper left corner) with a screw or double-side adhesive foam tape.

This LIDAR has a 3D printable lid design that uses acrylic window on all four sides that are cut and glued into the recesses. Use marine grade epoxy, silicone epoxy, or other low-stress sealing epoxy so the window is not deformed when the glue dries.

25m XV LIDAR Details

For the SWEEP LIDAR, a 3D printable base file is available that has integrated supports at the correct height.

The SWEEP LIDAR is a time-of-flight type, so can utilize curved windows unlike the other LIDAR types where using curved windows result in distorted distance readings. The lid design for the SWEEP uses a camera dome cover to provide a full unobstructed 360 degree view. The 3D printable design allow the dome to be directly glued onto it. Use marine grade epoxy, silicone epoxy, or other low-stress sealing epoxy so the dome is not deformed when the glue dries.

12m RP LIDAR A1M8 Details

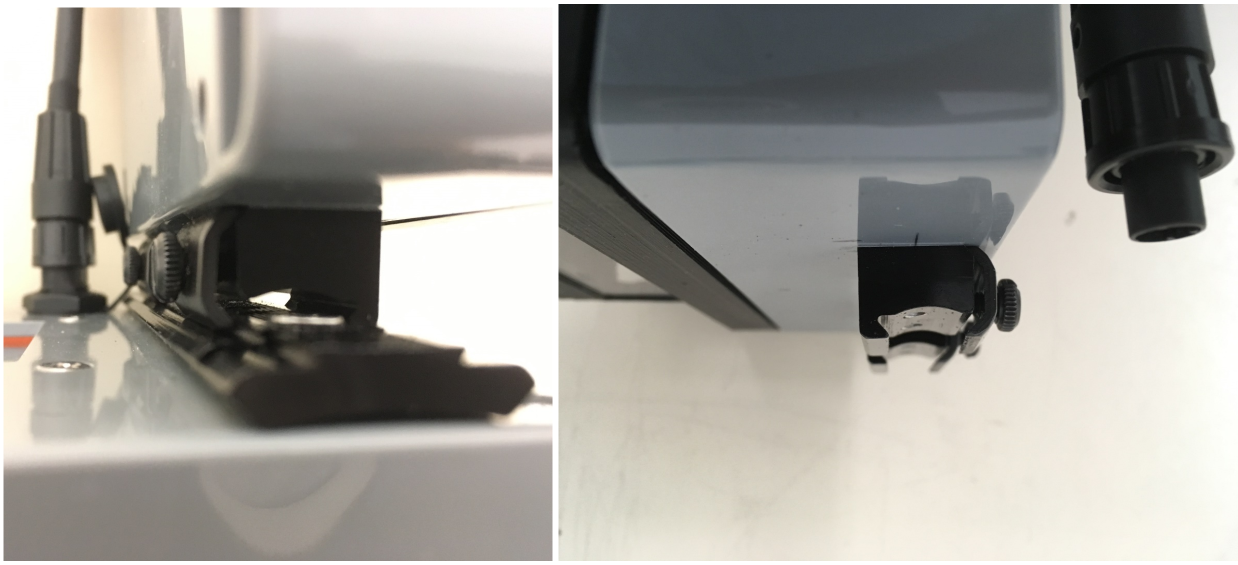
A full 3D printable enclosure is available for this LIDAR which includes all mounting locations and hole cutouts. The base portion requires installing 8 heat set threaded inserts which is easily done using a soldering iron to gently press the inserts into the holes until they are flush with the top. Be careful to ensure they do not end up tilted at an angle. This can be done by inserting a screw slightly into the insert and using a screwdriver to adjust the angle while heating the insert until it appears vertical. To mount the LIDAR, first remove the base circuit board that comes with it, it is not used as the two connectors we will use go directly to the ones on the underside of the LIDAR motor and main part (sensor). Use the longer standoffs that come with the LIDAR that have one end with a male thread (the shorter ones are not needed).

The lid is printed in two parts and uses the acrylic windows as a structural support between the bottom and top pieces. This creates the smallest possible corner obscuration which is reduced to just the junction point between the acrylic pieces. Cutting the windows to as close to the exact size is important in this design but can be done with a band saw. Use marine grade epoxy, silicone epoxy, or other low-stress sealing epoxy so the window is not deformed when the glue dries. First put epoxy into the slots in the bottom half of the lid. Be sure to coat the walls to get a good seal but not put so much in that it will ooze out when the windows are inserts. Wipe off any excess. Next, insert the windows carefully so as not to get epoxy on the exposed part and press them down firmly – it is a close fit. As you put in the side windows, but a small amount of epoxy on the surfaces where the window pieces will touch each other and press them together. Finally after it looks like the windows are reasonably square, put epoxy in the slot on the top of the lid, wipe off any excess, and press it down on the windows until they are all in the slots (the slot on the top piece are slightly bigger to make the fit easier.) Again, be careful not to get any on the windows. Once everything looks nice and square, you can leave it overnight to cure. Finally insert the gasket material on the underside of the lid in the groove.

This LIDAR requires an adjustable regulator module to set the motor voltage. It can be mounted to the plastic baseplate in any convenient location with tape.

LIDAR Unit Attachment Clamps

These are used to mechanically attach the LIDAR Unit to the Base Unit. This may be one of the harder things to get done since it requires metal cutting and threading but I have not yet developed a better way to securely mount the LIDAR Unit. The clamps are cut off of the base part of two riflescope support rings designed to mount to the base rail. These are cut just below the bottom of the ring portion to form a flat-topped surface. Two 4-40 (or similar sized) holes are drilled and threaded into the newly cut flat top surface. The four screw holes in the base of the LIDAR enclosure mate up with these threaded holes. A small curved piece that comes with the scope rings threads into the existing hole on the long side of the clamp with a provided thumbscrew. Tightening this onto the base rail securely clamps the LIDAR unit in place.



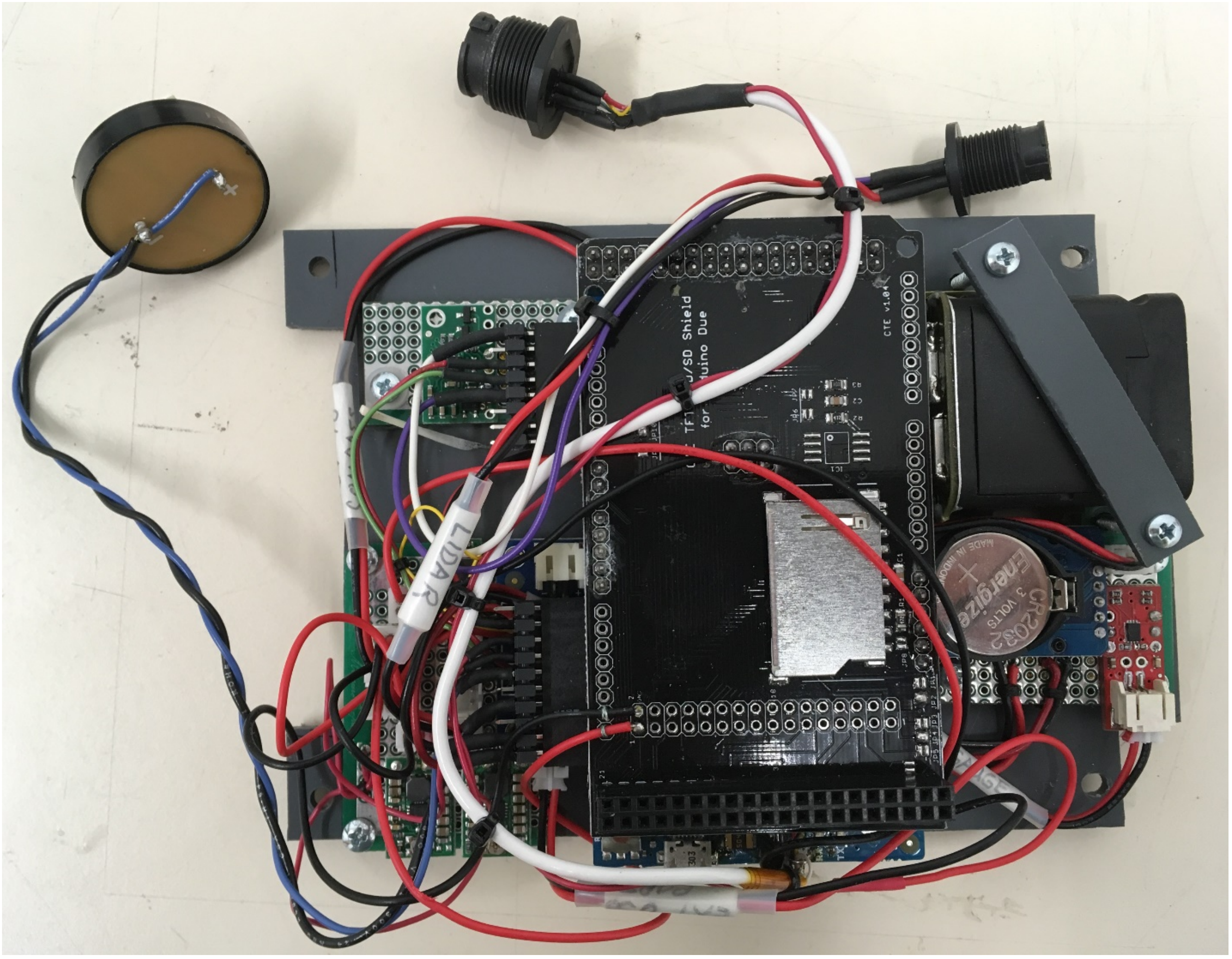
Close up of the LIDAR rail and attachment clamps.

Interior of base of 4m LIDAR enclosure showing how some of the mounting boss material must be dremeled out to avoid interference with screws in the base plate and the LIDAR motor.

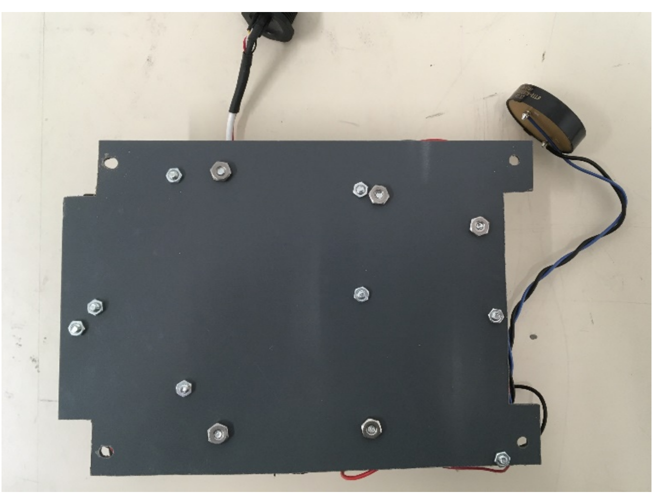
Suggested Assembly Sequence

1. Attach the LCD display to the adapter and to the Arduino. Insert an SD card into the slot on the LCD Display Board (do not use the SD slot on the LCD adapter board as it is not connected). Set the code to test mode, load it and verify that it works.
2. Prepare the Power Board and Accessory Board
3. Connect the Power Board to the Accessory Board and connect the i2C line from the Arduino to the Accessory Board. Connect a battery to the Power Board and try charging it by using the USB port on the Li Ion Charger Module
4. Verify it works by setting the clock time and verify the time is still correct after disconnecting power to the Arduino and the clock module.
5. Prepare the compass board and connect to the Arduino. Plug it in and test that you see inclination and compass readings in manual mode
6. Prepare the Arduino Board connectors and wire it to the Power Board including the regulator control lines. Test that everything powers on.
7. Wire up the LRF module to the Power Board and Arduino. Test that it can acquire readings off of regular surfaces.
8. Wire up the Pizeo Buzzer and verify that it works when taking a Shot with the LRF. At this point everything in the main body has been tested.
9. Prepare the baseplate. Cut it out to the dimensions shown on the drawing and drill the mounting holes. Now you will need to make many additional holes, not shown in the drawing to mount the various components. Lay these out as approximately shown in the electronics illustration and measure/mark positions of the components holes. Check the hole sizes in the components and drill holes to match. Be sure to check positions to avoid mechanical interferences. Cut out extra spacers or other pieces for each part as noted in the Mechanical Component Notes section.
10. Mount everything to the plastic baseplate and test again.
11. Wire up the external USB connector and the power switch and verify you can charge the battery, that the power switch LED comes on, that you can turn on and off the system and that you can connect to the Arduino board by USB.
12. Prepare the enclosure. Glue the front window on the inside using a silicone epoxy being careful not to get any on the exposed part of the window.
13. Place the assembled baseplate into the enclosure and mount the USB jack., the Power Switch and the LIDAR jack.
14. Mount the LCD display on the enclosure lid and attach the 40 pin ribbon cable.
15. Attach the neckstrap to the rear of the lid by inserting nuts into the noted slots behind the screw holes and screwing on the D-rings then threading the strap through the rings.
16. Screw the lid onto the enclosure and test the system
17. Assemble the LIDAR Unit in a similar way by mounting the components in the base of the enclosure.
18. Assemble the enclosure for the LIDAR unit by cutting and attaching the base clamps and drilling the cable gland hole (if required). For the 4m LIDAR version only, you will also need to dremel away some of the non-threaded mounting bosses in the enclosure base which interfere with the LIDAR.
19. Wire the 4 conductor cable to the LIDAR plug and through the cable gland. After connecting everything up, test the LIDAR operation.
20. Finish LIDAR Unit assembly by placing everything into the enclosure and fabricating the lid.
21. Calibrate the system as described in the Calibration Instructions Document.

Base Unit Photos

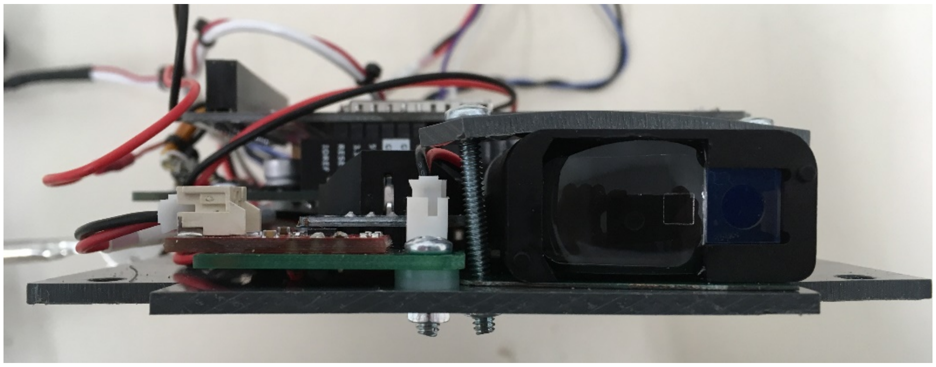


Top view of assembled Caveatron electronics mounted on the baseplate. Note that the build on this page and the next page uses an older, no longer available Compass module with a different orientation than the current one.

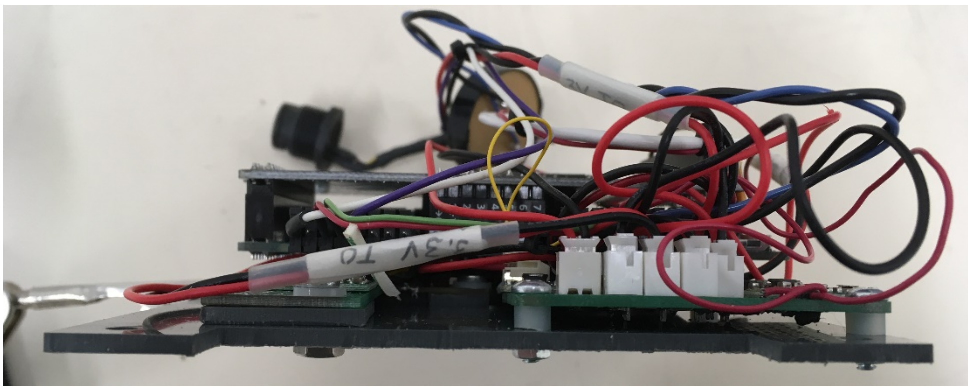


Bottom view of an assembled baseplate (left) and the inside of the enclosure (right) showing the battery the foam adhesive for the piezo buzzer and the front window with the neutral density filter material taped on.

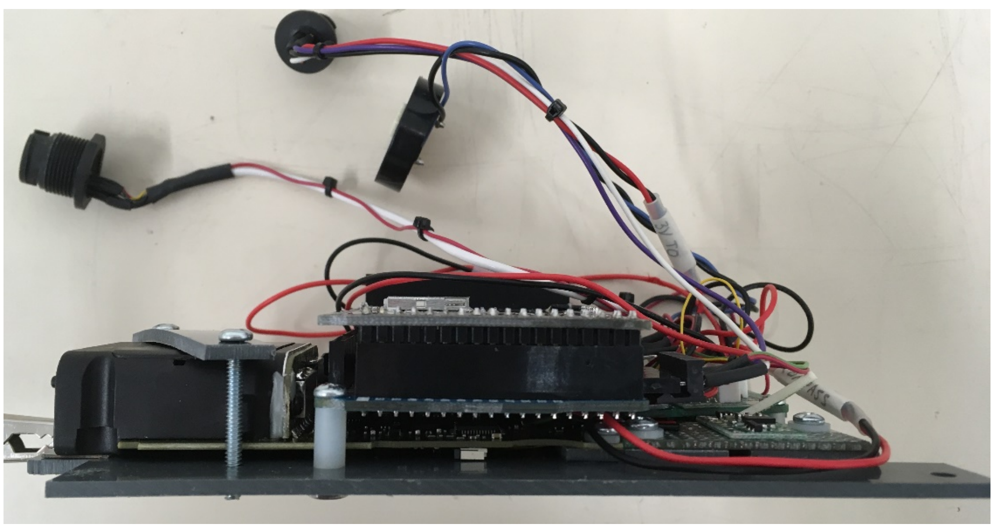
Following page: Various views of the assembled Caveatron electronics mounted on the baseplate.



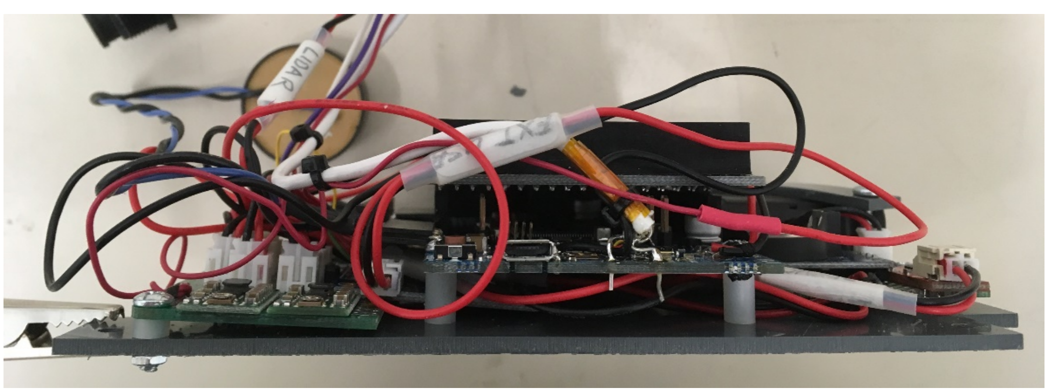
Front View



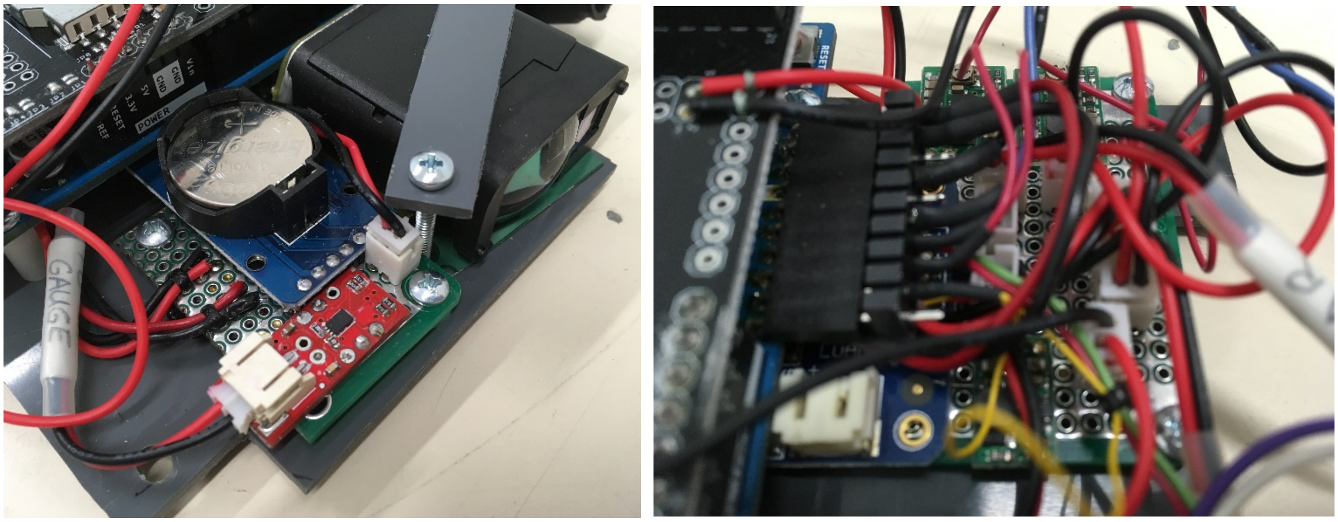
Rear View



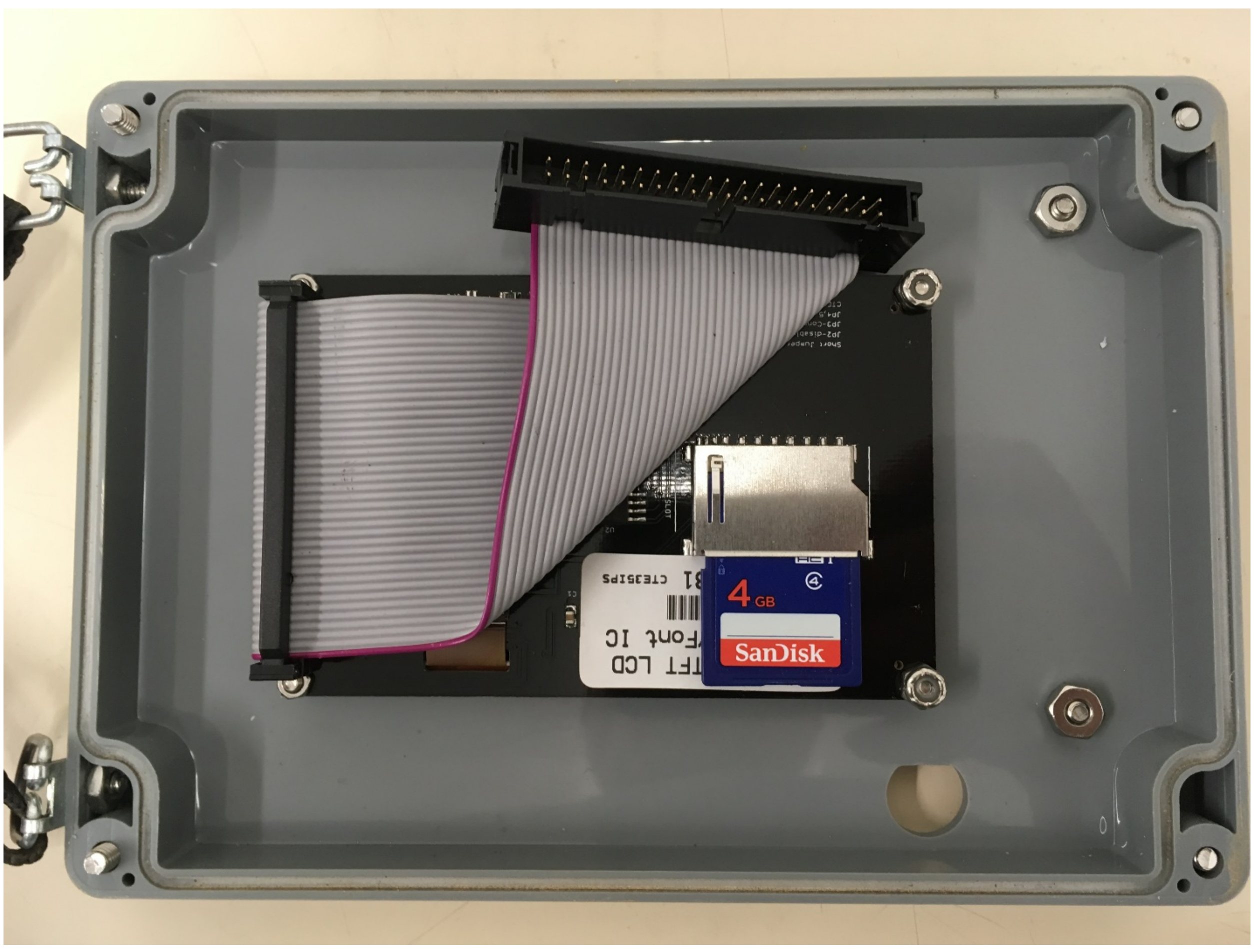
Left View



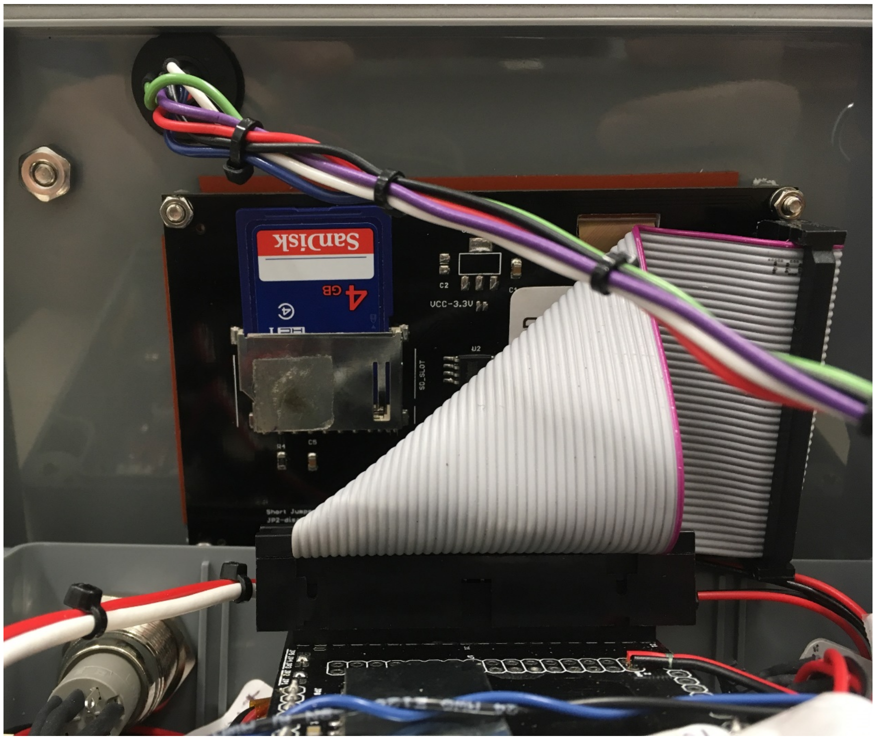
Right View



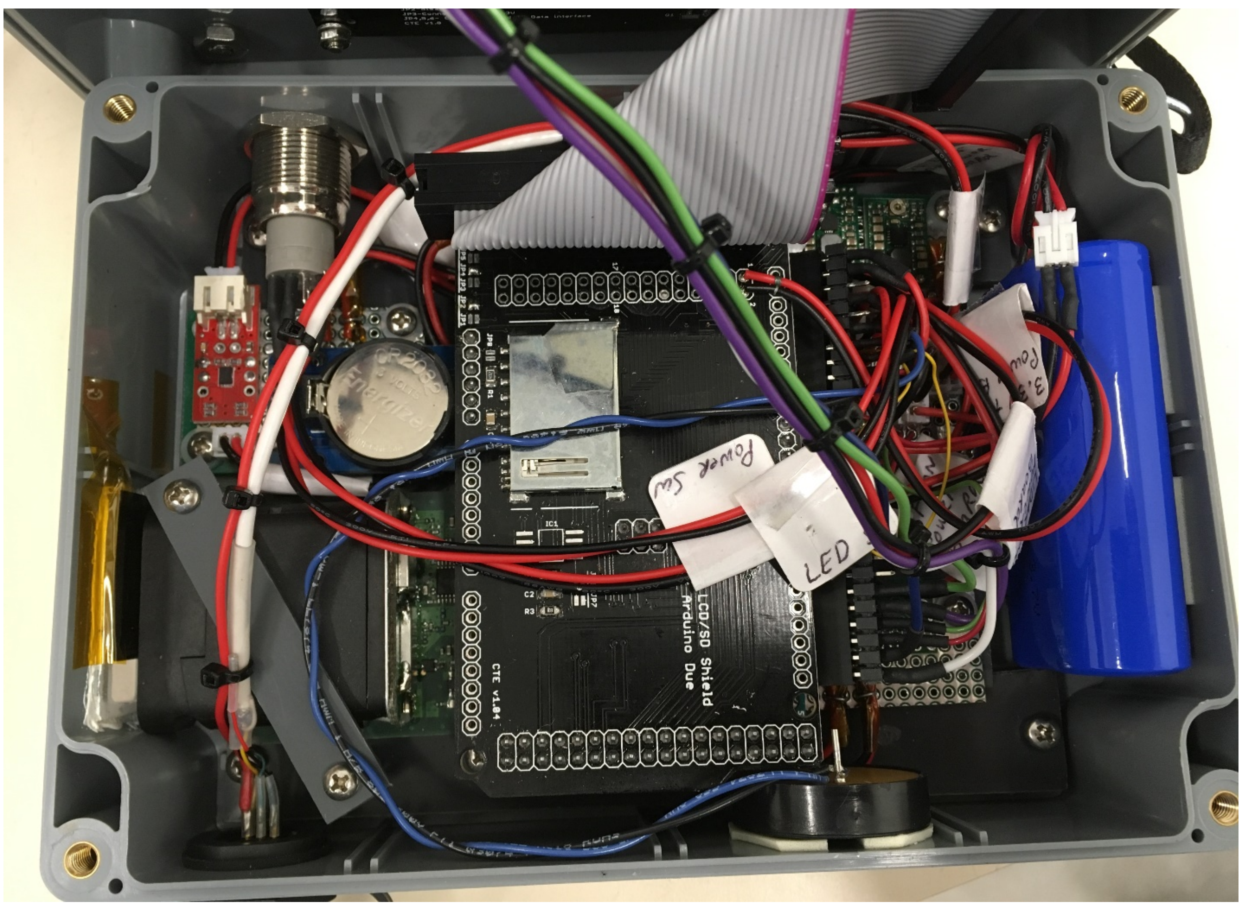
Views of the Accessory Board (left) and Power Supply Board (right).



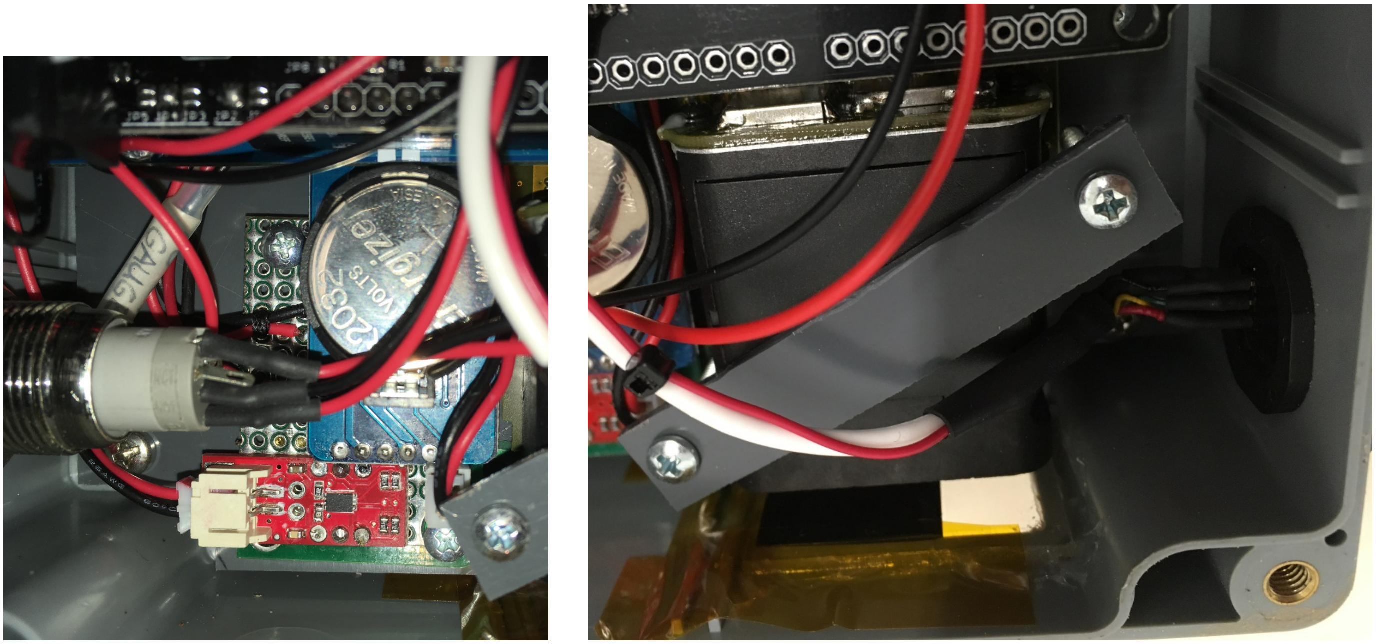
Views of the inside of the lid showing the LCD module with correct ribbon cable orientation and the attachment method for the D-rings for the neck strap.



Views of the inside of the lid with all components installed.



Views of the inside of the base showing with all components installed.



Close up of the parts installed near the front of the enclosure.

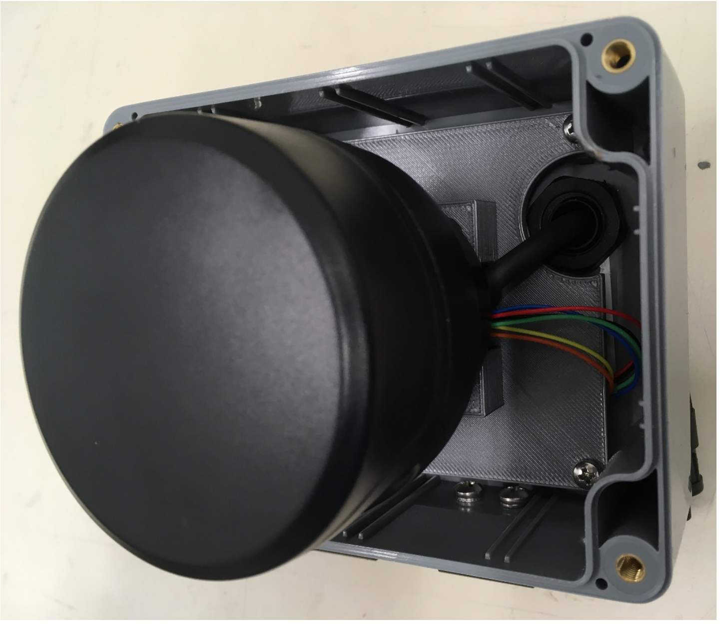
Exterior views of the assembled enclosure showing the neck strap attachment (left) and the LCD and LIDAR attachment rail (right).

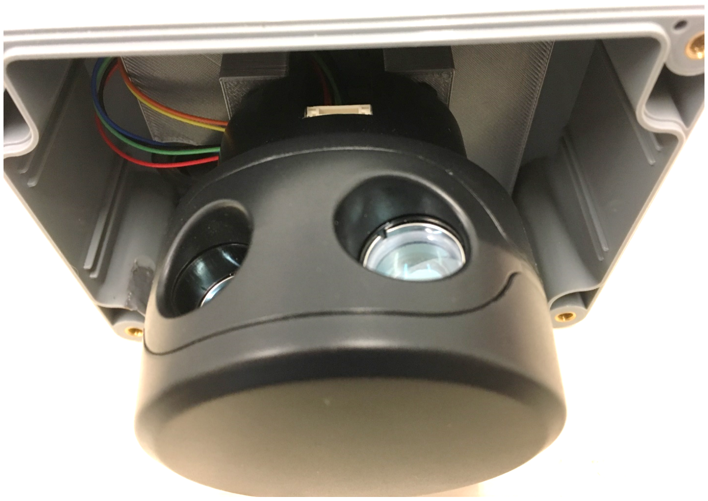
4m LIDAR Module Photos


Rear of the 4 m LIDAR enclosure (left) and side view (right) showing the 3D printed lid with acrylic windows glued in place.

Early alternative lid design using the lid provided with the enclosure. The windows can be glued on the inside (harder to machine but more protected) or outside (not fully sealed).

25m LIDAR Module Photos

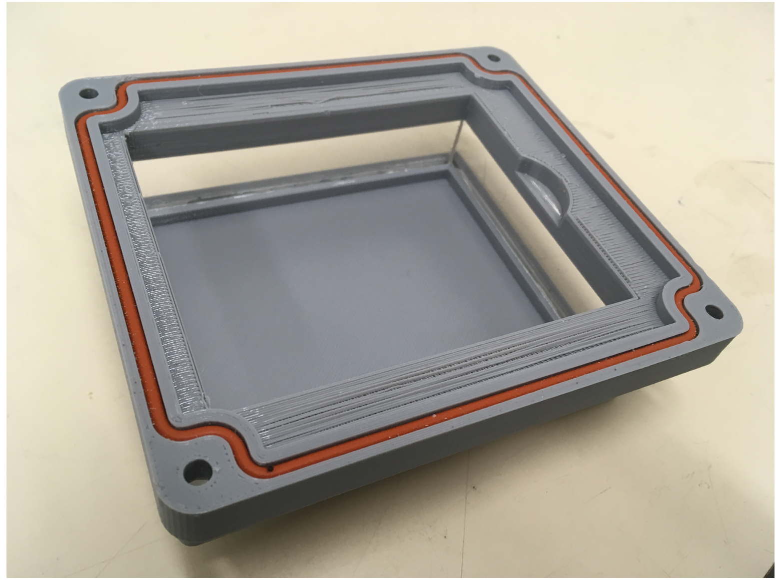




Interior views of the 25m LIDAR enclosure with the LIDAR mounted on a 3D printed base plate. It is not readily visible in the photo at right, but the wires plug in to the connector on the underside of the LIDAR and go through an opening in the base plate.

Photos of the 25m LIDAR with the 3D printed lid from the bottom side (left) and rear (right).

12m LIDAR Module Photos

Interior views of the 12m LIDAR 3D printed enclosure The LIDAR is mounted using the provided standoffs into M2.5 threaded inserts set into the base. The voltage regulator is held with tape under the LIDAR. M4 inserts are set into the corners to attach the lid. The 3D printed lid is in two parts that are held together by the acrylic windows. The windows are inserted into slots in the top and bottom pieces and glued into place and together at the corners with marine epoxy. Gasket material is placed into the groove.


Photos of the exterior of the 12m 3D printed LIDAR enclosure.