

AutoRally Chassis Instructions



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1 Getting Started

This is a step-by-step guide to construct a complete AutoRally chassis. Starting from a 1/5 scale HPI Baja 5SC chassis, you will replace the gasoline engine with an electric conversion, upgrade many of the stock parts, and install sensors and a few custom fabricated components. The result is an off-road autonomous research' chassis capable of high-speed aggressive maneuvers.

The chassis is controlled with a standard RC transmitter or by a computer connected to the electronics box. Seamless remote switching between autonomous and manual control is done with a switch on the transmitter. The last channel on the transmitter, controlled by another button, is a remote run-stop. It controls a live-man relay on the chassis that sits between the throttle signal and electronic speed controller (ESC).

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 chassis. The most common problems (and often most frustrating to debug) are loose wire housings, bad crimp connections, and failing solder joints.

Wire routing is the final step in the chassis build. **Make sure to leave sufficient length when cutting wires to allow proper routing on the chassis with slack for moving parts such as steering and suspension.**

While this chassis is the basis for 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 chassis at all times.

This document is best viewed in color.

1.1 Total Time

Total estimated time to construct a complete chassis for one person is 41.75 hours, not including the time to print 3D printed and laser cut 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 chassis: tool kit included with the HPI Baja 5SC, hex key set, Phillips 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 3D Printed Parts

Models for all components that require 3D printing are located in [models/](#). These parts include the electronics box assembly, brake disc aligners, rear wheel rotation sensor mounts, rear wheel rotation sensor magnet mounts, brake master cylinder mount. It is advised to use a 3D printer with support material. Print time for a complete set of chassis components is 26 hours and 35 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 chassis parts is 238.27 cm³, not including support material. 3D printed parts were made on a Dimension SST 768.

1.5 Laser Cutting

The GPS box lid (available in [models/](#)) is laser cut out of acrylic.

1.6 Software

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

- [Castle Serial Link](#)
- [Arduino IDE](#)

1.7 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/](#)

1.8 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 3D Printing

Time 30 hours 27 minutes (print time)
Parts

- Models for all chassis components are .stl files located in [models/](#)

Instructions

- Print all custom chassis components:
 - Electronics box
 - Electronics box lid
 - GPS box
 - GPS box connector mount tab
 - 2 front brake aligners (1 is a mirrored part) – **only print if front brakes are used**
 - 2 front wheel rotation sensor mounts – **only print if front brakes are not used**
 - 2 rear wheel rotation sensor mounts
 - 2 rear wheel rotation sensor magnet mounts
 - Brake master cylinder mount

3 Laser Cutting

Time 0 hours 30 minutes

Parts

- Models for all chassis components are .stl files located in [models/](#)

Instructions

- Cut out electronics box lid

4 Capacitor Precharge Circuit

Time 4 hours 0 minutes

Parts

- Castle Creations Mamba XL-X ESC
- 1 6500 mAh chassis battery
- 1 pair 4mm banana plugs (male and female)
- 2 pieces red shrink wrap for 4mm banana plugs
- 4 resistors, 5 ohm
- 2 6.5mm male CC Bullet
- 1 piece red shrink wrap for 6.5mm bullet
- 1 piece black shrink wrap for 6.5mm bullet
- red wire (12-16awg)
- assorted shrink wrap

Caution: When working with batteries, always keep one exposed contact covered to avoid short circuits. Instructions

- Watch [How to Solder Bullet Connectors](#)

4 CAPACITOR PRECHARGE CIRCUIT

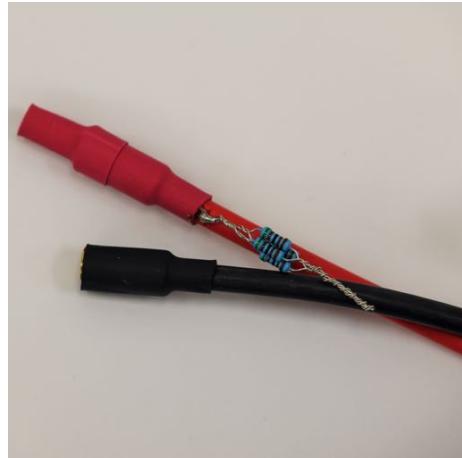
- b. Solder 6.5 mm male bullets to ESC leads



- c. Apply heat shrink for 6.5mm bullets to ESC leads
- d. Cut away a small portion of insulation on one side of the red ESC power wire and on one side of the red battery lead close to the bullet connectors.



- e. Twist the 4 resistors in parallel and solder one end of the resistor leads to the exposed wire on the red battery lead with the free end of the resistors pointing away from the bullet connector



- f. Cut 2, 2.5-inch pieces of the wire. Solder one 4mm connector to each wire piece, and heat shrink the connectors
- g. Solder wire with 4mm female connector to free end of resistors. **Refer to steps h) and i) for correct wire orientation.**



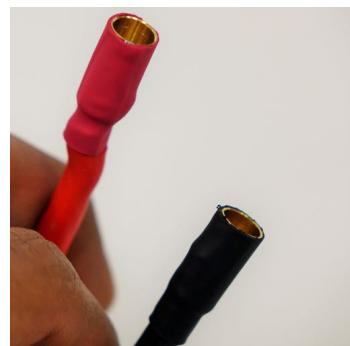
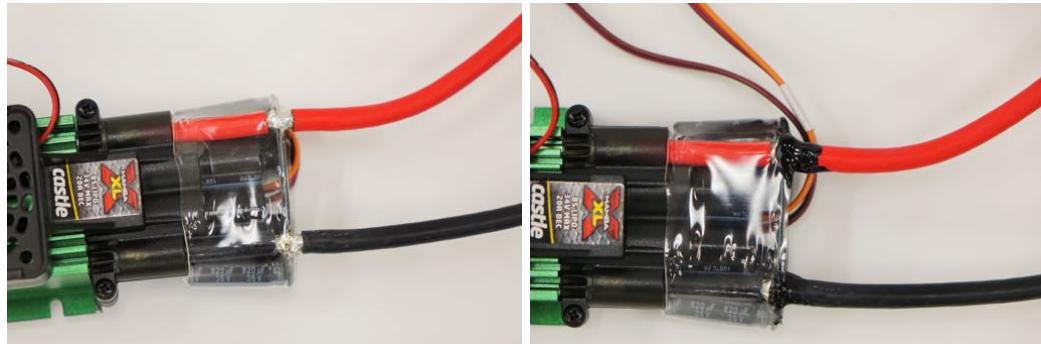
- h. Use black heat shrink to cover resistors from where they are soldered to the battery lead so no bare wire is exposed



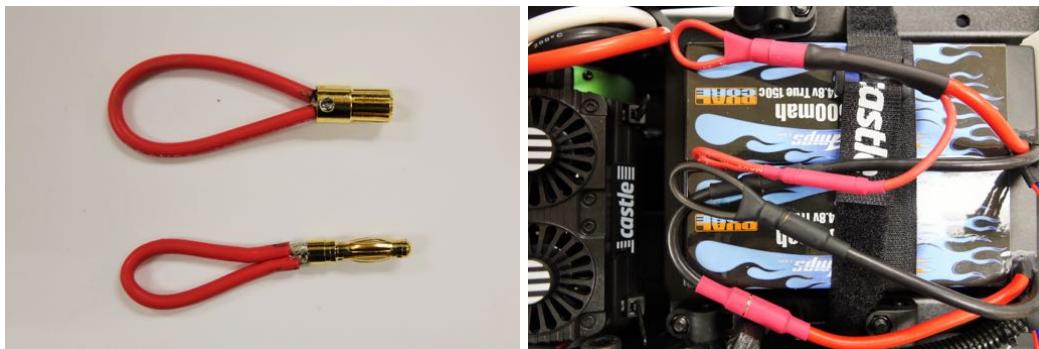
- i. Solder wire with 4mm male connector to bare wire on battery lead with 4mm connector facing away from the 6.5mm female bullet connector



- j. Apply heat shrink to cover exposed solder joints and hold priming wires in place on ESC wire. Also, use liquid electrical tape to cover the exposed connections on the ESC as seen in the images below.



- k. Loop a length of red 16 awg wire and solder both ends into the solder cup of a male banana connector. Heat shrink the solder joints to ensure that they are not exposed.
- l. Repeat the process in the previous step to create two red loops with 6.5 mm male connectors and two black loops with 6.5 mm male connectors. Heat shrink the solder connection to ensure that no part of the connection is exposed. **Bring the heat shrink down to the edge of the connector body above the part that actually forms the connection.**



- m. Use the plugs created in the previous two steps to plug the battery connectors when the vehicle is not in use. This will prevent inadvertent battery connections or short circuits.

5 Electric Conversion

Time 8 hours 0 minutes

Parts

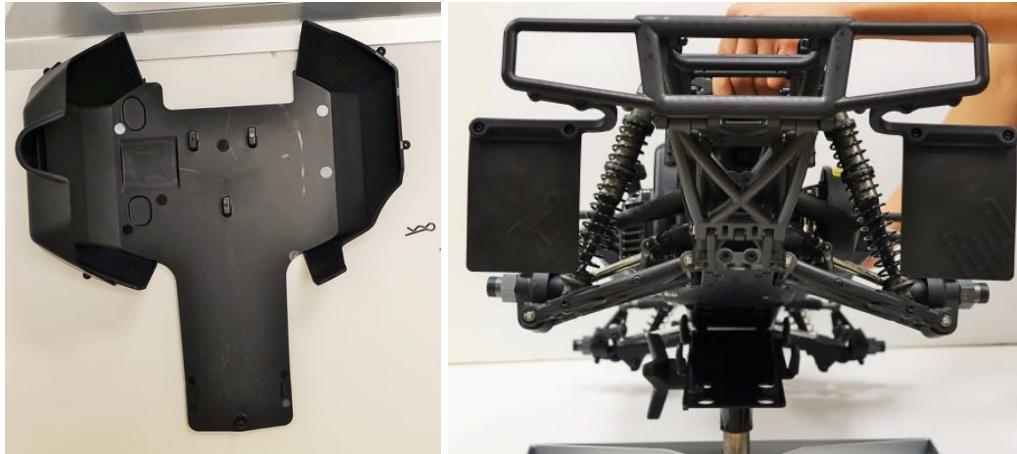
- Castle Creations ESC
- Castle Creations 2028 motor
- Castle Creations motor fan
- Castle Creations Baja conversion hardware

Instructions

- a. A link to videos is provided in Useful Links or they can be found in the Baja_Electric_Conversion_Videos in the [videos/](#) folder. Modifications to video instructions are listed below.
- b. Remove the wheels, rear skid plate, engine plate, side covers, both side rail guards, and the roll cage.



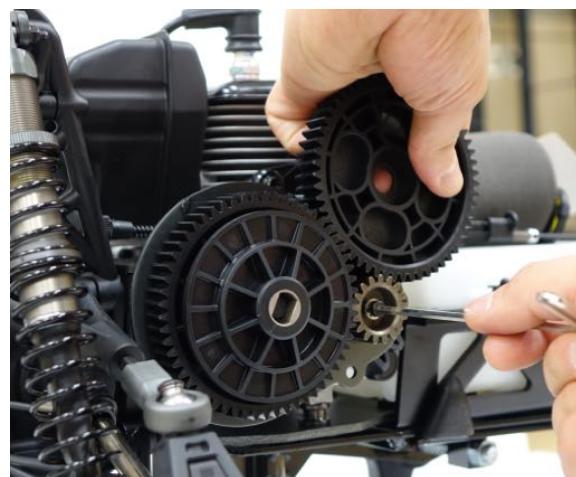
- i. Removal of rear skid plate: Remove the single body clip at the back holding the skid plate to the frame. Then pull the skid plate out.



- ii. Removal of side guard rails: For each guard rail, remove the 2 screws on the top (front side), 2 at the bottom (rear side) and 1 body clip each (rear side). Use provided tools with the conversion kit.



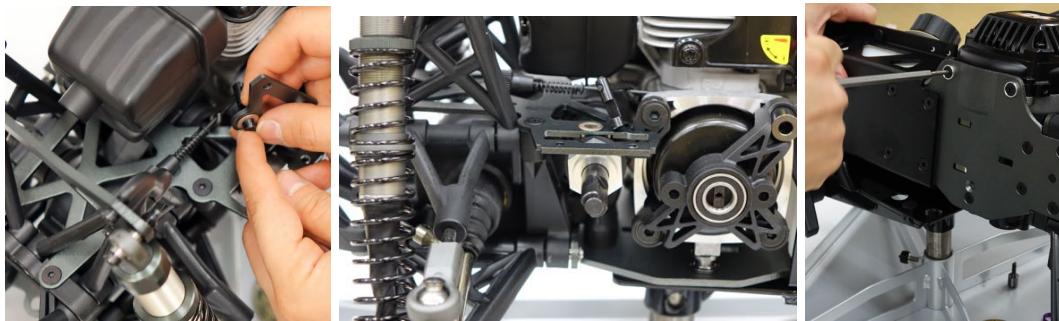
- c. Disassemble the transmission. **Remove the C-clip first (you can use pliers for this).** Use the extra spur gear provided to remove the pinion gear (refer to the images).



- d. Remove the rear brake and clutch, both engine mount braces, the air filter sleeve set, and all engine screws on the base plate (on the bottom of the chassis).

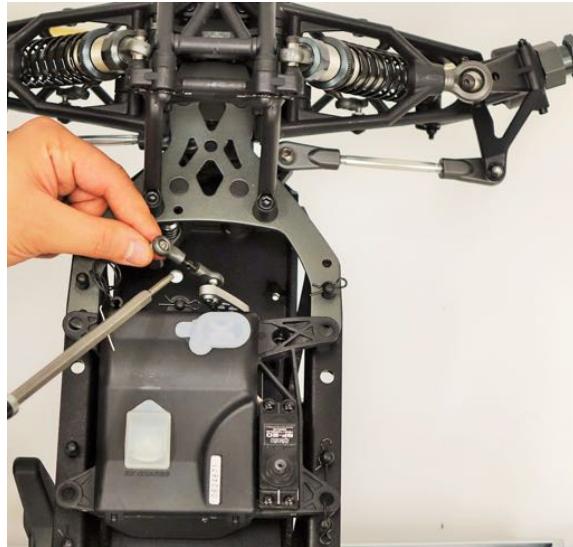


e. Disconnect the throttle linkage, and remove the engine.

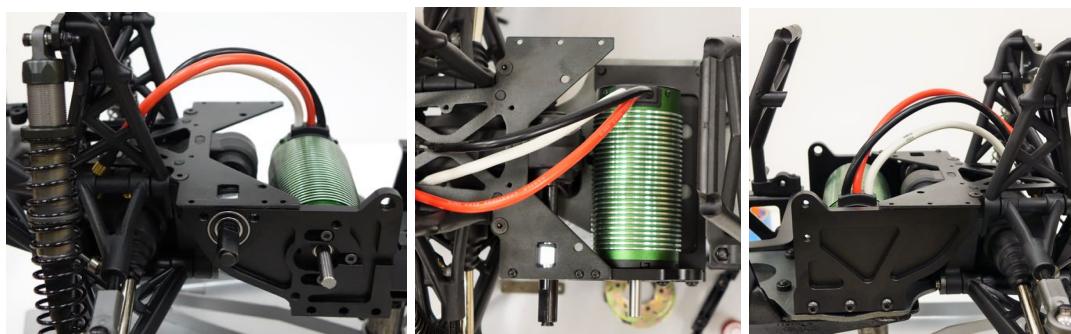
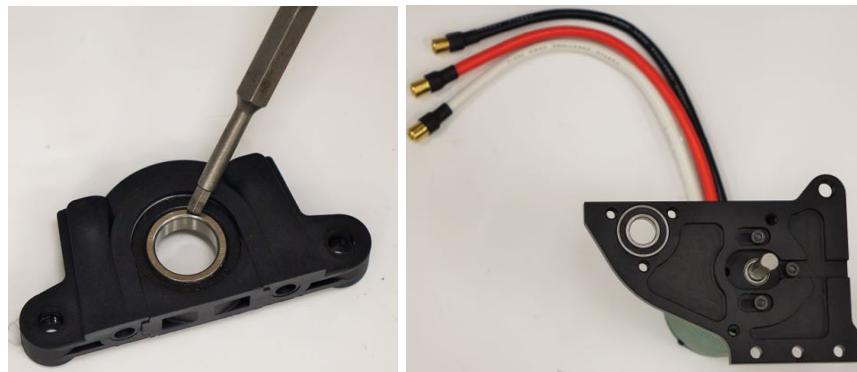


f. Disconnect the fuel lines and remove the gas tank. Reserve the plastic supports that connect the tank to the aluminum chassis for the Electronics Box installation.

g. Disconnect the steering servo and remove the battery box.



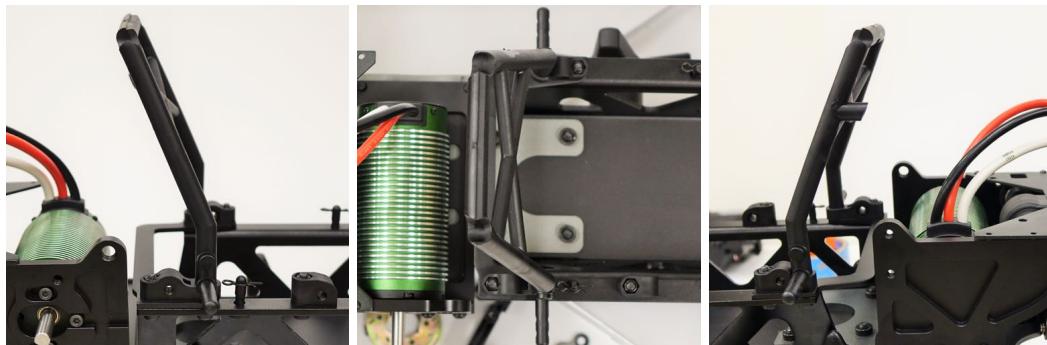
- h. Remove the rear upper plate.
- i. Install the motor with the wires facing up. The video will say to install the wires with the motor wires facing to the side, but disregard that instruction. Additionally, disregard how the wires are routed in the videos. Wire routing instructions are included in a later section. **Remember to always use thread lock (use Z186 red threadlock or use blue Loctite 243 instead of the greenish-blue colored thread lock Z159) for metal on metal connections.**



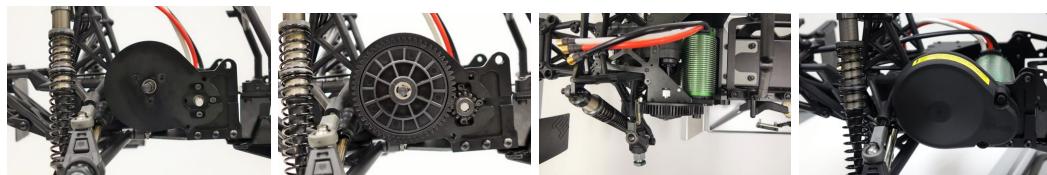
- j. **Follow the details of the next two steps exactly as written.** Keep the M4×8 screws very loose to align the motor mount plate and tighten the bottom screws.

5 ELECTRIC CONVERSION

k. In electric conversion video #4, the roll cage is installed. Prior to installing the roll cage, first place the Passenger Frame Plate (item #9 in the electric conversion kit) and loosely install the M8 x 10mm long socket head cap screw (item #25). Then loosely insert the screws for the roll cage. Then, loosely install the two M5 x 15mm screws (item #22) into the Passenger Frame Plate. Finally, tighten all the screws on the Passenger Frame Plate first, and then tighten the screws for the roll cage.



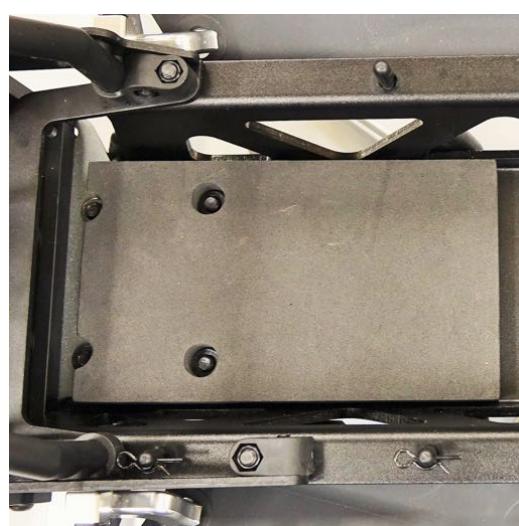
l. Follow electric conversion video #5 to set up the mesh.



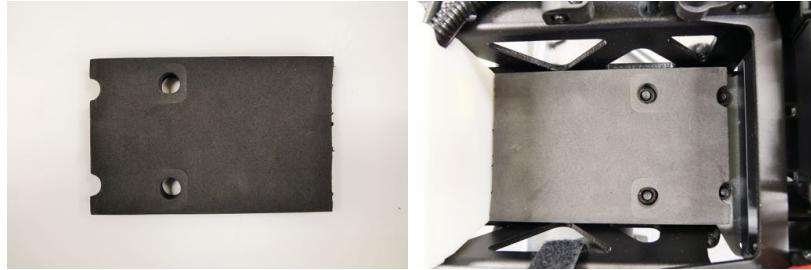
m. Do not reinstall the front side rail guards, battery box with servo, and wheels.

n. After completing the electric conversion, cut 1/2 inch off the foam board for the batteries end facing the front of the chassis.

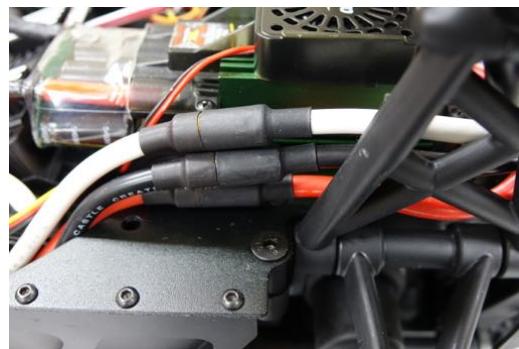
o. Picture of foam before cutting:



p. Below are pictures of foam after cutting. This is done to allow the custom electronics box to sit in the space between the batteries and the servo.



- q. **Do not follow steps in video #8.** However, it is still useful to watch.
- r. In video #9, only perform the steps required to connect the motor and the ESC. Remember to connect white to white and black to black. Do not follow the steps in the remainder of video #9. Refer to the photo.



6 Steering Linkage and Side Rail Guards

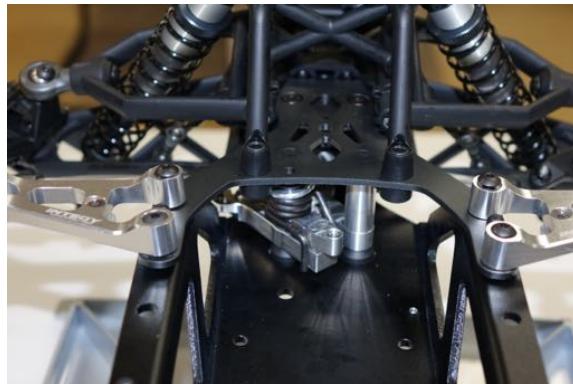
Time 1 hours 0 minutes

Parts

- Turtle Racing Billet Servo Saver
- Integy Side Rail Guards
- Low-temperature threadlock

Instructions

- a. Complete through step 13 of the [Steering Linkage Instruction Booklet](#), also located in [manuals/](#)



- b. When remounting the side rail guards, use the Integy Side Rail Guards instead of the stock plastic side rail guards and add a drop of threadlock on each of the 4 mounting screws



7 Battery Box Eliminator and Steering Servo

Time 1 hours 0 minutes

Parts

- Team Fast Eddy Battery Box Eliminator Kit
- Savox steering servo
- 2 small body pins
- M3 lock nut (part no. Z663 in the Baja kit)

Instructions

- a. Secure steering servo to battery box eliminator with 4 included screws ensuring correct orientation.
 - i. To secure the steering servo into the battery box eliminator, remove the 4 screws on the base of the servo and take-off the base. Then slide the servo into the eliminator bottom

first. Put the base back onto the servo and secure it with the 4 screws (Refer to images for proper orientation of the servo with respect to the battery box eliminator). Finally, secure the servo to the battery box eliminator using the 4 provided screws. Use thread lock as they are metal-to-metal connections (Disregard the nuts, spacers, etc. provided with the servo for now). **Ensure that the gasket is aligned and the servo base plate is seated correctly.**

- ii. Position the servo horn such that the arm is vertical when the servo is centered. To find the vertical position, first move the horn to either extreme. The rightmost photo below shows the position of the servo horn when the servo is centered.



- b. Complete steps 14-15 in the Billet Steering Linkage instructions to attach steering servo to servo saver
- i. Next, install the servo link arm. Use thread lock on the screw. Use the tie arm from original steering servo mechanism to connect the servo link arm to the servo saver assembly. To do this use a M3 lock nut (Baja part # Z663) from the spare parts provided with the Baja. This is crucial as any different sized lock nut would obstruct the motion of the servo link arm (180 degrees).
- c. Install the battery box eliminator onto the chassis using two body clips, such that you are able to read “TEAM FAST EDDY” on the top of the eliminator when looking from the front of the chassis toward the back.



8 Shocks

Time 2 hours 0 minutes

Parts

- Front springs: 5.8"
- Back springs: 2" and 4"
- 2 59 ml bottles of Factory Team 60w silicone shock oil

Instructions

9 AXLE EXTENDERS

- a. Refer to the **shock maintenance** instructions in the Baja 5SC instruction manual. Remove the 2 cap head screws (94510 and 94520 at the top and bottom of the front shocks; 94510 and 94512 at the top and bottom of the rear shocks) that hold each of the shocks to the chassis.
- b. Referring to the **Shock Disassembly** instructions, disassemble each of the 4 shocks.



- c. Refer to the Shock Assembly section in the Instruction Manual to replace the HD Piston 16mm C-1 (16 holes) with HD Piston 16mm A-1 (2 holes). **This is required to be done before filling the shocks with oil.**
- d. Refer to **Filling with Shock Oil** instructions. Make sure to fill all the 4 shocks with 60w oil.
- e. Refer to **Shock Spring Installation** to replace the original springs with new stiffer springs.



- f. Reverse the steps above to reinstall the 4 shocks.



9 Axle Extenders

Time 2 hours 0 minutes

Parts

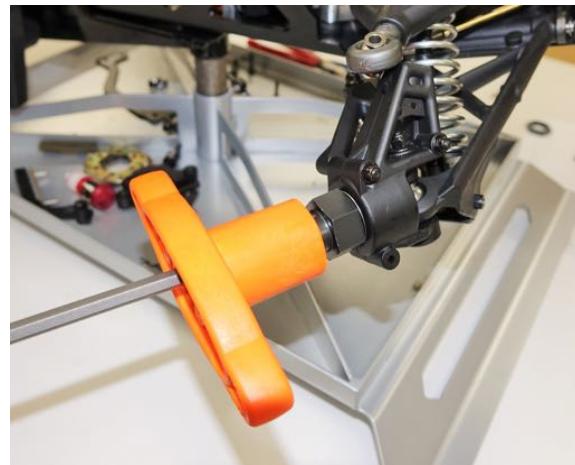
- Darksouls Baja axle extender set

Instructions

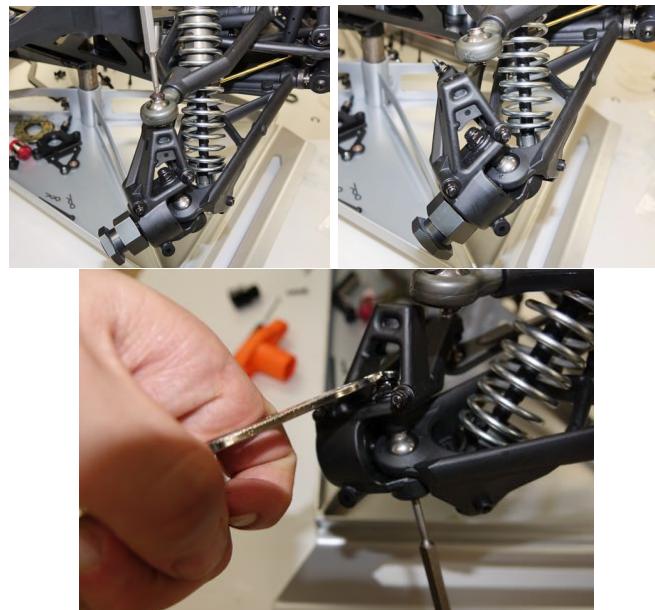
9 AXLE EXTENDERS

a. Front axle extenders

- i. Remove the screws from the inside of the front axle extenders.



- ii. Remove the top and bottom screws that hold the front axles boots to the rest of the axle assembly.



- iii. Remove the stock axle extenders and replace with the Darksouls front axle extenders.



- iv. Secure the front axle extenders using C-clips.



- v. Replace the screws that connect the axle boots to the rest of the axle assembly.

b. Rear axle extenders

- i. Remove the screws from inside the rear axle extenders.



- ii. Push out the pins that hold the rear axle extenders to the drive shaft.



iii. Remove the stock axle extenders and replace with the DarkSouls rear axle extenders.



iv. Replace the pins.



v. Loosely screw in the nuts on the rear axle extenders so that they do not get misplaced.

10 Wheel Rotation Sensor Magnet Mounts

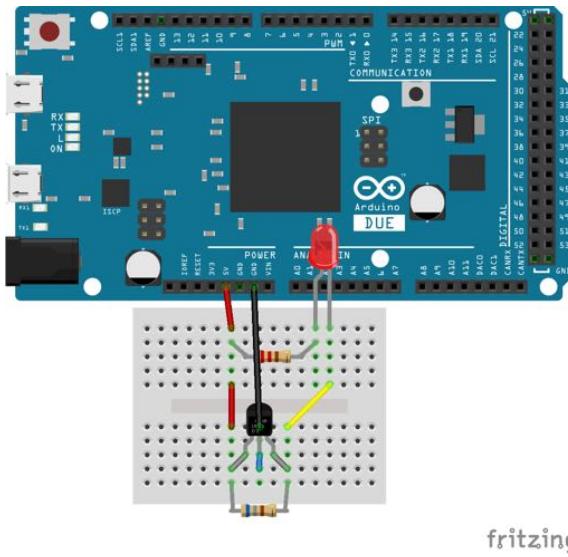
Time 1 hours 15 minutes

Parts

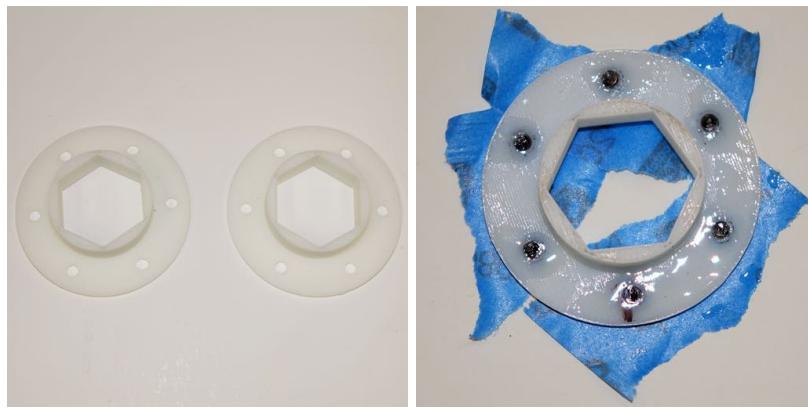
- 2 3D printed front wheel magnet mounts (if front brakes are not used)
- 2 3D printed rear wheel magnet mounts
- 4x12 wheel rotation sensor magnets
- Arduino Due (or alternative 5V source)
- Red LED
- 220Ω resistor
- 680Ω - 820Ω resistor
- Optek OH090U Hall-effect sensor
- epoxy

Instructions

- a. Assemble the magnet test circuit as shown in the figure below.



- b. Take one of the magnets and bring it near the front face of the Hall-effect sensor of the test circuit assembled in the previous step. **The front face has writing on it.** If the LED does not light up, flip the magnet over and try again.
- c. The side of the magnet facing the front face of the sensor when the LED lights up is the south pole of the magnet. For **each** of the wheel rotation magnet mounts, mark the south pole of 12 magnets.
- d. Epoxy the magnets to the magnet mounts. The magnets must be correctly oriented; **ensure that the south pole of the magnets faces the side of the mount opposite the large protrusion.**



- e. The epoxy may take some time to dry; if necessary, use tape on the side of the mounts without epoxy to hold the magnets in place.

11 Front Brakes, Disc Aligner

Time 3 hours 0 minutes

Parts

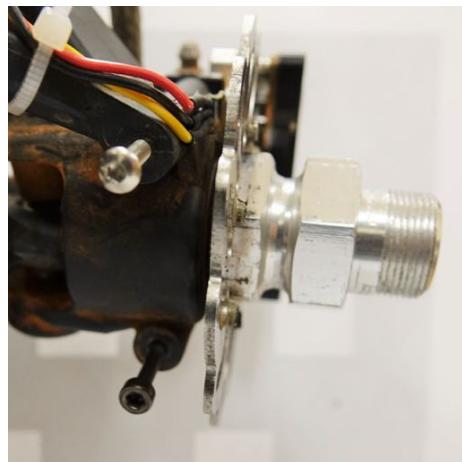
- Mecatech front brake kit
- 3D printed master cylinder mount
- 2 front brake disc aligners
- Zip ties
- 2 M3×42mm screws (stock)
- 2 M3×50mm screws
- 12 1/8" diameter magnets (6 for each disc)
- epoxy

Instructions

- a. Epoxy the 6 magnets to the brake discs such that the south pole of each of the magnets faces outward towards the rotation sensor. To determine the south pole side of the magnet, use the test circuit detailed in the previous section. Refer to the picture below for the correct face to epoxy the magnets.



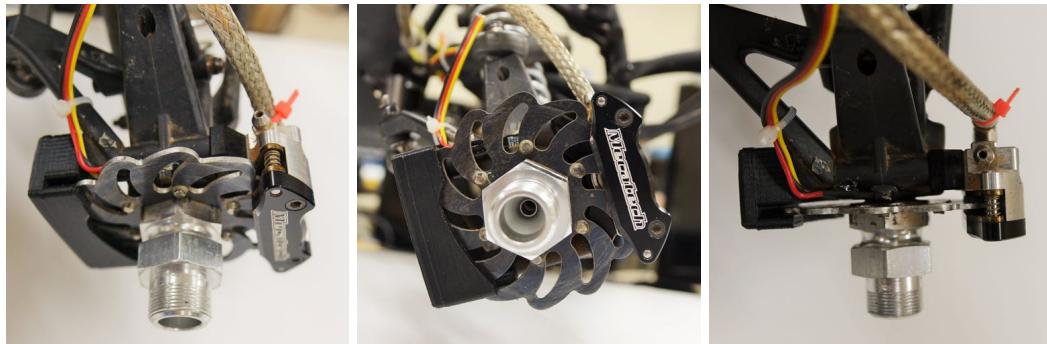
- b. Follow Mecatech front brake installation except for the master cylinder placement and wait to bleed the brakes until the end of this section.
- c. Remove two screws as seen in the picture.



- d. Orient the brake disc aligner such that the brake disc slot is on the outer side.

12 FRONT AND REAR ROTATION SENSORS

- e. Insert the M3×50mm screw in the top hole of the brake disc aligner and the stock M3×42mm screw in the bottom hole of the brake disc aligner. Leave both screws loosely installed.
- f. Spin the brake disk and allow the slot in the brake disk aligner to adjust so that the brake disk can spin freely. Then tighten down the bolts.



- g. Bleed the brakes. A video tutorial is available at [Mecatech Brake Bleed Tutorial](#).

12 Front and Rear Rotation Sensors

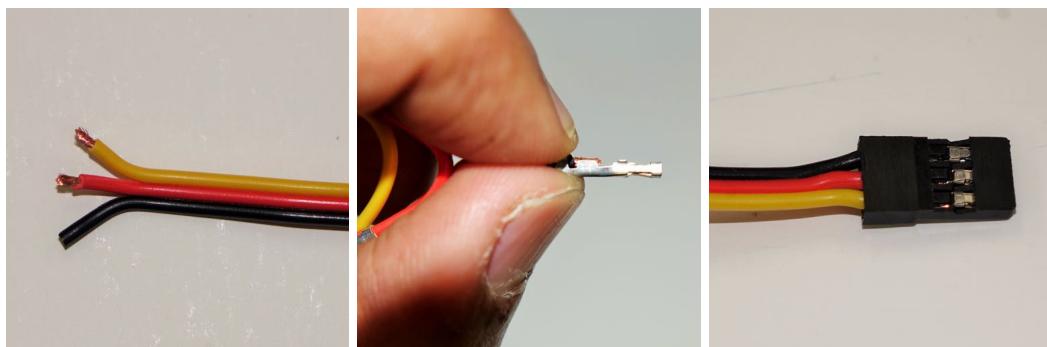
Time 1 hours 30 minutes

Parts

- 6 Optek Hallogic OH090U Hall Effect Sensors
- 6 Futaba J female connector assemblies
- 6 11" lengths of servo wire
- Heat shrink
- Zip ties

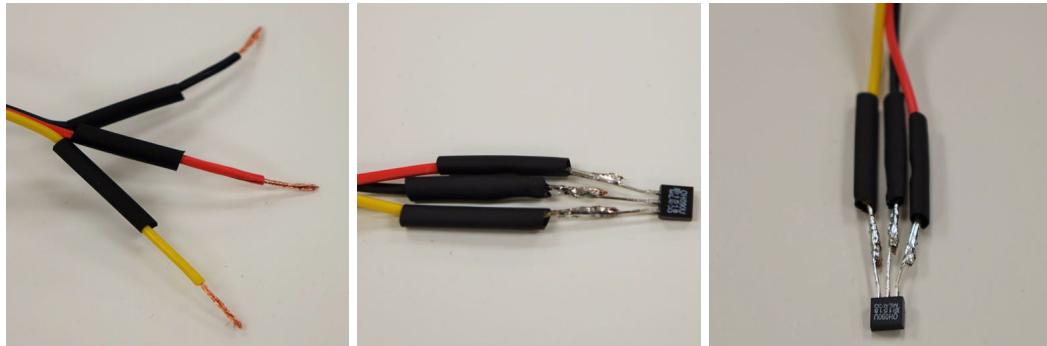
Instructions

- a. Follow this [Crimping Tutorial](#) and the [Molex Crimping Guide](#) to learn how to crimp these connectors. [Crimp Pins Pictures](#) shows some well-made crimps.
- b. Crimp one Futaba J connector to one side of each of the 11" lengths of servo wire.

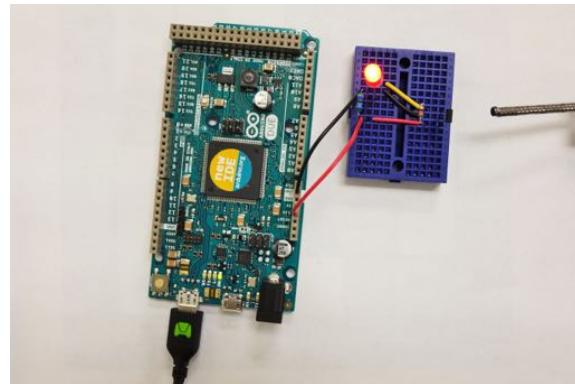


- c. Solder one sensor to the opposite end of each of the 6 lengths of servo wire. Note that the ground lead of the sensor is the middle lead, so ensure that the correct wire is soldered to each lead.

See the [Rotation Sensor Datasheet](#) for more details. Note that when the writing on the sensor face is facing you, the leftmost lead is VCC, the middle lead is ground, and the rightmost lead is the sensor output. Note that a small piece of heat shrink should be slipped onto each lead prior to soldering.



- d. Heat the heatshrink on each lead and ensure that the lead and the solder joint are completely covered. No conductive part of the assembly should remain exposed.
- e. Test each of the completed rotation sensor assemblies using the test circuit and the wheel rotation magnet mounts created in previous steps.



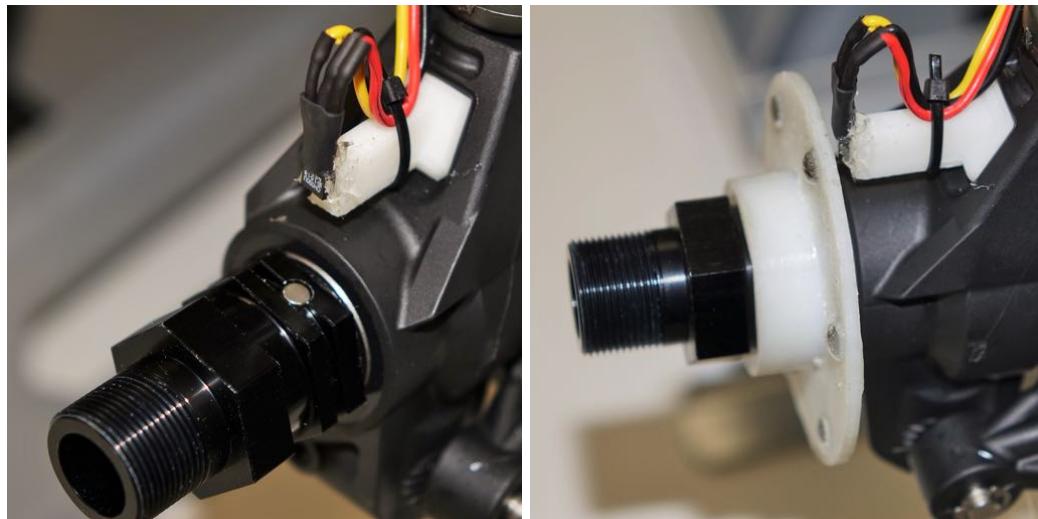
- f. Install the 3D printed rear rotation sensor mounts as shown in the photo. Note that the lock nut should be installed with the protrusion facing downward as shown in the photo.



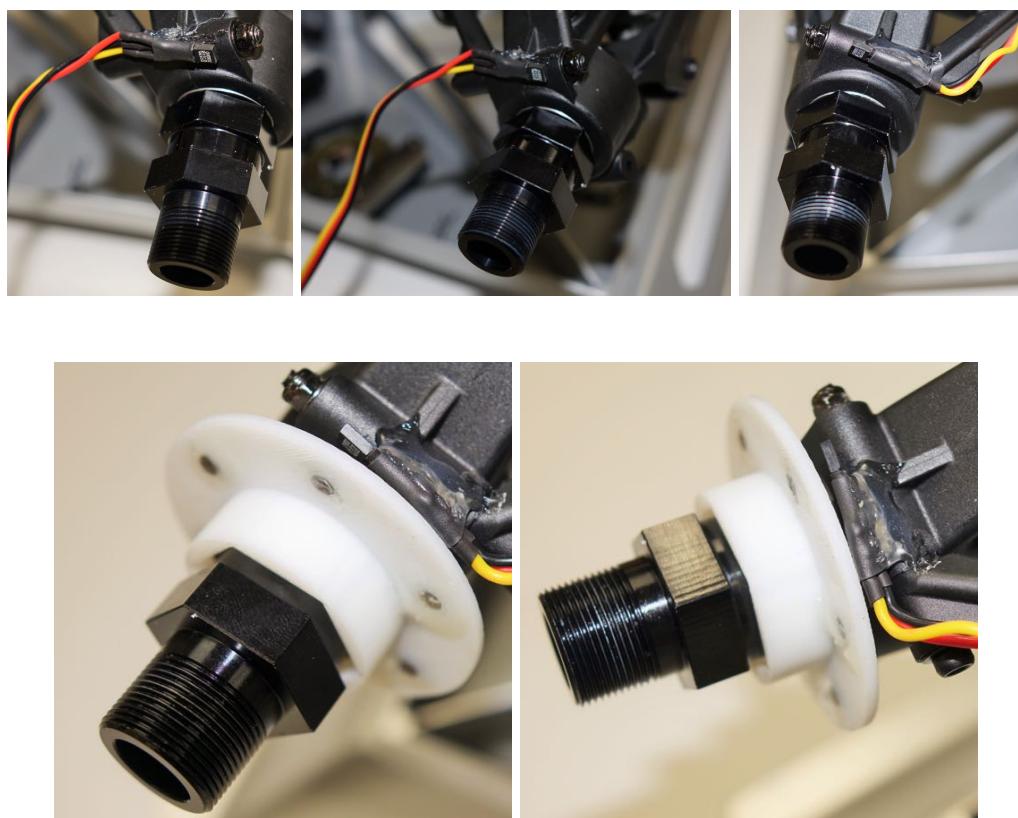
- g. Hot glue one sensor assembly to each of the sensor mounts. Carefully align the sensor with the magnets on the rear rotation sensor magnet mount in order to ensure that the sensor will reliably detect each magnet as it passes the sensor face.

12 FRONT AND REAR ROTATION SENSORS

- h. Slide the assembled magnet mounts from the section “Wheel Rotation Sensor Magnet Mounts” onto the axles with the large protrusion facing outward.



- i. Use hot glue to secure one of the sensor assembly to each of the front hubs. **Carefully align the sensor with the magnets on the front rotation sensor magnet mount/brake disc** in order to ensure that the sensor will reliably detect each magnet as it passes the sensor face.



- j. Note that only 4 sensor assemblies are required for the chassis; two of the 6 assemblies are spares.

13 Tire Foams

Time 2 hours 0 minutes

Parts

- Zero-growth tire foams front (red)
- Zero-growth tire foams back (blue)

Instructions

- a. Refer to the Baja 5SC manual for tire foam replacement diagrams
- b. Remove all of the bolts on both sides of the tire. Remove the beadlocks and slide off the rubber tire and remove the inner foams.

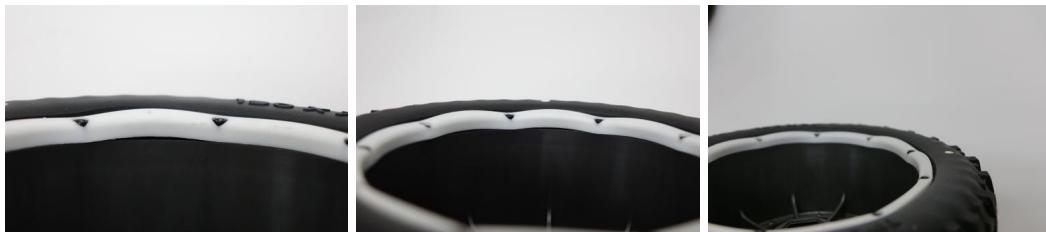


- c. Slide the new front tire foams onto the front tire rims. Front foams are 1cm narrower than the rear.



- d. Slide the new rear tire foams onto the rear tire rims. **Rear foams are 1cm wider than the front.**
- e. Slip the tire rubber over the foams and begin to screw in the bolts in an alternating pattern. Refer to the HPI Baja 5SC manual for example diagrams. It may be difficult to align the bolts and holes for the rear tires.
 - i. Ensure that the rubber tire material is properly seated into the respective slots. Then ensure that the rims slots properly align with the tire material.
 - ii. This step may require more than one person.
- f. Make sure the beadlocks sit flat and do not pucker when the screws are installed. If there is pucking, loosen the screws, realign the tire rubber and then retighten. Properly seated rubber inserts will make it easier to get the beadlock to sit flush against the tire. **The photos show good and bad examples of seated beadlocks.**

g. The photos below show bad examples



h. The photos below show acceptable examples



14 Cut Roll Cage

Time 0 hours 10 minutes

Parts

- Large zip ties
- Roll cage from Baja 5SC

Instructions

a. Cut the roll cage just in front of the rear shock tower. The blue tape in the photos below shows the approximate location at which to cut.



b. Remove all roll cage components forward of the cut. The remaining components are shown below.



c. Secure remaining cut ends to shock tower with large zip ties



d. Cut center roll bar off just above side rail guards. Discard the part of the roll cage shown below.



15 RC Transmitter

Time 0 hours 30 minutes

Parts

- Futaba 4PLS transmitter
- Futaba receiver

Instructions

- a. Refer to the included Futaba 4PLS manual or the PDF file in the [manuals/](#) folder to locate and set the specified parameters.
- b. Apply power to the receiver while the transmitter is on and verify the transmitter connects to the receiver. If not, follow instructions in the manual to pair the devices.
- c. On the transmitter, configure RX MODE to be T-FH (NORM).



- d. On the transmitter, set the Throttle Channel (THR) to Reverse (REV).



- e. On the transmitter, configure SW2 to operate Channel 3 (CH3).
- f. On the transmitter, configure SW1 to operate Channel 4 (CH4).



- g. On the transmitter, configure the SW1 mode to ALT (alternate).

16 ESC

Time 0 hours 20 minutes

Parts

- Castle Serial Link software installed from [Castle Serial Link](#)
- Castle Link programmer
- Futaba 4PLS and receiver

Instructions

- a. Connect ESC to Castle Link according to the Tuning With Castle Link section in the Mamba XL X Driver's Ed Guide.
- b. Use Castle Link software to change the following settings
 - i. Basic → BEC Voltage to 7.5 V.
 - ii. Basic → Auto-Lipo Volts/Cell to 3.1V.
 - iii. Power → Start Power to High.
 - iv. Advanced → Throttle Dead Band to 0.0625 ms.
 - v. Advanced → Link Live Enable to Enabled.
 - vi. Logging → Sample Frequency to Disabled
- c. Save the ESC settings by pressing the Update button in the Settings Control area of the Castle Link software

17 Castle Serial Link

Time 0 hours 20 minutes

Parts

- Castle Serial Link installed
- Castle Link Programmer

Instructions

- a. Connect Castle Serial Link to Castle Link according to instructions.
- b. Use Castle Link software to change the following settings
 - i. Basic → Communication Mode to TTL Serial (with PPM Input)
 - ii. Basic → TTL Serial Baud Rate to 115200
 - iii. Basic → Fail Safe Output to Center (1.5ms)
- c. Save the Castle Serial Link settings by pressing the Update button in the Settings Control area of the Castle Link software

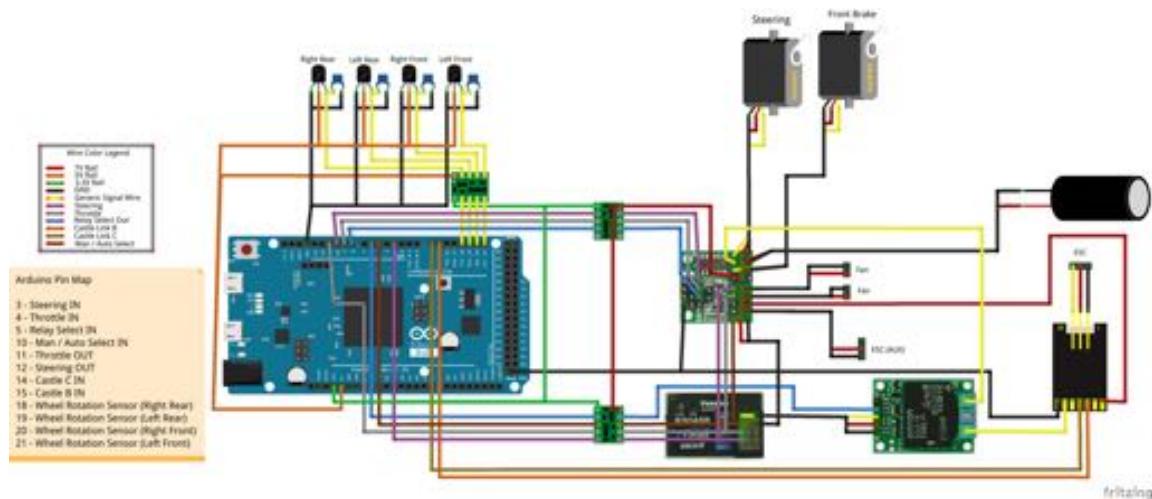
18 ProtoShield Assembly

Time 5 hours 0 minutes

Parts

- Adafruit ProtoShield
- 3 Pololu Level Shifters
- 4 20pF capacitors
- 26 AWG wire
 - 20" blue
 - 7" red
 - 26" yellow
 - 4" black
- Servo cable
 - 70" yellow-red-black
 - 18" green-blue-purple (any 3-conductor ribbon cable, preferably different colors than the YRB servo cable)
- 6" red-black cable
- 4 Male Futaba J-Connectors
 - 12 crimps
 - 4 housings
- Female 0.1" Crimped Headers
 - 3 single-position
 - 5 two-position
 - 2 three-position

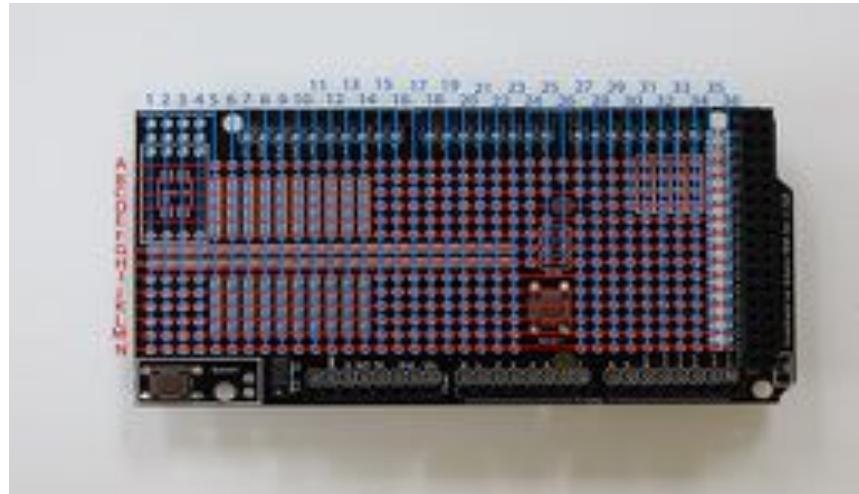
The following diagram shows the schematic for the components within and connected to the Electronics Box. This schematic defines the connections we will be making on the ProtoShield.



NOTE: A scalable version of the drawings (AutoRally Electronics Box) is available in the folder [wiringDiagrams/](#).

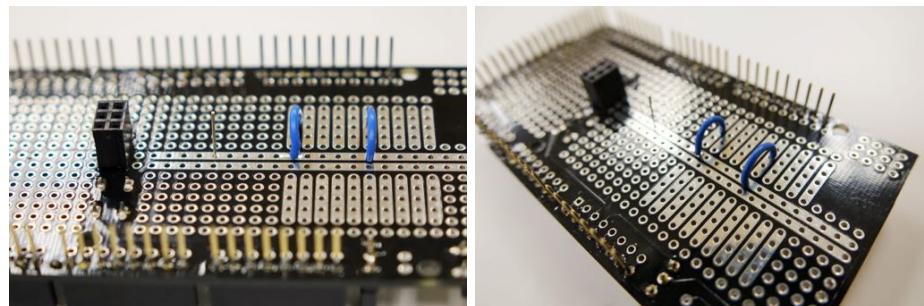
If you have not soldered before, or would like a refresher course, please consider watching this [Adafruit Soldering Tutorial](#).

During the following instructions, individual pads on the ProtoShield grid will be identified using the coordinates defined in the following diagram.

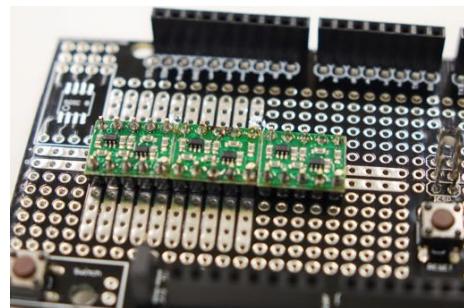


Instructions

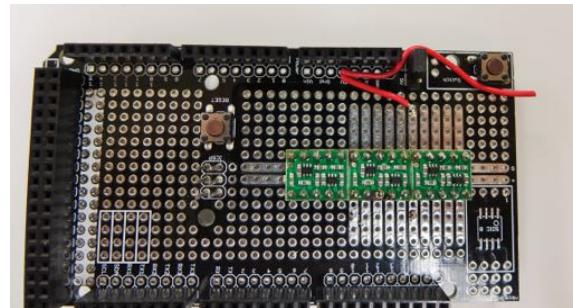
- a. Assemble the base protoshield kit, including its various headers, buttons, and jumpers.
- b. Make sure the voltage selection jumper on the ProtoShield is set to 3.3V.
- c. Cut two 1" lengths of blue wire and one 1/4" length of uninsulated wire (or scrap leads cut from capacitors or resistors). Solder one blue wire to connect pads D9 to G9 and D14 to G14. Solder the uninsulated wire to connect pads F19 to G19.



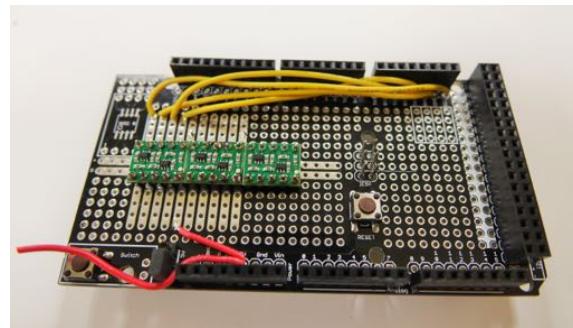
- d. Place and solder the 3 level shifters. Pin 1 of the level shifters (octagonal pad next to the exposed circular pad) should be placed in pads I9, I14, and I19.



- e. Cut two short lengths, one about 1 1/2" and one about 2" of red wire. Solder one end of each wire to the 5V output pin of the arduino footprint. Solder the other end of the 3/4" length wire to via M9.



- f. Cut four 3 1/2" lengths of yellow wire. Solder these wires to connect pads B5 to D I/O 21 (SCL), B6 to D I/O 20 (SDA), B7 to D I/O 19 (RX1), and B8 to D I/O 18 (TX1).

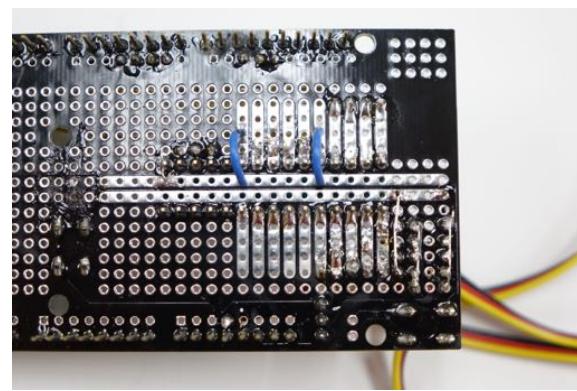
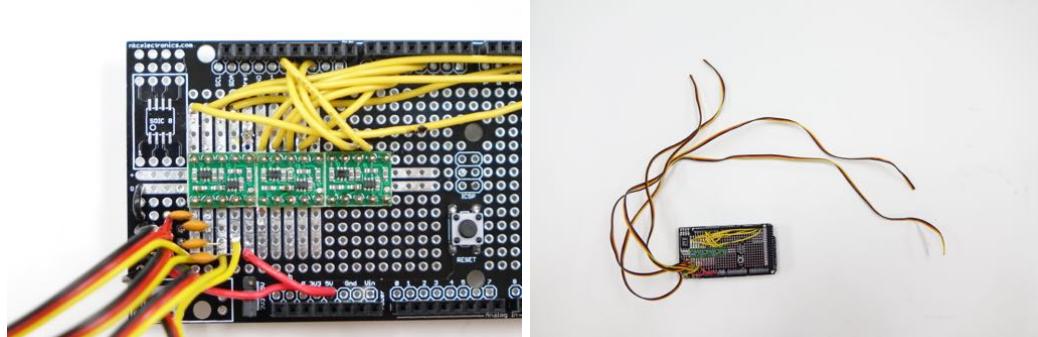


- g. Cut seven 1 1/2" lengths of yellow wire. Solder these wires to connect the following via pairs.

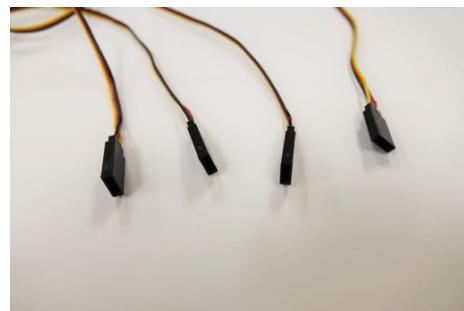
- i. E10 - D I/O 3
- ii. E11 - D I/O 11
- iii. E12 - D I/O 5
- iv. E13 - D I/O 6
- v. E16 - D I/O 8
- vi. E17 - D I/O 9
- vii. E18 - D I/O 10



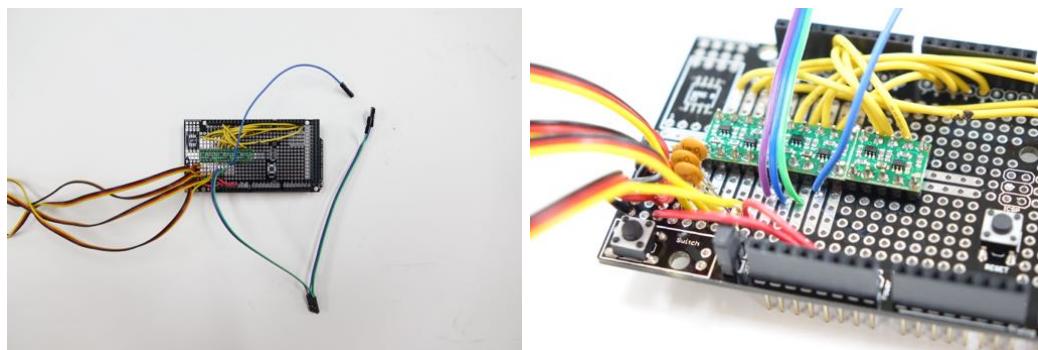
- h. Cut four lengths of Yellow-Red-Black servo cable. Two of length 13" and two of length 22". These will be used for the wheel rotation sensors. Also, cut one 1/2" length of black wire. Solder the black wires of all of the servo cables to pads K1 through N1. The order is not important. Solder the short black wire to connect J1 to H1. On the bottom side of the shield, connect this row of black wires with a length of uninsulated wire.
- i. Solder all of the red wires of the servo cables introduced in step 8 to pads K3 through N3. Solder the longer red wire from step 4 to via J3. Use a section of uninsulated wire to connect all of these red wires on the bottom side of the board.
- j. Solder four 20pF capacitors to connect the following pads.
- J4 and J5
 - K4 and K6
 - L4 and L7
 - M4 and M8
- k. Using a short length of uninsulated wire, connect pads H4, J4, K4, L4, and M4 on the bottom side of the board.
- l. Solder the yellow wires of the servo cables into the following pads.
- M5 (13" cable)
 - M6 (13" cable)
 - M7 (22" cable)
 - L8 (22" cable)



- m. Crimp a male Futaba J connector, with outer housing, to the end of each of the wheel rotation sensor servo cables.

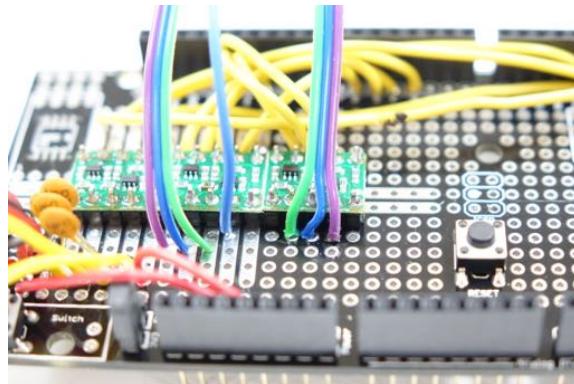


- n. Cut a 6" length of blue wire. Crimp one end into a single-position, female 0.1" header. Solder the other end to via J13.
- o. Cut two 6" lengths of Green-Blue-Purple servo cable. Crimp one end of each cable into the same three-position, female 0.1" header to form a Y-cable harness. On the other end of one cable, add female crimps to all three wires. Then, insert the blue and purple wires into a two-position, female 0.1" header and the green wire into a single-position, female 0.1" header.
- p. Solder the remaining end of the Green-Blue-Purple servo cable Y-harness to the following pads
- K10 (Purple)
 - K11 (Blue)
 - K12 (Green)

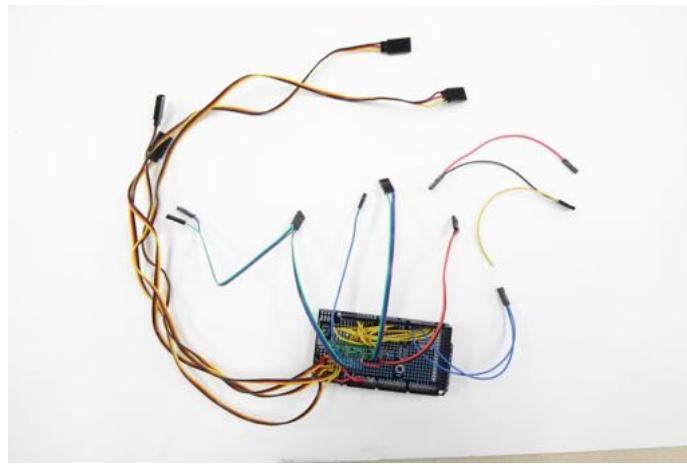


- q. Cut a 6" length of Green-Blue-Purple servo cable. Crimp one end of this cable into a three-position, female 0.1" header. Solder the other end to pads J16 (Green), J17 (Blue), and J18

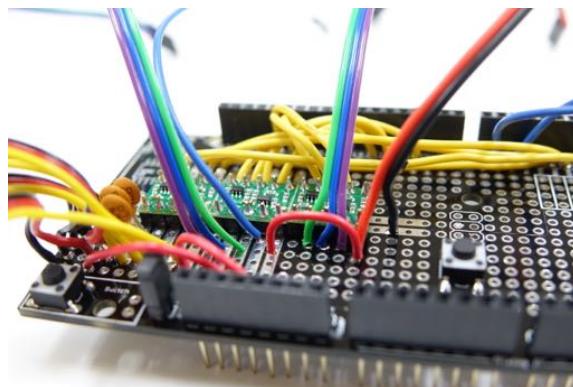
(Purple).



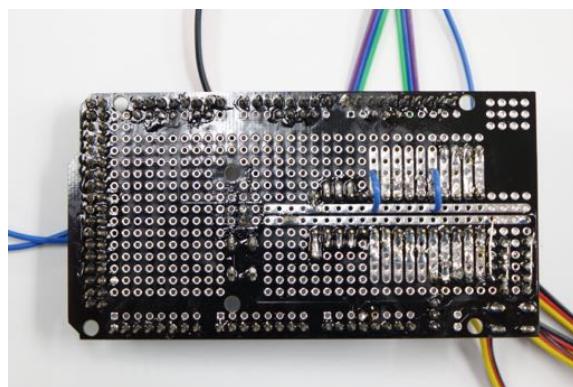
- r. Cut 6" lengths of Red and Black wires. Crimp and insert one end of each wire into a two-position, female 0.1" header. Solder the other end to pads J19 (Red) and H21 (Black).
- s. Cut two 6" lengths of blue wire. Cut a 4" length of yellow, red, and black wire. (Individual wires, not a servo cable). These wires will be used to create the harness for the Castle Creations Serial Link.
 - i. Solder one end of one blue wire to D I/O 15 (RX3) and crimp and insert the other into the first space of a two-position, female 0.1" header.
 - ii. Solder the other blue wire to D I/O 16 (TX3) and crimp and insert its other end to the second space of the same two-position header.
 - iii. Crimp and insert the black wire into the first position of another two-position header.
 - iv. Crimp and insert one end of the yellow wire into the second space of the two-position header, leaving the other end exposed.
 - v. Crimp and insert the black wires other end into the first space of a two-position, female 0.1" header.
 - vi. Crimp and insert one end of the red wire into the second space of that same two-position header.
 - vii. Crimp and insert the other end of the red wire into a single-position, female 0.1" header.



- t. Cut a 1" length of red wire. Solder it to connect pads K14 to K19.



- u. On the bottom of the ProtoShield, use excess solder to connect the following sets of pads. Be careful not to accidentally short neighbouring pads with the extra solder.
- i. I19, J19, and K19
 - ii. I18 and J18
 - iii. I17 and J17
 - iv. E18 and F18
 - v. E17 and F17
 - vi. F19 and G19



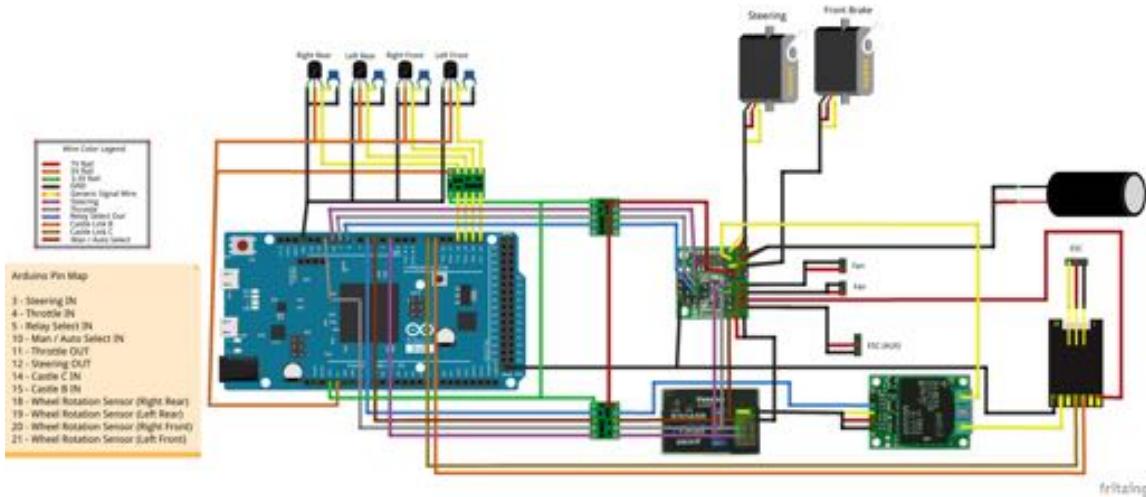
19 Electronics Box Assembly

Time 2 hours 0 minutes

Parts

- Arduino DUE
- Assembled ProtoShield from previous step
- Castle Creations Serial Link
- Pololu RC Relay
- Pololu Servo Multiplexer
- Futaba RC Receiver

- 1 assembled 6" female-to-female servo cable extension
- 6" of 26 awg yellow wire
- 12" of 26 awg red wire
- 6" of 26 awg black wire
- 3 single-position, 0.1" header housings with female crimps
- 2 two-position, 0.1" header housings with female crimps
- Racers Edge Glitch Buster Power Capacitor (optional)

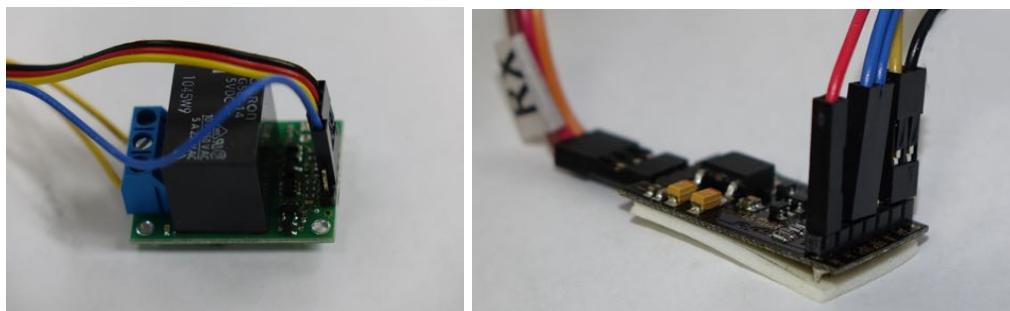


NOTE: A scalable version of the drawings (AutoRally Electronics Box) is available in the folder [wiringDiagrams/](#).

Instructions

- a. Upload code to Due and verify it is sending data using a serial monitor (data values should be garbage right now).
- b. Mount assembled Protoshield to the Arduino DUE.
- c. Plug the middle connector of the Green-Blue-Purple Y-harness to the signal pins of channels 1, 2, and 3 of the Futaba RC Receiver, with the purple wire plugged into channel 1.
- d. Plug the remaining end of the Y-cable into the Pololu Servo Multiplexer. The purple and blue wires should plug into master channel signal pins 1 and 2 (M1 and M2), respectively. The green wire should plug into the select signal pin (SEL).
- e. Plug the non-Y, Green-Blue-Purple harness, connected to pads J16 through J18 on the Proto-Shield, into the Pololu Servo Multiplexer. The purple, blue, and green wires should plug into slave channel signal pins 1, 2, and 3 (S1, S2, S3), respectively.
- f. Create a female-to-female Black-Red jumper cable by crimping and inserting each end of a 6" length of red wire and a 6" length of black wire into a two-position, 0.1" female header.
- g. Plug one end of the female-to-female two-wire, red-black jumper cable into the power (red) and ground (black) pins of the select channel (SEL) on the Pololu Servo Multiplexer.
- h. Plug the other end of the female-to-female two-wire, red-black jumper cable into the power (red) and ground (black) pins of channel 3 of the Futaba RC Receiver.
- i. Plug the single, blue wire from the Protoshield into the output pin on the Pololu RC Relay.

- j. Plug one end of the female-to-female servo cable extension into channel 4 of the Futaba RC Receiver.
- k. Plug the other end of the female-to-female servo cable extension into the input (yellow), power (red), and ground (black) pins of the Pololu RC Relay.
- l. Crimp and insert one end of the 6" length of yellow wire into a single-position, 0.1" header. Plug this header into output channel 2 on the Pololu Servo Multiplexer.
- m. Insert the exposed end of the 6" yellow wire into the Pololu RC Relay screw terminal labelled "NO".
- n. Plug the Black-Yellow end of the Castle Creations Serial Link harness (made in protoshield assembly step s) into the ground and D pins of the Castle Creations Serial Link
- o. Plug the Blue-Blue end of the Castle Creations Serial Link harness into the A and B pins of the Castle Creations Serial Link. The blue wire from Protoshield D I/O pin 15 should go to Serial Link pin A.
- p. Insert the exposed yellow wire of the Castle Creations Serial Link harness into the Pololu RC Relay screw terminal labelled "COM".
- q. Create a female-to-female red jumper cable by crimping and inserting each end of a 6 length of red wire into a female, 0.1 header. Plug one end of this cable into the Castle Creations Serial Link +BUS pin and the other end into the power pin of master channel 3 (M4) on the Pololu Servo Multiplexer.
- r. If you have the Racers Edge capacitor, plug it into the power (red) and ground (black) pins of output channel 2 (OUT2) of the Pololu Servo Multiplexer



20 Electronics Box Installation

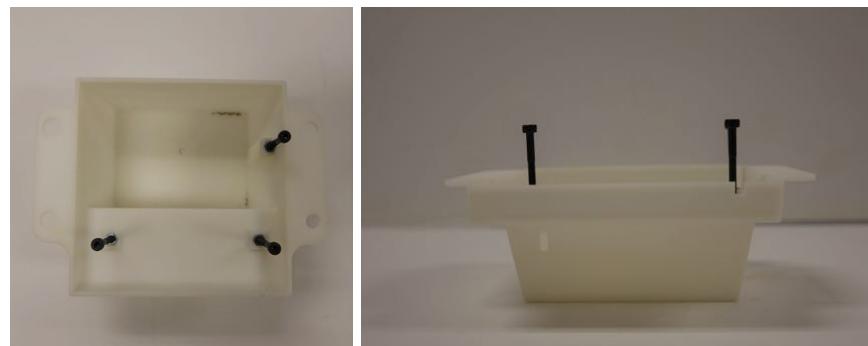
Time 1 hours 30 minutes

Parts

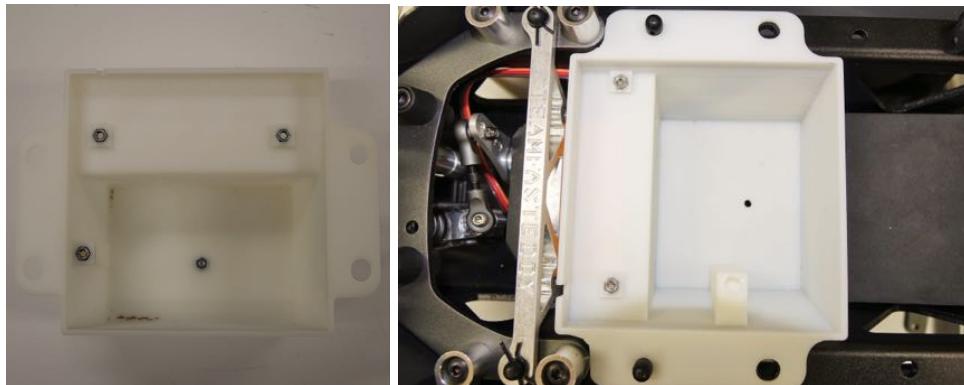
- Printed electronics box
- Electronics box assembly from previous step
- 4 completed wheel rotation sensor assemblies
- 2 reserved plastic supports (Baja part number 85420-6) reserved from fuel tank removal
- 3 M3 nylon washers
- 4 M3 hex nuts
- 1 M3×6 mm screw
- 3 M3×30 mm screws
- 3 M3×13 mm nylon spacers
- 2.0m male weather-proof USB 2.0 cable
- USB breakout board
- Zip ties and zip tie saddle
- Double-sided sticky foam

Instructions

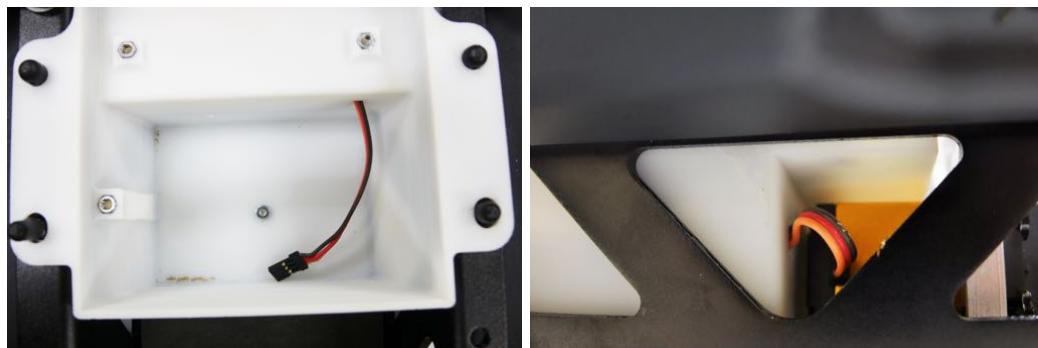
- a. Epoxy nuts to the electronics box plastic supports. To do this, first place the nuts into the supports along with epoxy. Screw the 3 M330 mm screws into the 3 nuts and ensure that they stand vertically in order to ensure that the nuts are placed horizontally inside the supports. Refer to the picture below. Remove the screws once the epoxy is set.



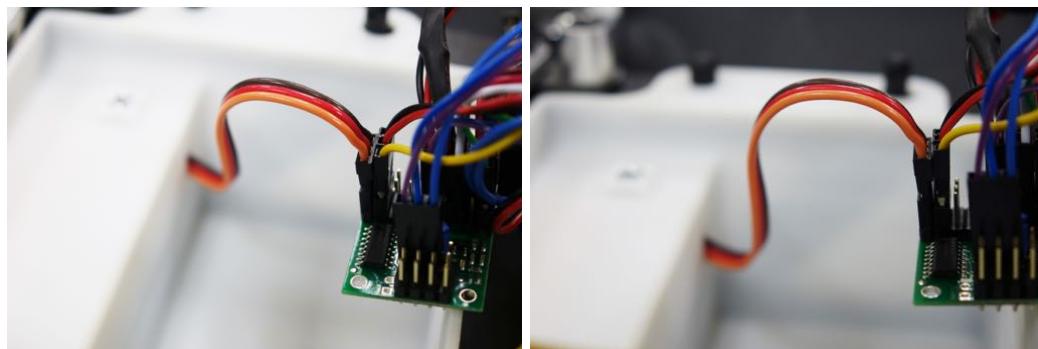
- b. Install the M3×6 mm screw and an M3 nut in the hole at the bottom of the electronics box with the head of the screw on the bottom of the electronics box. Place electronics box assembly in chassis with the mounting holes pressed over the plastic supports on the chassis.



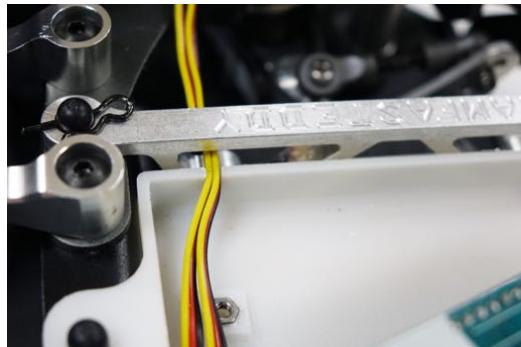
- c. Route the steering servo cable into the electronics box through the steering servo cable hole on the front of the box (near the base of the box).



- d. Plug the steering servo cable into the appropriate pins on the servo multiplexer per the diagram.



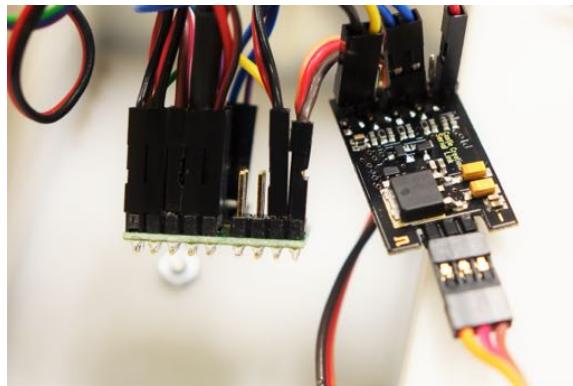
- e. Bring the components put together in the previous section near the box to install them inside. Route only the front rotation sensor harnesses through the slot in the box as shown in the picture below. The rear rotation sensor harnesses should go out the back where they will eventually go through the split loom.



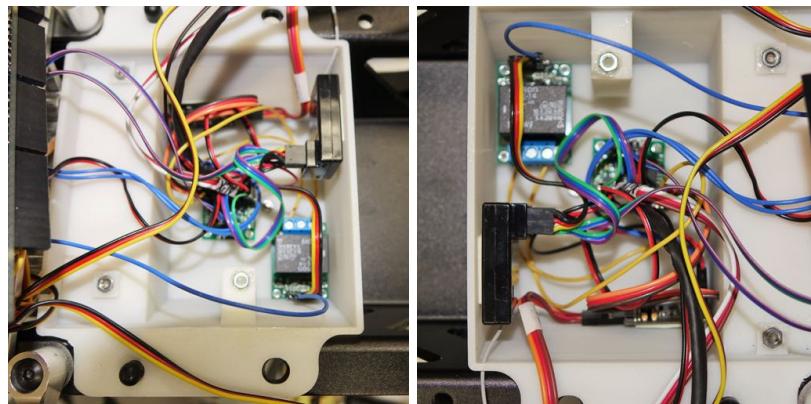
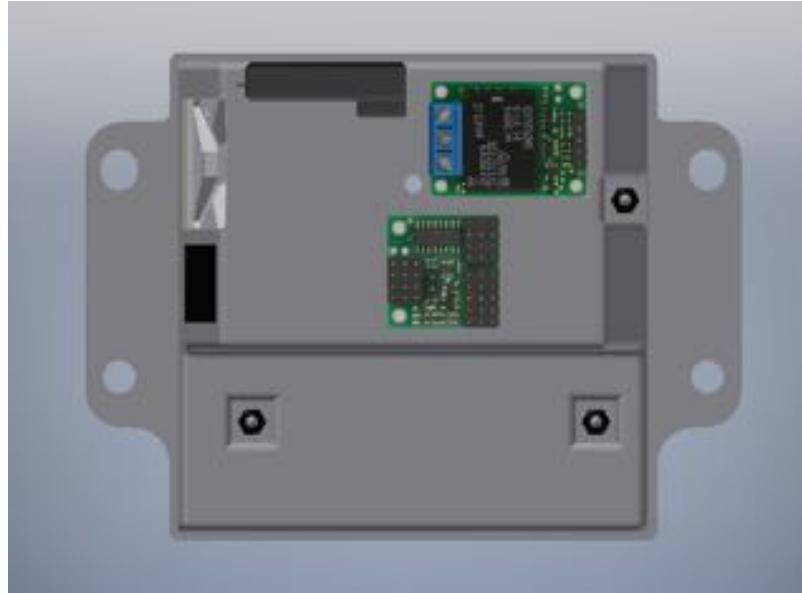
- f. Replace the 3×1 female housings of the motor shroud fan and the ESC fan cables with 2×1 female housings.



- g. Plug the motor shroud fan wires, ESC fan wire, and ESC power wires into the connections specified in the schematic.
- h. Plug the castle serial link wire to the RX wire of the ESC and the AUX wire from the ESC to the multiplexer as per the schematic. The RX wire has an orange signal line while the AUX has a white signal line.

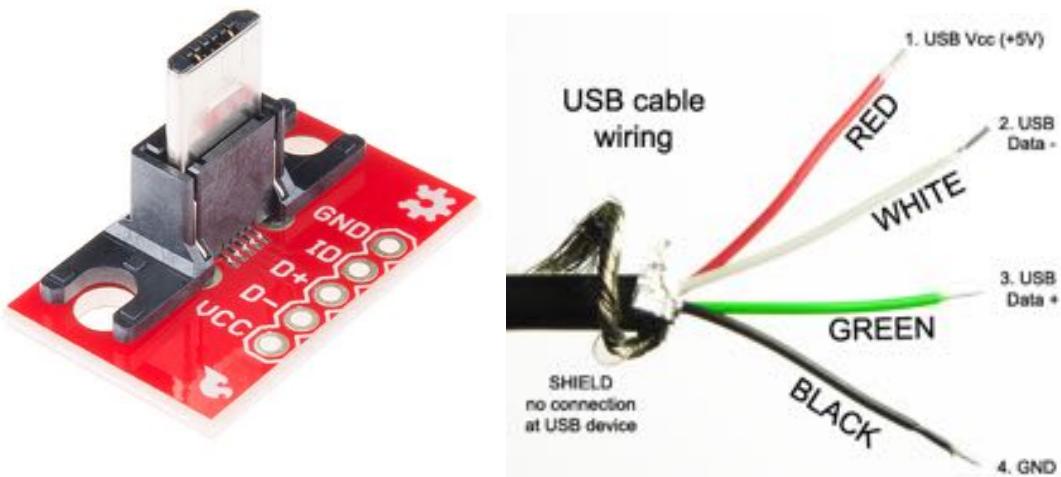


- i. Route the receiver antenna wire through the small hole near the back right top corner of electronics box. Put a piece of double-sided sticky tape to the back of the receiver, castle serial link, relay and multiplexer in order to start securing them to the walls of the electronics box. **Do not remove the sticky-tape cover. The cover is to be removed only once you are sure where you want to secure the components.** Now secure the components to the walls and the base of the electronics box. Refer the diagram and photos below for component placement.

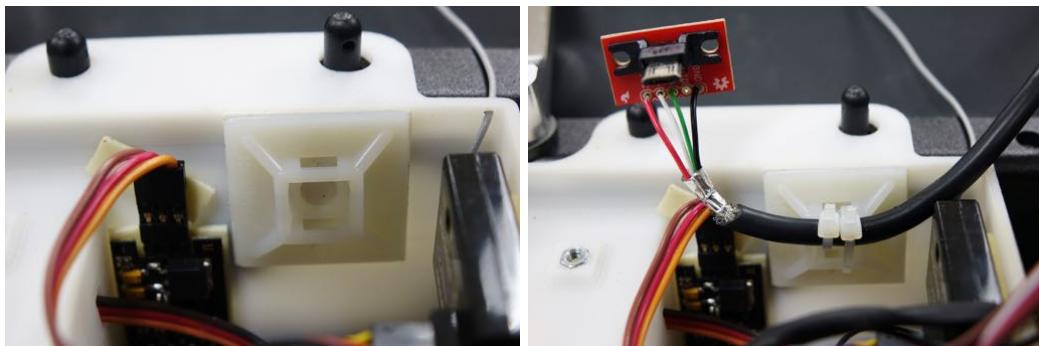


- j. Cut the USB cable down to a 2' length.
- k. Solder the 4 wires into the appropriate pin slots of the USB breakout board as shown in the images below.

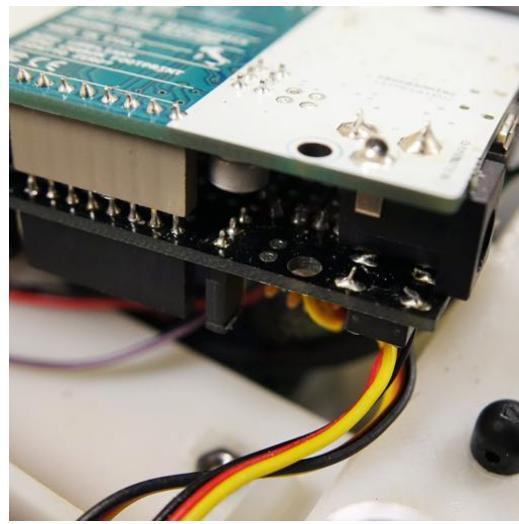




1. Secure the USB wire to the wall of the electronics box using a zip tip saddle and two zip ties as shown in the images below. Note the position of the zip-tie saddle in between the castle serial link and the receiver.



- m. Use pliers to flatten the solder tips of the button of the protoboard.



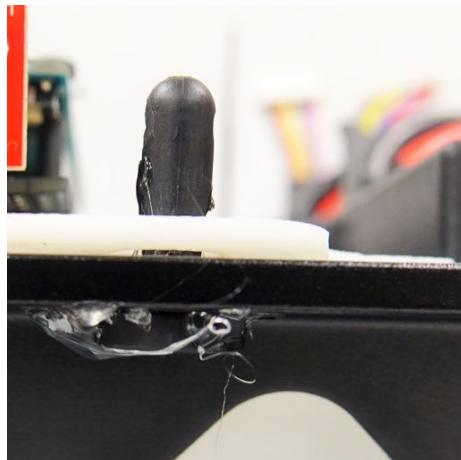
- n. Clip-off two of the nylon washers as shown in the images as they do not sit flat on the Arduino.



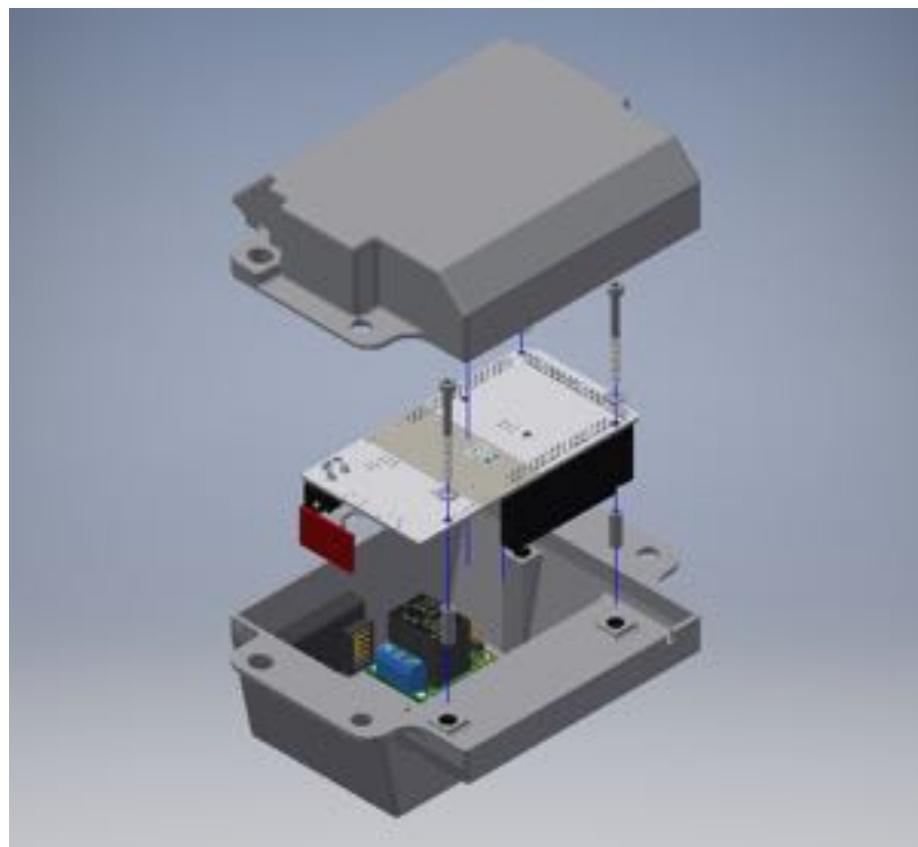
- o. Attach the Arduino Due to the electronics box using 3 M3×30 mm screws, 3 M3 nylon washers, 3 M3×13 mm nylon spacers to the 3 nuts epoxied in Step 1; do not over-tighten. Refer to the image to see which clipped-off washer goes where.



- p. Plug the USB breakout board into the programming port of the Arduino Due.
- q. Hot glue the rear bumpers (Baja part number 85420-6) to the underside of the chassis to ensure that they do not fall off when the body clips are secured.



- r. Each wheel rotation sensor wire assembly has 2 parts. One going from the sensors to the shock tower with Futaba J female connector assembly. And, the other part starts from the Due proto-shield and goes into the Futaba J male connector assembly. Connect the parts coming out of the proto-shield into the cable harness connectors at the front and back shock towers.



21 Test Electronics Box

Time 1 hours 0 minutes

Refer to the Operating Procedures document to power the chassis, for the ESC power sequence, and transmitter usage.

Instructions

- a. Calibrate ESC by following the How to Calibrate the ESC in the Castle Creations Mambla XL X Driver's Ed Guide. **You will have to toggle the throttle relay by pressing the button on the controller grip immediately after powering the ESC before it begins signal check.**
- b. Turn on the transmitter and power the ESC after sucessful calibration.
- c. Verify that steering is connected correctly by turning the steering control on the transmitter.
- d. Verify that throttle is connected correctly by using the throttle control with the transmitter set to manual mode.
- e. Verify that you can switch between autonomous and manual mode.
- f. Verify that pressing the run stop button on the transmitter handle disables throttle control.
- g. Connect electronics box USB cable to a computer.
- h. Use a serial monitor to connect to the USB cable and verify all data is being read and transmitted by the Arduino:

- i. Castle Serial Link data is being transmitted (battery voltage, motor speed, ...).
- ii. Spin each wheel to verify the wheel rotation sensors are mounted properly and plugged into the correct spot.
- iii. Manual and autonomous mode are correctly detected.
- iv. Run stop state is correctly detected.
- v. Manual throttle and steering commands from the transmitter are sensed correctly.

22 GPS Box Assembly

Time 4 hours 0 minutes

Parts

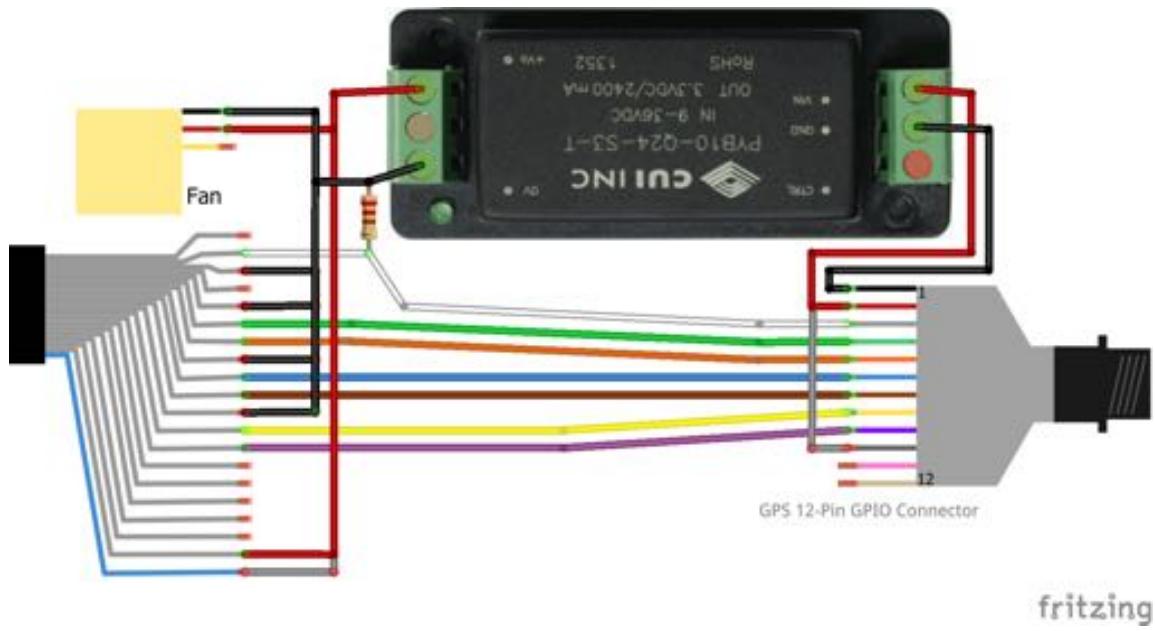
- GPS box
- GPS box lid
- GPS box tab
- Hemisphere P307 GPS unit
- GPS antenna cable
- 3 1/4" 6-32 screws for the GPS antenna
- 12" 20-pin ribbon cable
- 1 HIROSE HR-30 12-pin panel mount female solder connector
- HIROSE dust cap
- Cui 3.3V isolated voltage regulator
- 10k Ω Resistor
- Assorted wire
- Copper conductive tape
- Sunon UF3F3-500 fan
- 2 M1.4 fan screws
- 2 M1.4 fan nuts
- 4 M3 \times 8 mm screws
- 4 M3 \times 12 mm screws
- 8 M3 nuts

Instructions

- a. Cover the top of the GPS box lid with a single layer of copper conductive tape. Cut out the larger holes and poke through the smaller holes.



- b. Cut off and discard 5" of the 20-pin ribbon cable.
- c. Attach HR30 rubber washer (or rubber plug cap), metal lock washer, and nut to back side of HR-30 female solder cup connector.
- d. Referring to the AutoRally GPS Box wiring diagram in the [wiringDiagrams/](#) folder, solder the appropriate wires from the ribbon cable to the solder cups on the HR-30 connector. **Remember to slip a piece of small heat shrink over the wires to be soldered prior to soldering.**



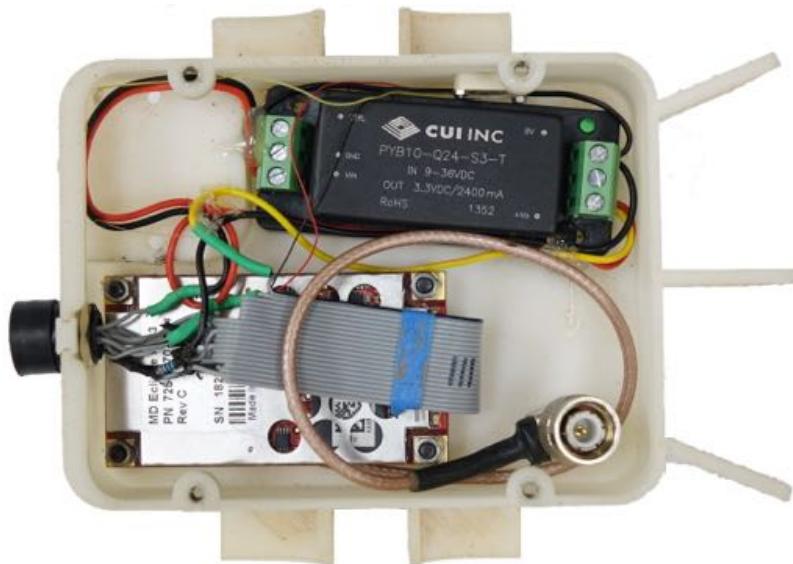
- e. Splice the ground wires as shown in the diagram and solder them together. Ensure that the resistor is neatly soldered to the indicated line. Ensure that the wires are approximately the same length. Referring to the diagram, note that the fan wires must be soldered onto the power and ground connections that will connect to the output of the voltage regulator. **Remember to slip a piece of heat shrink over the wires to be soldered prior to soldering.**
- f. Use a heat gun to heat all heat shrink ensuring that it covers all exposed wire and solder.



- g. Connect the ribbon cable to the GPS unit. The colored wire should be connected to the pin labeled with the small diamond mark on the GPS unit.

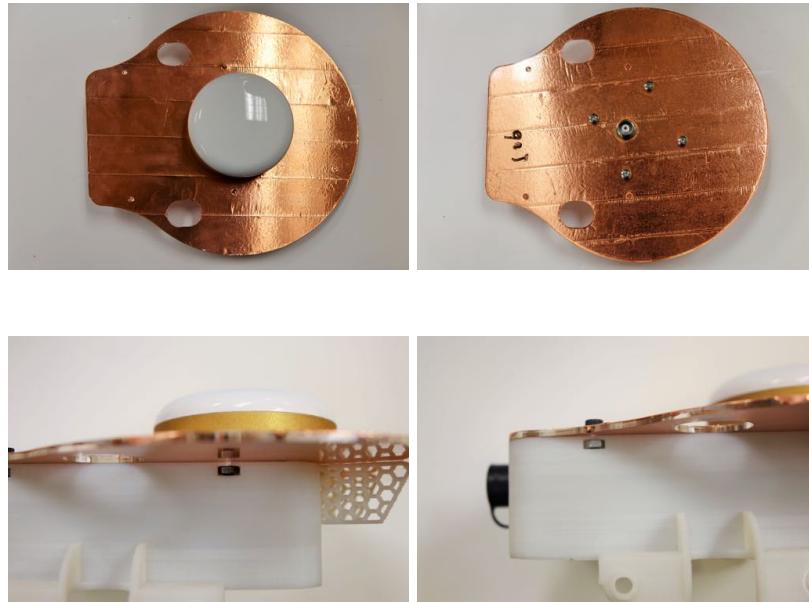


- h. Screw the GPS unit in place. Screw the fan in place. Carefully fold the ribbon cable so that all items – fan, cable, and GPS unit, voltage regulator – fit into the box.
- i. Mount the 12-pin connector to the GPS box with the rubber washer or dust cap on the outside of the box and the metal washer and nut on the inside. Ensure that the alignment triangle on the plug is facing up.
- j. Install the GPS box tab above the connector as you tighten the back nut on the plug.



- k. Put a few dabs of hot glue on the voltage regulator to secure it in place.

1. Attach the antenna to the lid and screw the lid into place using 4 M3×8 screws and 4 M3 nuts.
Put a dab of hot glue onto the nuts to hold them in place.



23 GPS Box Installation

Time 0 hours 20 minutes

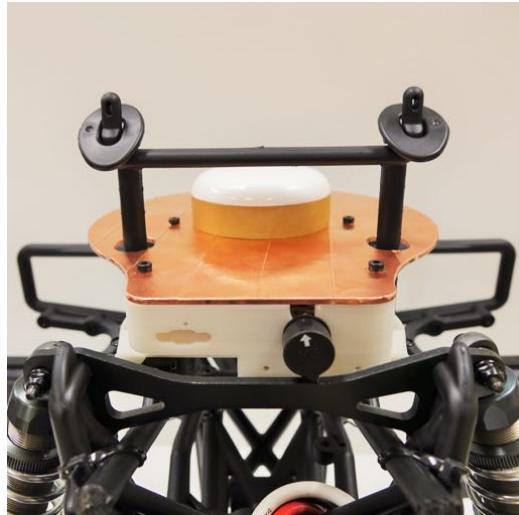
Parts

- Assembled GPS box
- Chassis
- 4 M4×20 mm screws

Instructions

- a. Mount the GPS box to the rear body mount area of the chassis (part 85417-3: see photo for exact placement) using 4 M4×20 mm screws.





24 Wire Management

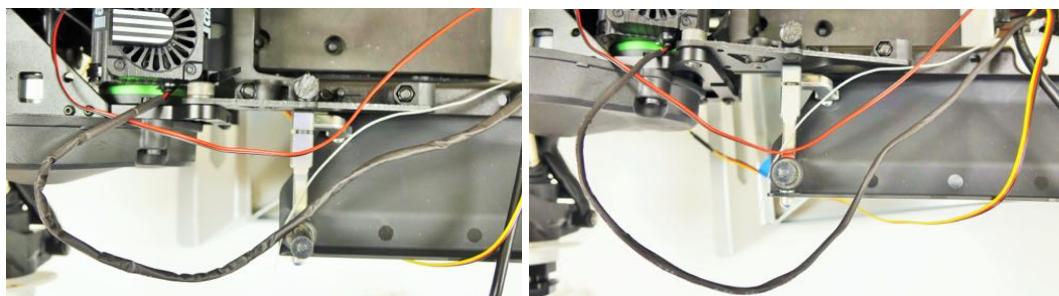
Time 0 hours 20 minutes

Parts

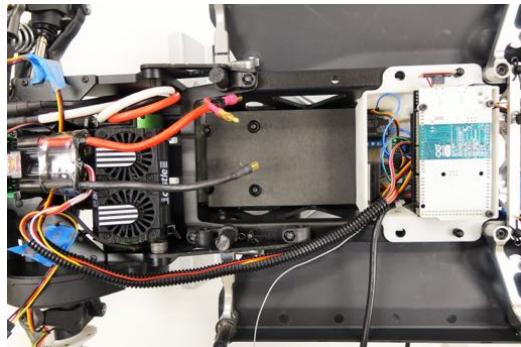
- 0.5" outer diameter split loom
- Small zip ties
- Electronics box lid
- 2 small body clips
- 2 large body clips

Instructions

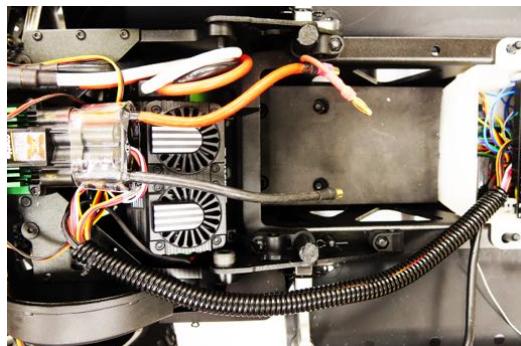
- a. Heat shrink the motor shroud fan wire.



- b. Cut an 11.5" piece of split loom.
- c. Route all fan wires from the ESC and motor, the ESC RX and AUX wires, the rear wheel rotation sensor wires and the front brake servo wire (if installed) from the electronics box through the split loom.



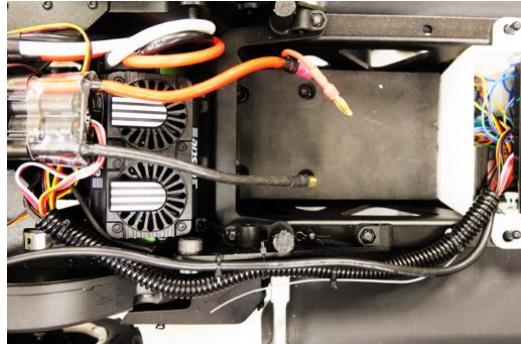
- d. Attach zip ties on each end of the split loom to hold the wires in place.



- e. Zip tie the split loom to the chassis near the electronics box using the hole that exists in the chassis, the engine mount brace above the side rail guards, and the hole in the back plate under the ESC.



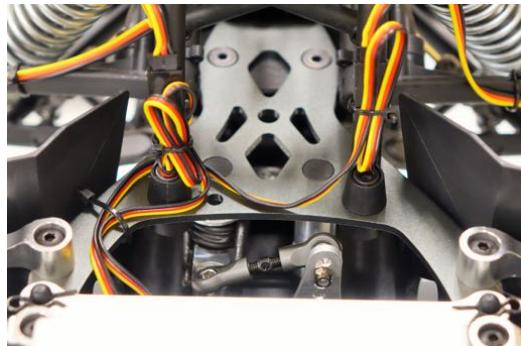
- f. Zip tie antenna to the split loom and the USB cable harness to the engine mount brace as shown in the picture. This point acts as a pivot for movement of the USB cable which will be plugged into the compute box.



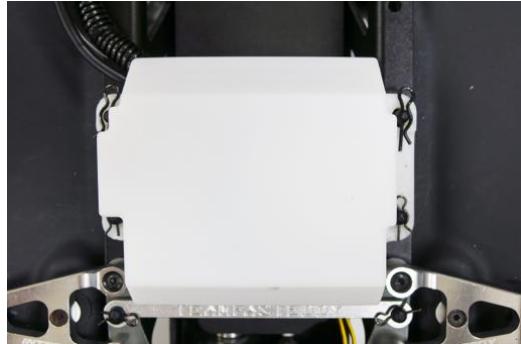
- g. Hot glue Futaba J male housing of the wheel rotation sensor wires to the shock towers of the chassis.



- h. Loop the front wheel rotation sensor wires around the front supports in order to reduce slack to the minimum required to route these wires, if needed.



- i. Zip tie front and rear wheel rotation sensor wires over the connector housings hot glued to the shock tower.
- j. Install the 4 body clips into the plastic electronics box supports. **Large body clips for rear supports and small body clips for the front supports.** Ensure that the USB cable, split loom, and front wheel rotation sensor cables are routed through the appropriate cutouts.



- k. Connect the engine guards to the under guard using body clips. Then, install the under guard and secure it with a body clip at the rear of the chassis. See below for pictures.



25 Sticker Removal

Time 0 hours 30 minutes

Parts

- Baja 5SC body

Instructions

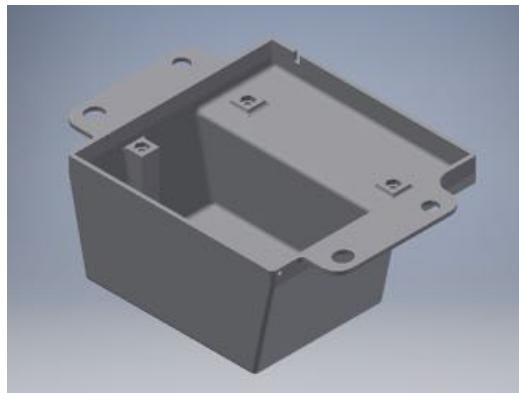
- a. Remove all stickers from the body.



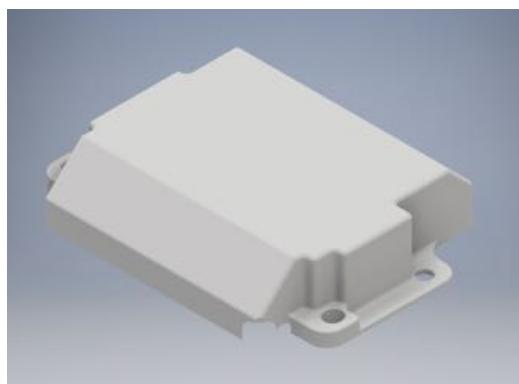
26 Appendix A: Parts

26.1 3D Printed Parts

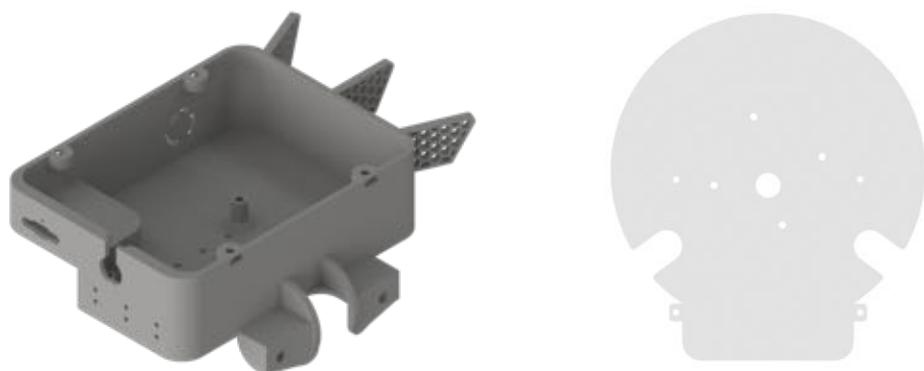
- Electronics box



- Electronics box lid



- GPS box (with laser-cut lid)



- GPS box connector mount tab
- Front brake aligners



- Rear wheel rotation sensor mounts



- Wheel rotation sensor magnet mounts

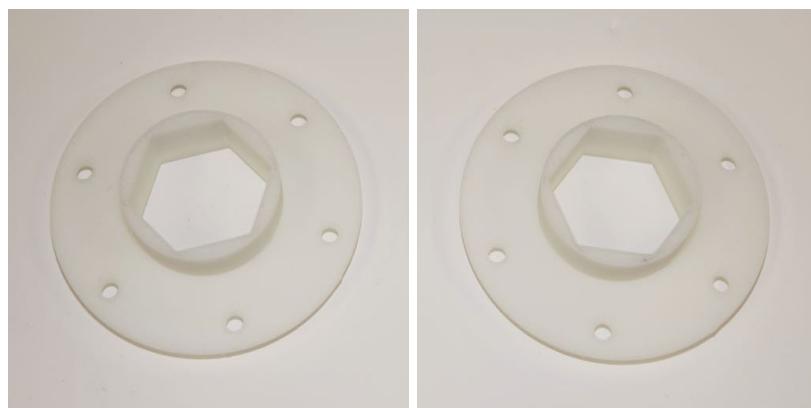
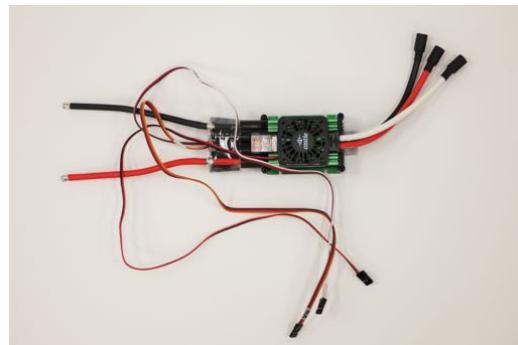


Figure 1: Front (left) and back (right) wheel rotation sensor magnet mounts

- Brake master cylinder mount

26.2 Upgrade Kits

- Castle Creations Mamba XL Electronic Speed Controller



- Castle Creations 2028 electric motor



- Castle Creations motor fan



- Castle Creations Baja conversion hardware



- Turtle Racing Billet Servo Saver



- Integy side rail guards



- Team Fast Eddy Battery Box Eliminator Kit



- Savox steering servo



- Shock springs

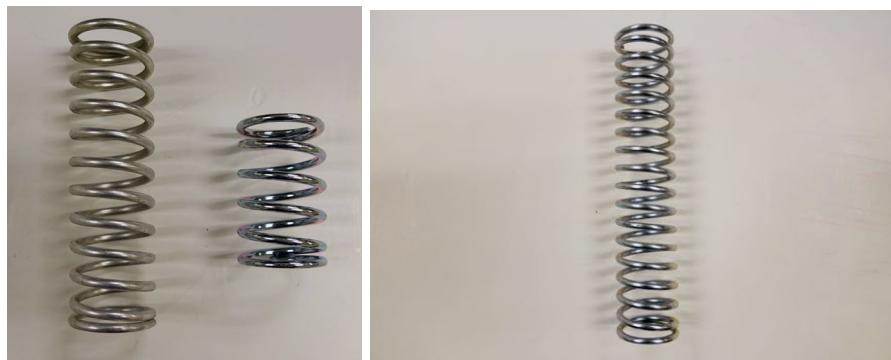


Figure 2: Back long and short shock springs (left) and front shock spring (right)

- 59 ml bottle of Factory Team 60w shock fluid



- Darksouls Baja Axle Extender Set



- Mecatech front brake kit for Baja



- Zero-growth tire foams



Figure 3: Red front tire (left) and Blue back tire (right)

26.3 Electronic Components

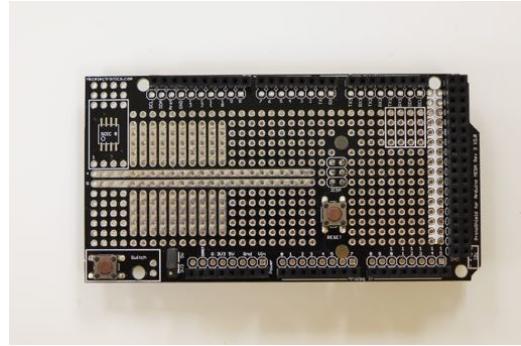
- 6500 4S 14.8v Chassis Battery Pair



- Arduino DUE



- Adafruit ProtoShield for DUE



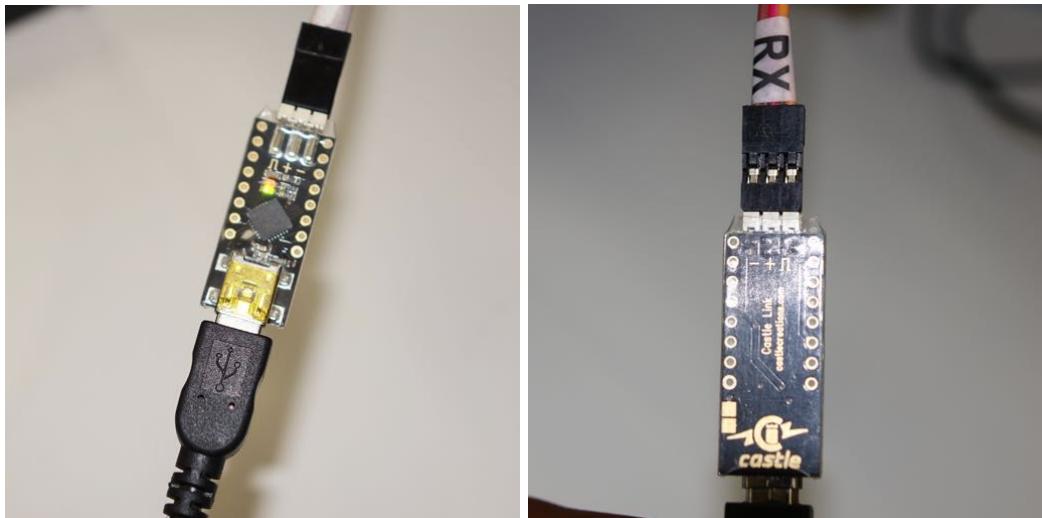
- Baja Series Adapter



- Castle Serial Link



- Castle Link Programmer



- CUI 3.3V 2.4A Voltage Regulator PYB10-Q24-S3-T



- Futaba 4PLS Transmitter



- Futaba R304SB Receiver



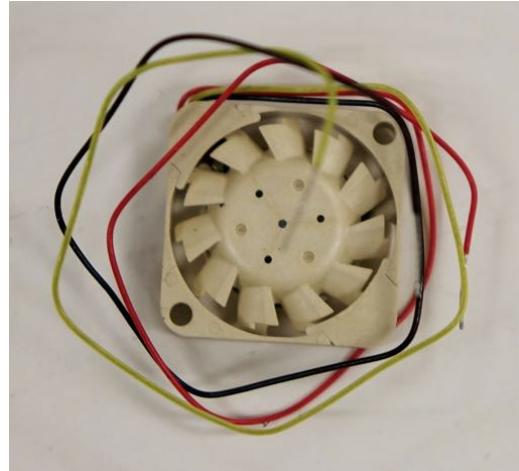
- GPS antenna



- GPS antenna cable



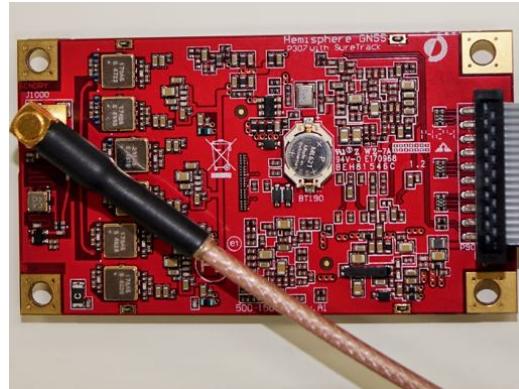
- GPS box fan



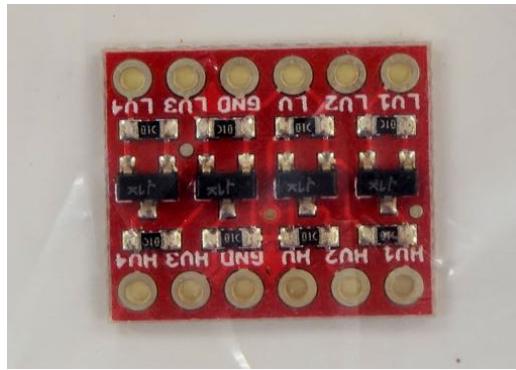
- Hallogic OH090U Hall-Effect sensors



- Hemisphere GPS P307



- Pololu Level Shifters



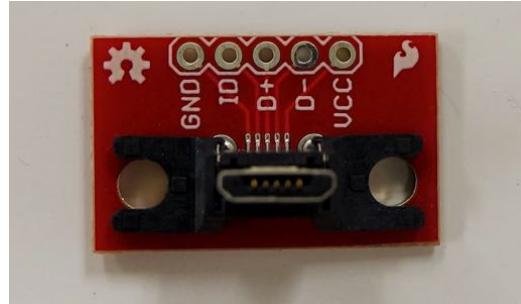
- Pololu RC Relay



- Pololu Servo Multiplexer



- USB breakout board



26.4 Connectors

- 0.1" Female Crimp Pins



- 0.1" 1x1 Crimp Connector Housing



- 0.1" 1x2 Crimp Connector Housing



www.pololu.com

- 0.1" 1x3 Crimp Connector Housings



www.pololu.com

- 4mm banana plugs



Figure 4: Male (left) and Female (right) 4mm banana plugs

- 6.5mm Bullet Connectors



Figure 5: Male (left) and Female (right) 6.5mm Bullet Connectors

- Futaba J-Connectors



Figure 6: Male (left) and Female (right) Futaba J-Connectors

- HIROSE Dust cap



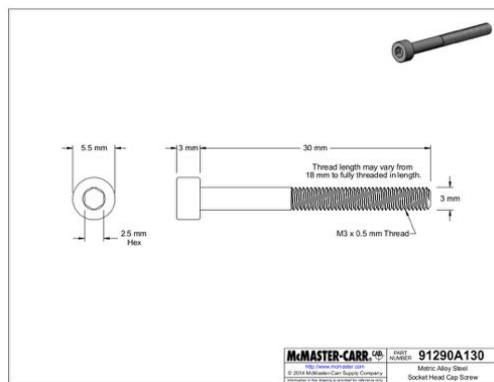
- HIROSE HR-30 12-pin panel mount female solder connector



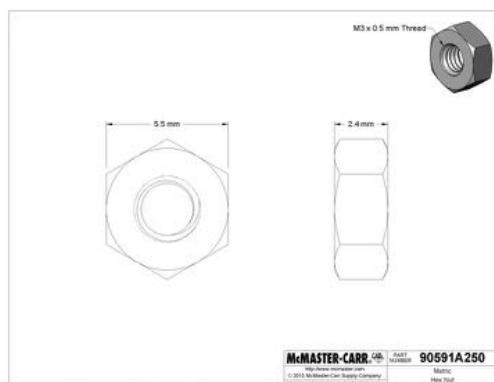
26.5 Extra Hardware

26.5.1 Electronics Box

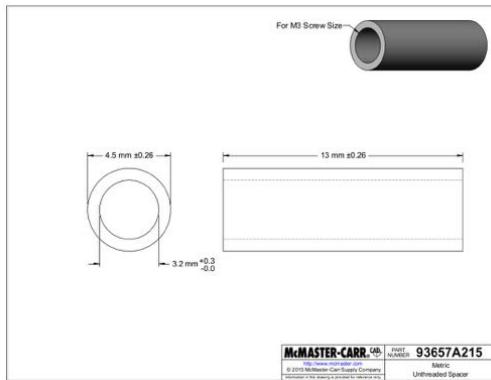
- 3 M3×30mm screws



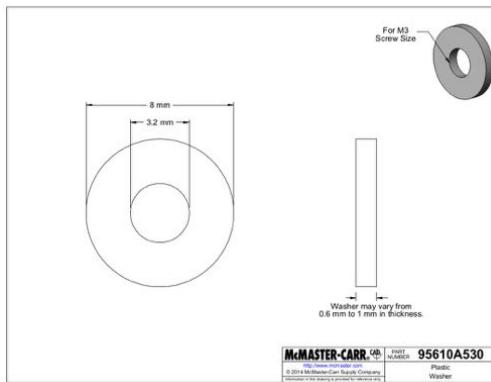
- 4 M3 hex nuts



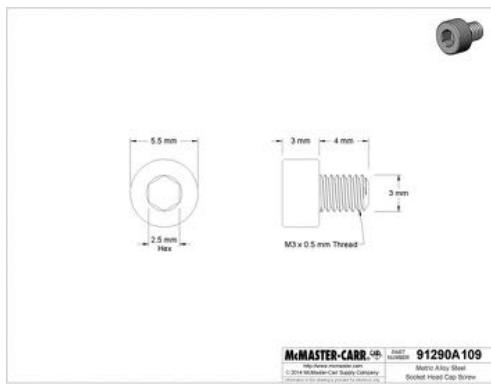
- 3 M3×13mm nylon spacers



- 3 M3 nylon washers

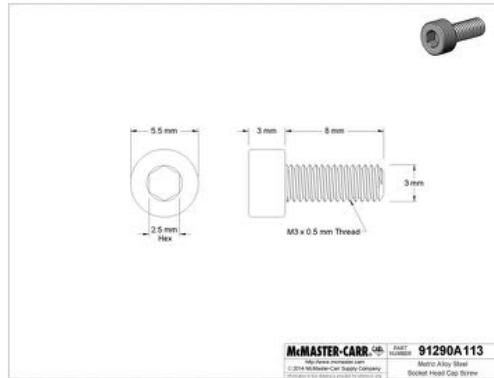


- 1 M3× 4mm screw

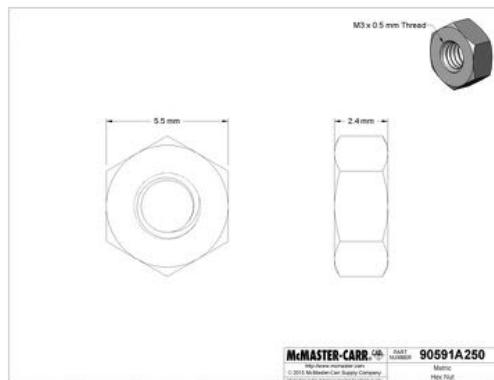


26.5.2 GPS Box

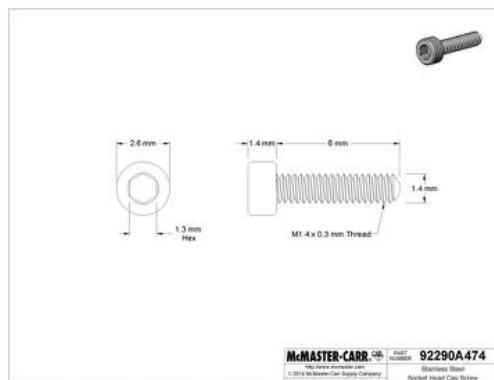
- 8 M3×8mm screws



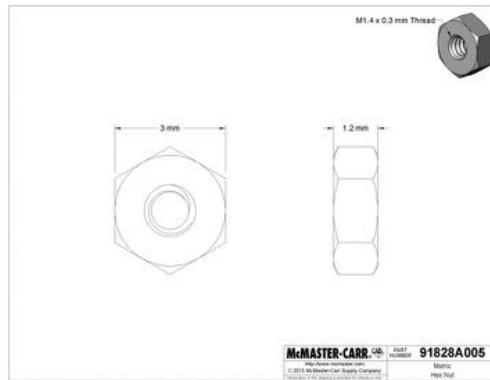
- 4 M3 hex nuts



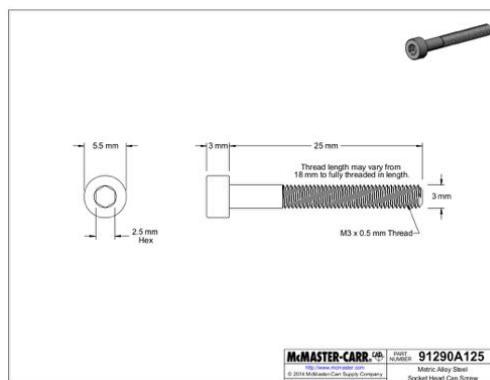
- 2 M1.4 fan screws



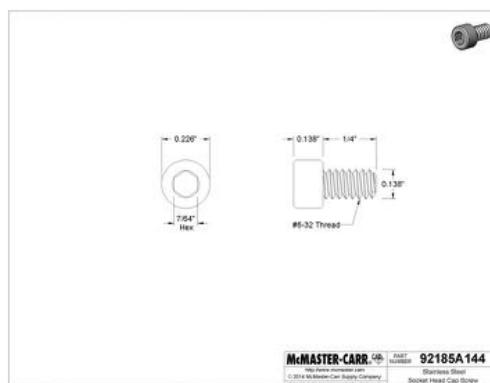
- 2 M1.4 fan nuts



- 2 M3×25mm screws

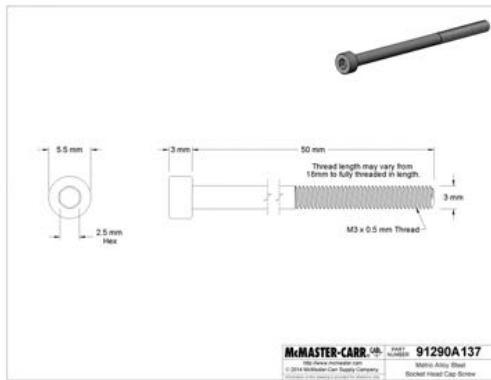


- GPS antenna screws 4 1/4" 6-32 screws



26.5.3 Front Brake

- 2 M3×50mm screws



27 Appendix B: Revision History

| Revision | Date | Author(s) | Description |
|----------|----------------|------------------------|---|
| 1.0 | April 2016 | KS, MP, BG, MB, SS, JM | created |
| 1.1 | July 2016 | KS, MP, BG, MB, SS, JM | updated electronics box instructions, updated images, cleaned up document |
| 1.2 | September 2016 | BG, MB | Fixed error in GPS breakout cable in compute box diagram, spelling fixes |
| 1.3 | February 2017 | BG | Moved GPS power supplies into GPS box, resolved inconsistencies between chassis wiring diagrams and text, improved wording, added missing items to appendix |

28 Appendix C: Contributors

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