

# AutoRally Compute Box Instructions





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## 1 Getting Started

This is a step-by-step guide to construct a complete AutoRally compute box. It is based on a standard mini-ITX form factor computer. The AutoRally compute box mounts on a AutoRally chassis.

Many of the steps refer to instruction booklets included with 3rd party components, the maintenance manual for the 5SC, or other documents located in [manuals/](#). To avoid extra work, make sure to follow only the portion of external instructions specified in this document.

These instructions assume some experience with, or willingness to learn: understanding manufacturer-provided documentation, soldering, 3D printing, laser cutting, servo motors, various crimps and housings, reading basic circuit diagrams, and Arduino programming.

**The quality of solder joints, crimp housing connections, heat shrink coverage, and wire routing are especially important for the reliability of the compute box.** The most common problems (and often most frustrating to debug) are loose wire housings, bad crimp connections, and failing solder joints.

**While this compute box is one of the two major parts of the AutoRally platform, which is an accessible research platform, it can cause serious injury and damage if operated in an unsafe manner. Only operate in an access-controlled space where the operator can maintain line-of-sight visibility to the robot at all times.**

This document is best viewed in color.

### 1.1 Total Time

Total estimated time to construct a complete compute box is 37 hours, not including the time to print 3D printed components which will vary significantly based on the printer used. Each step includes an estimated completion time but the actual time may be longer if you have to learn new skills.

### 1.2 Parts List

A complete parts list for the AutoRally platform (chassis and compute box) can be found in the [AutoRally Parts List](#).

### 1.3 Tools

Tools required for the assembly of the compute box: equipment for cutting, welding, and bending metal, hex key set, Philips screwdriver set, utility knife, wire cutters, wire strippers, needle nose pliers, crimp tool suitable for all crimps, soldering iron, 3rd hand, heat gun, hot glue gun, hand saw.

### 1.4 Fabricated Parts

Fabricated parts include

- Compute box base, front, rear, left, and right panels
- Compute box lid and rear hinge panel
- Compute box cross brace

- GPU strut
- Camera support plate
- 2 × rectangular camera covers
- 4 × right-angle camera cover supports
- Compute box rear panel hinge
- 10 Lid connectors
- Motherboard foam padding

## 1.5 3D Printed Parts

Models for all components that require 3D printing are located in [models/](#). It is advised to use a 3D printer with support material. Print time for a complete set of compute box components is 18 hours and 37 minutes, which will vary greatly based on the printer used, and is not included in the build time estimate. Material usage for a complete set of compute box parts is 241.55 cm<sup>3</sup>, not including support material. 3D printed parts were made on a Dimension SST 768. Parts to 3D print include

- 2 front compute box mounts
- 2 rear compute box mounts
- 2 side body mounts
- RAM holder
- Microcontroller holder
- Battery/power supply holder
- Graphics processing unit (GPU) holder

## 1.6 Laser Cutting

The motherboard foam (available in [models/](#)) is laser cut out of craft foam.

## 1.7 Software

A few software tools should be installed to complete the chassis configuration:

- [Castle Serial Link](#)
- [Arduino IDE](#) along with Teensyduino and support for the Arduino Due

## 1.8 Resources Included with Instructions

- [AutoRally Parts List](#)
- Component models for 3D printing in [models/](#)
- Product manuals and datasheets in [manuals/](#)
- Video tutorials saved for offline viewing in [videos/](#)
- Wiring diagrams for all major system components [wiringDiagrams/](#)

## 1.9 Useful Links

Note: all videos can also be found in the [videos/](#) for offline viewing.

- [Castle Creations Electric Conversion Video Tutorials](#)
- [How to Solder Bullet Connectors](#)
- [Mecatech Brake Bleed Tutorial](#)
- [Molex Crimping Guide](#)
- [Crimping Tutorial](#)
- [Crimp Pins Pictures](#)
- [Adafruit Soldering Tutorial](#)

## 2 Fabrication

### 2.1 Motherboard Foam Padding

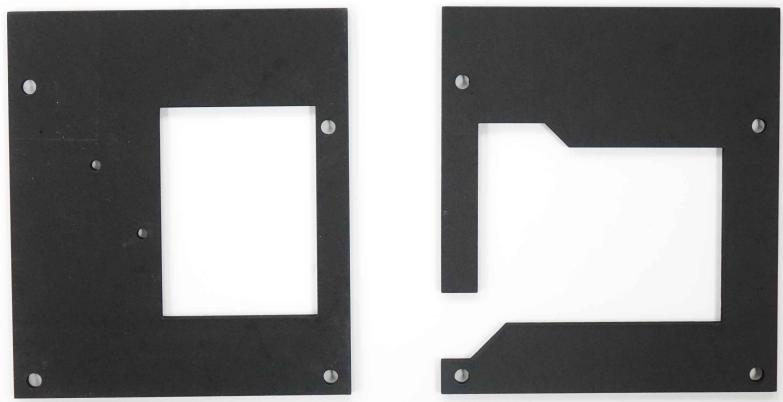
**Time** 0 hours 20 minutes

**Parts**

- 6mm-thick craft foam sheet

**Instructions**

- Cut out the motherboard foam by hand or using a laser cutter. Use the .pdf file in [models/](#) corresponding to the brand of motherboard you purchased as a stencil if cutting by hand or as input to the laser cutter. Patterns for ASRock motherboards, shown on the left, and Asus motherboards that have a bottom-mounted M.2 SSD, shown on the right, are included.



### 2.2 Compute Box Lid Connectors

**Time** 2 hours 0 minutes

**Parts**

- 6 inch × 12 inch, 0.25 inch-thick 6061 aluminum sheet
- 1 M3 × 10 mm screw

**Instructions**

- Use a waterjet to cut 10 Lid connectors out of the 0.25 inch-thick aluminum sheet. The cut pattern for a single lid connector can be found in "Compute Box Aluminum 6061 025 Cut Pattern.dxf" in [models/](#).
- Tap the smaller hole of each Lid connector all the way through with an M3 tap.
- Screw the M3 × 10mm screw all the way into and out of each tapped hole to clear any remaining aluminum debris.



### 2.3 Compute Box Panels and Internal Supports

**Time** 2 hours 0 minutes

#### Parts

- 24 inch × 36 inch, 0.09 inch-thick 3003 aluminum sheet

#### Instructions

- Cut all compute box panel and internal support parts out of the aluminum sheet using the .dxf cut patterns found in [models/](#).

### 2.4 Compute Box Welding

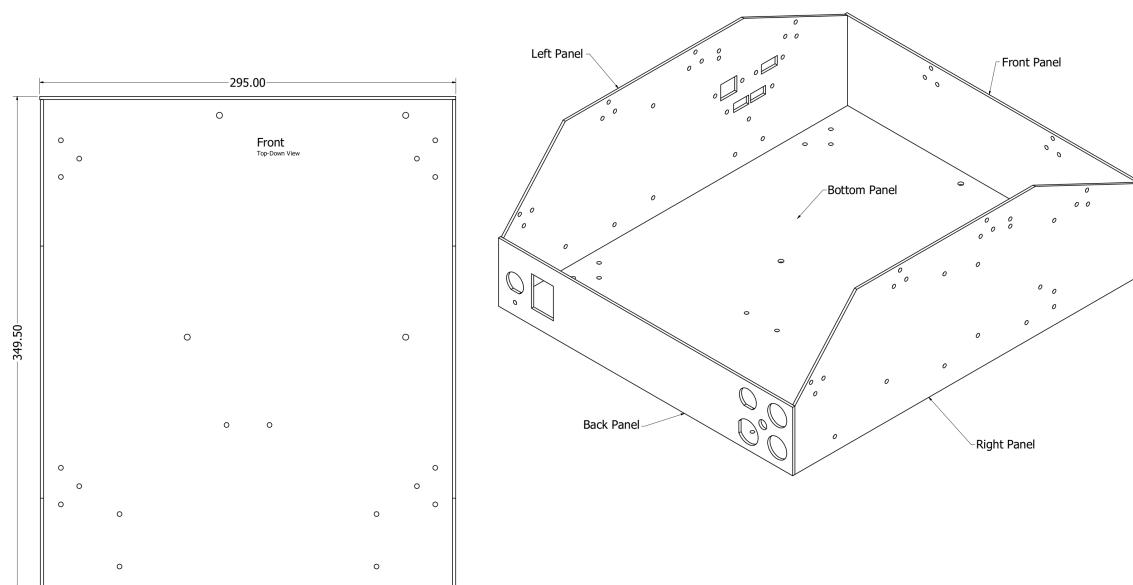
**Time** 3 hours 0 minutes

#### Parts

- Compute box base, front, rear, left, and right panels

#### Instructions

- Weld all the panels together and ensure that the outer dimensions of the box are as specified.





## 2.5 Compute Box Bending

**Time** 1 hours 0 minutes

### Parts

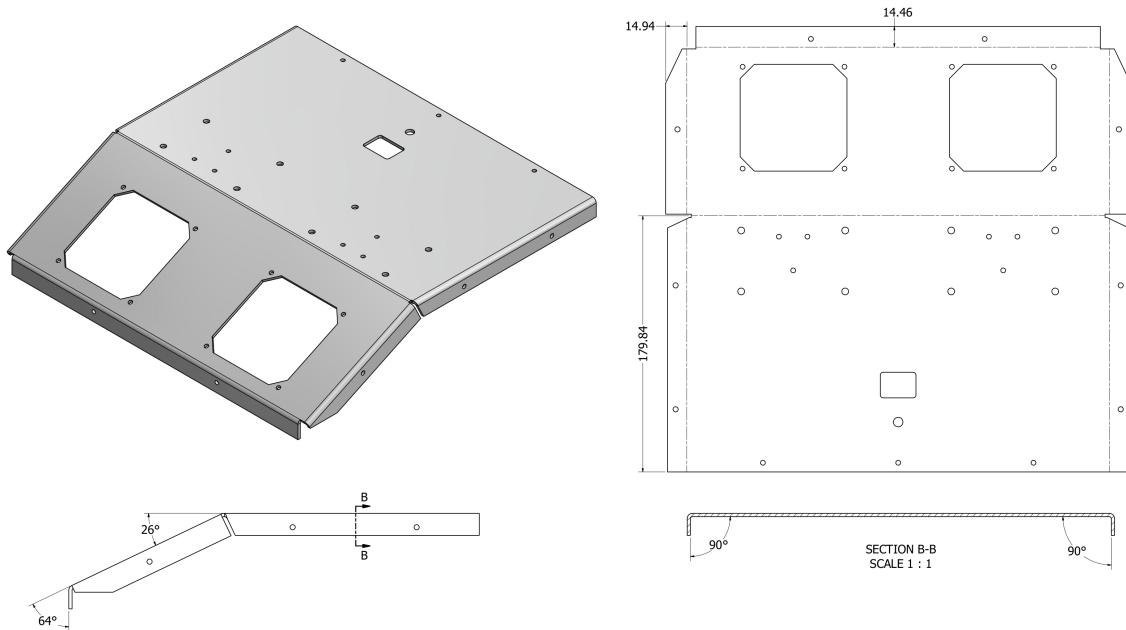
- Compute box lid
- Compute box rear hinge panel

### Instructions

## 2 FABRICATION

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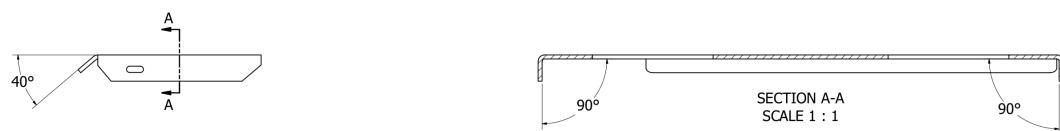
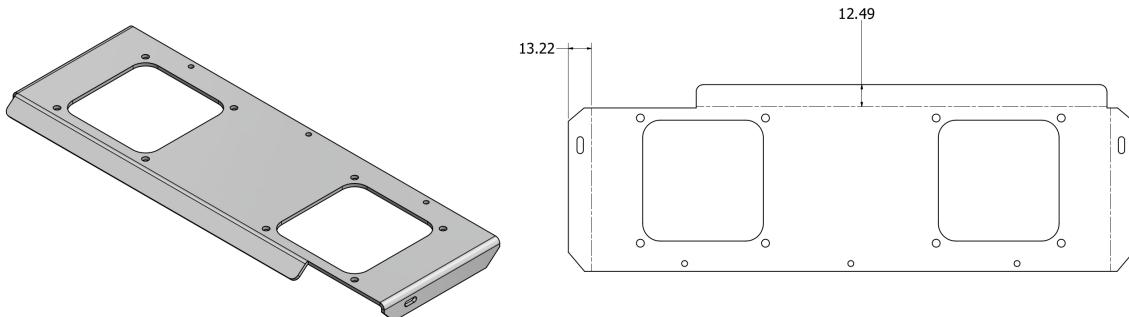
- Bend the front lid per the following diagram



## 2 FABRICATION

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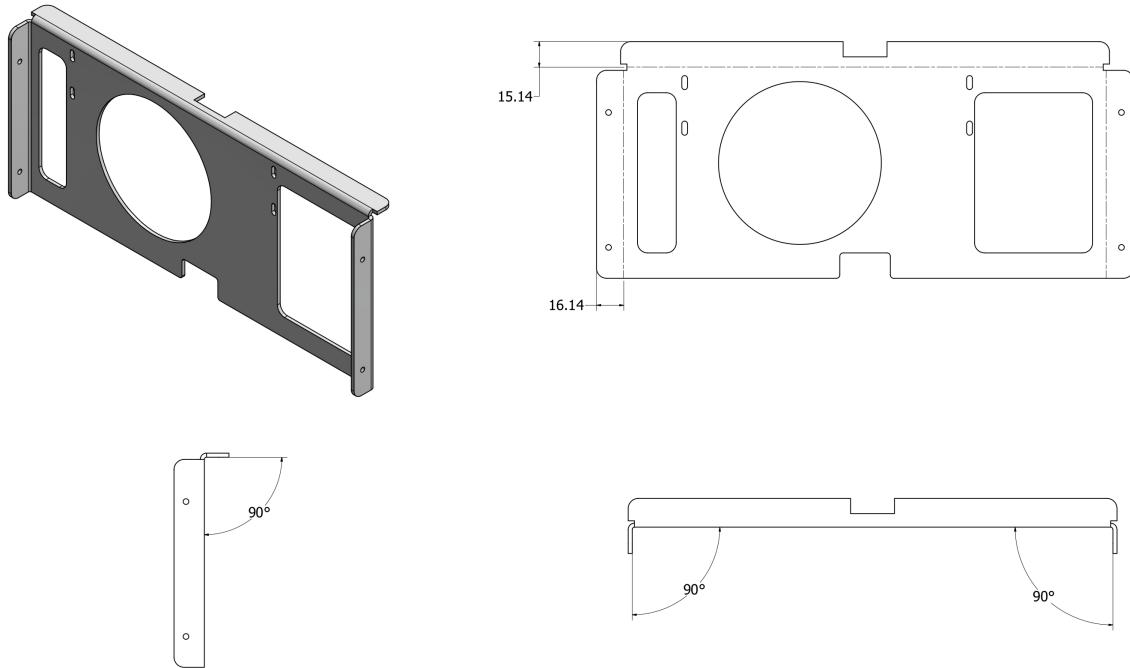
b. Bend the back lid per the following diagram



## 2 FABRICATION

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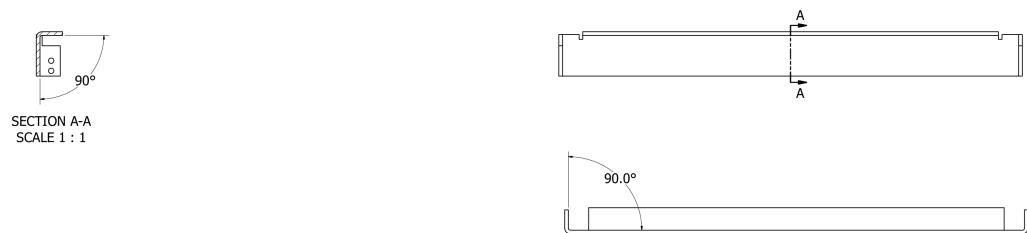
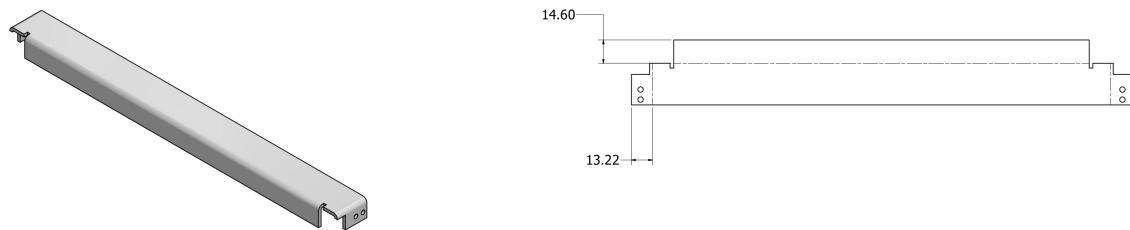
c. Bend the GPU strut per the following diagram



## 2 FABRICATION

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- d. Bend the compute box brace per the following diagram



- e. Test fit hole alignment and tolerances between the bent components and the welded compute box. Make any necessary adjustments to ensure that all holes are aligned.

### 2.6 Camera Support Plate

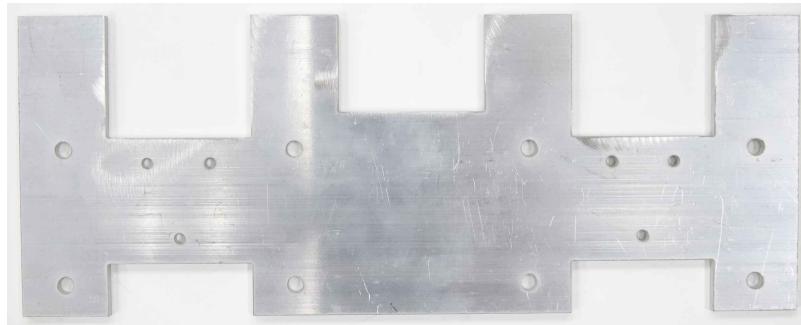
**Time** 0 hours 20 minutes

#### Parts

- 6 inch × 12 inch, 0.09 inch-thick 6061 aluminum sheet

#### Instructions

- a. Use a waterjet to cut the camera support plate out of the aluminum sheet. Use the cut pattern found in "Compute Box Aluminum 6061 090 Cut Pattern.dxf" in [models/](#).



## 2.7 Camera Covers

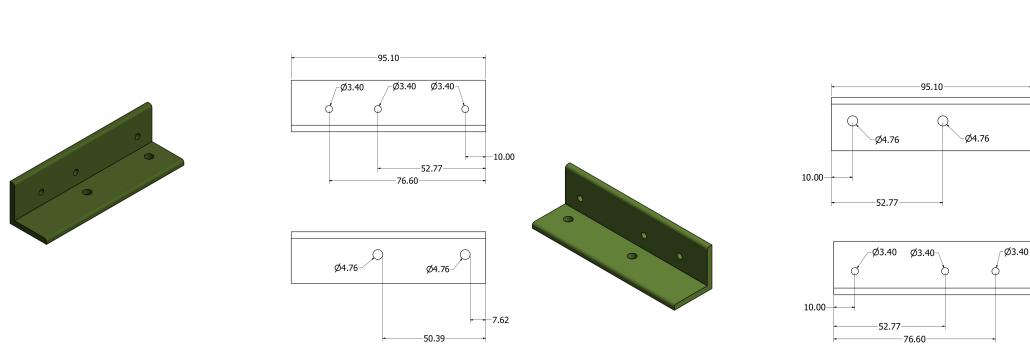
**Time** 2 hours 0 minutes

### Parts

- 2 inch × 2 inch rectangular structural fiberglass tube
- 1 inch × 1 inch 90-degree structural fiberglass angle
- 12 M3× 8 screws
- 12 M3× 8 nuts
- Camera support plate

### Instructions

- a. These parts can be fabricated with a band saw, hand saw, or similar cutting tool.
- b. Cut two 4 inch lengths of 2 inch rectangular structural fiberglass.
- c. Cut one side off of each of the rectangular tube sections, making sure to cut no more than the thickness of the wall off.
- d. Cut four 4 inch lengths of 90-degree structural fiberglass angle.
- e. Mark two of the angular sections as left side pieces and the other two as right side pieces.
- f. Clamp the angle brackets to the rectangular tube so that they sit flush. Match drill three holes with a 2.5mm drill bit through each angle bracket and the tube, for a total of 12 holes. Secure the angle brackets to the tubes with a M3×8 screw and nut through each match drilled hole
- g. Clamp the camera cover assemblies to the camera support bracket. Match drill holes in the angle brackets through the holes in the camera support plate using a 5/16 inch drill bit.



## 2.8 Fit Lid and Rear Hinge Panel

**Time** 2 hours 0 minutes

**Parts**

- Lid panel
- Rear hinge panel

**Instructions**

- Align the lid with the 8 mounting holes on the base. If the holes do not align, locate the place of interference between the panels and:
  - Unbend or bend further the lid flange causing interference.
  - File off sharp edges and weld seams that are causing interference.
  - Oversize a few of the holes on the lid flanges slightly.
- Repeat this process for the rear hinge panel.

## 2.9 Rear Panel Hinge

**Time** 1 hours 0 minutes

**Parts**

- 0.04 inch-thick, 1.25 inch-width unfinished steel piano hinge

**Instructions**

- Use a bandsaw or hand saw to cut a piece of piano hinge with length the same as the width of the lid.
- Clamp the hinge to the top of the lid panel such that the lid joint is pushed back against the lid as much as possible and is facing down.
- Match drill three holes with a 2.5mm drill bit in the top part of the hinge through the three M3 holes in the lid.
- Unclamp the hinge from the lid panel and repeat the same process for the other side of the hinge using the rear hinge panel. This time the hinge should be clamped to the rear hinge panel with the hinge joint pushed against the rear hinge panel and is facing down. Match drill three more holes in the other side of the hinge through the holes in the rear hinge panel.



## 2.10 Filing

**Time** 0 hours 30 minutes

**Parts**

- All fabricated aluminum parts

**Instructions**

## 2 FABRICATION

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- a. Use a file to remove all sharp edges and remaining burrs. Pay special attention to the rectangular wire routing hole in the lid panel as well as the cutout in the top flange of the GPU strut.

### 3 3D Printing

**Time** 18 hours 37 minutes

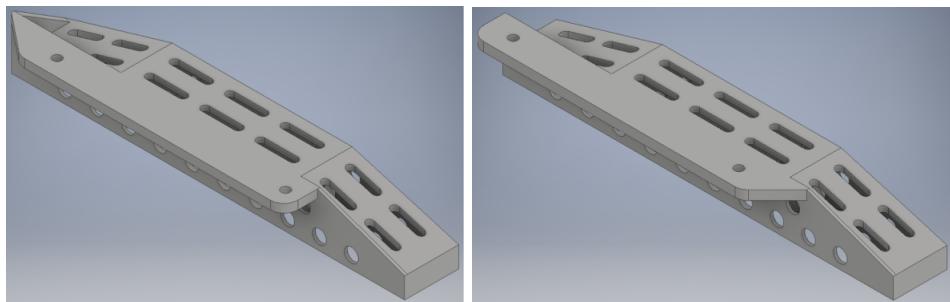
#### Parts

- Models for all compute box 3D printed components are .stl files located in [models/](#)

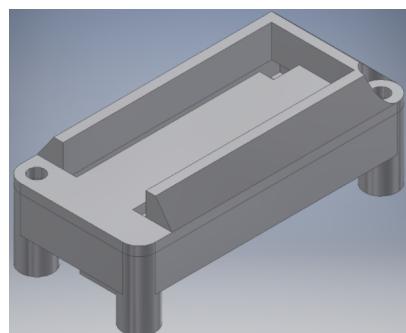
#### Instructions

- a. Print all custom compute box components:

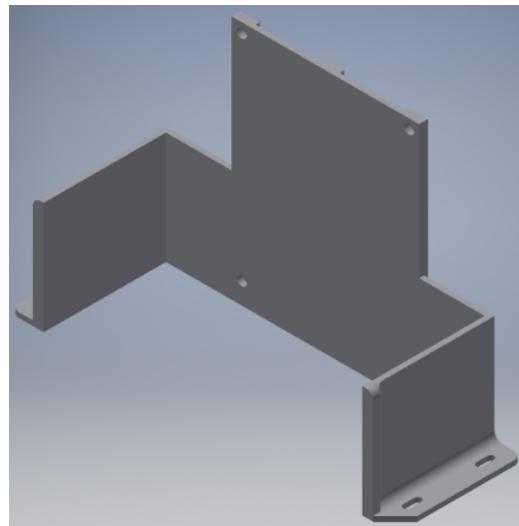
- a) RAM holder (left for Asus motherboards, right for ASRock motherboards)



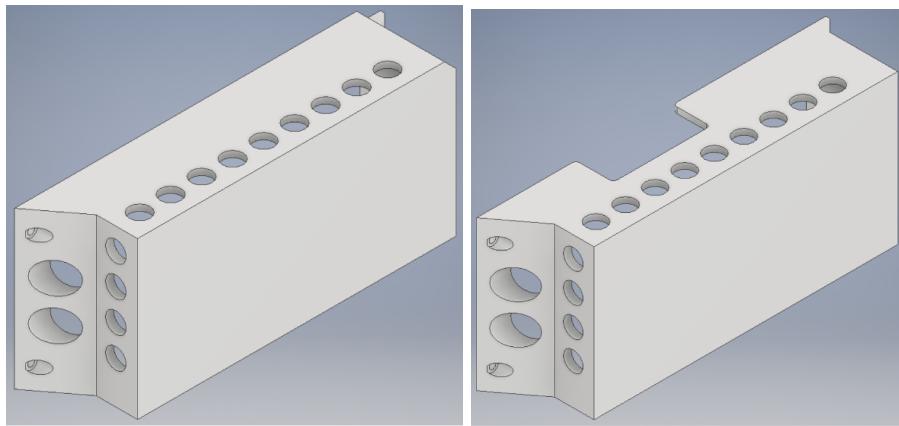
- b) Microcontroller holder with lid



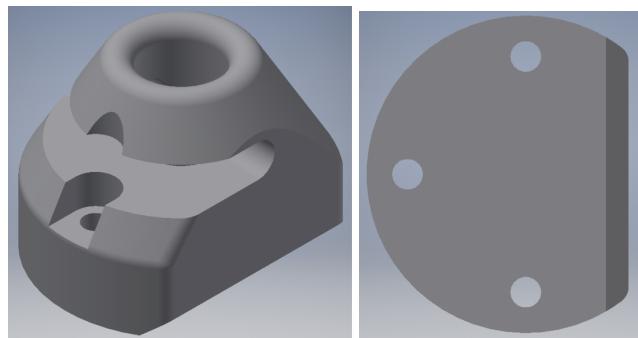
- c) Battery/Power supply holder



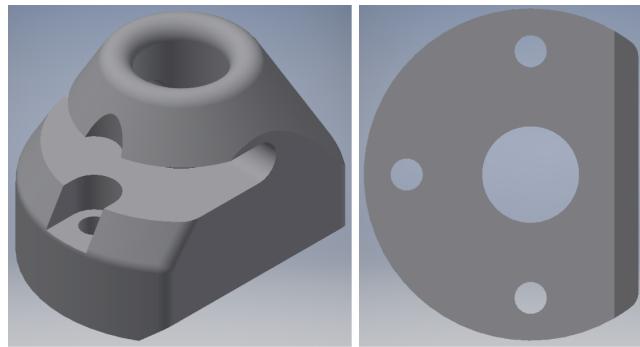
d) GPU holder (left for GTX 750ti, right for GTX 1050ti)



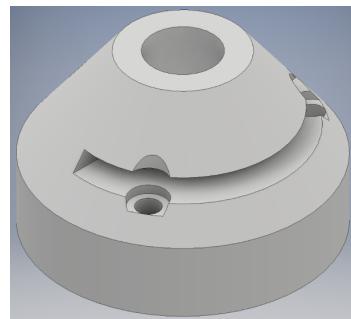
e) 2 × Front compute box mount



f) 2 × Rear compute box mount



g) 2 × Side body mount



## 4 Device Serial Numbers

**Time** 0 hours 25 minutes

### Parts

- AutoRally Chassis
- Laptop with Ubuntu and cutecom installed
- 2 Xbee USB adapters
- UART-USB 2.0 3.3V cable
- 2 TTL-USB 2.0 3.3V cables
- **Optional**, Hemisphere R330 GPS base station
- **Optional**, GPS base station power cable assembly
- **Optional for GPS base station**, USB A male to A male cable, 10 ft
- **Optional for GPS base station**, USB A male to DB9 serial converter cable, 10 ft

### Instructions

- a. Open a terminal on the laptop.
- b. Note the existing contents of the `/dev` directory using the command `ls /dev` so that you can recognize the names of new devices as they are added.
- c. Plug the chassis USB cable from the electronics box into your computer. Run `ls /dev` command and find the new item in the list. It will *probably* resemble `ttyACMxx` or `ttyUSBxx`.
- d. Run `udevadm info --query=property /dev/ttyACMxx` replacing `/dev/ttyACMxx` with the correct name noted in the previous step.
- e. Find the field called **ID\_SERIAL\_SHORT** and write down the value shown exactly. Save both the device name and the value of **ID\_SERIAL\_SHORT** for later use.
- f. Repeat the process for the two Xbee USB adapters. Use a sharpie to designate one adapter the Xbee node and the other the Xbee coordinator. The Xbee node will be mounted inside the compute box, whereas the Xbee coordinator will be mounted inside the run-stop box. The Xbee modules need not be plugged into the Xbee adapters in order to get these serial numbers.
- g. Repeat the process for the UART-USB 2.0 cable and each of the TTL-USB 2.0 cables. Using a sharpie mark one of the TTL-USB cables as Port A and the other as Port D. The UART-USB cable is for Port B. These are the serial numbers for Ports A, B and D for the GPS rover.
- h. Repeat the process for Ports A and B of the Hemisphere R330 GPS base station **You will have to complete the GPS Base Station Power Cable Assembly prior to this step**. Power up the GPS base station. Connect Port A to the laptop using the USB A male to USB A male cable and obtain the serial number. Connect Port B to the laptop with the USB A male to DB9 serial converter cable and obtain the serial number.
- i. Save the serial port numbers gathered in the steps above in a text file. They will be needed to perform configuration steps later.

## 5 Compute Box Base Assembly

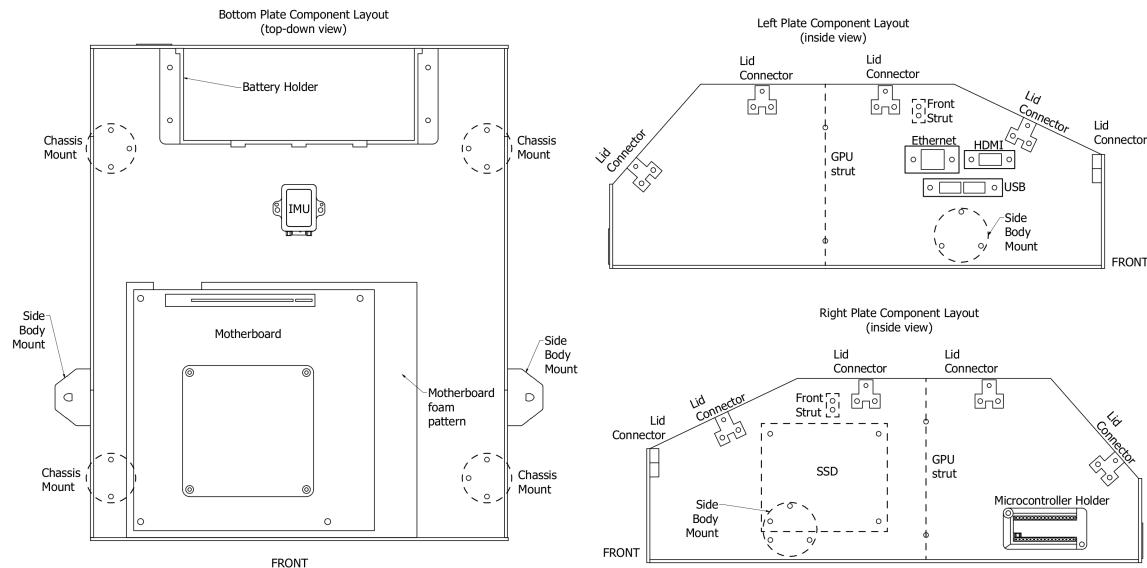
**Time** 1 hours 0 minutes

### Parts

- Compute box base
- GPU support strut
- 10 Lid connectors
- $2 \times$  3D printed front compute box mounts
- $2 \times$  3D printed rear compute box mounts
- $2 \times$  3D printed side body mounts
- 4 M3  $\times$  10mm screws
- 20 M3  $\times$  12mm screws
- 18 M3  $\times$  16mm screws
- 42 M3 nuts
- Motherboard
- Motherboard foam padding
- GPU
- 3D printed GPU holder
- M3 washers (quantity depends on fabrication tolerance)

### Instructions

- a. Refer to the compute box layout diagrams below to determine the mounting positions of the GPU and the motherboard for this section of instructions.

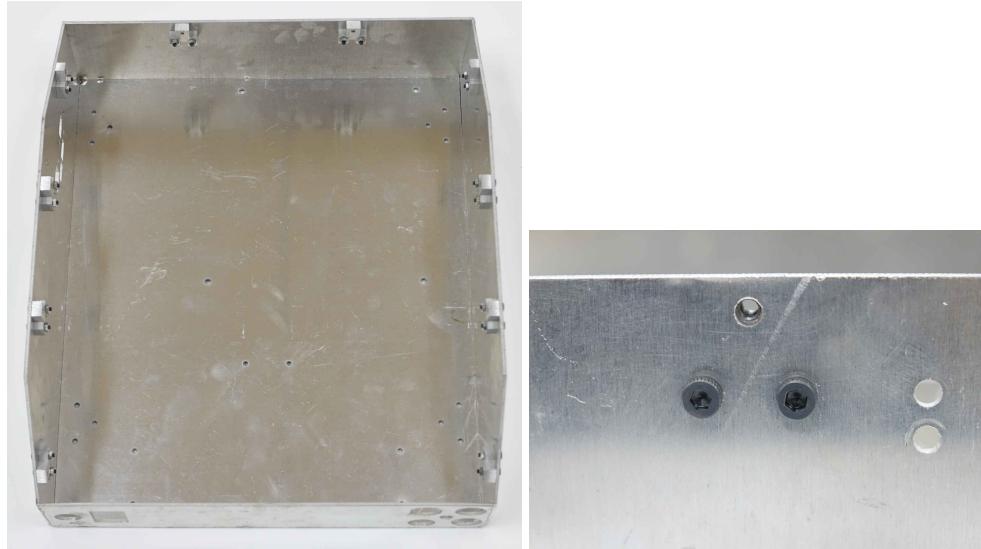


- b. Using 20 M3  $\times$  12mm screws and 20 M3 nuts, attach the 10 lid connectors to the inside of the compute box base with the 2 through holes in each lid connector. Make sure to align the threaded

## 5 COMPUTE BOX BASE ASSEMBLY

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hole of the eid connector with the through hole on the compute box base before tightening the screws.



- c. Attach the GPU support strut to the side walls of the compute box base using 4 M3×10mm screws and 4 M3 nuts. The side flanges should be pointing toward the front of the box. **Depending on your fabrication tolerance you may need to add spacers or washers between the strut and the walls of the compute box in order to prevent movement and ensure proper alignment of the strut.** It is recommended to put the motherboard, foam padding, GPU, and 3D printed GPU holder in place and check the alignment of the GPU with respect to the GPU holder to determine the appropriate number of spacers.



- d. Attach the front and rear compute box mounts to the underside of the base using 12 M3×16mm screws and 12 M3 nuts. The rear mounts are different than the front mounts as the compute box mount hole passes all the way through the part. The flat sides of the mounts should face outward and be almost flush with the walls of the base. **Depending on weld seam thicknesses the top outward corner of the mounts may need to be shaved down a little.** Loosely screw in the mounts first and then check the alignment by attaching the base assembly to the chassis. Once alignment is confirmed, remove the compute

## 5 COMPUTE BOX BASE ASSEMBLY

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**box base from the chassis, add the nuts, and tighten the screws.** Note that the rear compute box mounts have holes that go all the way through them.



- e. Attach the side body mounts to left and right walls of the compute box using 6 M3×16 mm screws and 6 M3 nuts. The slot in the body mounts should face down when installed.



## 6 Compute Box Lid Assembly

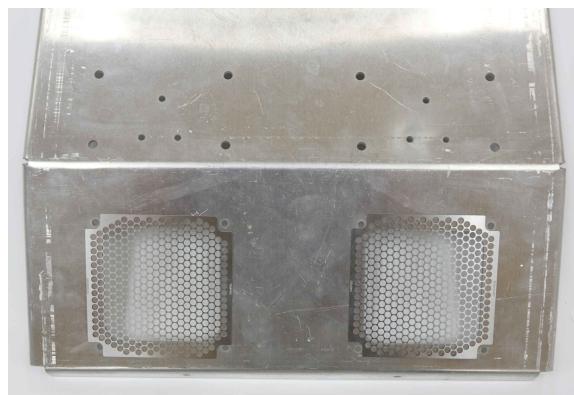
**Time** 2 hours 0 minutes

### Parts

- Compute box lid
- Compute box back lid
- Hinge
- Camera support plate
- 2 camera lenses
- 2 FLIR cameras, Flea3 or Blackfly S
- 4 Camera cover supports
- 2 aluminum dust filters
- 2 fans, 80mm × 80mm
- 2 fan dust filters
- 2 EMI-blocking dust filter guards
- 24 metal body clips
- 18 M3×8 screws
- 8 M3×10 screws
- 8 M3×35 screws
- 6 M3×8 mm spacers, 6 mm outside diameter
- 40 M3 nuts
- 6 M3×14 mm screws
- 8 3/8 inch dia, 5/16 inch usable clevis pins
- 8 8mm body clips

### Instructions

- a. Align the EMI-blocking dust filter guards over the fan opening of the compute box lid.



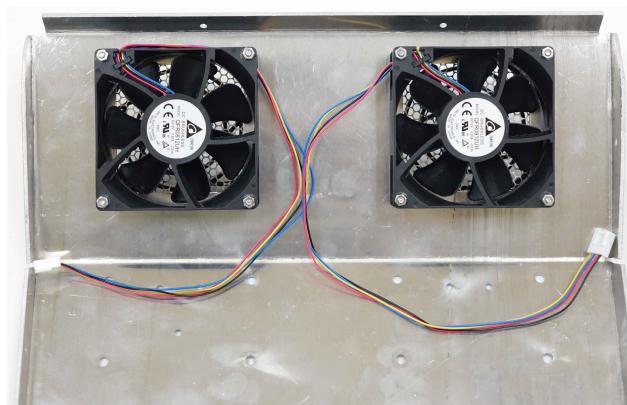
- b. Open the filter assemblies, place the bottom part of the assemblies over the EMI-blocking dust filter guards, and insert 4 M3×35 screws through all of the components.

## 6 COMPUTE BOX LID ASSEMBLY

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- c. Install fans onto the screws protruding from the fan filter assemblies on the inside of the compute box lid with the wire alignment shown. The fans should be oriented so that they suck air through the filter assembly into the box. Use 4 M3 nuts per fan to secure the fans to the inside of the lid assembly.



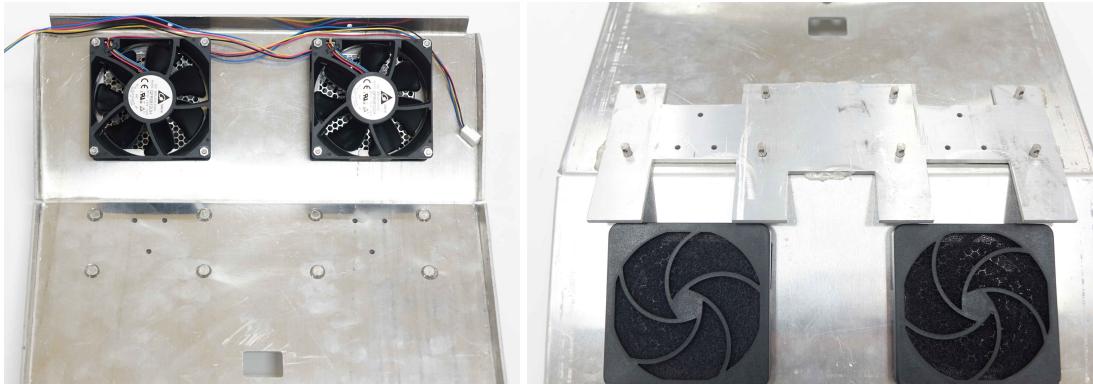
- d. Reassemble the fan filter assemblies to attach the dust filter to the lid.



- e. Insert the 8 clevis pins into the bottom surface of the lid. Epoxy the pins to the bottom surface of the lid with the clevis pin holes aligned front-to-back. **You can use a couple drops of hot glue to secure the camera support plate to the lid to help with the clevis pin alignment before epoxying the clevis pins.** These will hold the camera mount support plate and camera mount assemblies with cotter pins.

## 6 COMPUTE BOX LID ASSEMBLY

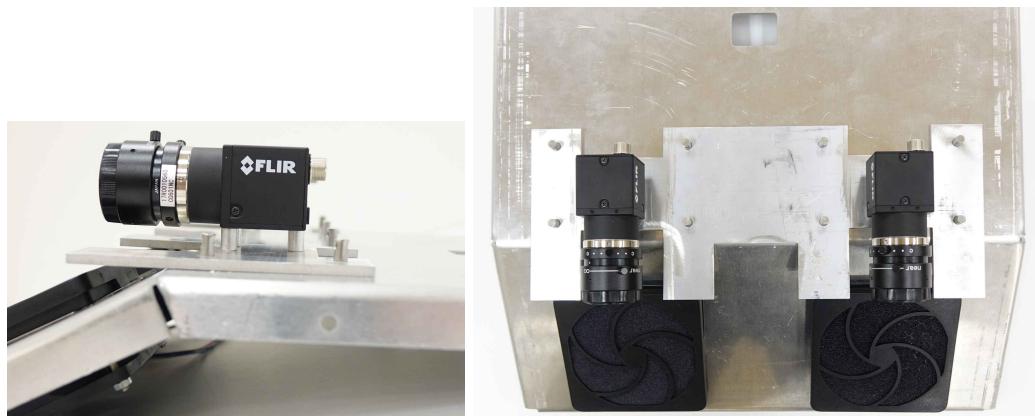
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f. Install the camera lenses on the cameras, leave the lens caps attached.



g. Push the camera mount support plate down onto the clevis pins with the protrusion pointing over the fan dust covers as shown. Insert 6 M3×14 mm screws through the camera mount holes from the underside of the lid. Place an 8mm long spacer on each screw. Seat the cameras onto the screws protruding from the spacers and tighten the screws.



h. Place the camera cover assemblies over the cameras and secure to the lid with the 8mm body clips.

## 6 COMPUTE BOX LID ASSEMBLY

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- i. Attach the hinge to the compute box back lid using 3 M3×8 screws and 3 M3 nuts with the hinge joint facing inward.



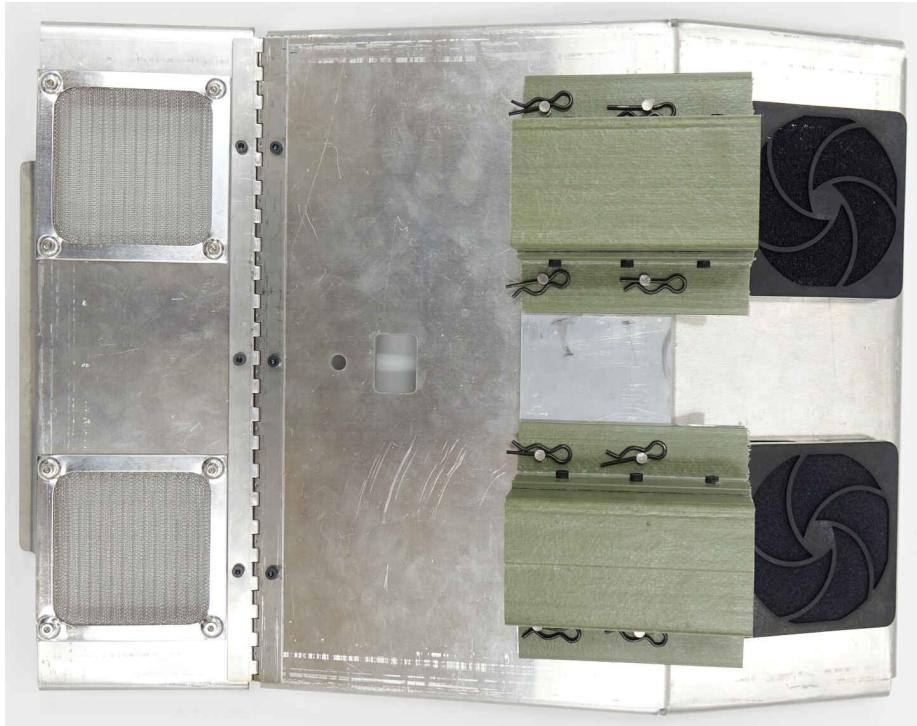
- j. Attach the back panel filters to the compute box back lid using 8 M3×10 screws and 8 M3 nuts.



- k. Attach the compute box lid assembly to the rear hinge panel assembly with 3 M3×mm screws and nuts.

6 COMPUTE BOX LID ASSEMBLY

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## 7 Wire Assembly

### 7.1 Fan Wire Assemblies

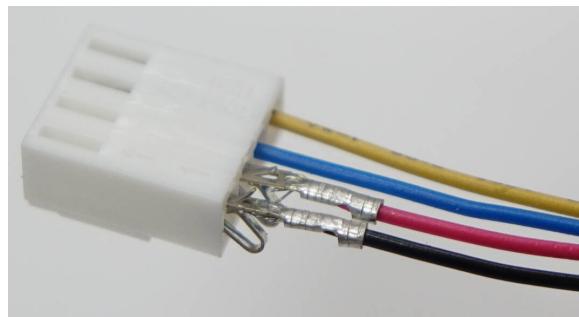
**Time** 0 hours 20 minutes

#### Parts

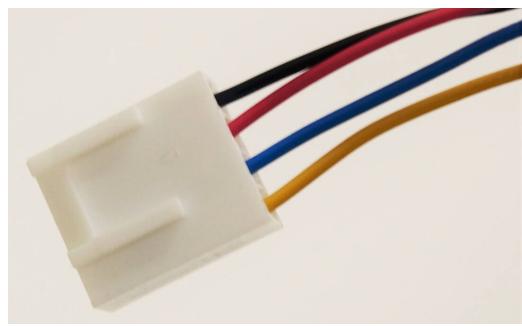
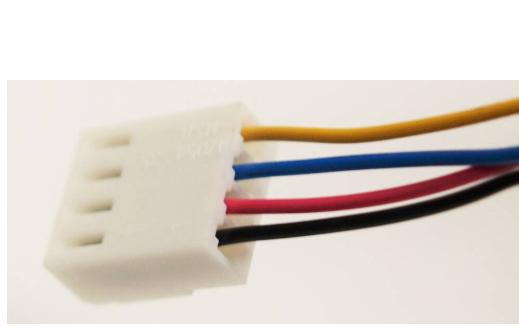
- 22-30 AWG female connector crimps
- 4-pin 2.54 mm female connector housing
- Compute box lid fans

#### Instructions

- a. Cut the exposed ends of the fan leads down to approximately 3 mm.
- b. Carefully crimp the female connector crimps to the fan leads. Ensure that the round “hook” is not crushed by the crimp.



- c. Insert the crimped leads into the housing. You should hear a faint “click” when the connector seats. The photo below shows the correct orientation of the leads with respect to the tabs on the connector housing.



### 7.2 GPS Base Station Power Cable Assembly

**Time** 0 hours 30 minutes

#### Parts

- Hemisphere R330 GPS base station

- Hemisphere R330 power cable, 3 meters
- GPS Base Station AC Adapter with cable
- Heat shrink

#### Instructions

- a. Strip and tin the red and black wires of the Hemisphere R330 power cable.



- b. Cut the barrel plug off of the AC adapter, strip off 1 inch of the outer insulation to expose the two wires. **Be very careful not to cut deeper than the insulation when stripping as the metal braid immediately under the insulation is the ground wire.** Separate the metal braided wire from the center white wire and heat shrink the braided wire together. Tin the ends of the heat shrunk braided and white wires.



- c. Slide a small piece of heat shrink over each wire of the Hemisphere R330 power cable, and a 4 inch long piece of heat shrink over the entire power cable. Solder the red wire of the power cable

to the white wire of the AC adapter and the black wire of the power cable to the twisted and heat shrunk wire from the AC adapter.



d. Shrink all of the heat shrink



e. Plug the AC adapter cable into the AC adapter. Test the power cable by plugging the power cable assembly into the GPS base station and power to verify the GPS base station powers.



### 7.3 Internal GPS Connector

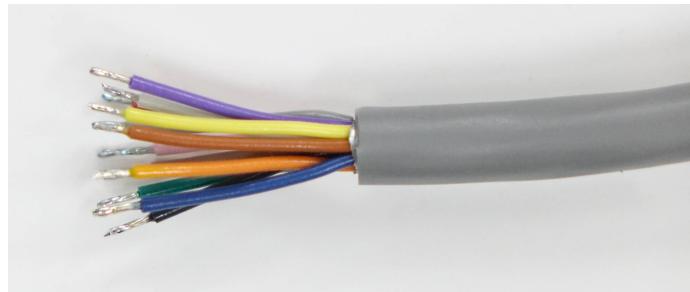
**Time** 1 hours 30 minutes

#### Parts

- 12 inch length of 12-wire cable
- 1 Hirose RM 12-pin panel mount female solder connector
- 1 Hirose RM washer
- 1 Hirose RM nut
- 12 0.1 inch male crimp pins
- 1 2×6 0.1 inch header housing
- Heat shrink

#### Instructions

- a. Remove one inch of insulation and foil from one side of the 12-wire cable.
- b. Strip a small amount of insulation from each of the exposed wires and tin each wire.



- c. Place a small piece of heat shrink over each of the 12 wires and solder each wire to the Hirose RM connector according to the diagram below.

P1: Black

P2: Red

P3: White

P4: Green

P5: Orange

P6: Blue

P7: Brown

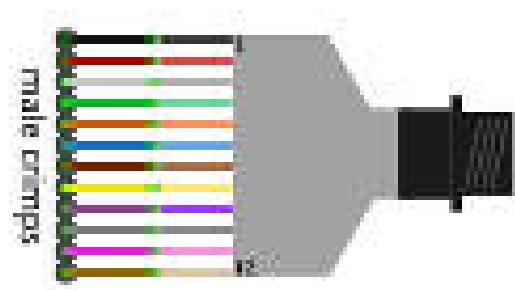
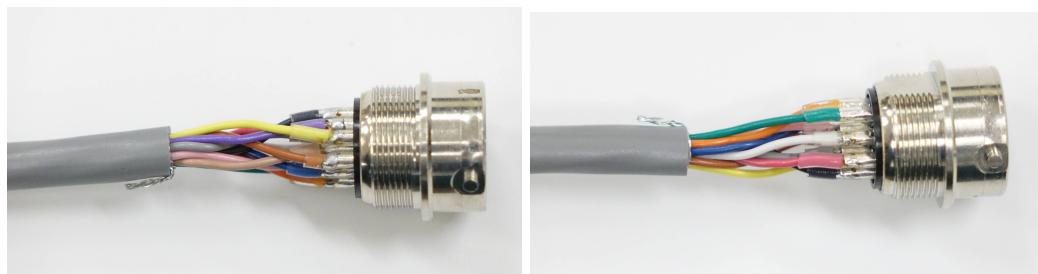
P8: Yellow

P9: Purple

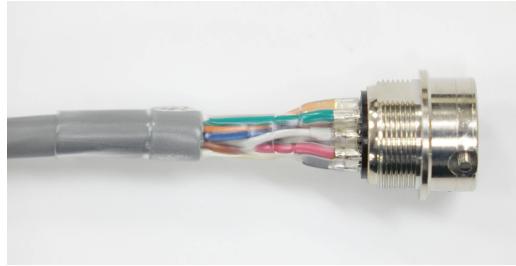
P10: Grey

P11: Pink

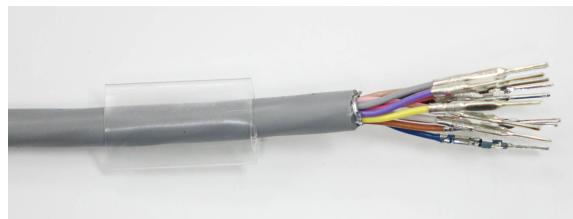
P12: Tan



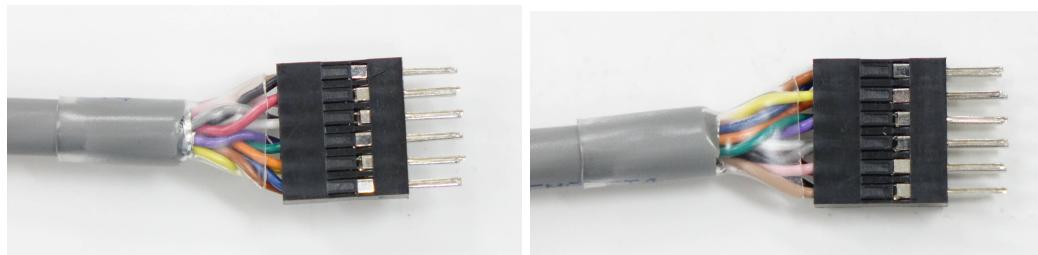
- d. Put a piece of largeheat shrink over the entire cable and wires.



- e. Strip and remove 1 inch of insulation from the opposite side of the cable.
- f. Slide a 1 inch long piece of heat shrink over the cable and crimp one male 0.1 inch pin to each wire.



- g. Install all 12 pins into the 2x6 housing according to the wiring diagram and the images below. Note that pin 1 is inserted in the slot marked with the triangle.



- h. Position all heat shrink and use heat gun to shrink.

## 7.4 Internal GPS Breakout Assembly

**Time** 2 hours 0 minutes

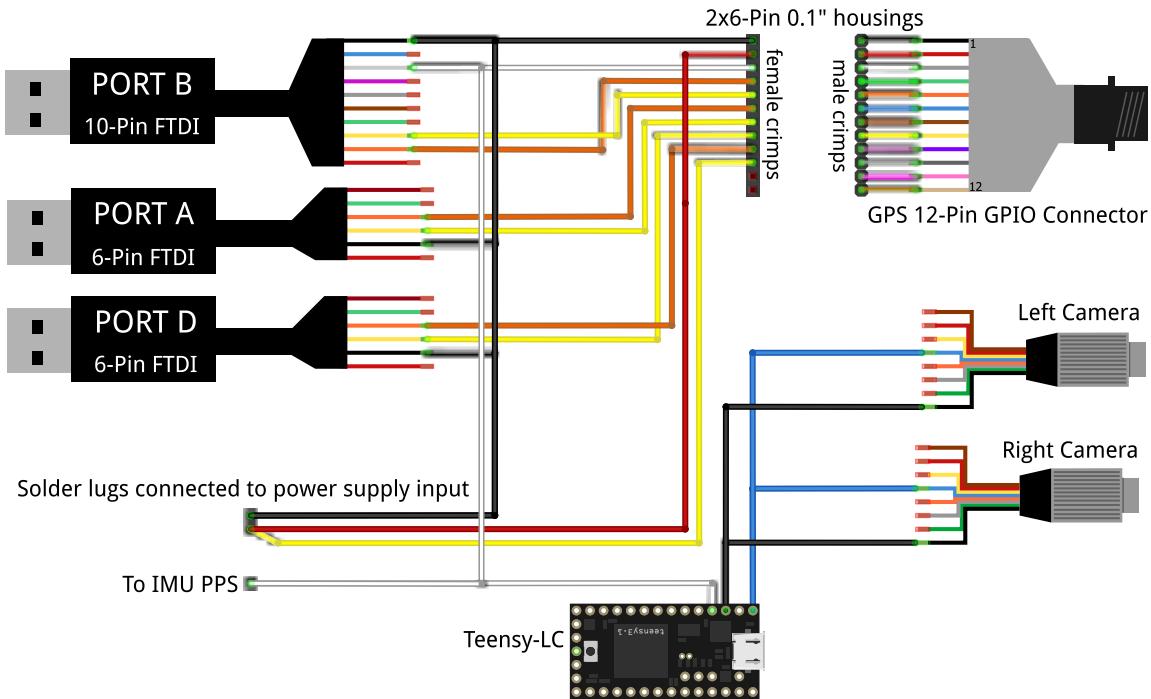
**Parts**

- UART-USB 2.0 3.3V cable, cut to 1 foot long
- 2 × TTL-USB 2.0 3.3V cables labeled Port A and Port B, cut to 1 foot long
- 2 × 6 0.1 inch header housing
- 13 × 0.1 inch female crimp contacts
- Servo cable
- Blue and white wire pieces (can be all blue or white if only one is available)
- 1 1x1 header crimp housings
- 2 1x1 Spade terminal

- 1 2×6 0.1 inch header housing
- Heat shrink

### Instructions

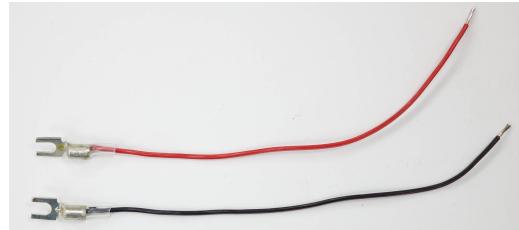
- a. Refer to the compute box wiring diagram below, also available in [wiringDiagrams/](#), throughout this subsection.



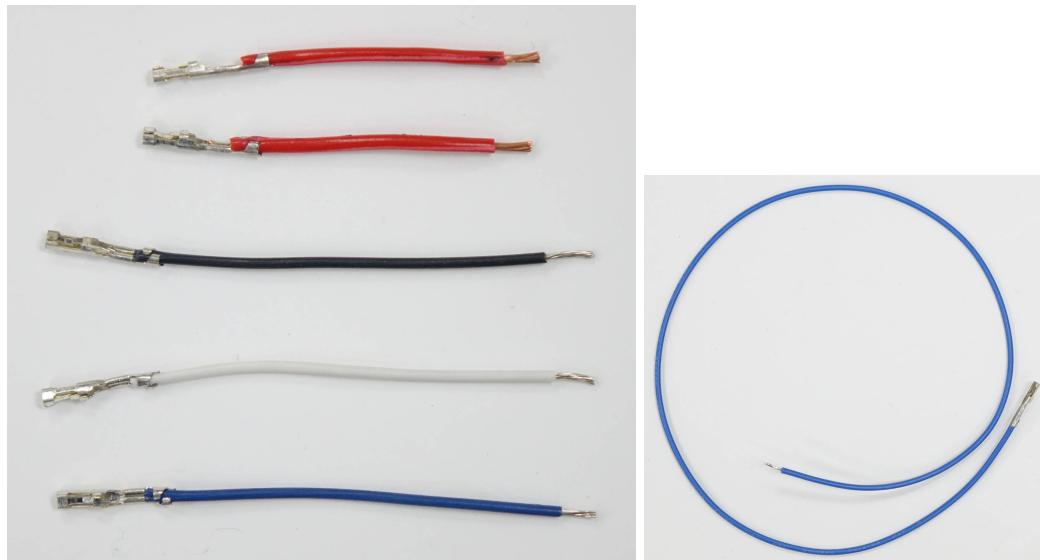
- b. Cut-off approximately half of the thickness of the plastic housing of the UART- USB 2.0 cable as shown in the picture below. This is done in order to accommodate another TTL-USB 2.0 cable into the motherboard Back I/O slots.



- c. Strip 1.5 inch of insulation from the non-USB ends of each of the 3 USB cables.
- d. Crimp 0.1 inch female contacts onto the yellow and orange wires of each of the 3 USB cables.
- e. Cut an 8 inch length of servo cable and separate the wires. On the red and black wires, solder the spade terminals onto one side of the wire along with a piece of heat shrink. Strip and tin the other end of each wire.



- f. Cut  $2 \times 1$  inch long red wire pieces,  $1 \times 1.5$  inch long black wire piece,  $1 \times 1.5$  inch long wire white piece,  $1 \times 1.5$  inch long blue wire piece, and  $1 \times 13$  inch long blue wire piece. Crimp a female crimp to one end of each wire and strip and tin the other end.



- g. Solder and shrink wrap the 2 red wire pieces to the red wire with the spade terminal.



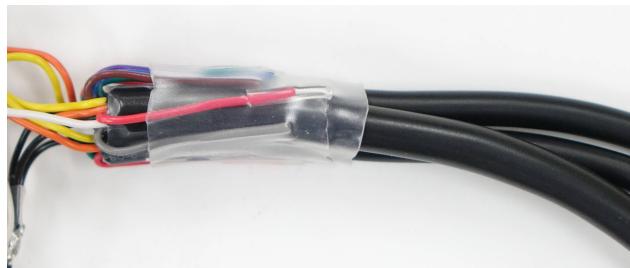
- h. Solder and shrink wrap the black wire piece and the black wire with the spade terminal to all 3 black ground pins from the USB converters.



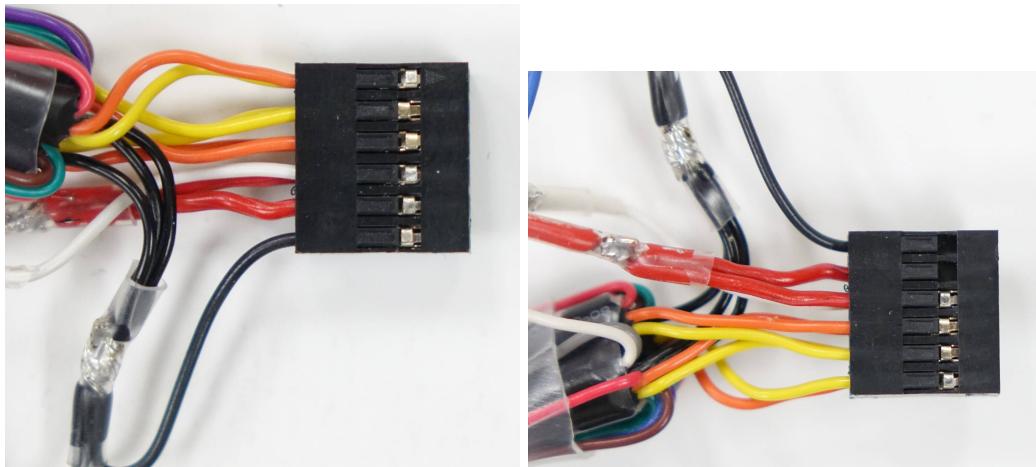
- i. Solder and shrink wrap the blue and white wire pieces to the white wire of the UART-USB (DCD signal wire). This is for the PPS signal that will be sent to the IMU.



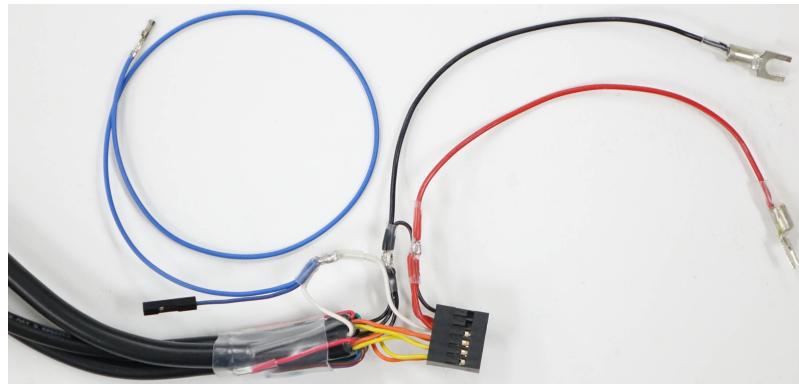
- j. Put a small piece of heat shrink on the end of each uncrimped wire of the USB converters to protect them from shorting. Fold back all wires from the USB cables without crimp housings and use a large piece of shrink around all 3 USB converter cables and folded wires to secure the assembly together.



- k. Insert all crimped wires into the  $2 \times 6$  header housing except the blue wire pieces connected to the white wire of the UART-USB as shown in the compute box wiring diagram. Note that only 10 of the 12 holes in the header housing will be occupied.



1. Install the  $1 \times 1$  header crimp housing onto the shorter of the 2 blue wires connected to the white wire of the UART-USB.



## 7.5 IMU Cable

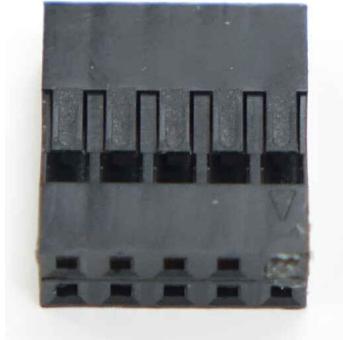
**Time** 1 hours 00 minutes

### Parts

- Mini-DB9 cable with flying leads
- 26 AWG stranded wire
- 12 0.1 inch female crimps
- 1 0.1 inch male crimp
- $1 \times 4$  0.1 inch header housing
- $1 \times 1$  0.1 inch header housing
- $2 \times 5$  0.1 inch header housing
- 0.1 inch header keying plug
- Heat shrink

### Instructions

- a. Put a small amount of epoxy on the keying plug, and insert it into the hole on the connector marked with the triangle. The pin should be inserted on the side closest to the triangle. The keying plug will not be flush with the header housing. After the epoxy sets, use a razor to cut off the part of the keying plug that sticks out.



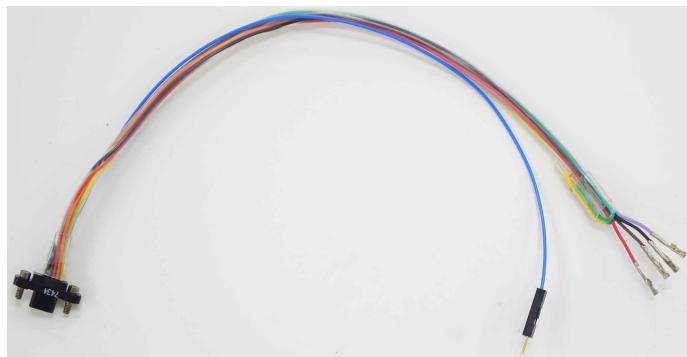
- b. Cut 12 inch lengths of red, black, blue, and yellow wire . Crimp female crimp connectors to both ends of each length of wire. Insert one end of each into the  $1 \times 4$  housing. **When looking at the housing from the wiring end, the order of wires from right to left is: ground, USB D+, USB D-, and Vcc.** Insert the free end of the cables into the row of the keyed header housing. **The wire nearest the keyed hole should be ground. From there, the remaining wires are, in order: USB D+ (blue), USB D- (yellow), and Vcc (red).**



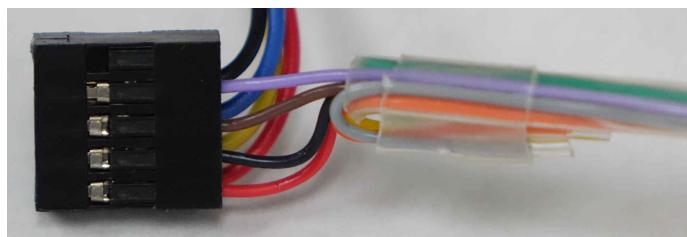
- c. Cut half the length of the wires off of the Mini-DB9 cable with flying leads. Crimp 0.1 inch female crimp connectors to the black, red, violet, and brown wires of the IMU cable. Crimp a 0.1 inch male crimp connector to the blue wire of the IMU cable.

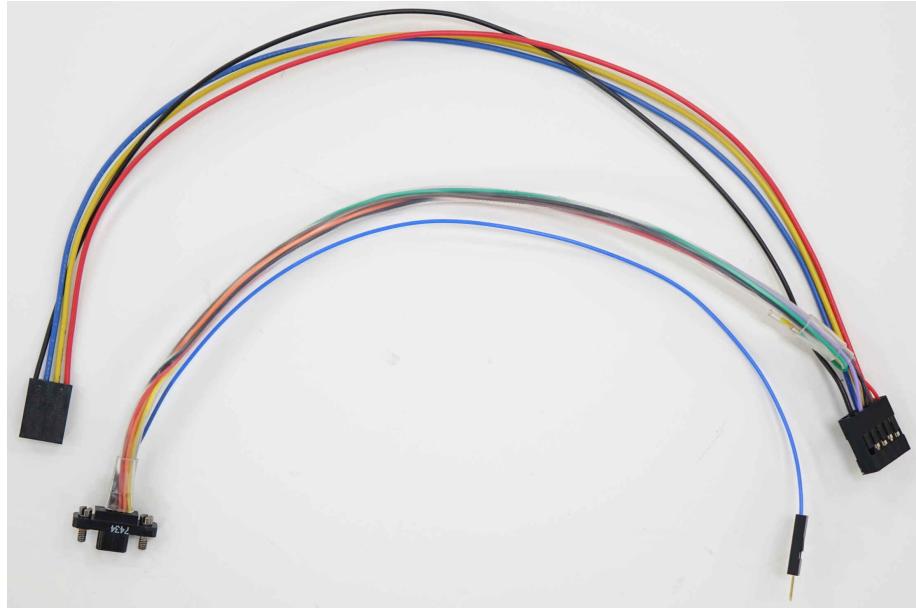


- d. Heat shrink the tips of each of the unused wire. Then, heat shrink the whole length of the entire set of wires **except the blue lead** together, making sure to fold down the unused wires into the heat shrink so that they are secured.



- e. Insert the blue wire with the male crimp into a  $1 \times 1$  0.1 inch header housing. Insert the 4 wires with female crimps into the second (unkeyed) row of the  $2 \times 5$  keyed header housing. **The violet wire lead should be directly under the ground lead inserted in the previous step. From there, the remaining wires are, in order: brown, black, and red.**





## 7.6 Power Switch Assembly

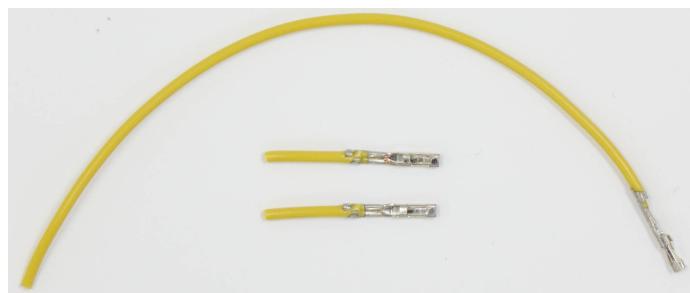
**Time** 1 hours 0 minutes

### Parts

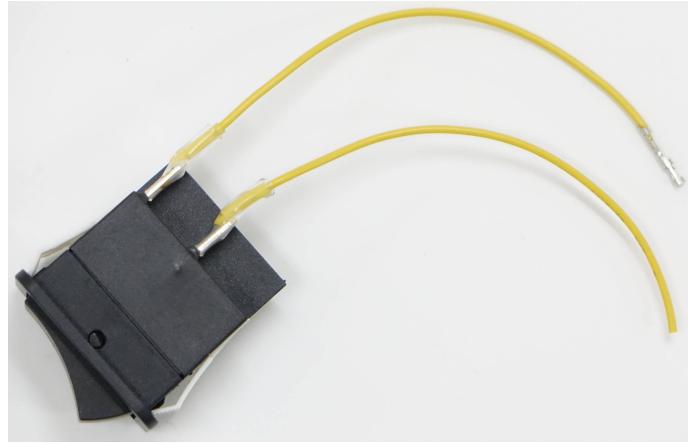
- 1 DPST rocker switch (20A, 125V)
- 3 0.1 inch female crimp contacts
- 1  $1 \times 5$  0.1 inch header housing
- 1  $1 \times 1$  0.1 inch header housing
- 1  $820\Omega$  resistor
- 26 AWG yellow wire
- Heat shrink

### Instructions

- a. Cut 2, 4 inch pieces of yellow wire and 2, 1/2 inch pieces of wire.
- b. Crimp a female contact to one end of one of the 4 inch wires and each of the 1/2 inch wires.



- c. Solder and heat shrink the 4 inch wires to pins 1 and 2 of the rocker switch.



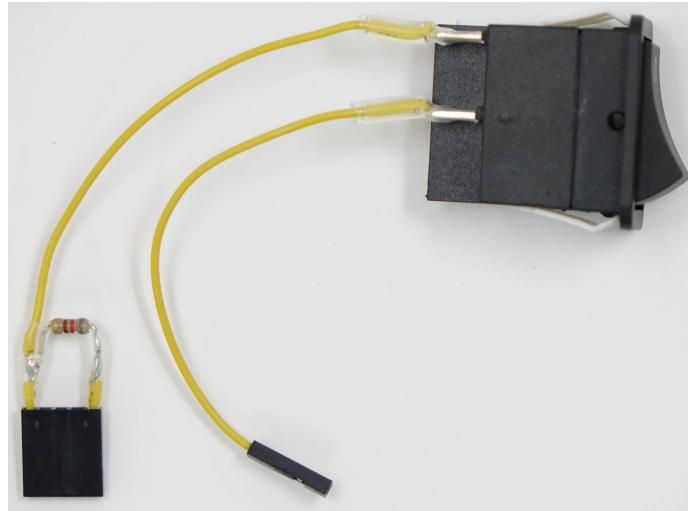
- d. Solder one of the 1/2 inch wires to one side of the resistor. Solder the other side of the resistor and the uncrimped 4 inch wire from the switch to the remaining 1/2 inch crimped wire.



- e. Put heat shrink over all exposed wires and solder joints.



- f. Insert the 4 inch wire with a crimped contact from the switch into a 1x1 header housing and insert the two remaining crimps into the ends of the 1x5 header housing.



## 7.7 Power Y-Splitter

**Time** 0 hours 15 minutes

### Parts

- Mini-Box Y-PWR power splitter
- 1 row of 9 0.1 inch through-hole header pins

### Instructions

- a. Solder the header pins to the H2 header holes on the YPWR.



## 7.8 Power Y-Splitter Cables

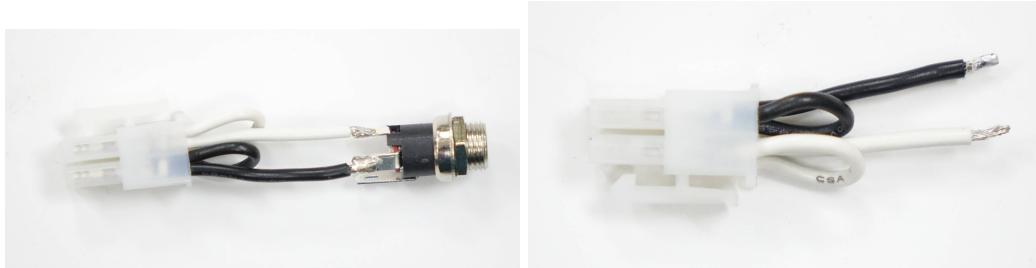
**Time** 0 hours 20 minutes

### Parts

- 1 8 inch 4-pin ATX power cable included with Y-PWR power splitter
- 1 4-pin power cable to barrel jack included with Y-PWR power splitter
- 1 Hirose RM 2 position female panel mount receptacle.
- 16 AWG red wire
- 16 AWG black wire
- 2 spade terminals
- 2 male 6.5 mm bullet connectors
- Heat shrink

**Instructions**

- a. Remove the insulation and desolder the barrel jack from the cable.



- b. Add heat shrink and solder the black wire that was connected to the barrel jack to pin 1 and the white wire to pin 2 of the Hirose RM panel mount receptacle.



- c. Cut the 8 inch 4-pin ATX power cable in half.

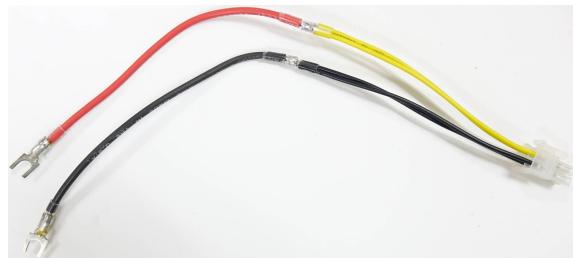


- d. Cut a 3 inch piece of red and black 16 AWG wire. Solder the ground wires of the remaining 4-pin ATX cable half to one end of the 16 AWG black wire, and solder the positive wires (yellow) to the red 16 AWG wire. Slide pieces of heat shrink over the exposed contacts and apply the heat shrink using a heat gun. Then, slide a piece of heat shrink over each of the end of the 5 inch 16 AWG wires. Solder a male 6.5 mm bullet connector onto the exposed end of the 16 AWG wires. Finally, apply the heat shrink using the heat gun.



- e. Cut a 5 inch piece of red and black 16 AWG wire. Solder the ground wires of the remaining 4-pin ATX cable half to one end of the 16 AWG black wire, and solder the positive wires (yellow) to

the red 16 AWG wire. Slide pieces of heat shrink over the exposed contacts and apply the heat shrink using a heat gun. Then, slide a piece of heat shrink over each of the end of the 5 inch 16 AWG wires. Solder a lug onto the exposed end of the 16 AWG wires. Finally, apply the heat shrink using the heat gun.



wire

## 7.9 Power Button, Reset Button, SSD LED

**Time** 0 hours 30 minutes

### Parts

- 1 Power button
- 1 Reset button
- 1 SSD activity LED
- 4 6.5 inch length of yellow 26 AWG wire
- 1 6.5 inch length of black 26 AWG wire
- 1 6.5 inch length of red 26 AWG wire
- 8 female 0.1 inch crimp contacts
- 4 1×2 header housings
- Yellow heat shrink
- Red heat shrink
- Black heat shrink

### Instructions

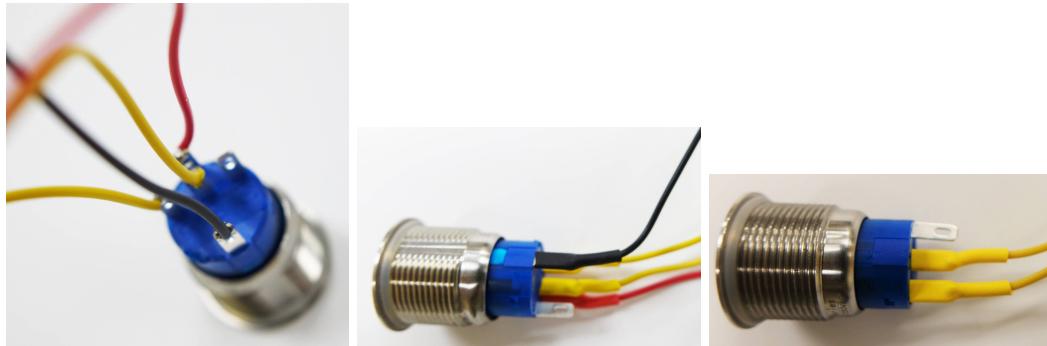
- a. Crimp female contacts to the wires of the LED. Insert the crimped ends into a 1×2 housing.



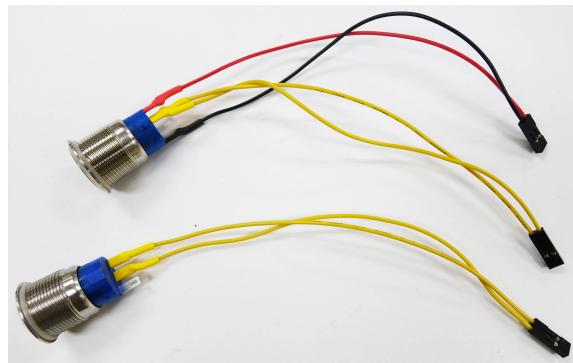
## 7 WIRE ASSEMBLY

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- b. Solder the red wire onto the positive contact of the power button. Cover the contact and exposed wire with red heat shrink.
- c. Solder the black wire onto the ground contact of the power button. Cover the contact and exposed wire with black heat shrink.
- d. Solder the yellow wires onto the normally open (NO) and common (C) contacts of the power button. Cover the contact and exposed wire with yellow heat shrink. Repeat for the NO and C contacts of the reset button.



- e. Crimp female contacts onto the free ends of all wires soldered to the power and reset buttons. Insert the crimps into the housings.



## 7.10 Camera Trigger Cable Assembly

**Time** 0 hours 30 minutes

### Parts

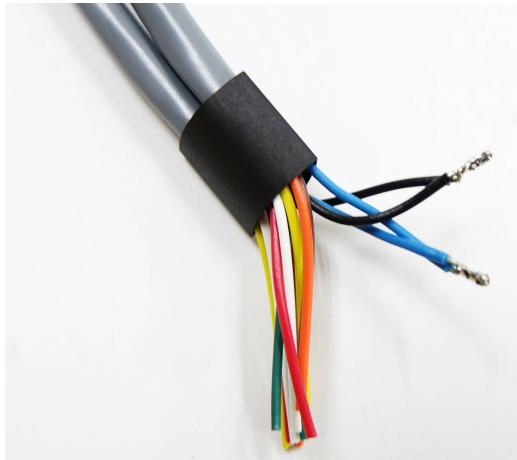
- 2 Hirose GPIO cables, 8 pins, 1m (if using Flea 3 cameras)
- 2 Hirose GPIO cables, 6 pins, 1 m (if using Blackfly S cameras)
- 2 0.1 inch female crimp connectors
- 1 4×1 header housing
- Heat shrink

### Instructions

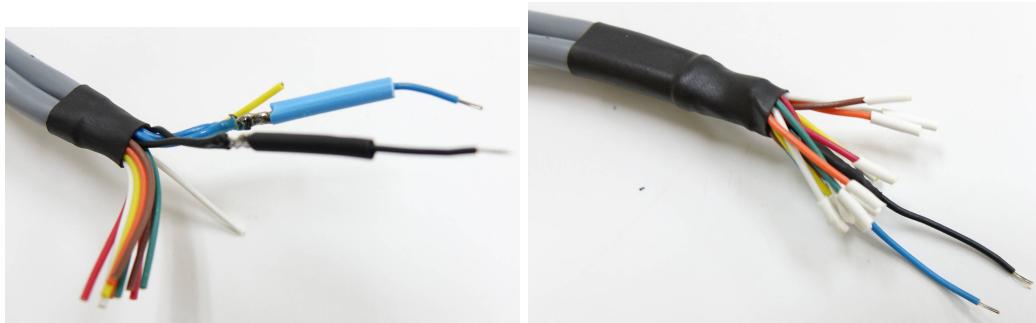
- a. Cut the GPIO connectors down to a 17 inch length. Remove 1.5 inch of insulation from the end to reveal the individual leads making up the cable.



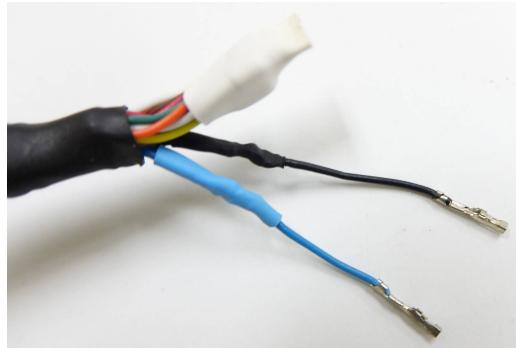
- b. Strip a small amount of insulation off of the black and light blue leads. Twist the exposed portion of the black leads of the two cables together and repeat for the light blue leads. Put a small amount of solder on the combined leads to hold them together.



- c. Slip a large piece of heat shrink so that it is half across the gray portion of the cables and half across the individual leads. Individually cover the tips of the unused leads with heat shrink.
- d. Cut off a 1.25 inch length of light blue and black wire **from another source**. Solder this onto the combined light blue and black leads to create a 1 inch (approximately) extension. Cover the exposed solder joints with heat shrink.



- e. Cover all the unused, heat-shrink-covered leads with a single larger piece of heat shrink. Crimp a 0.1 inch female connector to the extended (black and blue) leads.



- f. The triangle on the 4×1 header housing marks pin 1. Insert the blue lead into pin 1 and the black lead into pin 3.



## 7.11 Shore Power Cable

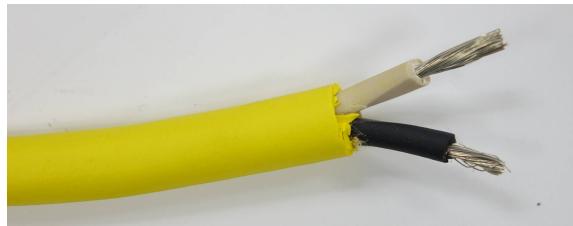
**Time** 1 hours 0 minutes

### Parts

- 10 feet of yellow power cable, 16 AWG wires
- Hirose RM 2 pin plug
- 2 4mm male banana plugs
- Heat shrink

### Instructions

- a. Strip 1/2 inch of outer insulation from one end of the 16 AWG power cable and tin the end of the black and white wires. **Be careful not to damage the insulation on the inner conductors while stripping off the outer layer of yellow insulation.**



- b. Solder the black wire of the 16 AWG power cable to pin 1 of the Hirose RM 2 pin plug. Solder the white wire of the 16 AWG power cable to pin 2 of the Hirose RM 2 pin plug.



- c. Shrink a 1 inch long piece of heat shrink over the soldered pins up to the back of the plug. Slide the back of the plug housing onto the wire.



- d. Screw the back of plug housing in place and secure with set screw. Tighten cable clamp around power cable.



- e. Strip about 3 inch of the other end of the 16 AWG power cable. Solder a 4 mm male banana plug onto each of the conductors.



- f. Slide short lengths of red and black heat shrink over the positive and ground wires respectively where the 4 mm banana plugs are soldered.
- g. Cut a 1 inch piece of yellow heat shrink and slide it over the the 4mm banana plugs such that half of it covers the yellow cable insulation and half covers the wires. Use heat gun to shrink wrap as shown.
- h. Perform a continuity test to ensure there are no shorts in the cable



## 7.12 RunStop Button Box Assembly

**Time** 1 hours 0 minutes

### Parts

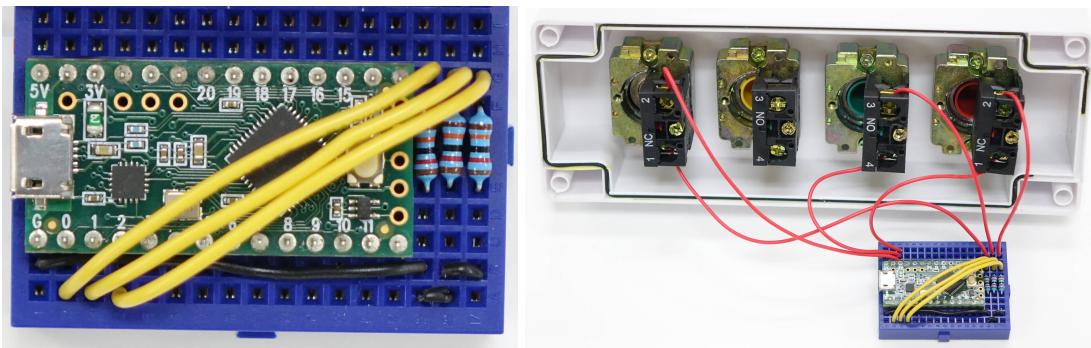
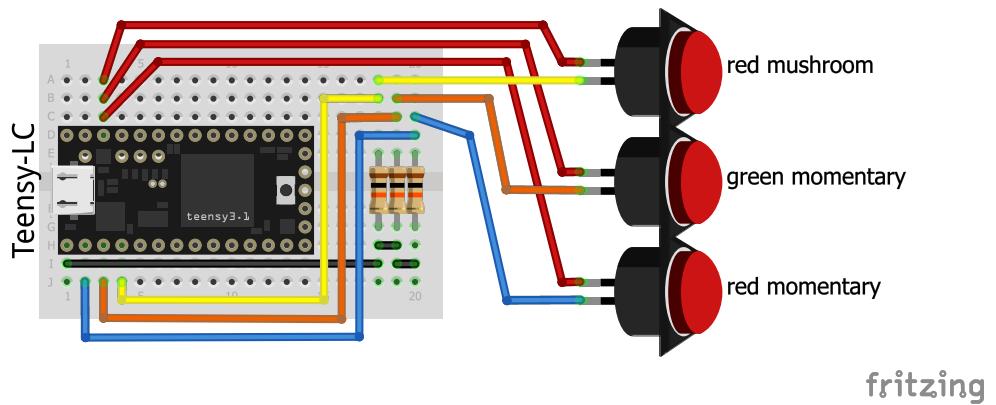
- Button box (base and lid) and included screws
- Teensy-LC
- Tiny Breadboard
- Xbee 900 Pro HP
- Xbee Adapter Board
- 900 MHz duck antenna
- 3 10kΩ resistors
- 3 foot USB A to mini-B cable for Xbee
- 3 foot USB A to micro-B cable for Teensy
- Red, black, and yellow 26 AWG wire
- Zip tie saddle and zip tie

### Instructions

- a. Use the Arduino IDE to compile the RunStop program from the AutoRally repository and upload to the board. If you are using a Teensy LC, the file to use is *autorally/autorally\_core/src/RunStop/RunStop\_teensy/R*
- b. Open the button box. Drill a hole through the top side of the black button box base for the Xbee antenna. A 1/4 inch drill bit works well. Ensure that the hole is drilled such that the Xbee antenna connector passes through the hole. Cut an X into the rubber insert on the other end of the black button box base.



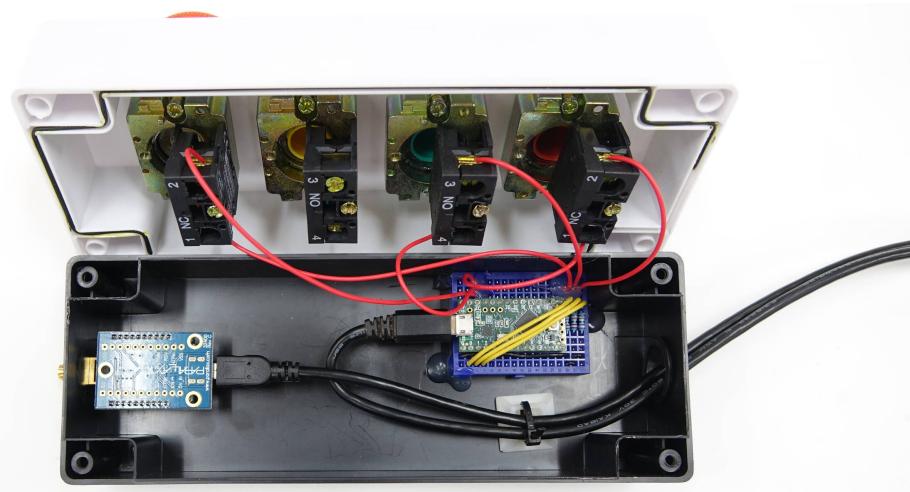
- c. Using the AutoRally Runstop Schematic, also available in [wiringDiagrams/](#), setup the Teensy LC with the resistors and wiring on the Tiny Breadboard and then attach leads from the proto-board to the appropriate terminals of the buttons on the lid of the box. **If no solid core wire is available, pieces of 26 AWG stranded wire with tinned tips fits nicely into the breadboard.**



- d. Attach the Xbee to the to the Xbee Adapter Board and then panel mount the Xbee through the drilled hole using the nut and washer included with the Xbee.



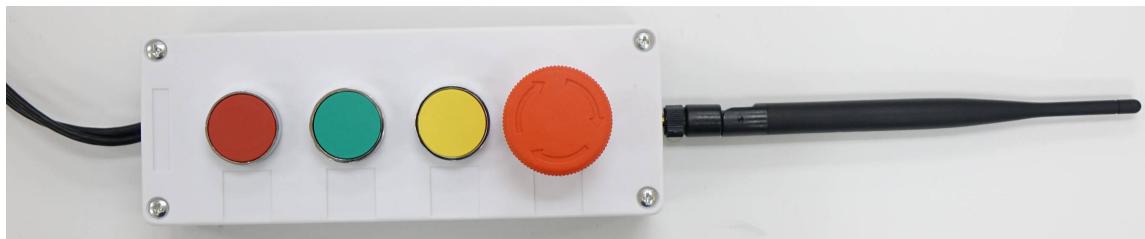
- e. Place the Tiny Breadboard into the black box base opposite the Xbee with the USB micro-B connector facing the Xbee. Secure the Tiny Breadboard to the box base using the tape backing, if present, or dabs of hot glue on the sides. **Wires going into the breadboard can also be secured with a dab of hot glue** Route the mini-B and micro-B USB cables through the cut rubber insert, and plug into each device. Use a zip tie saddle and zip tie close to the cut rubber insert to secure the cables to the black box base.



- f. Test the microcontroller functionality by plugging the microcontroller into a computer and opening the Serial Monitor in the Arduino IDE. As you press the red and green momentary buttons and the red mushroom button is latched and unlatched, the messages visible in the Serial Monitor should be changing appropriately. After a red button press (momentary or mushroom), the signal should remain red until the green momentary button is pressed. If this functionality is not correct, there is likely a wiring error.
- g. Close the box by connecting the two halves and screwing in the four screws. The red mushroom button should be closest to the protruding Xbee antenna connector. Attach the 900 MHz duck antenna to the Xbee antenna connector.

## 7 WIRE ASSEMBLY

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## 8 Installation and Routing

### 8.1 Microcontroller

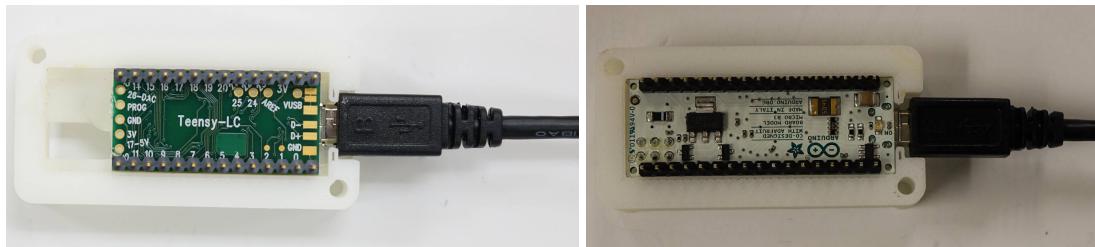
**Time** 0 hours 20 minutes

#### Parts

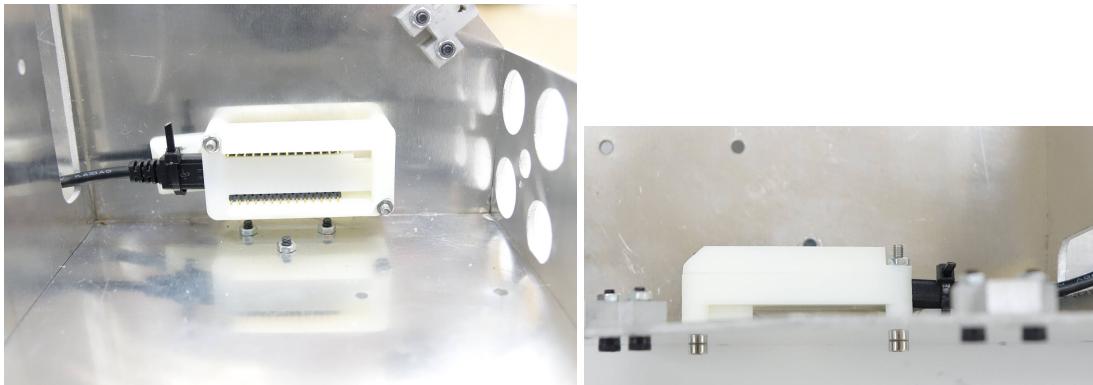
- AutoRally compute box base
- Teensy LC or Arduino Micro
- 3D printed microcontroller holder with lid
- USB A to micro-B cable, 1.5 ft
- 2 M3×25 mm screws
- 2 M3 nuts
- 1 zip tie saddle
- 1 zip tie

#### Instructions

- a. Use the Arduino IDE to compile the camera trigger program from the AutoRally repository and upload to the board. If you are using a Teensy LC, the file to use is *autorally/autorally\_core/src/camera\_trigger/camera\_trigger.ino*. If you are using an Arduino Micro, the file to use is *autorally/autorally\_core/src/camera\_trigger/camera\_trigger.ino*.
- b. Place the Teensy LC or Arduino Micro in the 3D printed microcontroller holder and plug in the 1.5 ft USB A to micro-B cable. Note that the lid of the holder is directional and must be mounted as shown. If using the Teensy LC, put a small dab of hot glue on the side of the board without the USB connector to hold the Teensy in place.



- c. Mount the entire assembly, with the lid, to the compute box right wall toward the back using two M3×25 mm screws and two M3 nuts. The screws should be inserted from the outside of the box. The USB cable should extend through the vertical slot in the GPU strut. Place a zip tie saddle against the Arduino holder, lining up the top of the saddle and the holder. Zip tie the USB connector itself to the holder.



## 8.2 Power buttons and LED

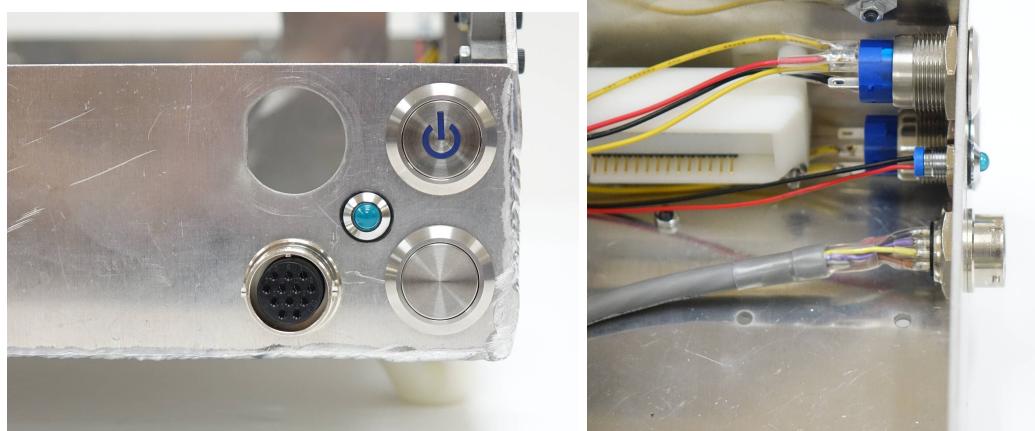
Time 0 hours 30 minutes

### Parts

- AutoRally compute box base
- Reset button assembly with silicone gasket and nut
- Power button assembly with silicone gasket and nut
- SSD LED with gasket, lock nut, and washer
- Panel mount USB 2.0 cable, 0.5m with nut **OR** Internal GPS connector with lock washer and nut, whichever fits the lower left cutout on the right side of the back panel. **The newest design, not pictured, has the USB 2.0 cable on the bottom.**

### Instructions

- a. Panel mount the reset button and power buttons with their included gaskets and nuts, and SSD LED with included lock nut and washer in that order to the back panel of the compute box. **Make sure the power button is oriented correctly.**
- b. Install the panel mount USB 2.0 cable, 0.5m or internal GPS connector, whichever fits into the lower of the 2 remaining mounting holes on the right side of the back panel. **Make sure that the alignment tab of the USB 2.0 cable is on the left, or the alignment tab of the internal GPS assembly receptacle connector is at the top.**



### 8.3 Power Receptacle

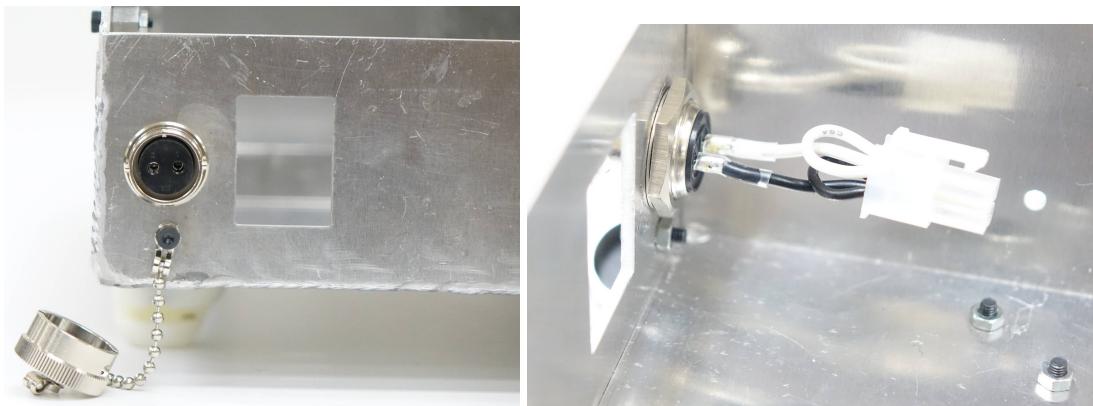
**Time** 0 hours 10 minutes

#### Parts

- AutoRally compute box base
- 1 M3×8 mm screws
- 1 M3 nut
- Panel mount Hirose RM power receptacle cable assembly with lock washer and nut
- Dust cover for Hirose RM receptacle

#### Instructions

- a. Attach the dust cap to the rear panel using one M3×8 mm screw and 1 M3 nut and the panel mount the power receptacle with included lock washer and nut. **Make sure that the alignment tab in the receptacle is at the top.**



- b. Attach the dust cover.



## 8.4 IMU

**Time** 0 hours 10 minutes

### Parts

- Lord MicroStrain 3DM-GX4-25 IMU
- IMU cable assembly
- 2 M3×8 mm screws
- 2 M3 nuts

### Instructions

- a. Connect the IMU cable assembly to the IMU.
- b. Slide the IMU wires through the slot in the GPU strut from the back toward the front. Mount the IMU using 2 M3×8 mm screws and 2 M3 nuts with the connector facing toward the front of the box.



## 8.5 Hot Swap installation

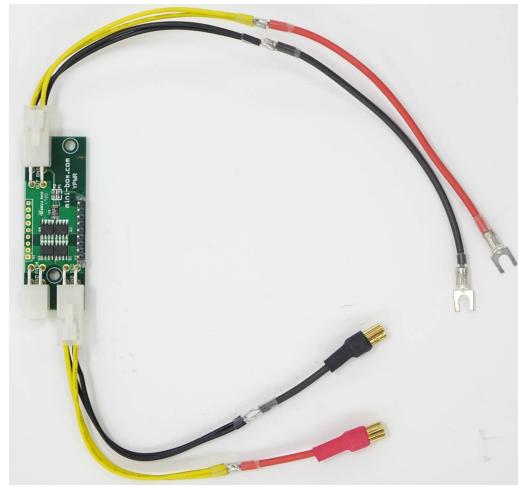
**Time** 0 hours 10 minutes

### Parts

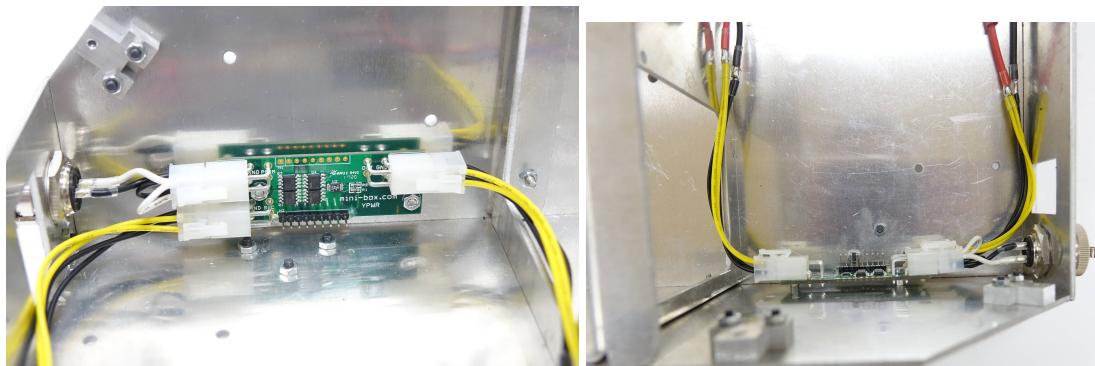
- AutoRally compute box base
- Mini-Box Y-PWR power splitter
- 4 pin ATX to 6.5 mm male bullet cable assembly
- 4 pin ATX to spade terminals cable assembly
- 2 M3×10 mm screws
- 2 M3×4 mm standoffs
- 2 M3 nuts

### Instructions

- a. Plug the 4 pin ATX to 6.5 mm male bullet cable assembly to the SEC connection on the power splitter and plug the 4 pin ATX to spade terminals cable assembly to the OUT connection on the power splitter.



- b. Plug the 4-pin ATX connector from the power receptacle mounted in the compute box base. Mount the Y-PWR power splitter to the compute box base using 2 M3×10 mm screws, 2 M3×4 mm standoffs, and 2 M3 nuts.



## 8.6 Power Supply

**Time** 0 hours 30 minutes

### Parts

- AutoRally compute box base
- Mini-Box M4 ATX power supply
- 3D printed power supply mount
- GPS breakout assembly
- Internal GPS
- 2mm foam
- 6 M3×4 mm standoffs
- 4 M3×12 mm screws

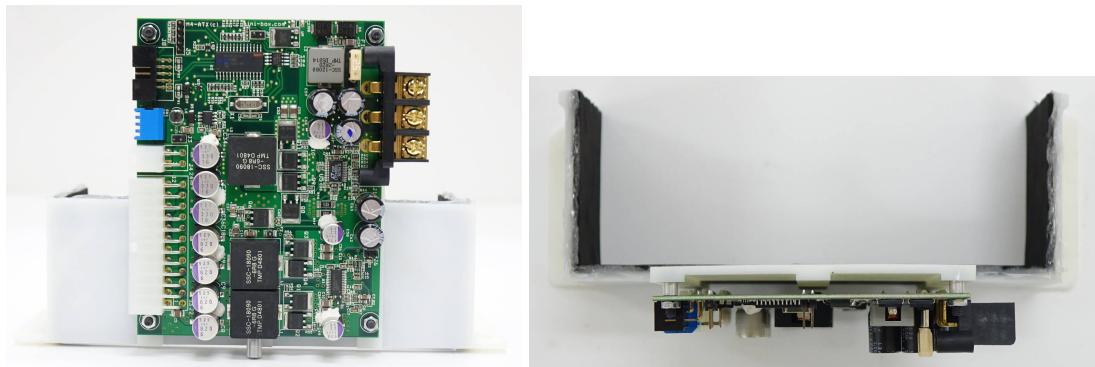
- 2 M3×10 mm screws
- 2 M3×8 mm screws
- 10 M3 nuts

### Instructions

- a. Line the inside of the lower portion of the 3D printed power supply holder with 2mm foam. Use hot glue to attach the foam to the mount. Use one piece of foam with dimensions 6.5 inch×2.25 inch and two pieces with dimensions 2.5 inch×2.25 inch. Also cut and reserve an additional piece with dimensions 6.5 inch×2.25 inch.

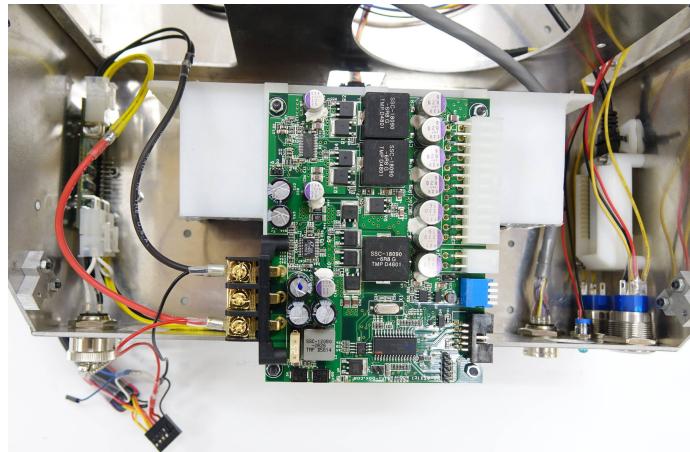


- b. Attach the power supply to the 3D printed power supply mount using 4 M3×12 mm screws, 4 4mm M3 standoffs, and 4 M3 nuts. Attach the 3D printed power supply mount to the compute box base using 4 M3×8 mm screws and 4 M3 nuts. **Depending on fit and finish, this 3D printed part may need to be clipped or cut slightly in the following steps.** After mounting, hot glue the additional piece of foam from the previous step on the compute box wall opposite the 3D printed power supply holder. Cut a slit down the center of the foam on both of the longer sides.

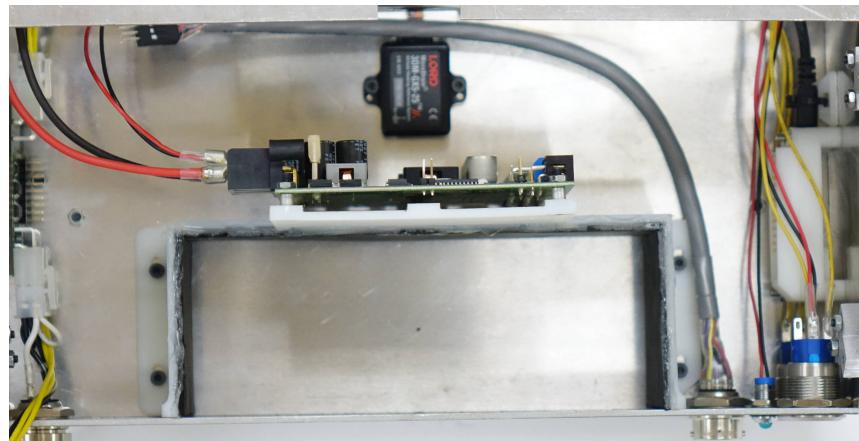


- c. Place the battery holder in the back of the compute box close to its mounting position. Attach the spade terminals from the 4 pin ATX to spade terminal from the installed power splitter and the spade terminals from the internal GPS breakout assembly to the screw terminals on the power supply. The red wires should both be attached to the top screw terminal and both black

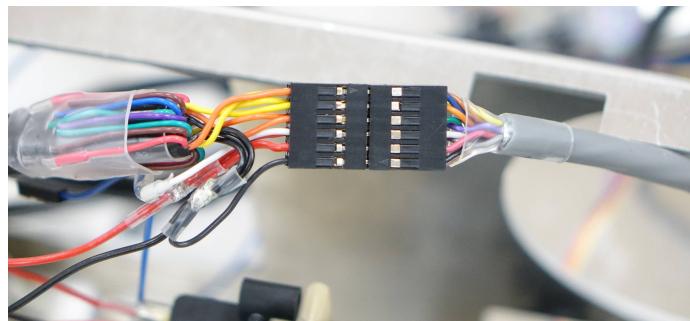
wires should be attached to the bottom terminal. Refer to the M4-ATX power supply manual for more information.



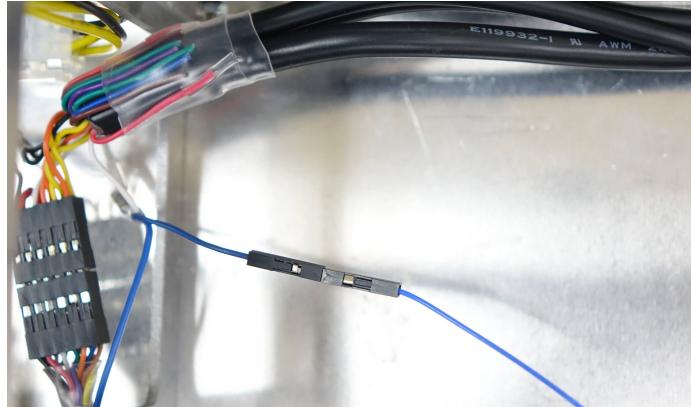
- d. Attach the battery holder to the compute box using 4 M3×8 mm screw and 4 M3 nuts.



- e. Connect the 2×6 connectors of the GPS breakout assembly and the internal GPS connector. Refer to the compute box wiring diagram to ensure proper wire alignment.



- f. Plug the blue wire from the IMU with a 1×1 0.1 inch male crimp into the remaining 0.1 inch 1×1 female crimp housing on the GPS breakout assembly.



## 8.7 Battery power switch and USB

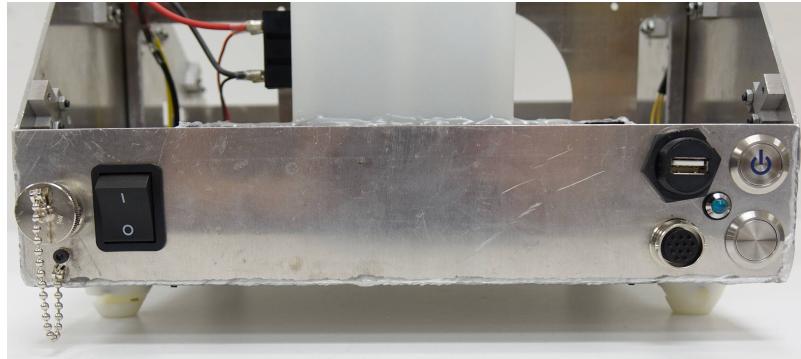
**Time** 0 hours 20 minutes

### Parts

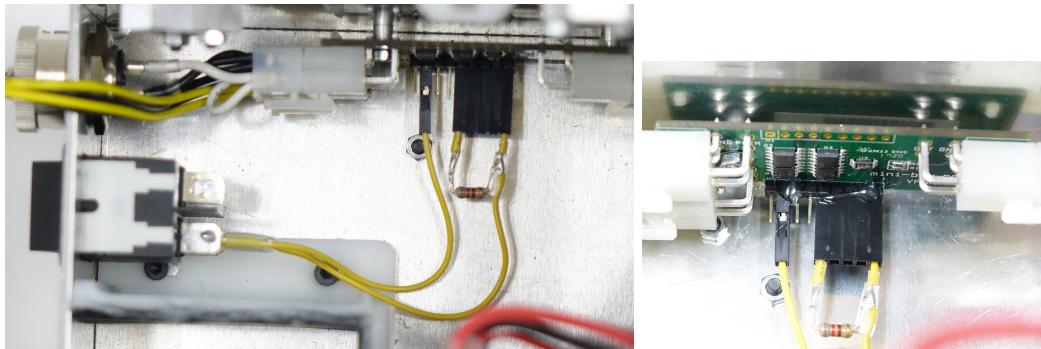
- AutoRally compute box base
- Power switch assembly
- Panel mount USB 2.0 cable, 0.5m OR

### Instructions

- a. Install the power switch assembly by pushing it into place with the “1” facing upward and screw in the panel mount USB 2.0 cable to the rear panel of the compute box.



- b. Plug the 1x5 connector housing from the power switch assembly into the secondary pin header on the power splitter closest to the output pins, with the wire from the switch plugged into last connector (pin 9 of the secondary header), and the connector connected to the resistor into pin 5. Plug the 1x1 header from the power switch into the second pin from the power receptable connection (pin 2 of the secondary header).



Put a dab of hot glue on the connector and board to hold it in place.

## 8.8 Camera Trigger Cable

**Time** 0 hours 20 minutes

### Parts

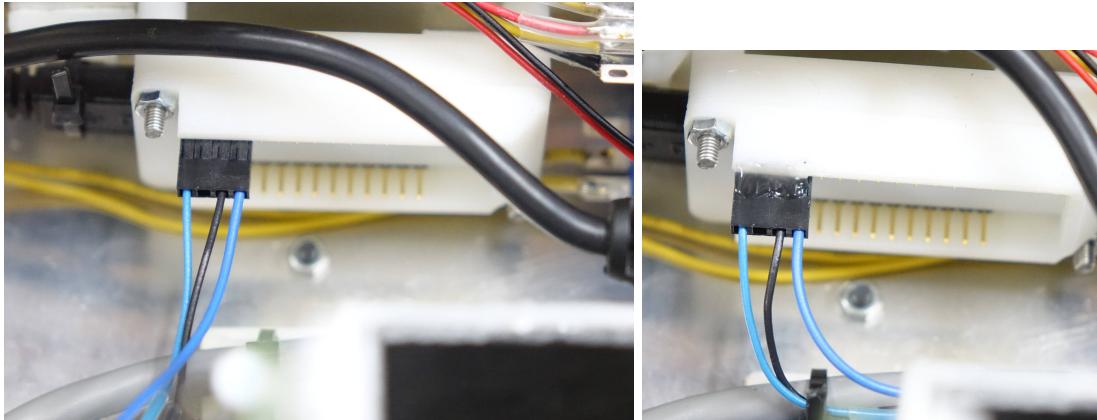
- AutoRally compute box base
- Camera trigger assembly

### Instructions

- a. Plug the 0.1 inch male crimp from the GPS breakout assembly into the outside position next to the black wire of the 1×4 connector housing of the camera trigger assembly.



- b. Plug the 1×4 connector housing of the camera trigger assembly into the microcontroller according the compute box wiring diagram. Put a dab of hot glue on the connector and board to hold it in place.



## 8.9 Wire Management

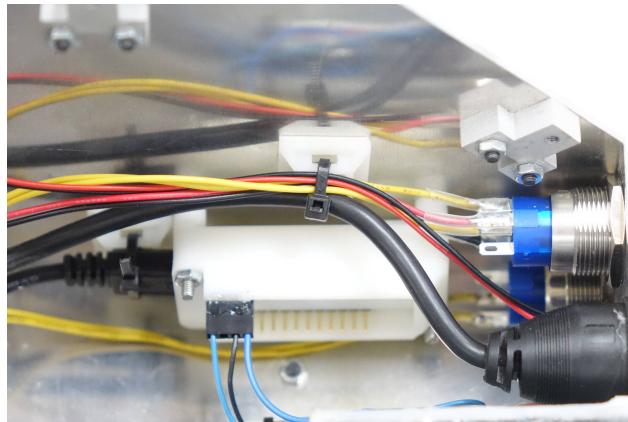
**Time** 0 hours 20 minutes

### Parts

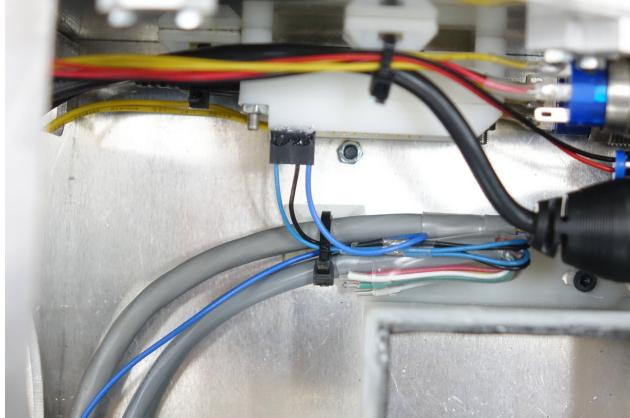
- AutoRally compute box base
- Zip tie saddles
- Zip ties

### Instructions

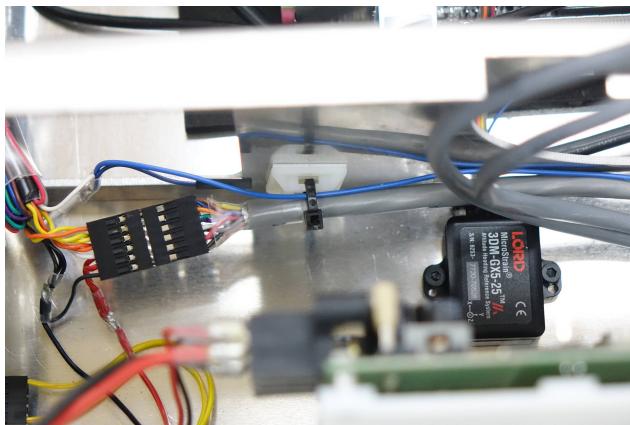
- a. Mount all of the wires from the power buttons and lights, except the reset button, to the inside wall of the compute box along with the panel mount USB 2.0 cable, if it is mounted through the top hole of the back panel.



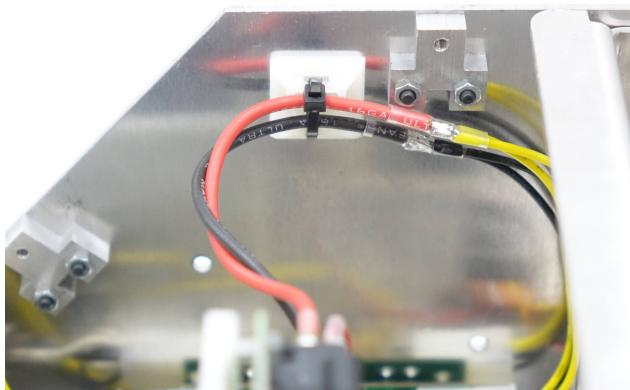
- b. Secure the internal GPS connector, camera trigger assembly cables, and the blue wire plugging into the microcontroller to the bottom of the compute box, along with the panel mount USB 2.0 cable, if it is mounted through the bottom hole of the back panel.



- c. Secure the internal GPS connector and blue wire running to the microcontroller to the GPU strut.



- d. Secure the power wires from the hot swap to the power supply to the inner wall of the compute box above the hot swap.



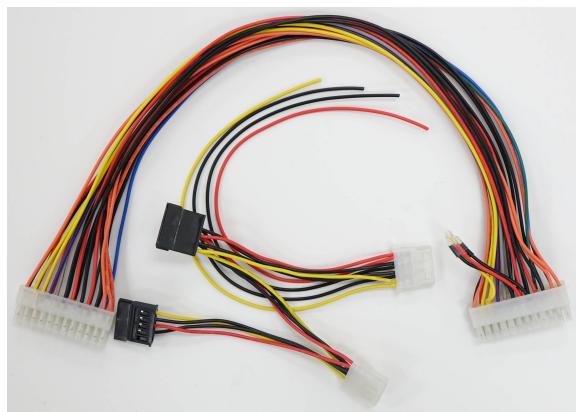
## 8.10 Motherboard and CPU Power Connectors

**Time** 0 hours 10 minutes  
**Parts**

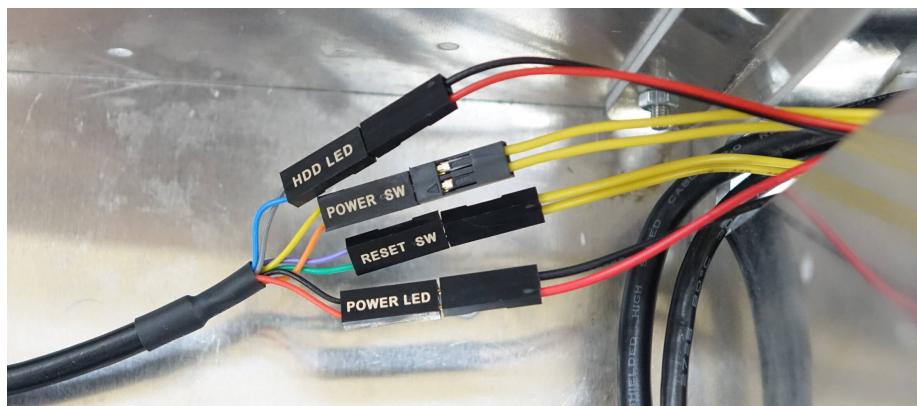
- AutoRally compute box base
- 24-pin ATX motherboard power cable (comes with power supply)
- 4-pin CPU power cable (comes with power supply)
- 4-pin CPU power cable extension
- Panel cable (comes with the motherboard)
- 1 zip tie
- 4 M3×6 mm screws
- 3 M3×8 mm screws
- 3 M3 nuts

### Instructions

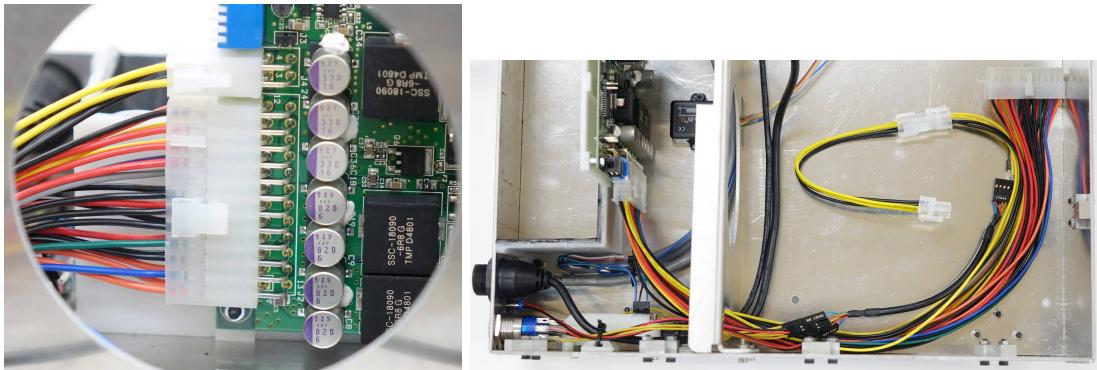
- a. **Optional** if you are only using an M.2 SSD and no SATA SSD, you can cut and heat shrink the SATA power leads off of the 24-pin ATX power cable.



- b. Plug the panel cable into the, power button, reset button, and power LED and and HDD LED. The connectors are marked on wires are marked on the panel cable. Be sure to connect the red wire from each of the LEDs to the corresponding + wire in the panel connector and the black wire from each LED to the – wire of in the panel connector.



- c. Plug the 24-pin ATX power cable and the 4-pin CPU power cables into the power supply. Connect the 4-pin CPU power cable extension to the CPU power cable. Route the cables through the skinny slot on of the GPU support



- d. Plug the  $1 \times 4$  connector from the IMU cable assembly into the power supply.



- e. Place a zip tie around the 24-pin ATX power cable, 4-pin CPU power cable and  $1 \times 4$  connector from the IMU cable assembly, bundling the wires together.



## 8.11 SATA SSD (Optional step if you are installing a SATA SSD)

**Time** 0 hours 10 minutes

### Parts

- AutoRally compute box base
- SATA SSD
- 4 M3×4 mm aluminum spacers, 4.5mm OD
- 4 M3×10 mm screws

### Instructions

- a. Attach the SSD to the compute box wall using 4 M3×4 mm aluminum spacers and 4 M3×10 mm screws with the power and data connections facing the front of the compute box. **One of the mounting holes will likely be blocked by the side body mount, use the remaining 3 mounting holes.** Route the ATX power and 4-pin CPU power cables underneath the SSD.

## 8.12 Motherboard and Computer Components

**Time** 1 hours 15 minutes

### Parts

- AutoRally compute box base
- Mini-ITX motherboard, Asus or ASRock (and included accessories)
- M.2 2280 SSD
- Intel Core i7 CPU
- Noctua L9i CPU cooler
- Thermal paste (included with CPU cooler)
- 32 GB (16 GB×2) DDR4 RAM
- 3D printed RAM holder (Asus or ASRock version for your motherboard)
- Laser cut motherboard foam (Asus or ASRock version for your motherboard)
- 4 M4×6 mm standoffs
- 4 M4×14 mm screws

- 4 M4 washers
- 4 M4 nuts
- 2 M3×20 mm screws

### Instructions

- a. Install the CPU on the motherboard according to directions included with motherboard.



- b. Install the CPU cooler according to the instructions included with the cooler. Ensure that the fan lead points toward the motherboard's USB ports. Plug the fan connector into the CPU Fan header on the motherboard and zip tie the fan wire to the plastic support of the CPU cooler.



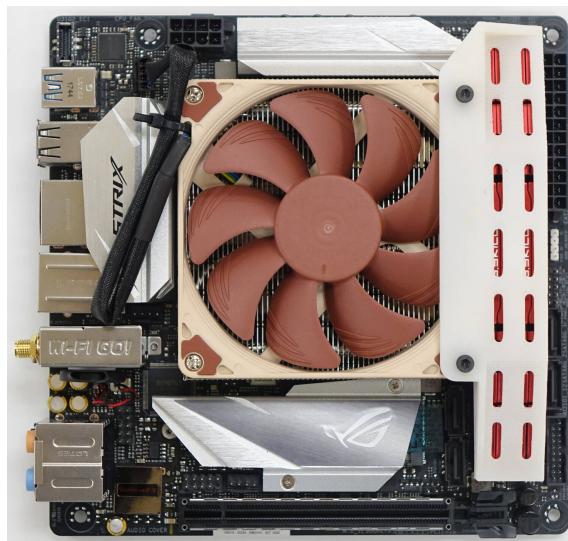
If your motherboard includes an M.2 heatsink on the top of the motherboard, you may have to file away a small portion of the heatsink so that the CPU cooler can be installed successfully.



c. Install the RAM.



d. Remove the two screws on the CPU cooler fan that are nearest the RAM. The RAM holder should press fit snugly against the RAM. Install the 3D printed RAM holder and replace the removed screws with 2 M3×20 mm screws to hold down the RAM holder. **Note that the RAM holder may not fit if the RAM used is not exactly as specified in the AutoRally Parts List.**

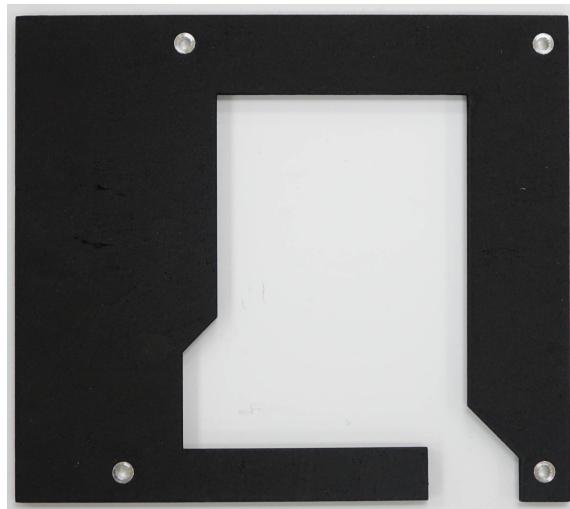


e. Install the M.2 SSD according to the motherboard instructions. Use the M.2 screw kit included

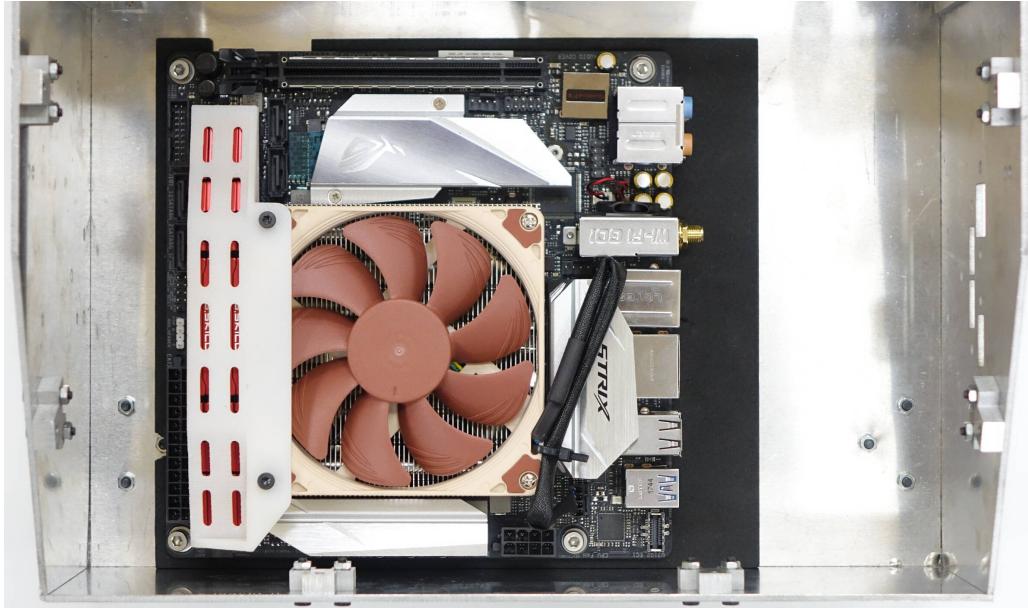
with the motherboard to install the drive. **Depending on your motherboard, the M.2 slot may be on the top or bottom of the motherboard.**



- f. Press 4 M4×6 mm standoffs into the laser cut foam.



- g. Place the motherboard foam and motherboard into the compute box with all of the ports facing to the left. Place a M4 washer and M4×14 mm screw in each of the 4 mounting holes. Secure the screws with 4 M4 nuts on the **underside** of the compute box. **Do not over-tighten to ensure that the motherboard does not bend.**



### 8.13 Motherboard Header Connections

**Time** 0 hours 30 minutes

#### Parts

- AutoRally compute box base
- Noctua NA-SYC1 fan power splitter cable (if motherboard only has one chassis fan connector)
- SATA-3 data cable (if using SATA SSD)
- Zip tie saddles (if using SATA SSD)
- Zip ties (if using SATA SSD)

#### Instructions

- a. Plug the system panel connector in to the system panel header on the motherboard.



- b. Plug the 2x5 keyed connector from the IMU cable assembly into the USB2 header on the motherboard. Depending on your motherboard the placement of this header will vary.



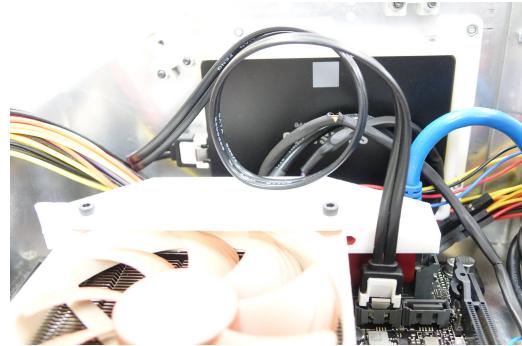
- c. **Optional if your motherboard has only 1 chassis fan connector (usually marked CHA\_FAN)** Install the Noctua NA-SYC1 fan power splitter cable into the chassis fan header.



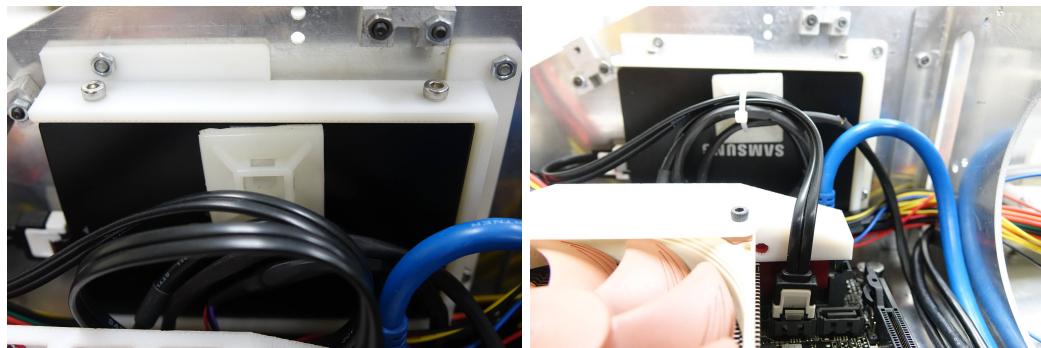
- d. Route the 4-pin ATX CPU power cable under the SSD, if present, and around the outside of the motherboard. Plug it into the ATX CPU power connector on the motherboard, pushing until it clicks. Route the 24-pin ATX motherboard power cable under the SSD and over the 4-pin connector, loop it around as shown in the photo, and plug it into the power connector on the motherboard. Push it in carefully until it clicks.



- e. **Optional if using a SATA SSD.** Plug one end of the SATA data cable into the SATA SSD. Plug the other end into one of the motherboard's SATA ports, looping the cable as shown in the photo if it is too long.



- f. **Optional if using a SATA SSD.** Place a zip tie saddle directly on the SSD. Zip tie the SATA data cable, the panel mount USB cable, and the IMU cable as shown in the photo below.



- g. **Optional if using a SATA SSD.** Plug one of the SATA power extensions on the 24-pin ATX power cable into the SATA SSD. Hot glue the remaining connectors to block exposed pins. Tuck the cables into the corner of the compute box, making sure not to stress the motherboard or the cables.



## 8.14 USB Connections

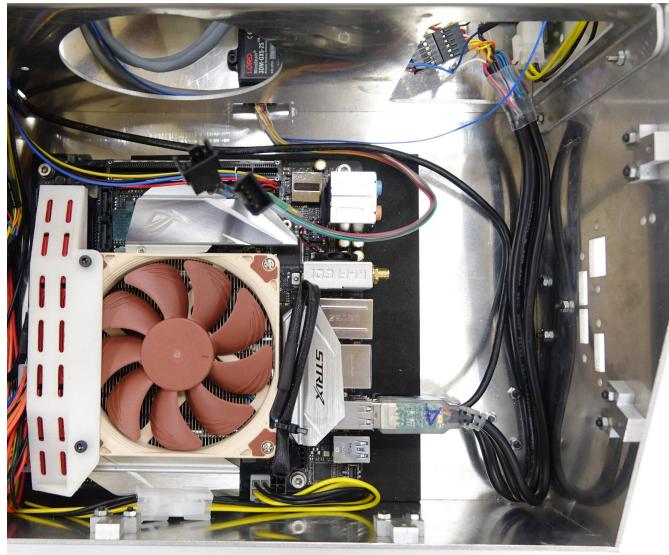
**Time** 0 hours 20 minutes

### Parts

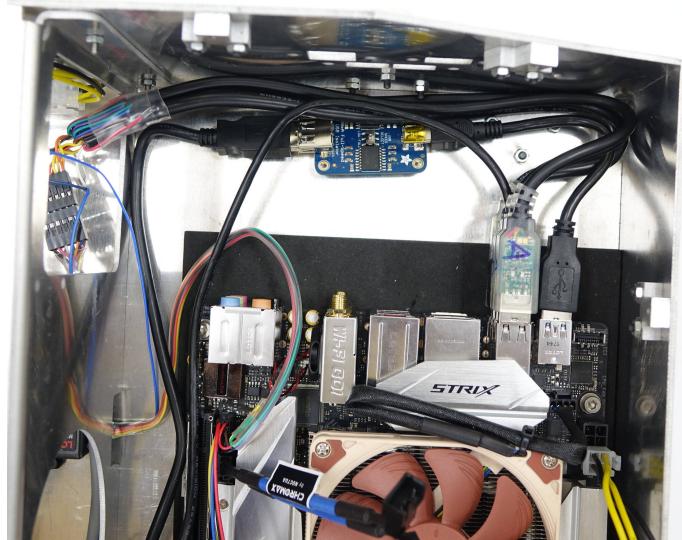
- AutoRally compute box base
- USB Isolator, Sealevel
- USB A to B cable, 1.5 ft

### Instructions

- a. Plug the 3 USB converters of the internal GPS breakout assembly into a USB 2.0 stack (USB 3.0 is also OK if 2.0 is not available). The 10-pin UART should be on the bottom of the stack to fit best.
- b. Plug the USB cable from the microcontroller into a USB 2.0 port, if available. A USB 3.0 port also works.



- c. Route the panel mount USB 2.0 cable between the motherboard and the GPU strut. Plug the end of the USB 2.0 panel mount into one side of the USB Isolator. Connect the USB A to B, 1.5 ft cable to the USB isolator. Plug the isolator USB cable into an open USB port on the motherboard. The USB isolator may have to be connected to the GPU stabilizer with double sided sticky foam or zip ties to the cross brace, to be installed later.



## 8.15 XBee

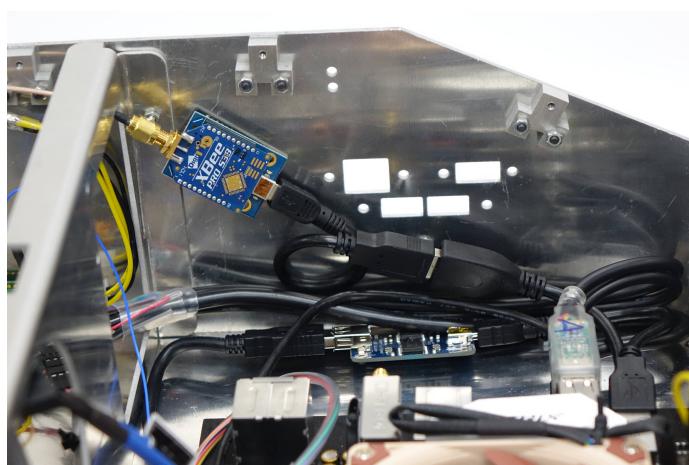
**Time** 0 hours 10 minutes

### Parts

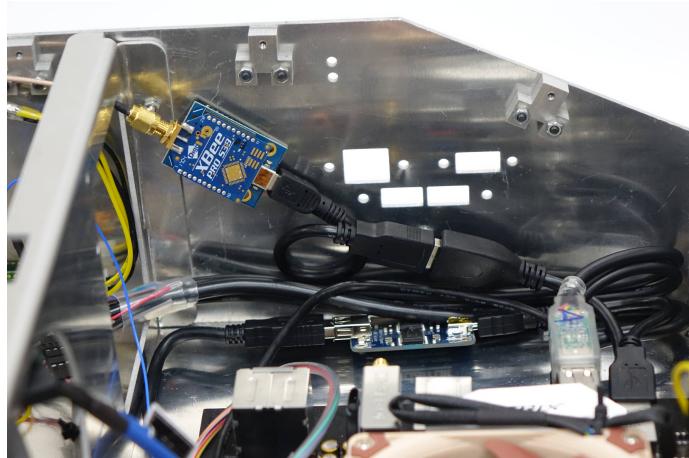
- AutoRally compute box base
- XBee Pro 900 HP
- Xbee Adapter Board
- USB A to mini-B cable, 6 inch
- USB A female to C male 50mm cable (if motherboard has USB C)
- 12 inch RP-SMA antenna cable

### Instructions

- a. Connect the XBee to the adapter board. Connect the 12 inch RP-SMA antenna cable to the Xbee.



- b. Use the 6 inch USB A to mini-B cable to connect the Xbee adapter board to an open USB port on the motherboard, making sure to keep 2 USB 3.0 ports open for connecting the cameras later. **If your motherboard only has a USB C port remaining, also use the USB A female to C male 50mm cable along with the 6 inch mini-B cable.** Position the XBee module at about a 45 deg angle in between the GPU strut and the cutouts for the panel mount components not yet installed, with the antenna facing the toward the back of the compute box.



## 8.16 Cable Management

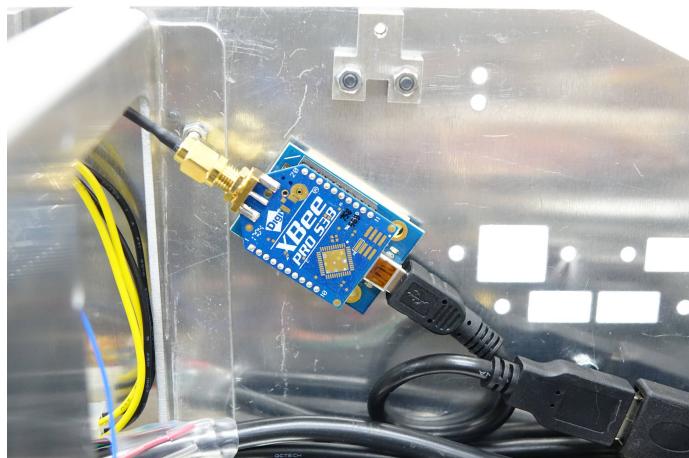
**Time** 0 hours 20 minutes

### Parts

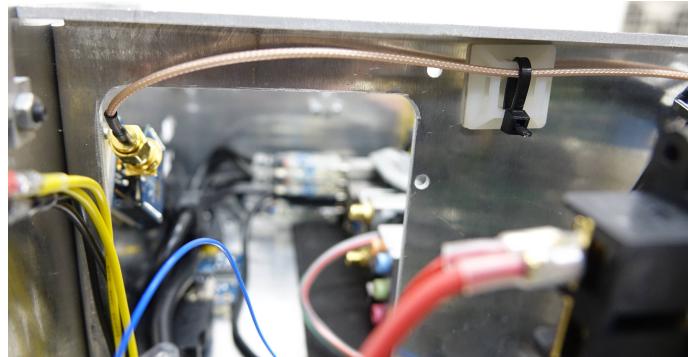
- AutoRally compute box base
- Zip tie saddles
- Zip ties
- Heavy duty mounting tape

### Instructions

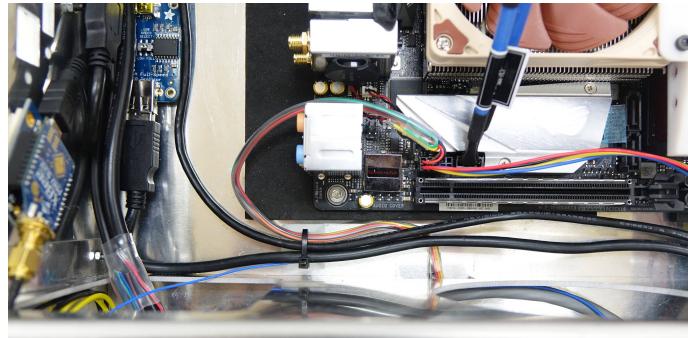
- a. Secure the USB isolator to the Cross Brace, which will be installed in the cross brace section, as it is too large to fit down by the motherboard USB connections.
- b. Secure the XBee to the wall of the compute box using heavy duty mounting tape. It may take 2 layers of mounting tape for the adapter board pins to not contact the compute box wall. The reason for doing so is to avoid straining the USB mini-B cable and connector from the XBee adapter board and so that the antenna wire can pass through the cut out in the GPU strut. Make sure that the antenna wire does not push against the edges of the GPU cutout in order to prevent damage.



- c. Route the XBee antenna wire under the top flange of the GPU strut. Secure the antenna wire to the wall of the strut using a zip-tie saddle.



- d. Use a zip tie saddle and zip tie to secure the IMU cable, the blue wire from the IMU, and the 2 USB cables passing between the GPU strut and the motherboard to the bottom of the compute box.



### **8.17 Camera USB Cable Shielding (Optional, it seems to help a little if the GPS has bad signal quality)**

**Time** 1 hours 00 minutes

#### **Parts**

- 2 USB 3.0 A to micro-B, 0.5m
- EMI shielding textile (not on parts list, <https://www.digikey.com/product-detail/en/wurth-electronics-inc/33025/732-10216-ND/6004962>)

#### **Instructions**

- a. Wrap each end of the USB 3.0 A to micro-B cables with the EMI shielding textile at the transition from the USB cable to the cable connectors.



- b. Wrap the length of the cable between the connectors with EMI shielding textile. This is easiest to do in two or three sections with the textile wrapped at a 45 degree angle relative to the cable.



- c. Wrap the USB A connector and the remaining exposed non-metal portion of the micro-B connector with EMI shielding textile. **Note that the EMI shielding textile on the micro-b housing should wrap around the housing and touch the metal micro-B connector.**



## 8.18 WiFi Antenna and Camera USB

**Time** 0 hours 15 minutes

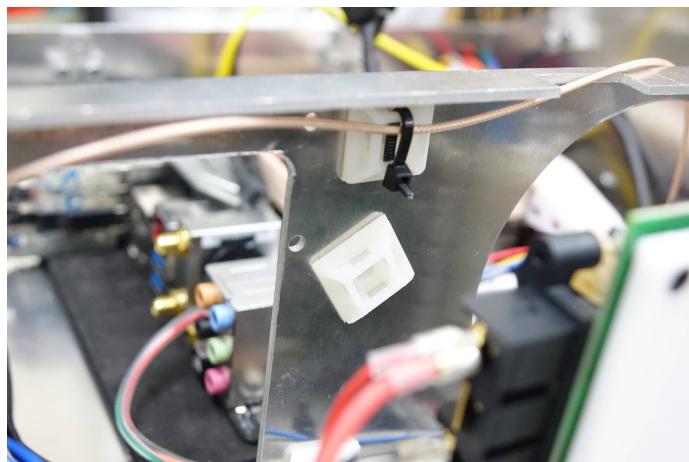
### Parts

- AutoRally compute box base
- 2 1.75 foot RP-SMA extension cable
- 2 USB 3.0 A to micro-B, 0.5m, with EMI shielding textile from previous step

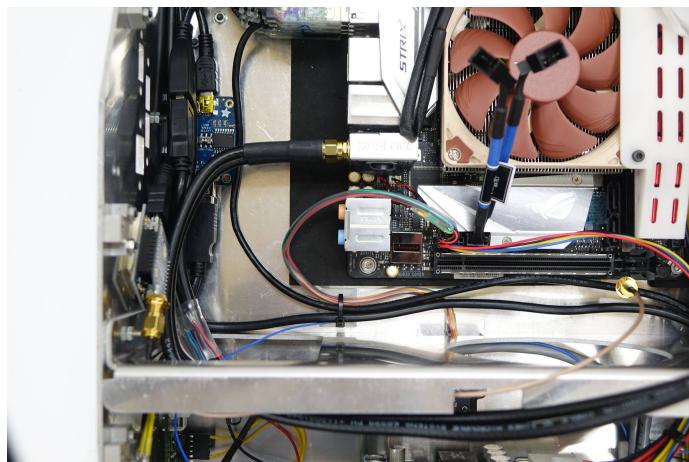
- Zip tie saddle
- Zip tie

Even though it is not reflected in the images, the USB 3 camera cables should be wrapped in EMI shielding textile per the previous section. Instructions

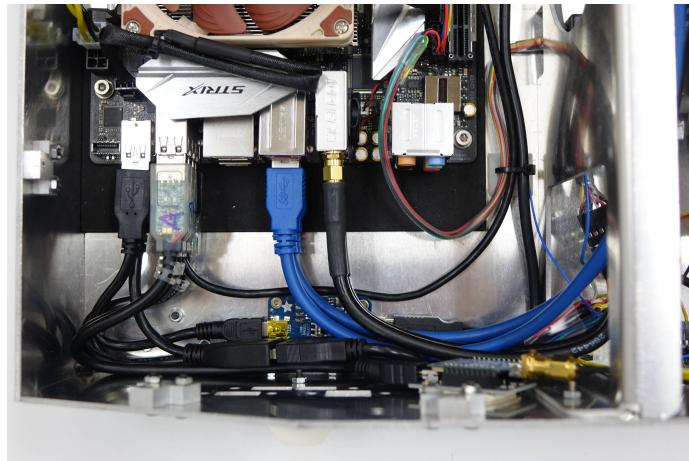
- a. Attach a zip-tie saddle at a roughly 45 deg angle under the Xbee antenna cable zip tie saddle on the GPU strut. This is done so that the saddle is able to hold down the WiFi antenna (1.75 foot RP-SMA extension) and camera USB 3.0 cables as they bend through the cut-out in the GPU strut.



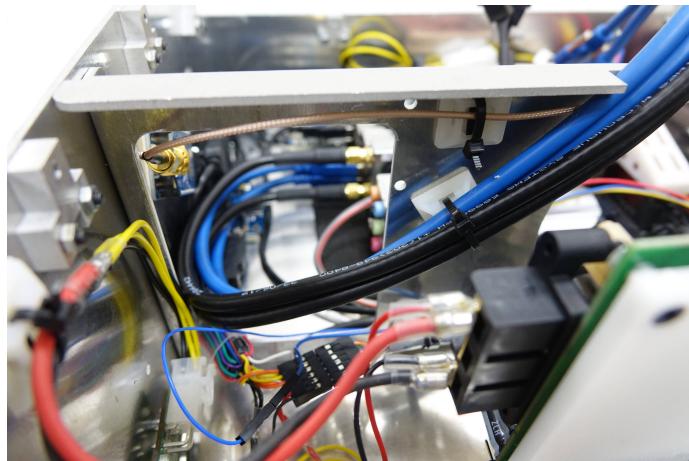
- b. Connect the 1.75 foot RP-SMA WiFi antenna cables to the motherboard. These can be bent and shaped before securing to minimize the strain on the motherboard connectors. **Be careful when connecting to not put too much strain on the ports on the motherboard.**



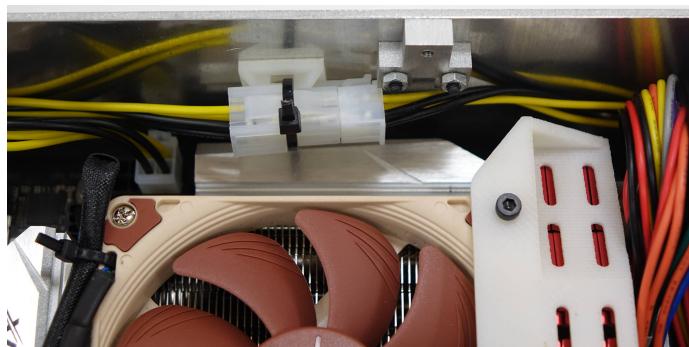
- c. Connect the USB 3.0 A to micro-B, 0.5m to the open USB 3.0 ports on the motherboard. Route these cables along with the WiFi cables through the cutout in the GPU strut.



- d. Secure the two RP-SMA WiFi and the two USB 3.0 camera cables to the zip-tie saddle installed on the GPU strut using a zip tie so that the unconnected ends go through the notch in the top of the GPU strut. Before securing the cables down with zip ties, route them such that they are as close as possible to the outside and base of the compute box.



- e. Secure the CPU power cable to the inside of the front compute box wall with a zip tie saddle and zip tie.



## 8.19 Panel Mount USB 3.0, Ethernet, and HDMI

**Time** 0 hours 10 minutes

### Parts

- AutoRally compute box base
- Panel mount ethernet cable
- Panel mount HDMI cable
- Panel mount USB 3.0 cable
- Ethernet dust cap
- HDMI dust cap
- 2 USB dust caps
- M3×8 mm screw
- 2 4/40× 1/2 inch screws

### Instructions

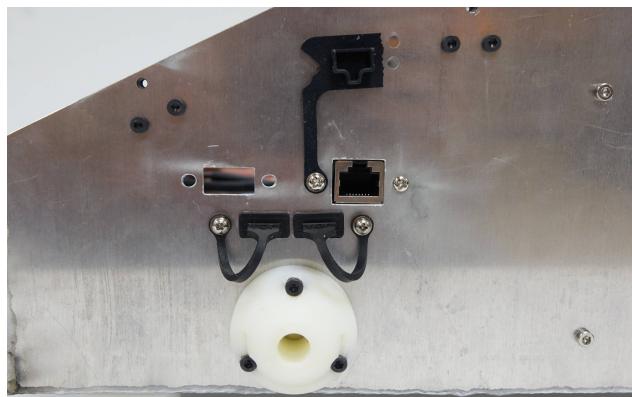
- a. If you are using the ethernet dust cap that can be permanently mounted to the compute box, trim the two edges of the ethernet dust cap to allow it to sit flat. Specifically, make a vertical cut to remove the “A” of the logo and a circular cut near the “o” and “l”.



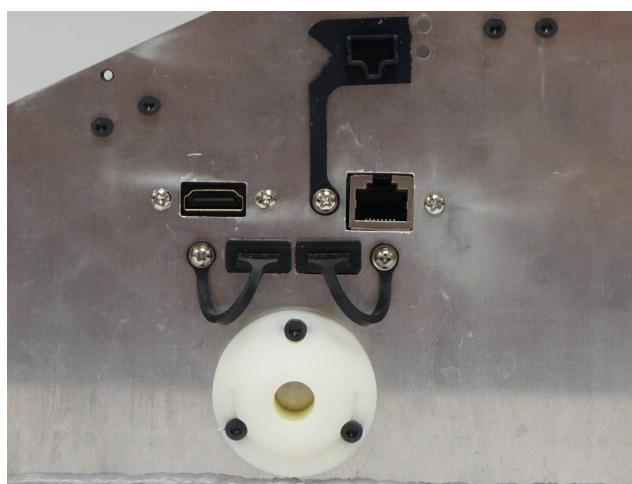
- b. Install the panel mount USB 3.0 port using 2 4/40× 1/2 inch screws and 2 USB dust caps. Make sure that the panel mount is installed so that USB connectors are right side up.



- c. Install the panel mount ethernet port along with the ethernet dust cap (if the dust cap is mountable). If the stock screws are not long enough to include the dust cap, use a M3×8 mm screw.



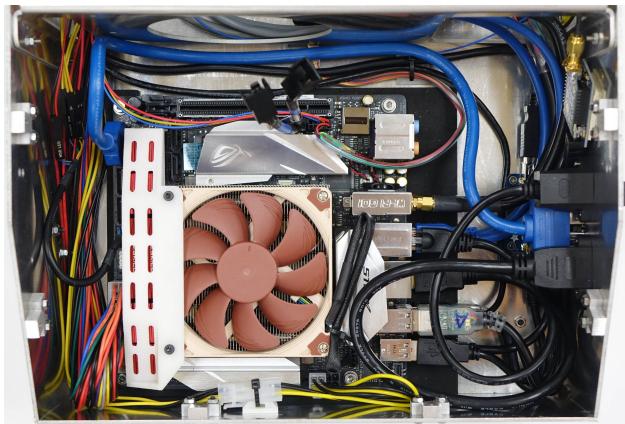
- d. Install the panel mount HDMI with the included screws.



- e. Plug the panel mount HDMI cable and panel mount ethernet cable into the motherboard.



- f. Plug the panel mount USB 3.0 cable into the USB 3.0 header on the motherboard. Route the cable along the bottom of the compute box in between the GPU strut and motherboard if your USB 3.0 motherboard header is on the far side of the motherboard from the panel mount location.



## 8.20 GPU

**Time** 0 hours 30 minutes

### Parts

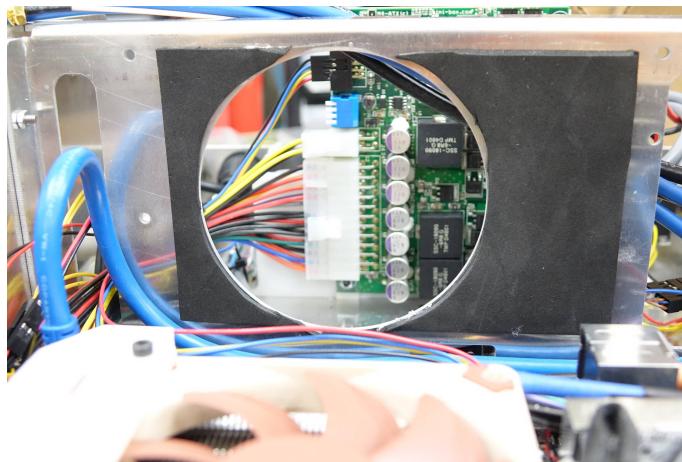
- AutoRally compute box base
- EVGA GTX 750ti GPU or 1050ti sc GPU
- 3D printed GPU cover
- 4 M3×8 mm screws
- 4 M3 nuts
- 2 mm foam

### Instructions

- a. Remove the metal GPU panel over the ports and then replace the panel screws on the GPU.



- b. Bend back the grounding tab on the DisplayPort so that it no longer sticks out in front of the port.
- c. Cut and place 2 mm foam around the fan hole on the metal GPU support strut. Ensure that the foam does not block the GPU fan and does not interfere with the small “lip” on the plastic surrounding the fan. **Place the GPU first and mark the boundaries. Remove the GPU and hot glue the foam in place, ensuring that it does not pass the edge of the marked areas.**



- d. Install the GPU, ensure that it latches in place into the motherboard.



- e. Cut and hot glue a rectangular piece of 2 mm foam to the inside of the 3D printed GPU holder.
- f. Slide the 3D printed GPU holder over the GPU from the top. Use 4 M3×8 mm screws and 4 M3 nuts to secure the holder to the GPU support strut.



## 8.21 Cross Brace

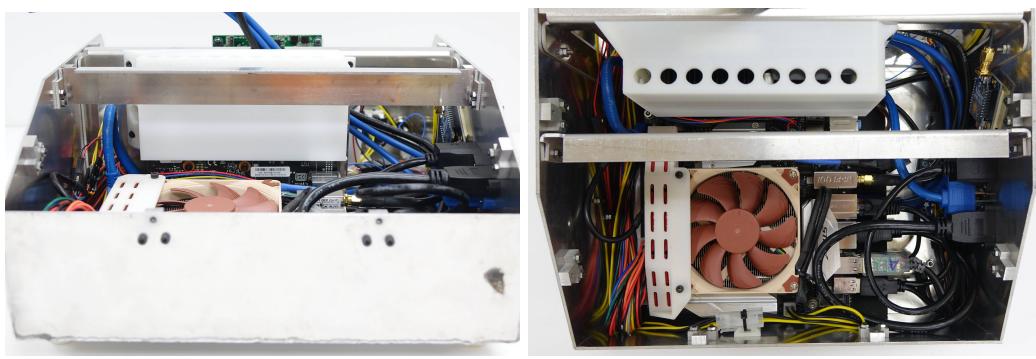
**Time** 0 hours 5 minutes

### Parts

- AutoRally compute box base
- Metal cross brace
- 4 M3×8 mm screws
- 4 M3 nuts

### Instructions

- a. Install the cross brace using 4 M3×8 mm screws and 4 M3 nuts with the top flange facing the front of the compute box.



## 8.22 Compute Box Battery

**Time** 0 hours 15 minutes

### Parts

- Compute box battery, 6s 11Ah

- 2 6.5 mm male bullet connectors
- 16 AWG wire
- Heat shrink
- Zip tie saddles
- Large and small zip ties

### Instructions

- a. Make 2 bullet connector plugs (as directed in the AutoRally Chassis Instructions, if you have none left) using the 6.5 mm male bullet connectors, 16 AWG wire, and heat shrink as directed in the AutoRally Chassis Instruction.
- b. Attach 3 zip tie saddles spaced evenly on the top of the battery along the centerline from left to right.



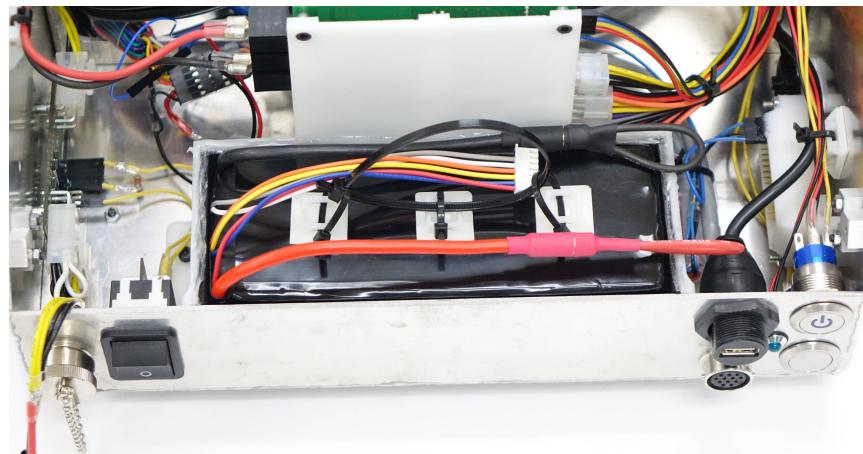
- c. Connect a small zip tie to each of the zip tie saddles forming loops perpendicular to the long dimension of the battery. The middle zip tie should be tightened as much as possible and the two outside zip ties should be half tightened.



- d. Connect a large zip tie through all 3 of the small zip ties to make a handle to hold the battery. The zip tie should be installed parallel to the longest dimension of the battery, tightened enough to still be able to fit your fingers through.



- e. Test fit into the battery holder in the back of the compute box. The battery should slide snugly into place. To remove the battery, slowly pull **vertically** on the handle made out of the large zip tie until the battery clears the back wall of the compute box.



## 9 Testing

**Time** 0 hours 30 minutes

### Parts

- AutoRally compute box base
- AutoRally compute box lid
- Shore power cable
- Power supply
- Battery
- Monitor
- HDMI cable
- Mouse
- Keyboard

### Instructions

- a. Unplug the  $4 \times 1$  0.1 inch header from the power supply.



- b. Unplug the 24 pin ATX power cable and 4 pin ATX CPU power cable from the power supply.



## 9 TESTING

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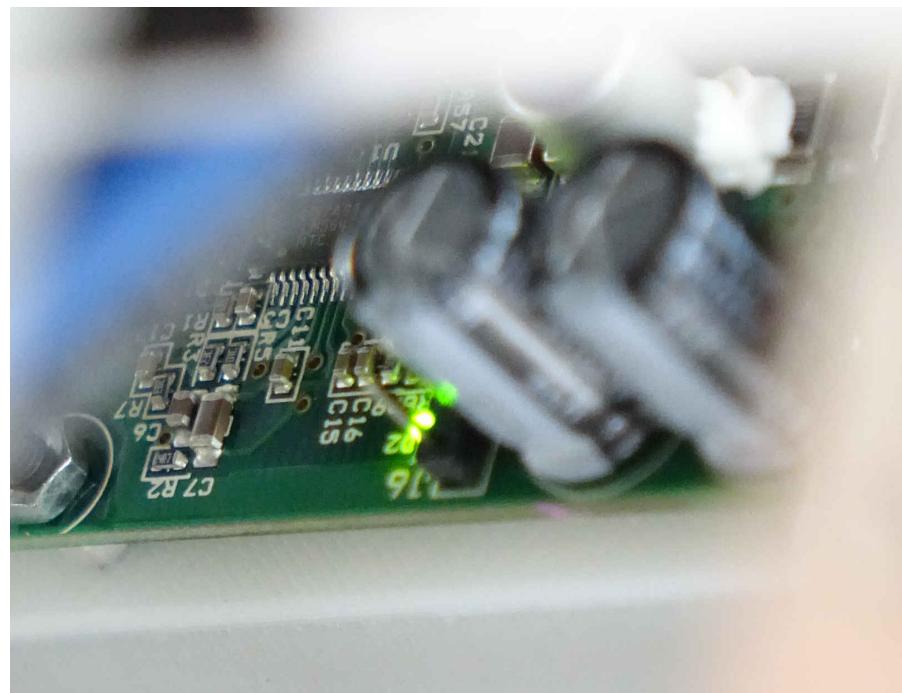
- c. Plug the shore power cable into a power supply, making sure to connect red to red and black to black. Turn the power supply on.



- d. Connect the shore power cable to the power jack on the back panel of the compute box.



- e. Look for a flashing green light (D2 from the power supply manual) on the power supply underneath the spade terminals. Only continue if this light is evident; if it is not, unplug the shore power cable and review the steps above to track down any incorrect wiring harnesses or connections specified previously in the instructions.



- f. Unplug the shore power cable.

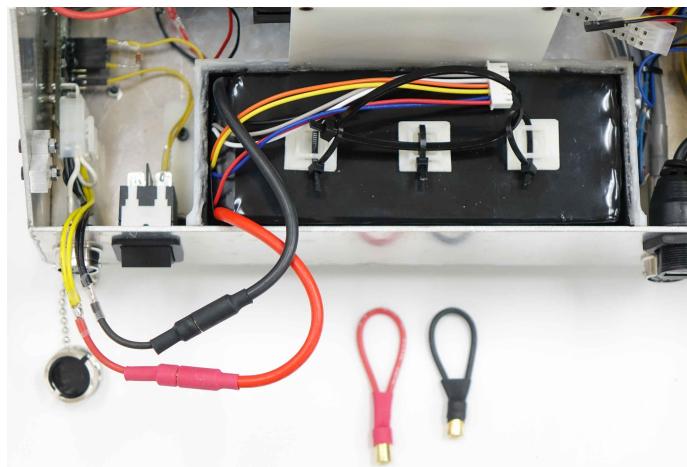
## 9 TESTING

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- g. Ensure that the rocker switch is in position **0** and install the battery into the battery holder with the wires closest to the power receptacle; ensure that the protector plugs are still connected to the battery leads.

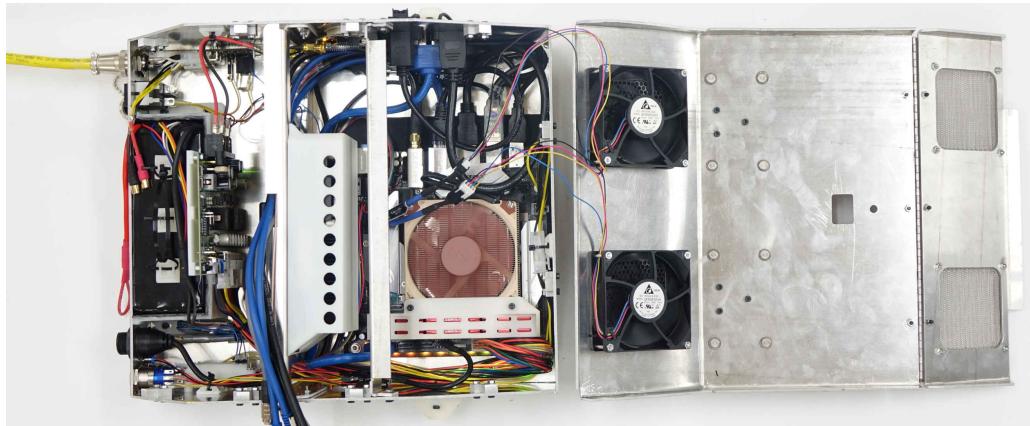


- h. Remove the wire plug from the black battery wire and plug it into the free black female connector going into the hot swap. **Note that you should not twist the protector plug connecting or disconnecting.**



- i. Remove the wire plug from the red battery wire and plug it into the red female connector going into the hot swap. **Do NOT let the red battery lead touch any metal component of the the compute box. Note that you pull the connectors, not the wires, when unplugging and you should not twist the plug when disconnecting.**
- j. Check that no light on the power supply is flashing. If there is a light flashing on the power supply, unplug and cap the battery leads. Likely there is a wiring error in the power switch assembly or hot swap configuration, check through the steps involving those components to locate and correct the error before continuing.
- k. Flip the battery power switch to the position **1**. Look for the green flashing light (D2 from the power supply manual) on the power supply. Only continue if this light is evident; if it is not, unplug the shore power cable. Review the steps above to track down fix the wiring error before continuing.

- l. Flip the battery power switch to the position **0** and then unplug and cap the red and then black battery wires.
- m. Plug the 24-pin ATX power cable, the 4-pin CPU power cable, and the  $4 \times 1$  0.1 inch header back into the power supply.
- n. Plug the fan connectors from the lid into the motherboard or fan cable splitter.
- o. Plug the HDMI cable **directly into the GPU** and plug a mouse and a keyboard into the panel mount USB ports. Connect shore power. The power status LED on the motherboard should light up.
- p. Press the power button, which should light up. The CPU, GPU, and motherboard fans should spin up. If the Lid fans do not spin up, the crimps on the ends on the fan connectors likely have to be redone.



- q. Change the default primary display from Auto to CPU Graphics, so that the Nvidia GPU is not used for display purposes. Once configured, move the monitor HDMI cable from the GPU to the panel mount HDMI port and replace the HDMI dust cap back on the GPU. The process for your motherboard may vary, but a common method is:

Enter the BIOS by repeatedly pressing F2 until the BIOS starts during boot.

Press F7 to go to Advanced mode.

Click the Advanced tab.

Click System Agent (SA) Configuration.

Click Graphics Configuration and change Primary Display from Auto to **CPU Graphics**.

- Click Exit and then click Save Changes and Exit.
- r. Shut down the compute box using the power button, unplug all power and remove the battery.

## 10 Compute Box Lid Installation

**Time** 0 hours 30 minutes

### Parts

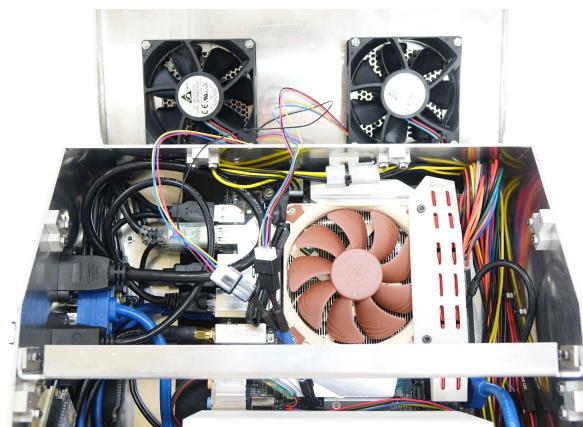
- AutoRally compute box base
- AutoRally compute box lid
- 1 900 MHz whip antenna for XBee
- 2 5GHz duck antennas, for WiFi
- 10 M3×10 mm screws
- 2 Knob with screw head mount, red, for M3 screws
- 2 zip tie saddles
- 2 zip ties
- 2 knob with screw head mounts

### Instructions

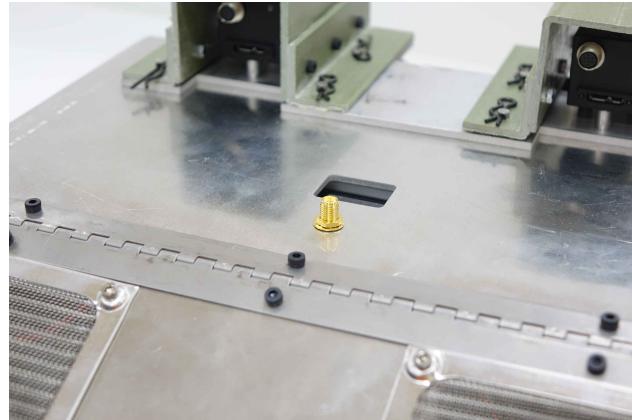
- a. Press the 2 knob with screw head mounts onto 2 M3×10 mm screws.



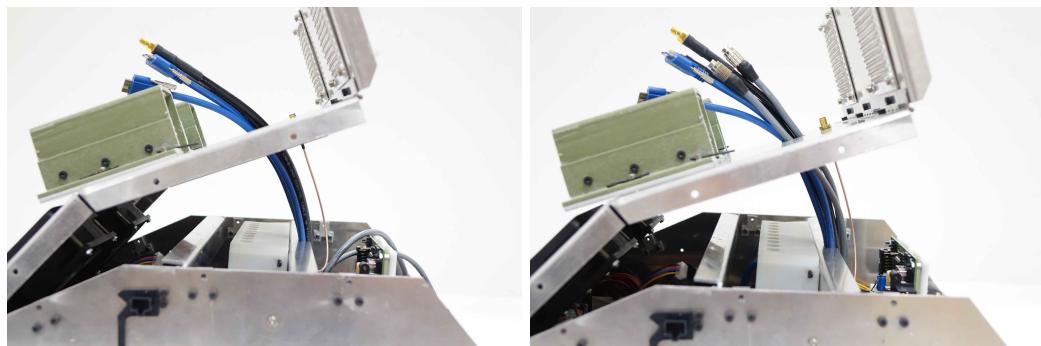
- b. Plug in the fan cables to the fan headers on the motherboard (if not already connected). The zip tied cable should be connected to the header near the CPU fan; the loose cable should be connected to the header nearer the GPU. Refer to the photos for exact placement.



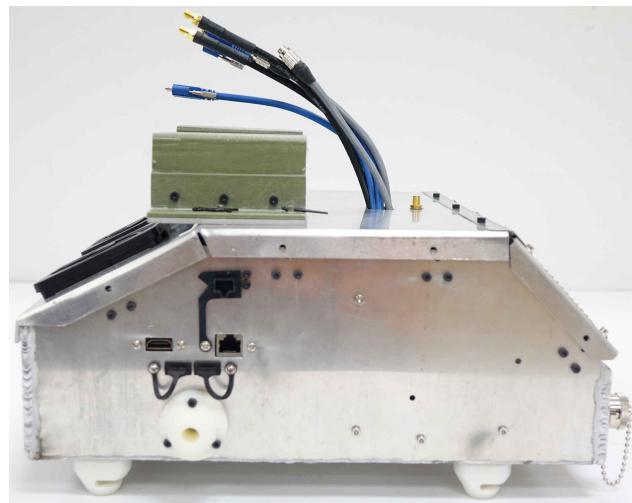
- c. Panel mount the RP-SMA Xbee antenna cable to the hole on the lid behind the large rectangular opening using the washer and nut included with the antenna cable.



- d. Pass the USB 3.0 camera cables through the rectangular cutout in the lid followed by the WiFi antenna RP-SMA cables. Pass the camera GPIO cables through the rectangular opening in the lid.

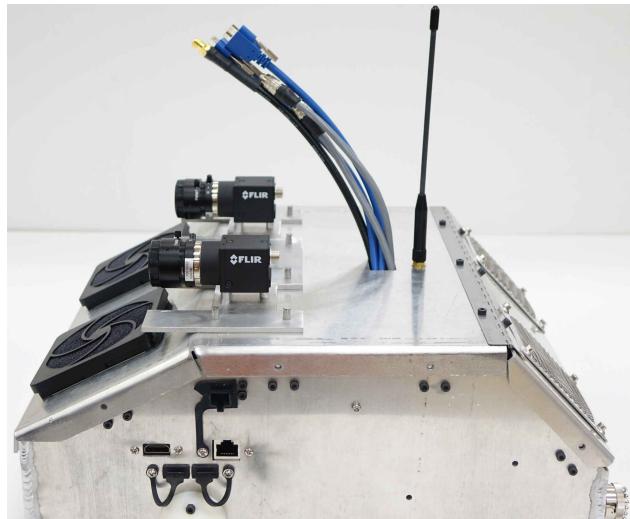


- e. Work the lid down so that it sits on the box.

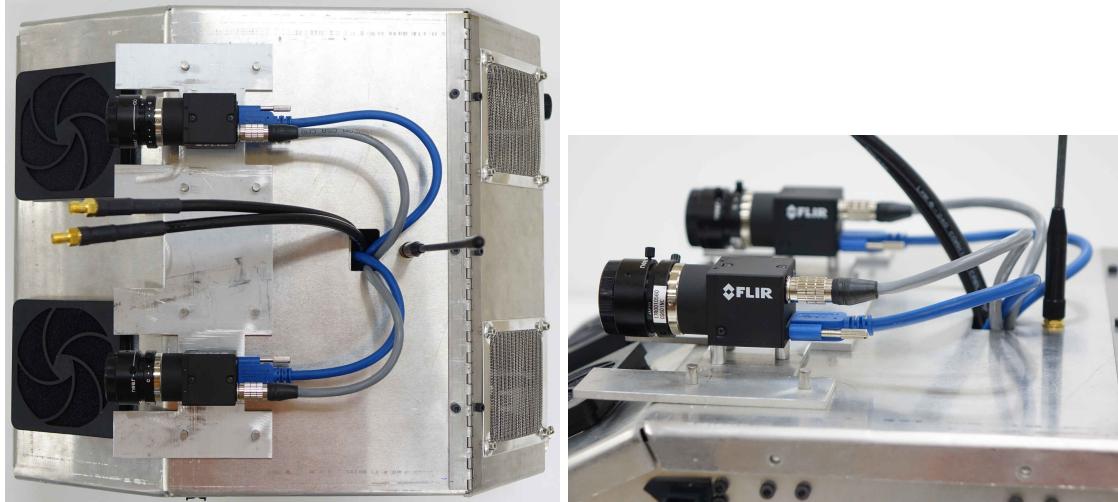


- f. Remove the camera covers and install the 900 MHz whip antenna onto the panel mount RP-SMA

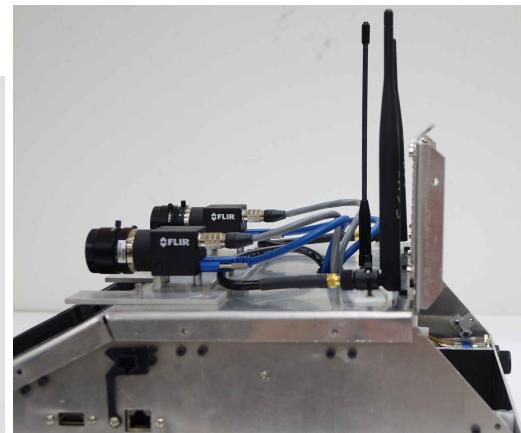
cable from the Xbee



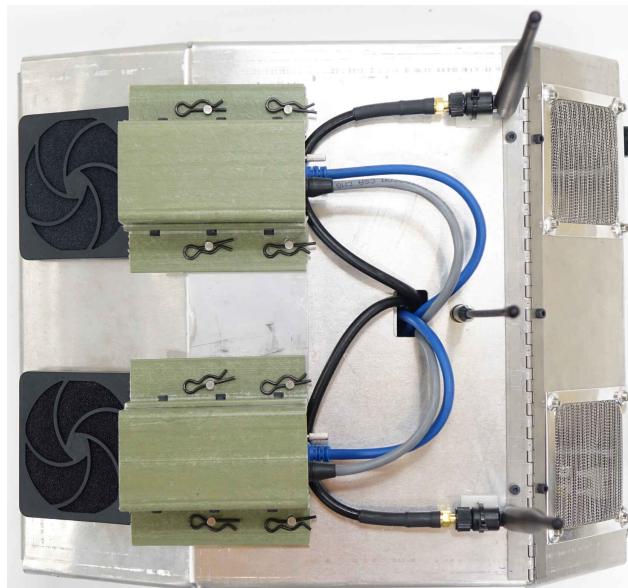
g. Connect the USB 3.0 cables and the GPIO cables for triggering to the cameras.



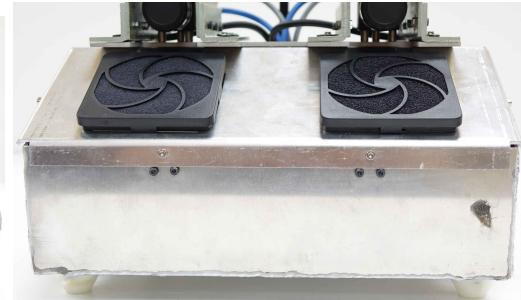
h. Place a zip tie saddle against the “lip” of the hinge, one inch in from either side of the lid as shown in the photos below. Firmly zip tie the WiFi antennas to the outer saddles, ensuring that the hinged lid can still open (and remain open without being held up).



- i. Reinstall the camer covers.



- j. Screw the lid into the base using 8 M3×10 mm screws and 2 thumbscrews. This step may require some maneuvering of the lid to make all of the mount holes align depending on fabrication tolerances.



- k. Screw the thumb screws made in the first part of this step to secure the back lid.

10 COMPUTE BOX LID INSTALLATION

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## 11 Integration with Chassis

**Time** 0 hours 25 minutes

### Parts

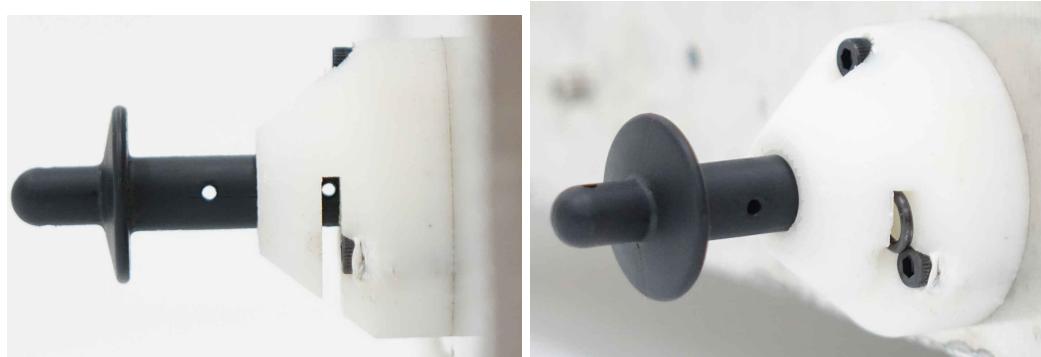
- AutoRally compute box
- AutoRally chassis
- Baja 5SC plastic body cover
- 2 Baja 5SC body pegs, part number 85419-6 in 5SC manual
- 2 8 mm body clips

### Instructions

- a. Cut each body peg just passed the third hole in the part.



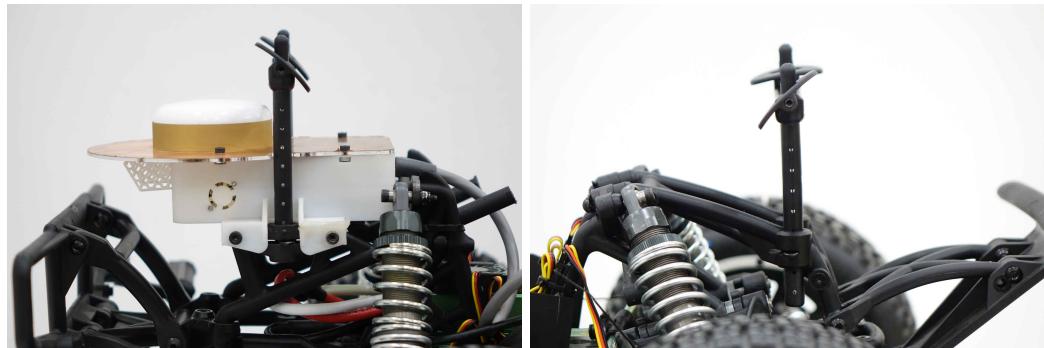
- b. Insert the cut body pegs into the side body mounts on the compute box so that they are as far in as possible and a hole in the body peg aligns with the cutout in the side body mount. Secure each body peg in place with a body clip through the open slot in the side body mounts.



- c. Mount the compute box onto the chassis. Refer to the AutoRally Operating Procedures for a detailed explanation if needed.
- d. Plug the chassis USB cable and GPS box into the compute box.



- e. Position the rear body mount so that it is secured to the chassis on the highest hole. Position the front body mount so that it is secured to the chassis through the 3rd hole from the bottom.



- f. On the plastic body cover, use a sharpie to make marks at 1.5 inch from each of the windshield sides, leaving a strip of 2 inch in the middle about 0.25 inch above the windshield seam. Depending on fabrication tolerances of the camera mounts and the kind of lens used, the location and size of the cut above the seam may have to be varied slightly.



- g. Cut the marked sections out of the windshield using a dremel or other cutting tool.



- h. Hold the body above the front and rear body mount pegs. Using a sharpie, mark where the WiFi and XBee antennas touch the plastic body in preparation for cutting holes. The goal is to have the antennas sticking straight upwards after the body is mounted onto the pegs.



- i. Cut out two, 1 inch diameter holes in the body to allow the WiFi antennas to pass through. Cut a third hole, 1 inch by 1.5 inches for the XBee antenna.



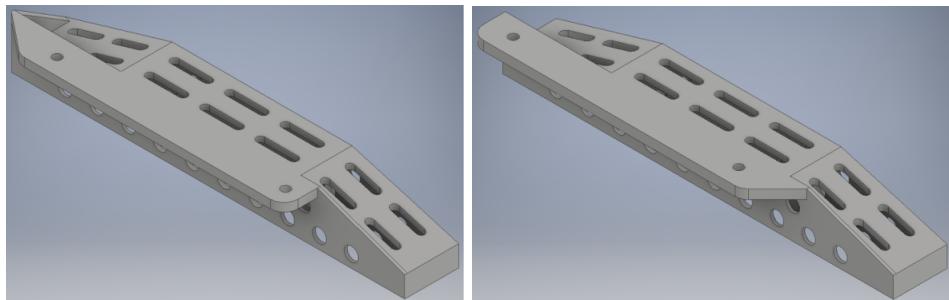
- j. Test fit by installing the plastic body onto the AutoRally platform. Make any necessary adjustments to ensure that WiFi antennas are pointing straight upwards, camera mounts are sticking out the windshield, and the front, back, and side body pegs align with the mounting holes in the plastic body cover and can be secured in place with the body clips attached to the body.



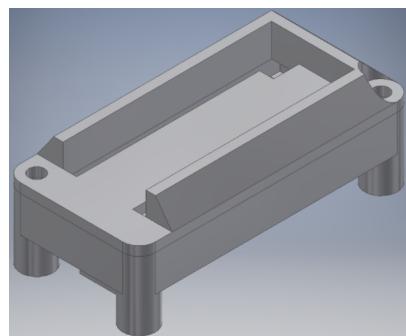
## 12 Appendix A: Parts

### 12.1 3D Printed Parts

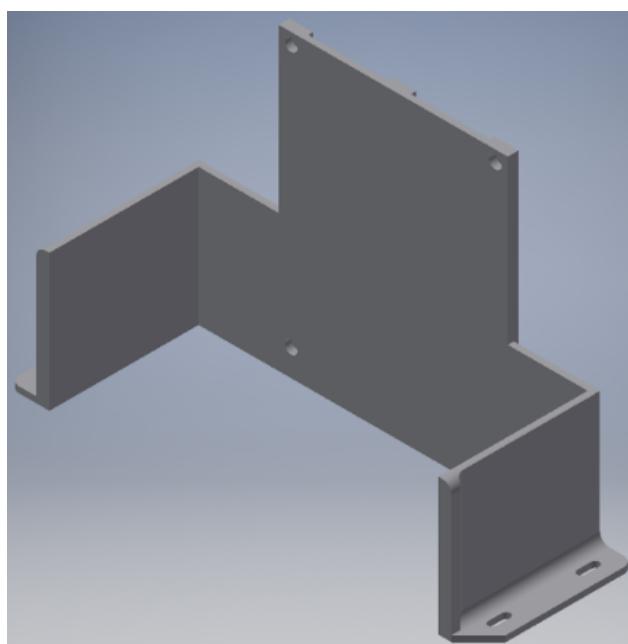
1. RAM holder (left for Asus motherboards, right for ASRock motherboards)



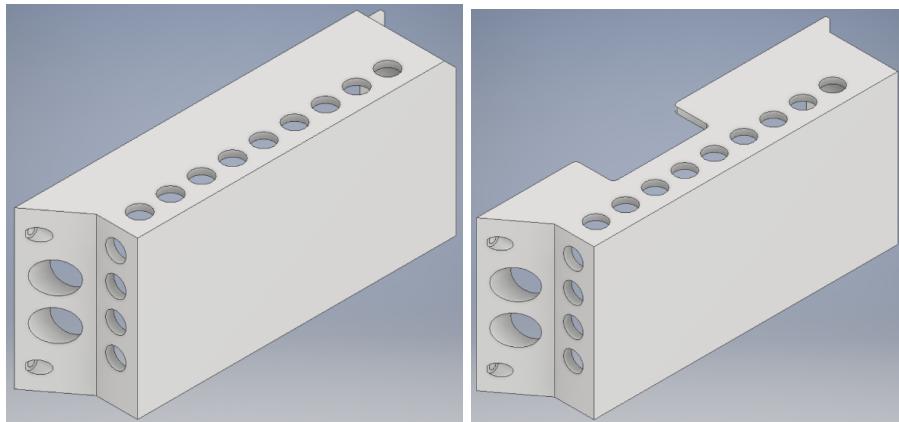
2. Microcontroller holder



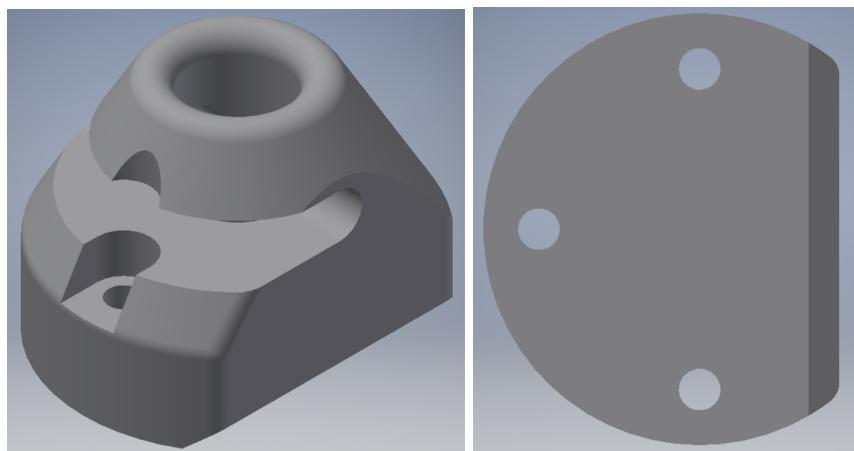
3. Battery/Power supply holder



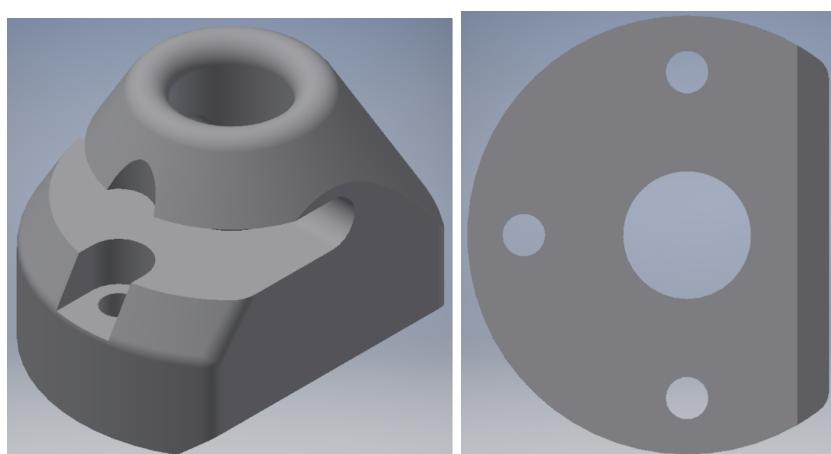
4. GPU holder (left for GTX 750ti, right for GTX 1050ti)



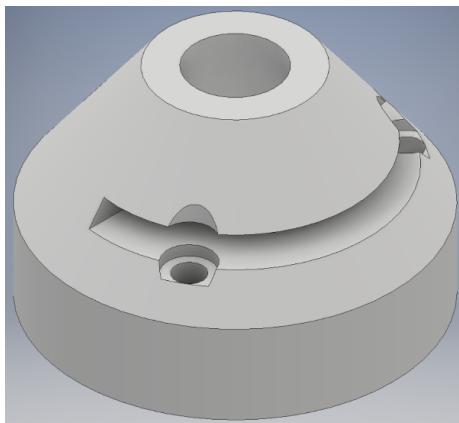
5. Front compute box mount



6. Rear compute box mount

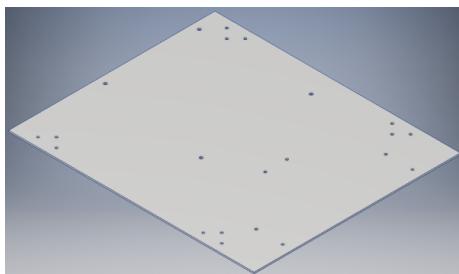


7. Side body mount

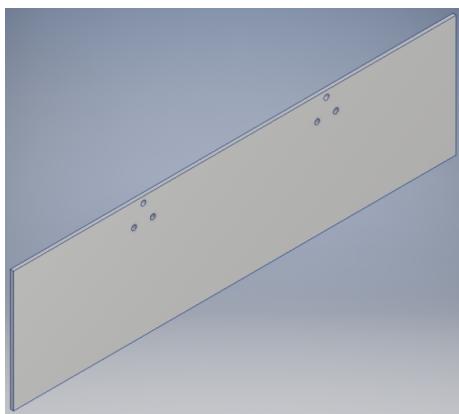


## 12.2 Fabricated Parts

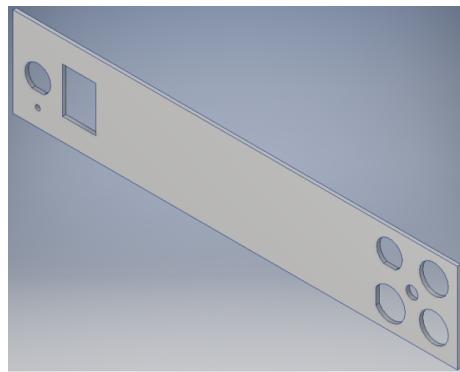
1. Compute box base



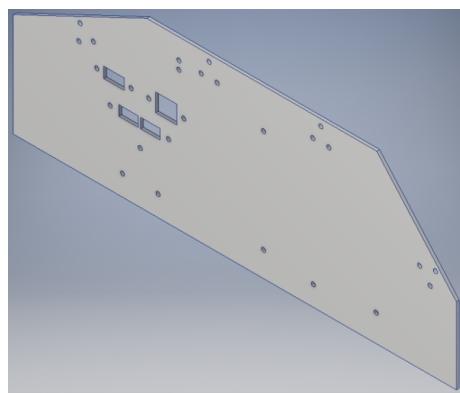
2. Compute box front panel



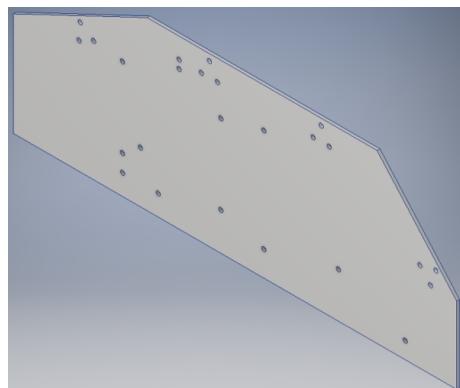
3. Compute box rear panel



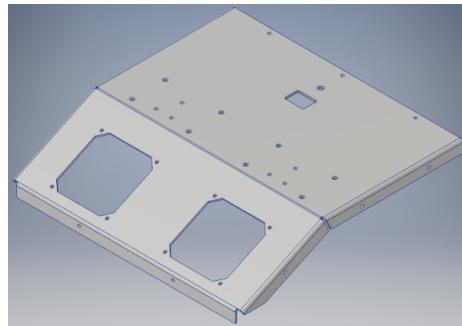
4. Compute box left panel



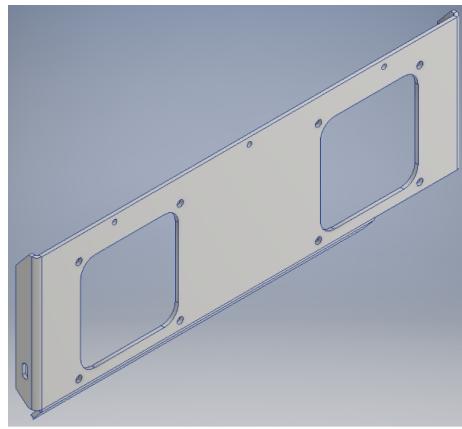
5. Compute box right panel



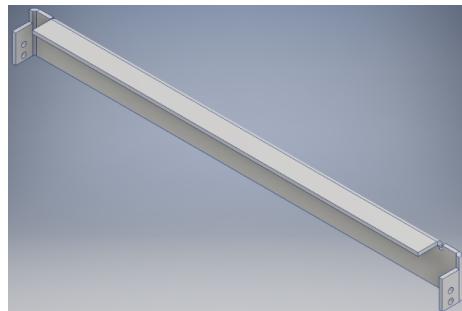
6. Compute box lid



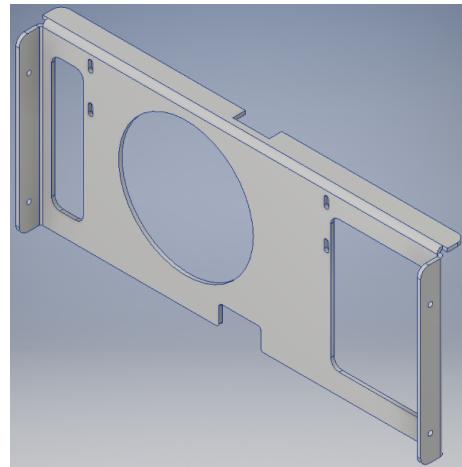
7. Compute box back lid



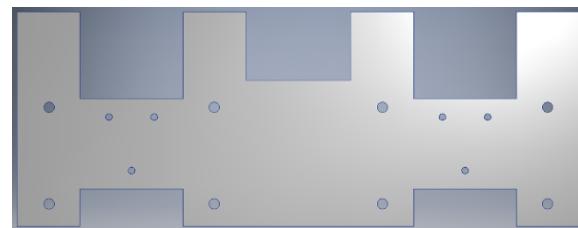
8. Compute box cross brace



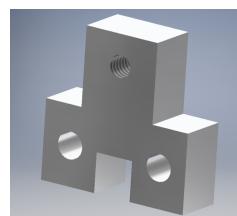
9. GPU strut



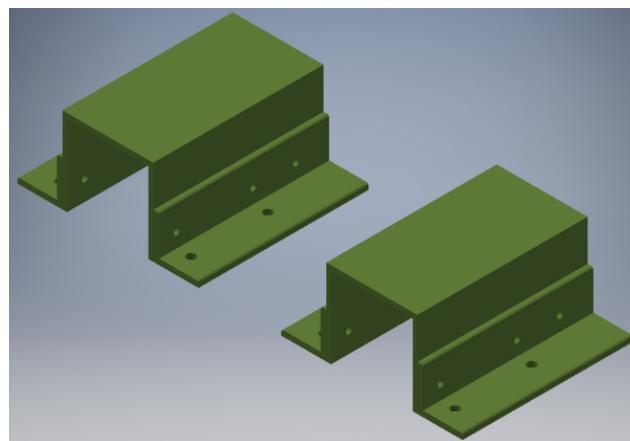
10. Camera support plate



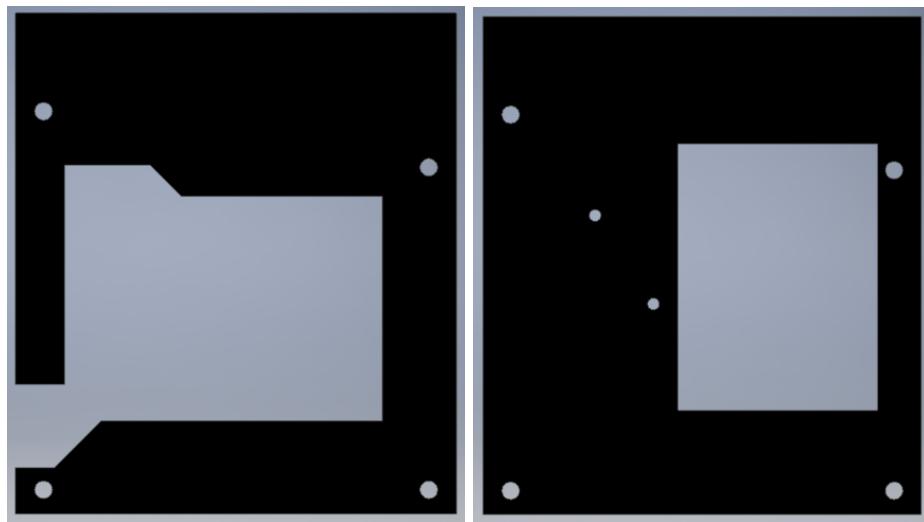
11. Lid connector



12. Rectangular camera cover and right-angle camera cover support



13. Motherboard foam padding (left for Asus, right for ASRock)



### 12.3 Computer and Electronic Components

1. Compute box battery, 6s 11Ah 22.2V LiPo battery pack



2. Power Supply, MaxAmps 24V 47A 1150W



3. ASRock Z270 Mini-ITX Intel Motherboard



4. GeForce GTX 1050ti SC GPU



5. SAMSUNG 960 Pro m.2 1TB PCI-Express SSD



6. Optional SAMSUNG 850 EVO 2.5" 1TB SATA SSD



7. Intel Core i7 Quad-Core, 65W LGA1151 Desktop Processor



8. G.SKILL Ripjaws V Series 32GB (2 x 16GB) DDR4 SDRAM



9. Noctua NH-L9i 95mm SSO2 CPU Cooler



10. 80×25.4mm 12VDC Axial Fan



11. Power Pushbutton, SPDT 3A 250V



12. Reset Pushbutton, SPDT 3A 250V



13. Panel Mount Indicator Blue LED



14. Rocker Switch, DPST 20A 125V



15. Red Mushroom Emergency Stop NC Latching Push Button Station



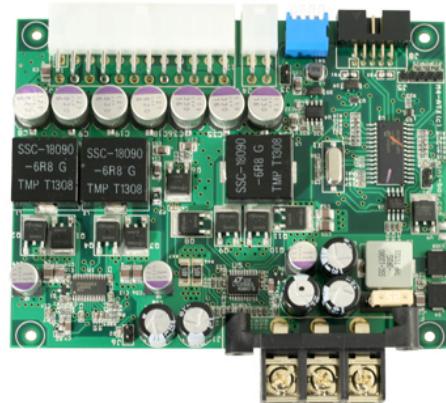
16. Xbee Pro 900 HP



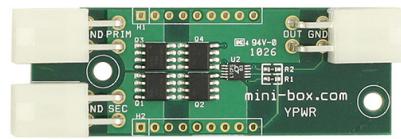
17. Xbee Adapter Board



18. M4-ATX, 250W Intelligent Automotive DC-DC Car PC Power Supply



19. Y-PWR, Hot Swap, Load Sharing Controller



20. Arduino Micro



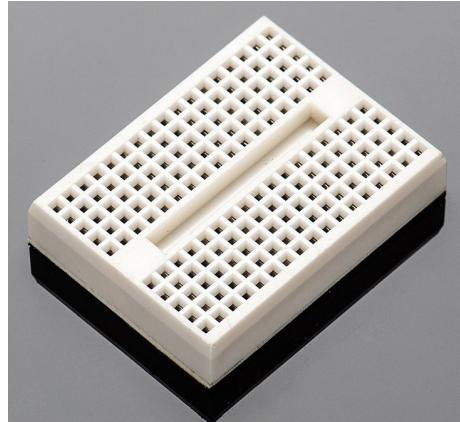
21. Tenny LC with pins



22. Tenny 2.6 with pins



23. Tiny Breadboard



24. USB Isolator, Sealevel



25. Microstrain 3DM-GX5-25 IMU



26. FLIR Blackfly S Color 1.3 MP USB3 Vision



27. 3.5mm C Series Fixed Focal Length Lens



28. Hemisphere R330 GPS Base Station



## 12.4 Cables

1. Hirose GPIO cable (for Flea 3), 8 pins, 1 m



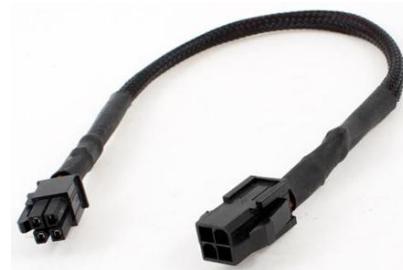
2. Hirose GPIO cable (for Blackfly S), 6 pins, 1 m



3. Mini-DB9 cable with flying leads



4. ATX 4 Pin P4 M/F Connector Motherboard CPU Power Cable Adapter, 30cm 11.8"



5. Fan power splitter cable, 4 Pin



6. 16awg yellow Power cable



7. USB to TTL Serial 3.3V Cable



8. USB to UART Cable



9. USB A to B cable, 1.5 ft



10. USB A to mini-B cable, 6 inch



11. USB A to mini-B cable, 3 feet



12. USB A to micro-B cable, 1.5 feet



13. USB A to micro-B cable, 3 feet



14. USB 2.0 Panel Mount



15. USB 3.0 Panel Mount



16. USB 3.0 A to microB with thumbscrews, 0.5 m



17. HDMI cable, 10 ft



18. HDMI Panel Mount



19. Ethernet Cable, 10 ft



20. Ethernet Panel Mount



21. Wifi antenna



22. Xbee Antenna



23. Wifi antenna cable



SMA Female Reverse Polarity



SMA Male Reverse Polarity

24. RPSMA extension, 12 in



25. Hemisphere R330 power cable, 3 m



26. GPS Base Station AC Adapter with cable



## 12.5 Connectors

1. 1×1 0.1 in header housing



[www.pololu.com](http://www.pololu.com)

2. 1×2 0.1 in header housing



[www.pololu.com](http://www.pololu.com)

3.  $1 \times 3$  0.1 in header housing



[www.pololu.com](http://www.pololu.com)

4.  $1 \times 4$  0.1 in header housing



[www.pololu.com](http://www.pololu.com)

5.  $1 \times 5$  0.1 in header housing



[www.pololu.com](http://www.pololu.com)

6.  $1 \times 7$  0.1 in header housing



[www.pololu.com](http://www.pololu.com)

7. 2×5 0.1 in header housing



[www.pololu.com](http://www.pololu.com)

8. 2×6 0.1 in header housing



[www.pololu.com](http://www.pololu.com)

9. Black Keying plug



10. 0.1 in male crimp connector



Pololu

11. 0.1 in female crimp connector



12. Fan 4-pin connector



13. Fan connector crimps (Non-Gendered Contact Tin 22-30 AWG Crimp)



14. Hirose RM 12-pin receptacle, panel mount, female pins, 15mm



15. Hirose RM 12-pin plug, free hanging, male pins, 15mm



16. Hirose RM 2-pin receptacle, panel mount, female pins, 15mm



17. Hirose RM 2-pin plug, free hanging, male pins, 15mm



18. Hirose RM receptacle dust cover, 15mm

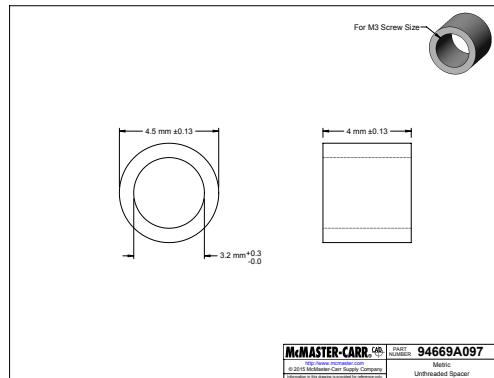


19. Hirose RM bushing

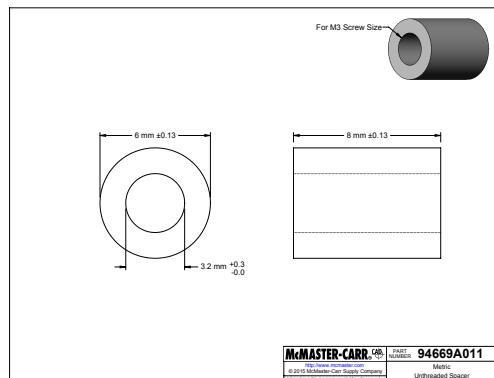


## 12.6 Hardware

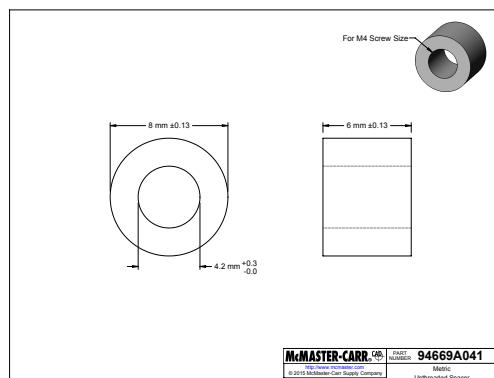
1. M3×4mm, 4.5mm O.D. Aluminum spacer



2. M3×8mm, 6mm O.D. Aluminum spacer



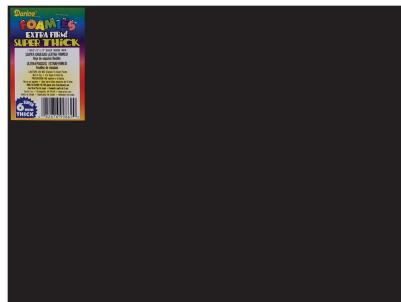
3. M4×6mm, 8mm O.D. Aluminum spacer



4. Craft Foam 2 mm thick



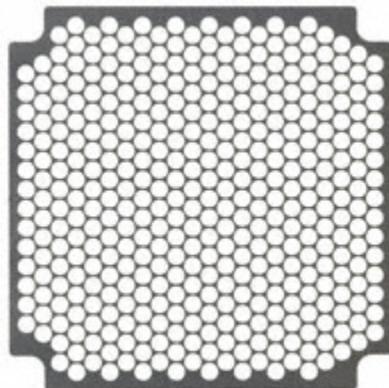
5. Craft Foam 6 mm thick



6. 80mm fan cover



7. 80mm EMI filter guard



8. 80mm fan filter guard assembly



9. EMI shielding textile



10. HDMI dust cap



11. M4 nut



12. M4×14mm screw



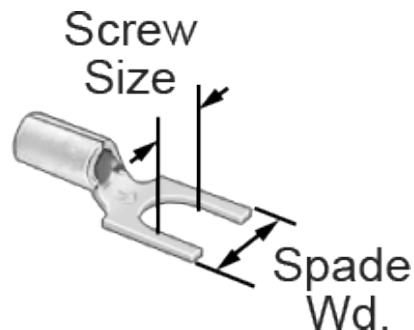
13. Ethernet dust cap



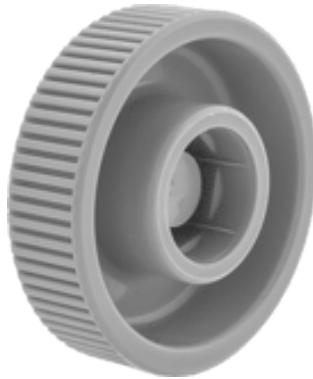
14. USB dust cover



15. Spade terminal



16. Knob with screw head mount (red)



## 13 Appendix B: Revision History

Revision	Date	Author(s)	Description
1.1	July 2016	KS, MP, BG, MB, SS, JM	created, version aligns with other documentation
1.2	September 2016	BG, MB	Fixed error in GPS breakout cable in compute box diagram
1.3	February 2017	BG, AM	Moved GPS power supply out of assembly, updated instructions and parts
1.4	March 2018	BG, AM	Updated compute box exterior and interior for usability, better connectors, and new computing hardware.

## 14 Appendix C: Contributors

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