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Snapdragon Rover 3D Printed Assembly

June 11, 2014

Qualcomm Technologies, Inc.

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U.S.A.

Contents

Figures

Introduction

Reference documents

File name	File location
Snapdragon Rover .STL repository	Included in the downloaded package
IOIO documentation	https://github.com/ytai/ioio/wiki
IOIO firmware	https://github.com/ytai/ioio/wiki/Downloads

Required tools

Component	Manufacturer
3D printer	Various (This document assumes Makerbot Replicator or Replicator 2X.)
One of either Samsung Galaxy S3 or S4, Motorola Moto G, or IFC Development Board	Samsung, Motorola, or Inforce Computing
4-40 thread tap	
Phillips screwdriver	
Torx screwdriver	
Hex screwdriver	

Bill of Materials

Part Number	Item Description	Quantity	Manufacturer
1	Snapdragon Rover RIGHT FRAME	1	3D Printed from .STL file
3	Snapdragon Rover LEFT FRAME	1	3D Printed from .STL file
5	Snapdragon Rover RIGHT UPPER FORKLIFT ARM	1	3D Printed from .STL file
7	Snapdragon Rover LEFT UPPER FORKLIFT ARM	1	3D Printed from .STL file
9	Snapdragon Rover RIGHT LOWER FORKLIFT ARM	1	3D Printed from .STL file
11	Snapdragon Rover LEFT LOWER FORKLIFT ARM	1	3D Printed from .STL file
13	Snapdragon Rover RIGHT FORKLIFT	1	3D Printed from .STL file
15	Snapdragon Rover LEFT FORKLIFT	1	3D Printed from .STL file
17	Snapdragon Rover FRONT WHEEL	2	3D Printed from .STL file
19	Snapdragon Rover BACK WHEEL	2	3D Printed from .STL file
21	Snapdragon Rover MIRROR MOUNT	1	3D Printed from .STL file
23	AR-3606HB ROBOT SERVO	2	http://www.pololu.com/product/2149/pictures
25	HD-3001HB ANALOG SERVO	1	http://www.pololu.com/product/1058
27	TURNIGY TG9 SERVO	1	http://hobbyking.com/hobbyking/store/__42420__Turnigy_TG9_9g_1_7kg_0_12sec_Eco_Micro_Servo_USA_warehouse_.html
29	IOIO-OTG	1	http://www.diygadget.com/
ALT-1	SPARKFUN VERSION OF IOIO BOARD WITHOUT BLUETOOTH MODULE (WILL NEED SEPARATE BLUETOOTH MODULE)	1	https://www.sparkfun.com/products/11343
ALT-2	ADAFRUIT IOIO BOARD	1	http://www.adafruit.com/product/885

Part Number	Item Description	Quantity	Manufacturer
	(MINT) WITH BLUETOOTH (NO OTG CABLE NEEDED)		
31	112-MM LENGTH, 6-MM DIAMETER O-RING	2	http://www.marshallshardware.com/products/product.aspx?pid=26886&lid=1%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20&kw=6112&st=0
ALT	CUSTOM POLYURETHANE BELTS	2	http://www.pyramidbelts.com/
33	1-INCH DIAMETER MIRROR	1	http://www.amazon.com/1-IN-ROUND-MIRROR-25PC-PKG/dp/B0018N66YC
35	3-PIN TOGGLE SWITCH	1	http://www.pololu.com/product/1407
37	MALE-FEMALE MICRO-USB OTG ADAPTER	1	http://www.amazon.com/CNE16187-Micro-USB-OTG-Adapter/dp/B005QX7KYU
39	3-BATTERY BAY	1	http://www.pololu.com/product/142
41	2-BATTERY BAY	1	http://www.pololu.com/product/1150
43	M2.5 PAN HEAD MACHINE SCREW, 6-MM LENGTH	13	ttp://www.marshallshardware.com/products/product.aspx?pid=2-52-733-158-9497&lid=1
45	2-56 X 7/8-INCH PAN HEAD MACHINE SCREW	6	http://www.mcmaster.com/#91772a085/=sda7o1
47	#2 FLAT WASHER	10	http://www.mcmaster.com/#90126a501/=sda9xs
49	2-56 HEX NUT	6	http://www.mcmaster.com/#90760a009/=sjt7h4
51	4-40 SOCKET HEAD MACHINE SCREW, 1-INCH LENGTH	2	http://www.mcmaster.com/#91251a115/=sd9pat
53	4-40 SOCKET HEAD MACHINE SCREW, 1 ½-INCH LENGTH	2	http://www.mcmaster.com/#91251a149/=sd9q3y
55	#8 X 3/8 X 1-INCH NYLON SPACER	2	http://www.marshallshardware.com/products/product.aspx?pid=14290&lid=1%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20&kw=0511107&st=0
57	3/8-INCH FLAT NYLON SPACER, LENGTH 1 1/8-INCH LENGTH	2	http://www.mcmaster.com/#94639a068/=sjs9om
59	8-32 PAN HEAD MACHINE SCREW, 1.625-INCH LENGTH	2	http://www.mcmaster.com/#91772a204/=sjs8kq
61	#10 X 3/4 X 0.040-INCH FLAT NYLON WASHER	2	http://www.marshallshardware.com/products/product.aspx?pid=11344&lid=1%20%20%20%20%20%20%20%20%20%20%20%20%20%

Part Number	Item Description	Quantity	Manufacturer
			20%20%20&kw=NYLON%20washer&st=0
63	MUSIC WIRE, 0.078-INCH DIAMETER, 1.40-INCH LENGTH	2	http://www.mcmaster.com/#8890k122/=su430w
65	MUSIC WIRE, 0.078-INCH DIAMETER, 1.60-INCH LENGTH	1	http://www.mcmaster.com/#8890k122/=su430w
ALT	NAIL, 0.080-INCH SHANK DIAMETER	3	http://www.mcmaster.com/#standard-nails/=se6097
67	4-PIN RIGHT ANGLE HEADER, 0.100-INCH SPACING	1	ttp://www.digikey.com/product-detail/en/0022288243/WM50026-24-ND/314229
69	2-PIN RIGHT ANGLE HEADER, 0.100-INCH SPACING	1	http://www.digikey.com/product-detail/en/0022288243/WM50026-24-ND/314229
71	2X4 STRAIGHT HEADER, 0.100-INCH SPACING	1	http://www.digikey.com/product-detail/en/67997-210HLF/609-3236-ND/1878541
73	18-8 THREAD FORMING SCREW, 1-32 THREAD, ¼-INCH LENGTH	8	http://www.mcmaster.com/#99461a615/=sjtall
75	4-40 NYLON SCREW, ½-INCH LENGTH	4	http://www.mcmaster.com/#93135a276/=sjtpg7
77	4-40 FLAT HEAD MACHINE SCREW, ¾-INCH LENGTH	1	http://www.mcmaster.com/#91771a113/=ske8x2

3D Printing

Acquiring the files

From the Qualcomm Research Robotics page at https://www.qualcomm.com/research, download the zip directory containing the STL files of the Snapdragon Rover.

Printing

The Makerbot Replicator 2X was used in the creation of the Snapdragon Rover parts shown in this document, using ABS 1.75-mm diameter filament. The use of other 3D printers or fabrication methods is outside the scope of this document.

STL files for the entire printed Snapdragon Rover assembly are provided as well as STL files for each individual part of the Snapdragon Rover. To minimize support material removal and potential damage of Snapdragon Rover components, is it recommended that novice users use individual part files for printing.

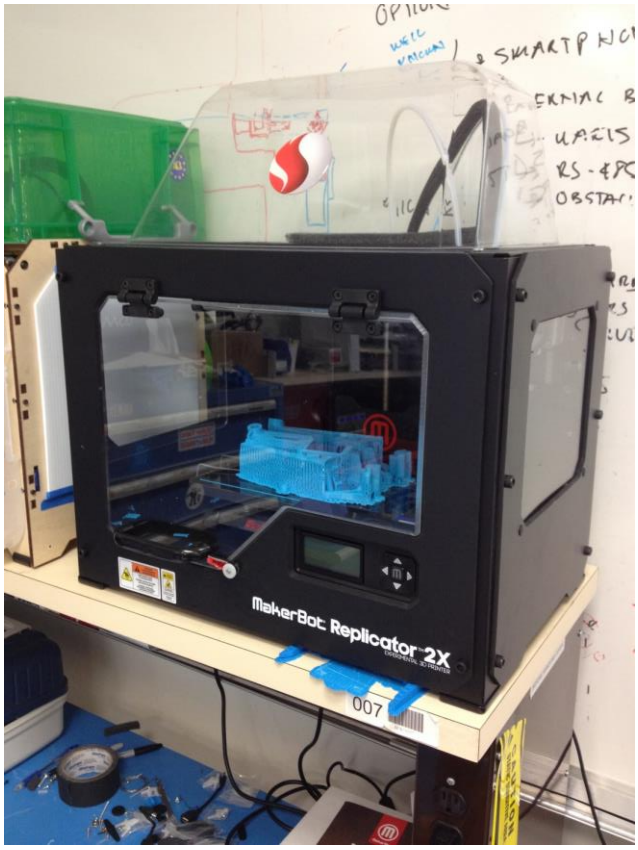


Figure 1 – MakerBot Replicator 2X Snapdragon Rover printer

Part modification

It may be necessary to modify the parts outside of what is detailed in this document. Variations in 3D printers and printing material can result in significant differences in tolerance and finish of the parts. Potential modifications include additional drilling, sanding, or tapping.

Snapdragon Rover Assembly

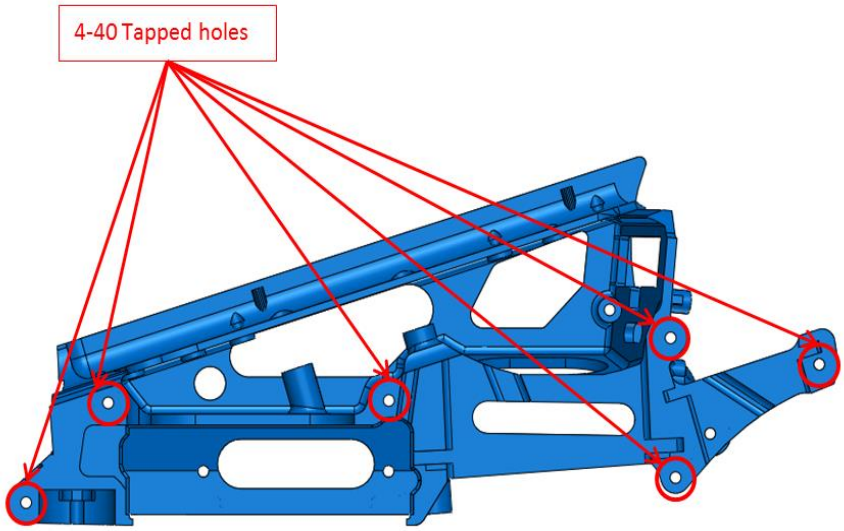
Snapdragon Rover frame tapping

Materials

- 1X Snapdragon Rover left frame

Instructions

1. Tap the holes with a 4-40 tap as indicated.



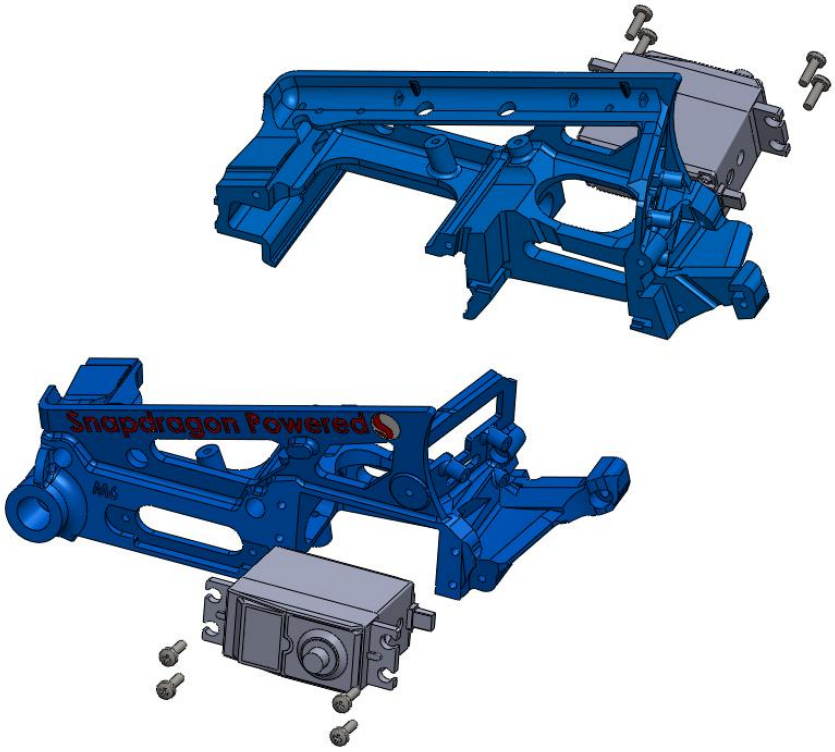
Wheel servo placement

Materials

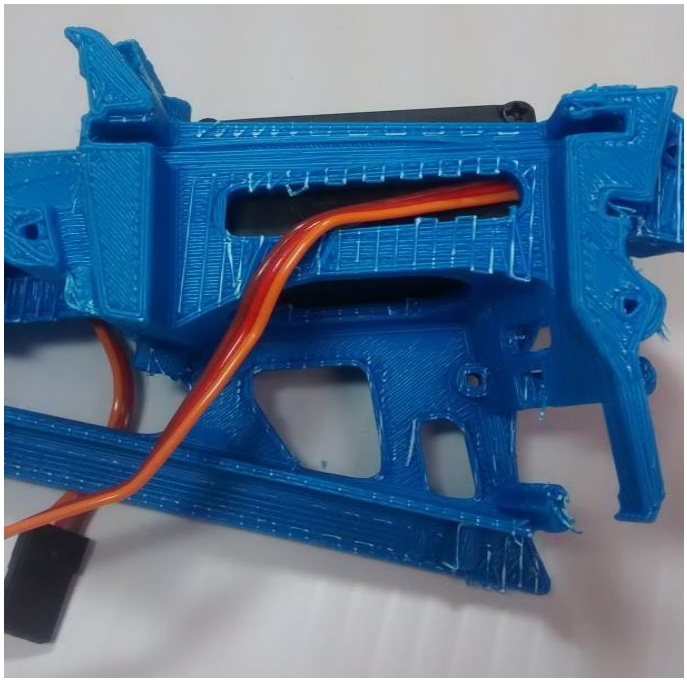
- 1X left Snapdragon Rover frame
- 1X right Snapdragon Rover frame
- 2X AR-3606HB robot servo
- 8X M2.5 pan head Phillips machine screw, 6-mm length

Instructions

1. Place each servo into the Snapdragon Rover main body, with the servo axle toward the front of the Snapdragon Rover body as shown.



2. Servo wires are slid through slotted cutouts in the frame.



Lower forklift arms

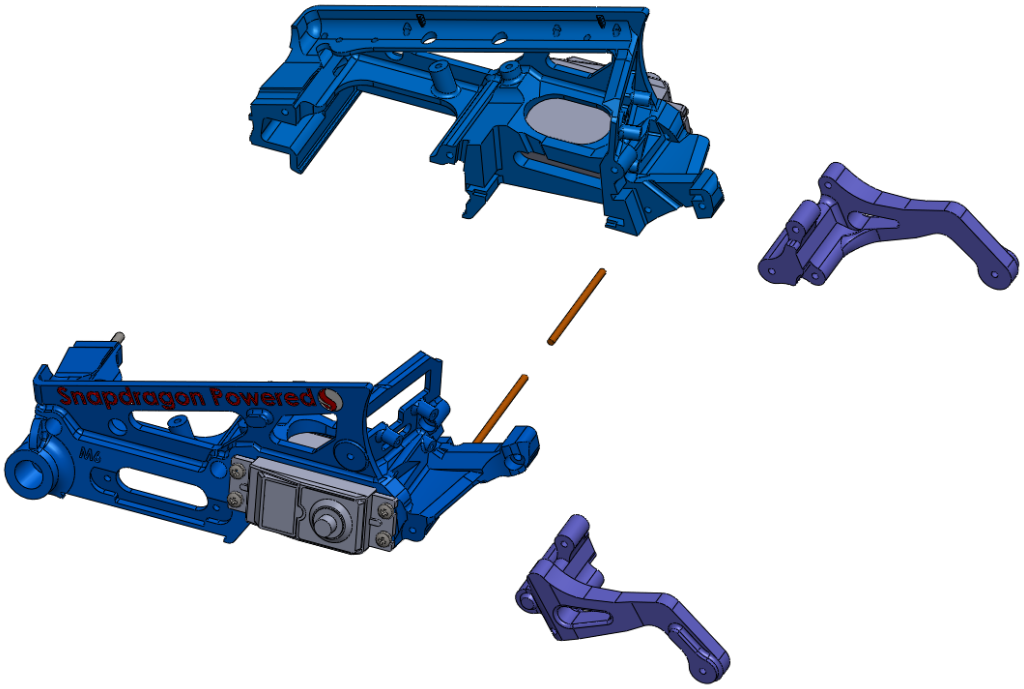


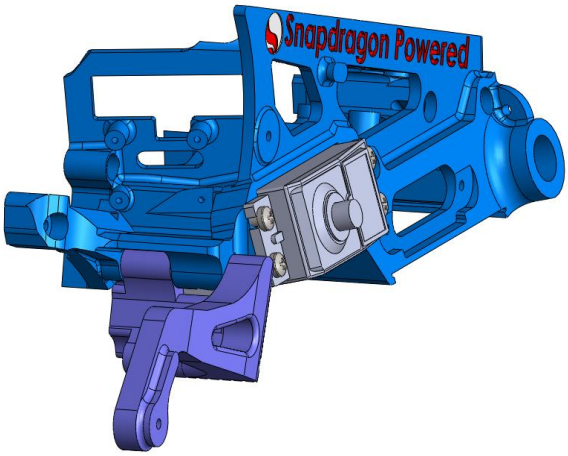
Figure 2 – Lower forklift arms, exploded view

Materials

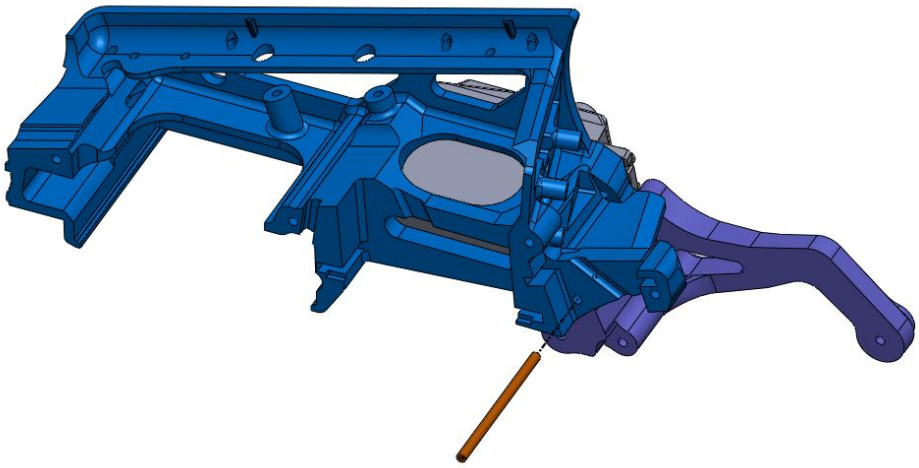
- 2X Snapdragon Rover lower forklift arms
- 2X music wire 0.078-inch diameter, 1.40-inch length

Instructions

1. Place the Snapdragon Rover lower forklift arm into the position shown.



2. Insert the 1.40-inch length music wire into the concentric holes of the lower arm and the main Snapdragon Rover frame.



3. Repeat for the other Snapdragon Rover half.

Upper forklift arms

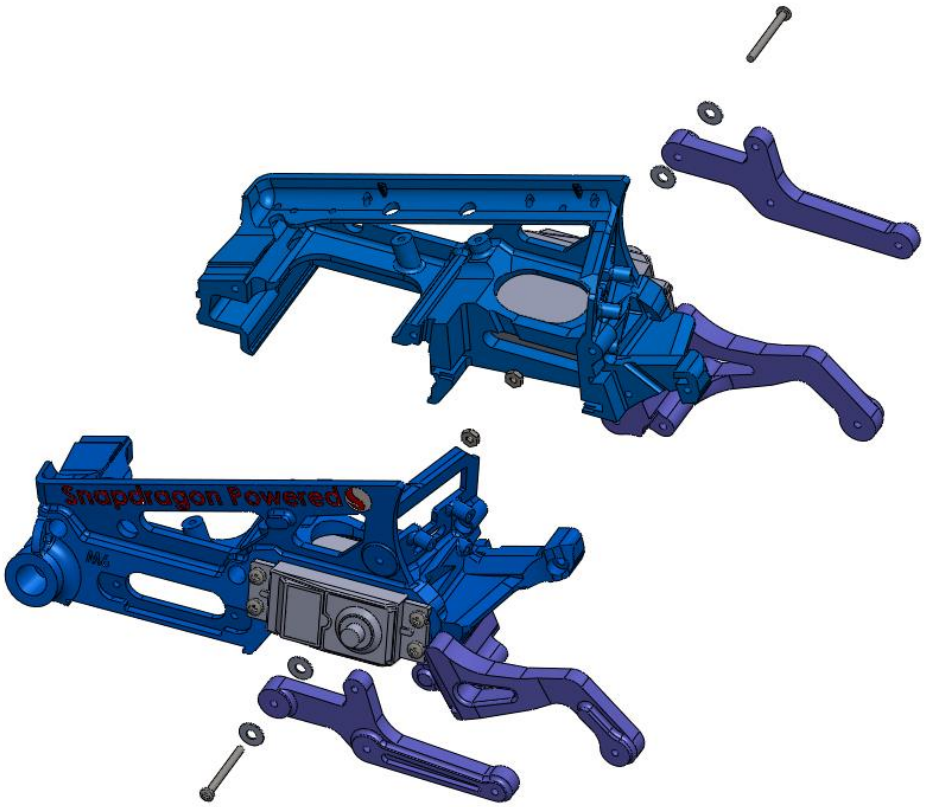


Figure 3 – Upper forklift arms assembly, exploded view

Materials

- 2X Snapdragon Rover upper forklift arms
- 2X 2-56 x ¾-inch pan head screws
- 4X washers
- 2X 2-56 nuts

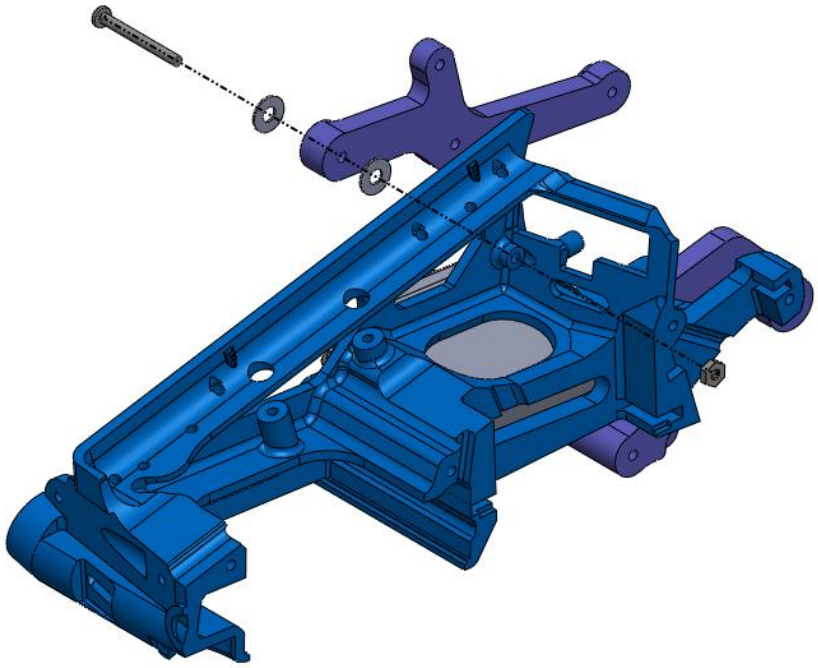
Instructions

1. Insert both washers and a 2-56 screw into the Snapdragon Rover upper arm.
2. Thread the screw into the main Snapdragon Rover frame.

   NOTE: The holes of the upper arm may need to be enlarged to fit the 2.56 screw into them. The screw should be able to slide into the upper arm and allow for rotation.

3. Thread the 2-56 nut onto the screw, tighten the screw until the arm is stable, with a smooth sliding rotation.

   NOTE: It may be necessary to use pliers or wrench to tighten the nut. After tightening the nut, apply a dab of Loctite to the threads to ensure there are no de-threading problems.



4. Repeat steps 1-3 for other Snapdragon Rover half.

Forklifts

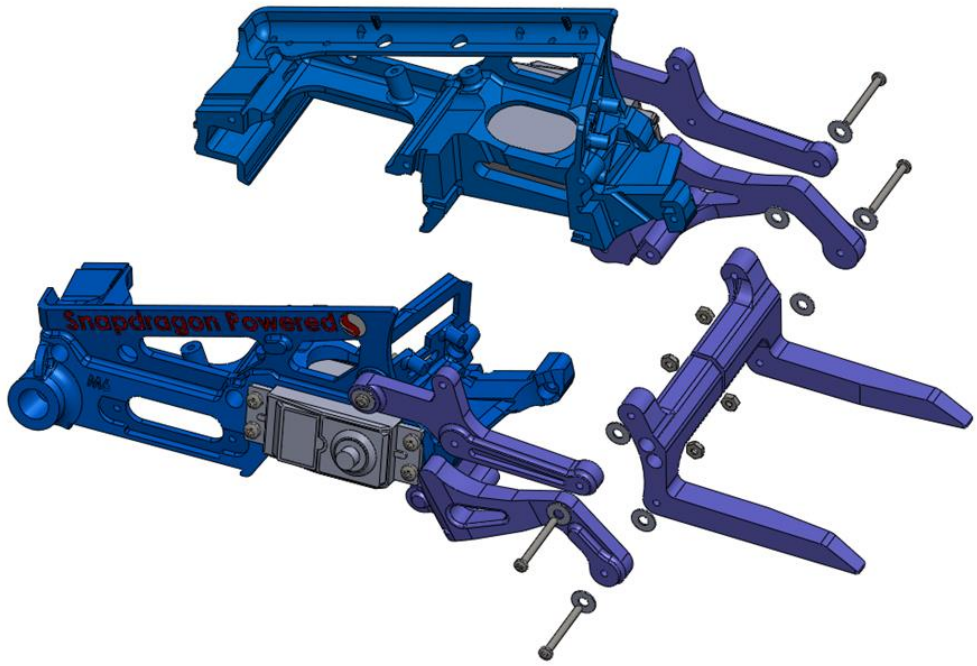


Figure 4 – Forklift assembly, exploded view

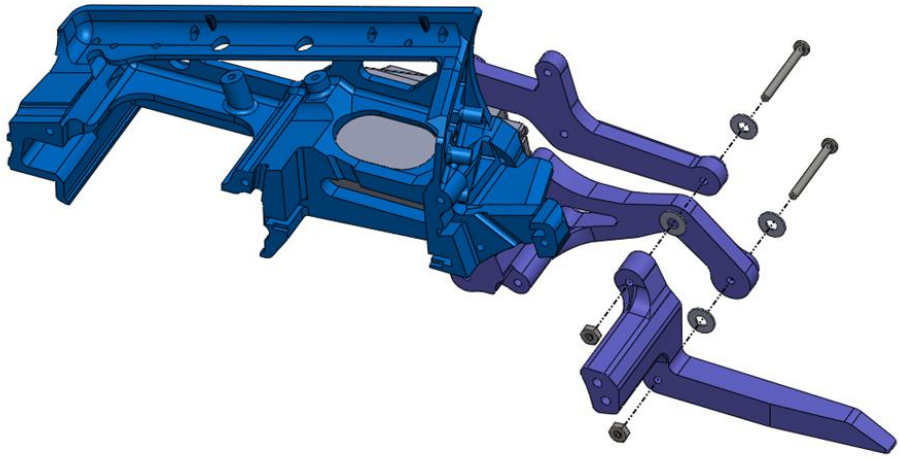
Materials

- 2X Snapdragon Rover forklifts
- 4X 2-56 x ¾-inch pan head screws
- 8X washers
- 4X 2-56 nuts

Instructions

1. Insert 2-56 screws with washers into Snapdragon Rover upper and lower arm slots.
2. Thread 2-56 screws into the corresponding holes on the forklift.

3. Tighten nuts onto both screws to allow for a smooth rotating fit.



4. Repeat steps 1-3 for other Snapdragon Rover half.

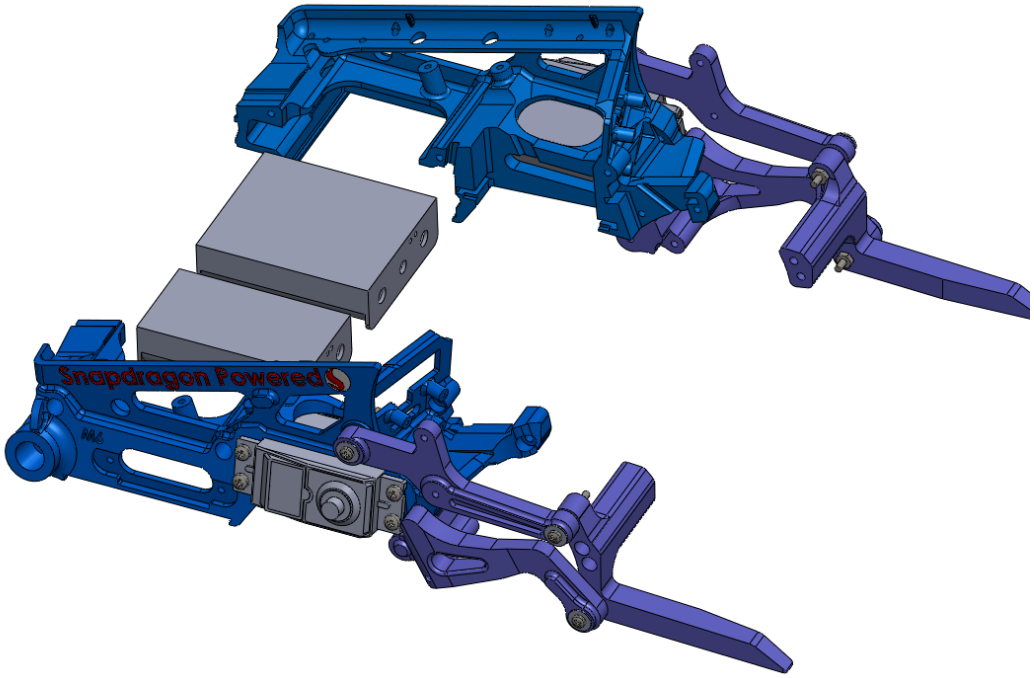
Battery bays

Materials

- 1X 3-AA battery bay
- 1X 2-AA battery bay

Instructions

1. Insert the 3-AA battery bay into the left Snapdragon Rover half, and the 2-AA battery bay into the right half, as shown.



NOTE: Make sure both sets of battery bay wires are marked accordingly and come up through the top groove.

Mirror servo placement

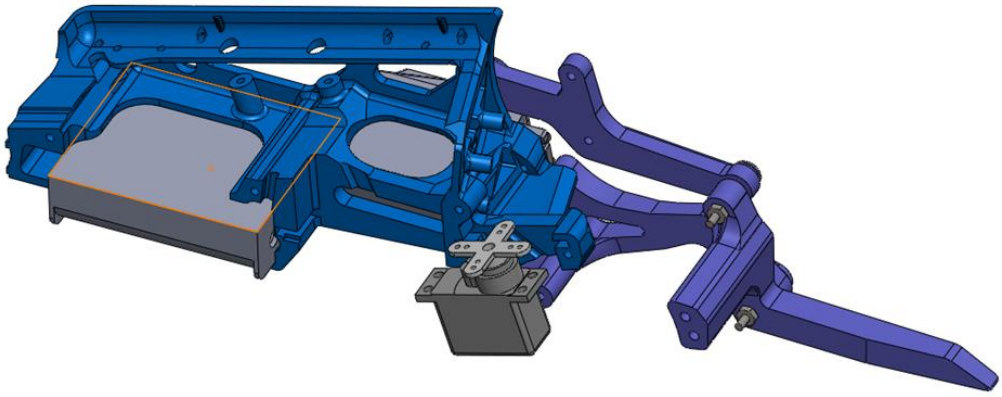


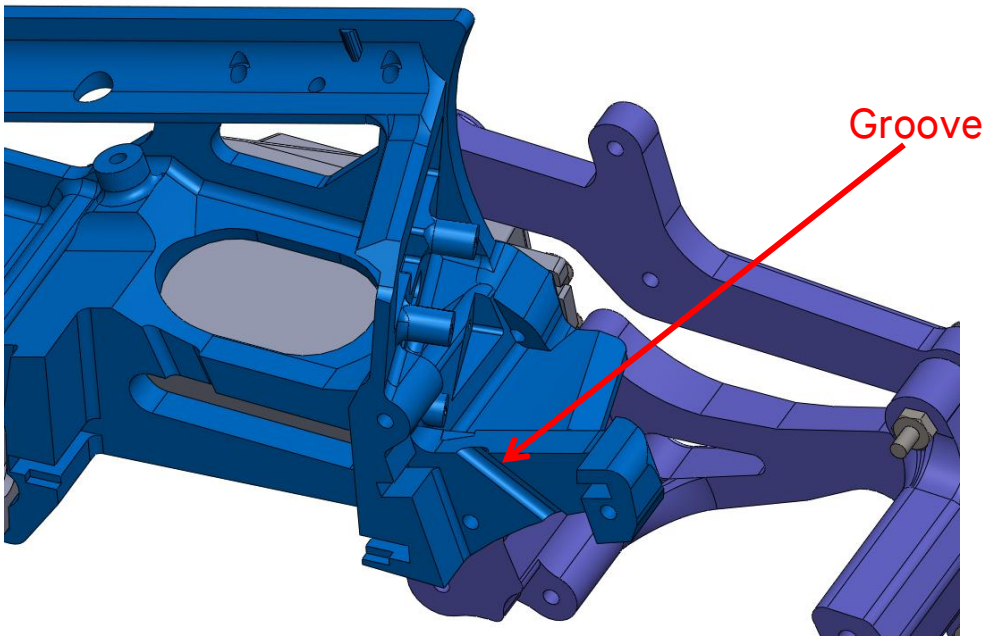
Figure 5 – Mirror servo placement

Materials

- Turnigy TG9 9 g/1.7 kg/0.12 sec eco micro servo

Instructions

1. Place the servo wires into the groove as shown.



2. Pull the servo wires through the corresponding slot of the left Snapdragon Rover half.
3. Place the servo into the slot on the front of the left Snapdragon Rover half.

   NOTE: The slot for the servo may need to be widened to allow for a snug fit.

Forklift servo placement

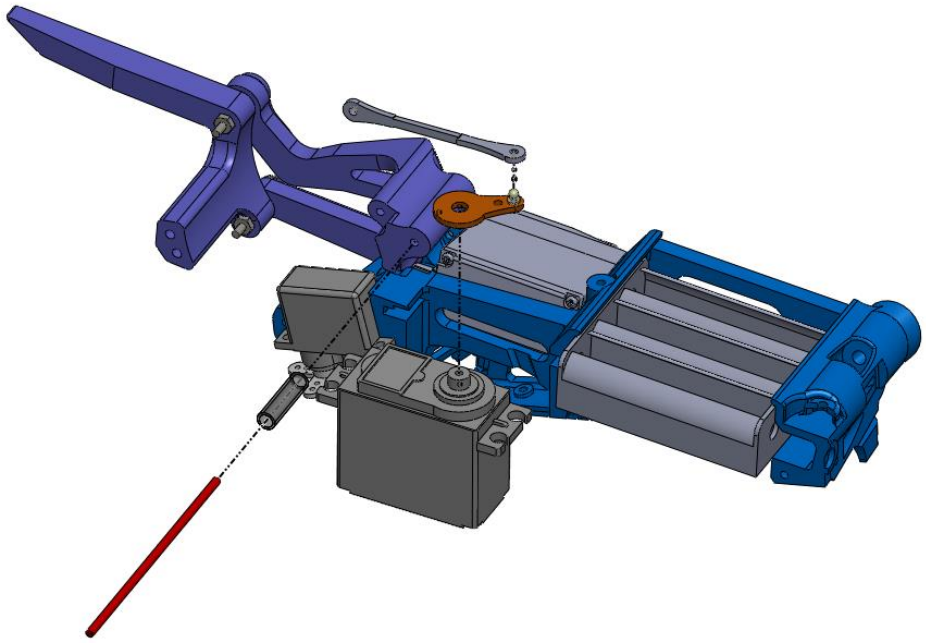


Figure 6 – Forklift servo hardware, exploded view

Materials

- 2X Snapdragon Rover forklift arm
- 1X power HD standard servo 3001HB
- 4-arm servo horn
- 1X 2-56 swivel ball link
- 1X 2-56 clevis
- 1X music wire, 0.078-inch diameter, 1.6-inch length
- 1X nylon tube 0.186-inch diameter, 0.75-inch length
- 2-56 threaded rod, 0.75-inch length

Instructions

1. Prepare the horn by removing three of the arms.

2. Use an X-Acto blade or other tool to widen the mounting hole of the horn to fit the locking pin of the clevis.

3. Attach clevis to the horn as shown.

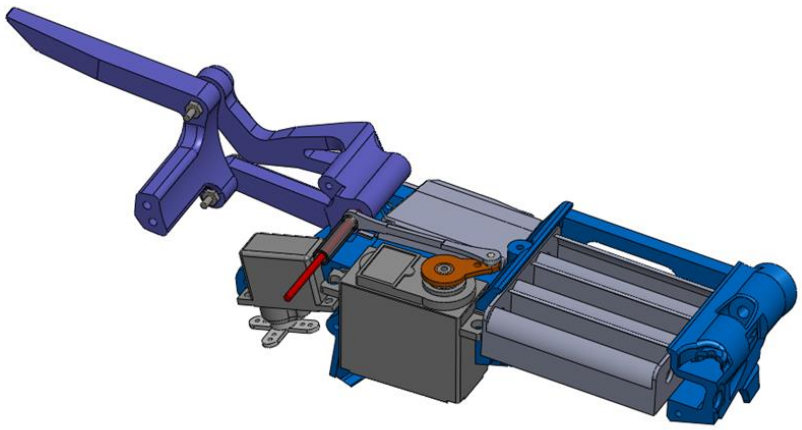
4. Insert servo into the center slot of the left Snapdragon Rover frame.

   NOTE: It may be necessary to widen the slot to fit the servo into the frame.

5. Use a drill to thread the 2-56 rod into the ball joint.

6. Thread the other end of the 2-56 rod into the clevis.

7. Insert music wire into the corresponding hole on the left lower Snapdragon Rover arm.
8. Insert the ball head joint onto the music wire.
9. Insert nylon tube over the music wire.
10. For now, leave the horn unattached to the forklift servo.



Main mounting screws

Materials

- 2X 4-40 pan head machine screw, 3/8-inch length
- 2X 4-40 socket machine screw, 1-inch length
- 2X 4-40 socket head machine screw, 1 ½-inch length

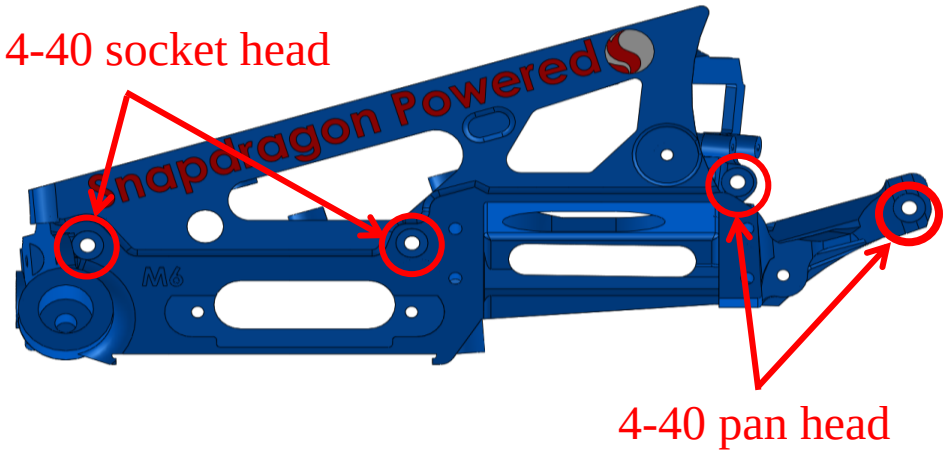
Instructions

1. Line up the mirror servo, forklift servo, and battery holders, and slide the two Snapdragon Rover halves together.

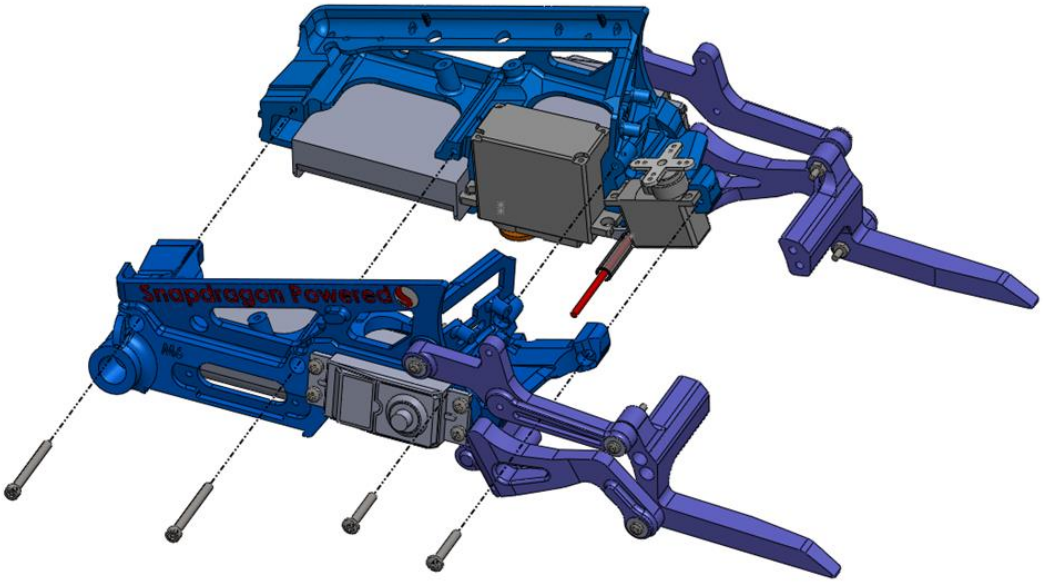
   NOTE: This can be a delicate operation, make sure the servo slots on the right Snapdragon Rover frame can fit the corresponding servos on the left Snapdragon Rover frame. It is also important to avoid pinching the battery or servo wires in between the frames.

2. Screw in the pan head 4-40 screws into the corresponding Snapdragon Rover mounting holes.

3. Screw in the socket head 4-40 screws into the corresponding Snapdragon Rover mounting holes.



4. Thread the screws into the forks, starting from the left side, as shown.



Back wheels

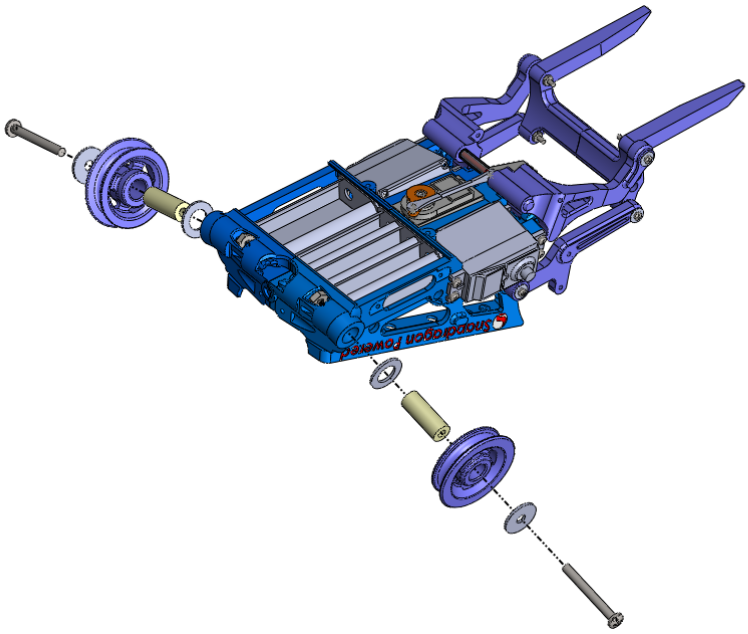


Figure 7 – Back wheels, exploded view

Materials

- 2X Snapdragon Rover small wheels
- 2X #8 x 3/8 x 1-inch nylon spacer
- 2X 3/8-inch flat nylon washer
- 2X #10 x ¾ x 0.040-inch flat nylon washer
- 2X 8-32 pan head Phillips machine screw, 1.5-inch length
- 2X 8-32 nuts

Instructions

1. Use a 3/8-inch drill bit or end mill to manually (not in a drill press) increase the diameter of the rear wheel axle holes to accommodate the nylon spacers.

2. Insert the nylon spacers into the rear wheel axle holes of the Snapdragon Rover frame.
3. Insert the nylon inner rings onto the nylon spacers.
4. Use the drill bit to widen the inner diameter of the wheels.
5. Insert the small wheels onto the nylon spacers.
6. Insert the outer rings onto the nylon spacers.
7. Insert the screws into the shaft holes.
8. Thread the nuts onto the screws, tighten until the wheel has a smooth sliding fit.

Front wheels

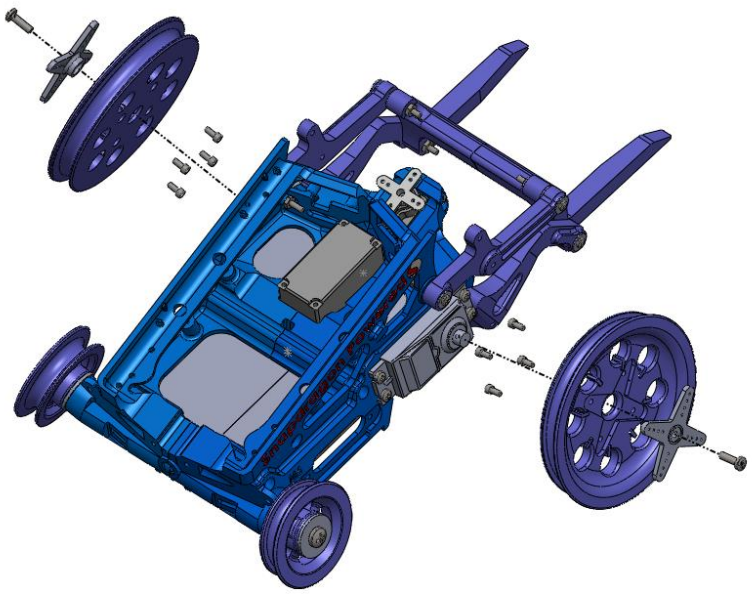


Figure 8 – Front wheels, exploded view

Materials

- 2X Snapdragon Rover front wheels
- 2X AR-3606HB robot servo drive shaft screws
- 2X “Cross” servo horn
- 8X Torx drive screws, #3, 0.25-inch length

Instructions

1. Widen both wheel inner holes to allow for the servo horns to fit.
2. Insert the servo horn into the wheel.

3. Screw the Torx screws into the corresponding holes, which are on the back side of each wheel.

4. Insert the wheel + horn assemblies onto the toothed servo axles.
5. Screw the shaft screws into the wheels, securing them to the servos.

   NOTE: Try to keep the shaft screws as straight as possible to keep the wheels aligned.

Wiring

Wiring diagram

It is possible to wire the IOIO board using different tools and parts than those shown in Figure 9, e.g., replacing the crimped connectors with direct solder connections. This document does not cover all potential wiring methods.

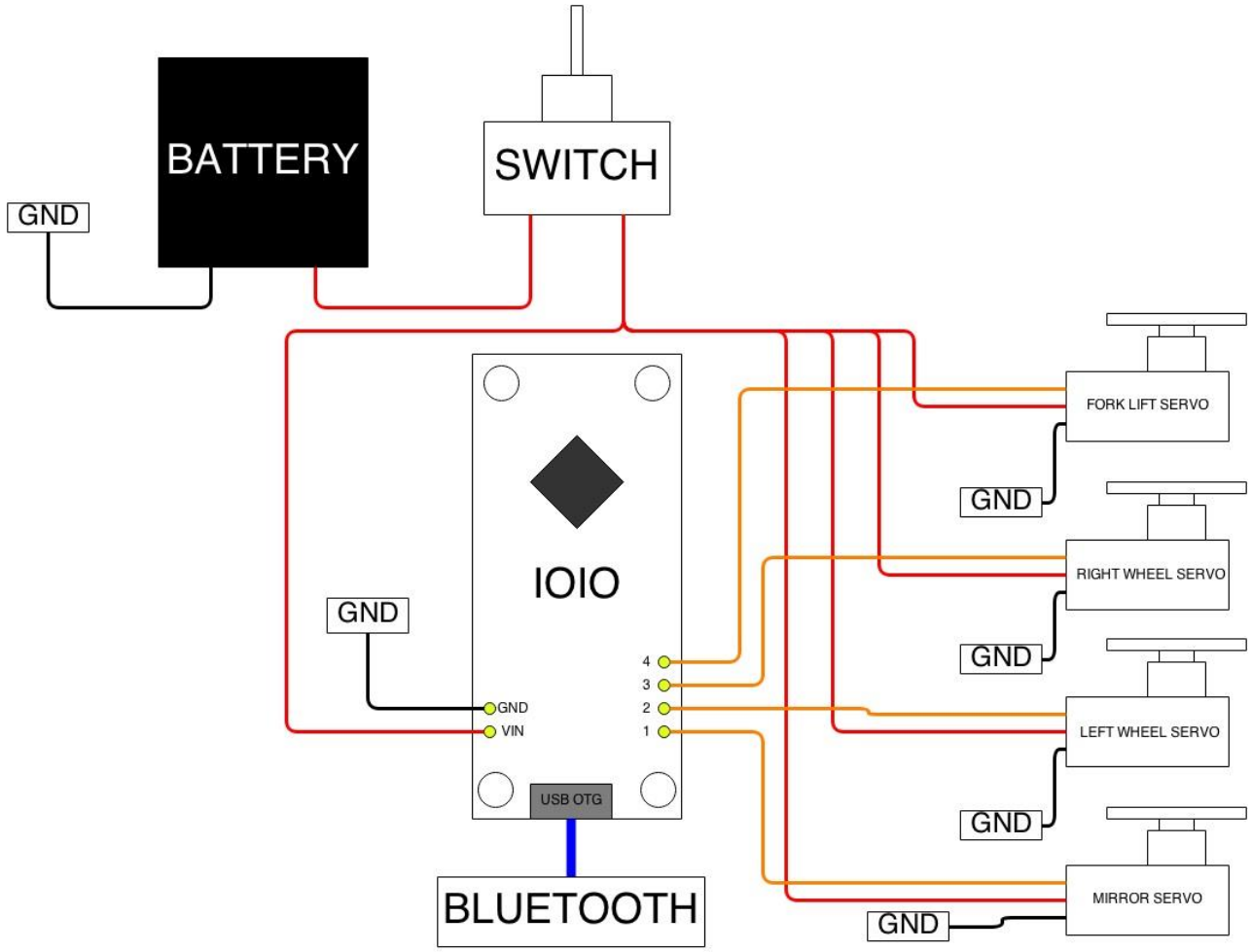


Figure 9 – IOIO wiring diagram

Materials

- 1X IOIO board
- 1X 4-pin right angle header
- 1X 2-pin right angle header
- 1X 2-pin Molex connector + 2 crimp terminals
- 1X 2x4 straight header
- 1X toggle switch: 3-pin, SPDT, 5A

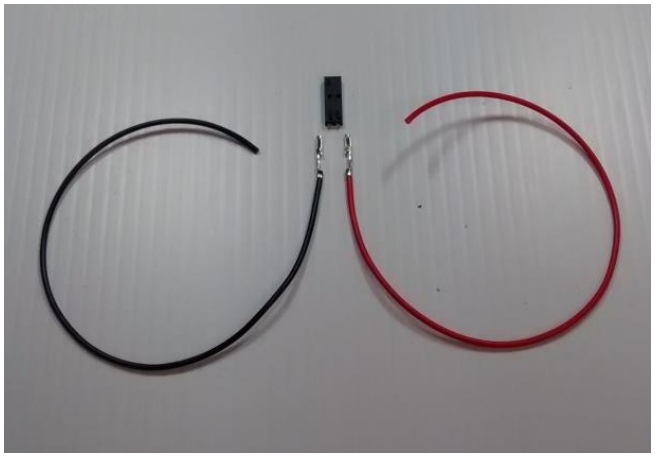
- 2X 22AWG, red, 5-inch length
- 2X 22AWG, black, 5-inch length

Instructions

1. Crimp one of the red wires and one of the black wires to the crimp terminals.

2. Insert the crimp terminals into the Molex connector (GND on the side of the arrow).

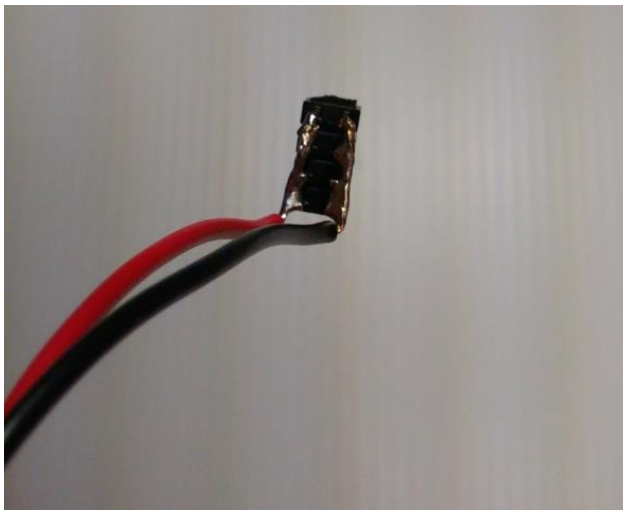
   NOTE: Make sure the locking tab of the crimps snap into place on the Molex connector. If it is pulled, the crimp should not slide out of the Molex connector.



3. Solder the other black wire to all four pins of one side of the 2x4 header, then solder the other red wire to the other four pins.

4. Put a separate piece of heat shrink tubing over each wire.

   NOTE: Keep solder on the outside of the pins, to make room for heat shrink tubing.



5. Solder the right angle 4-pin header to the IOIO board digital input pins #1 through #4.

6. Solder the right angle 2-pin header to the IOIO board VIN and GND pins.

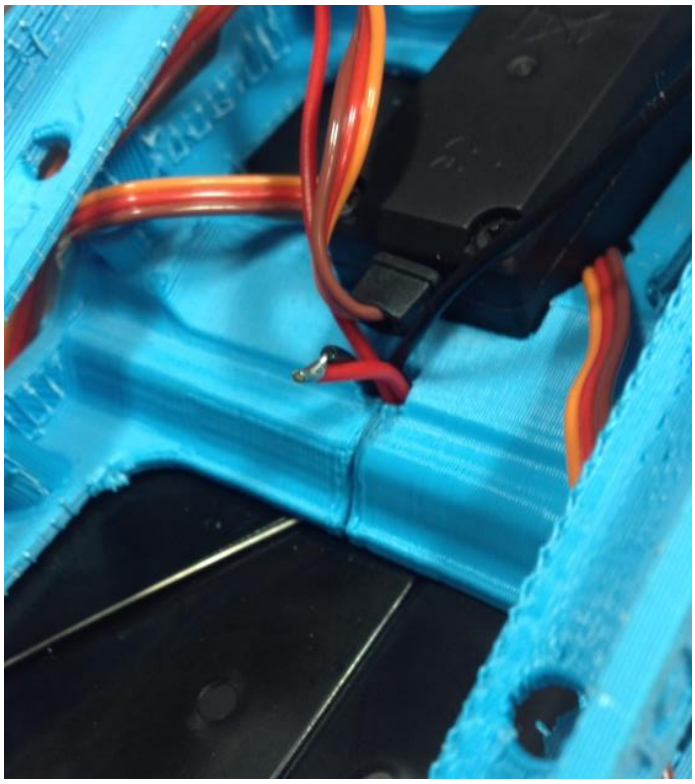
7. Solder the positive (red) wire of the crimped Molex connector and positive (red) wire from the 2x4 header together.

8. Solder the connected wires to one of the sides of the switch.

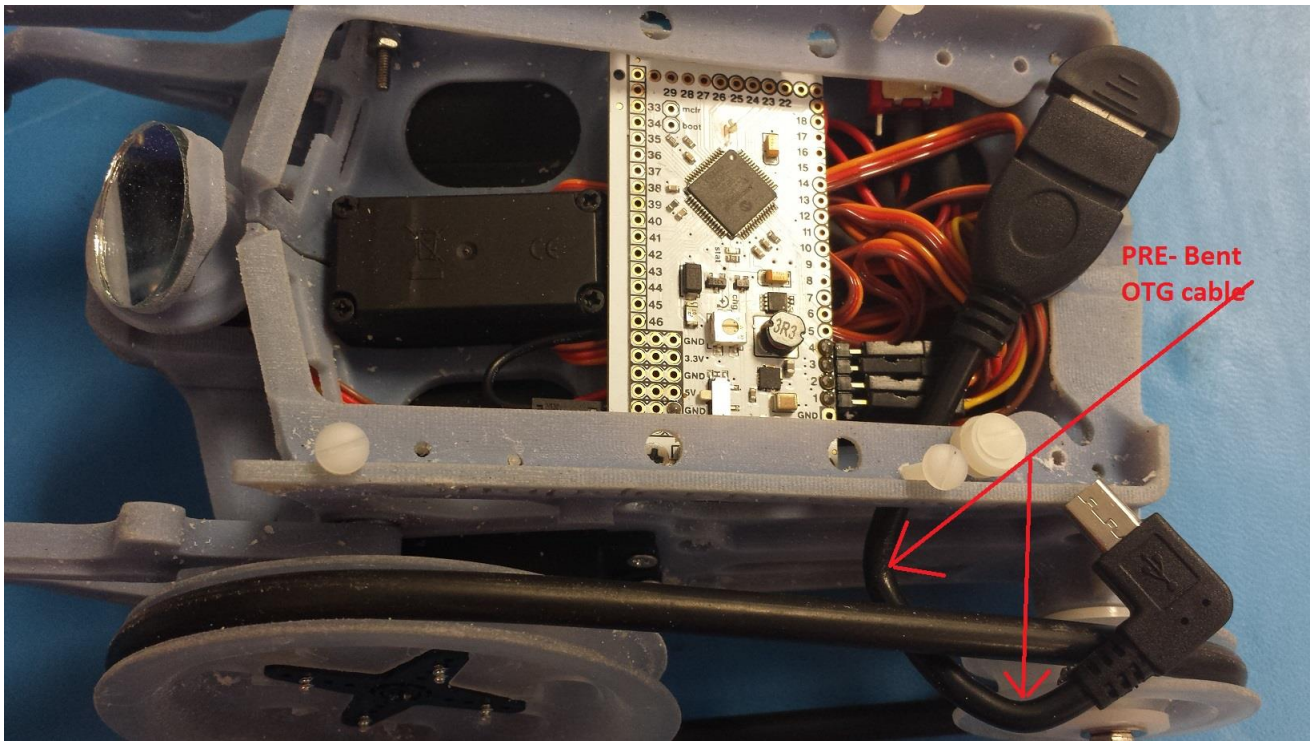
   NOTE: Do not forget to put heat shrink tubing around the soldered wires before soldering the switch.

9. Solder the positive end of the 2-AA battery bay to the negative end of the 3-AA battery bay.

   NOTE: Use a multimeter to make sure that the correct wires are being shorted together.



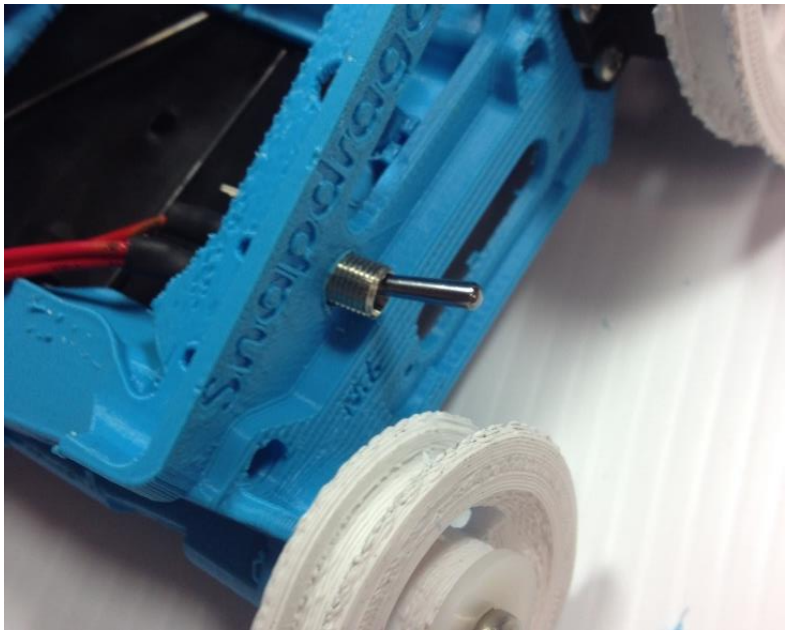
10. To get ready to install the IOIO board and neatly tuck the USB-OTG cable into Snapdragon Rover, add two bends to the 90-degree version of the OTG cable (using a heat source of some sort), slide the 90-degree side through the left frame slot and lay it out of the way as shown:



11. Solder the positive end of the 3-AA battery bay to the center terminal of the switch.

    NOTE: Do not forget to put heat shrink tubing around the soldered wires before soldering the switch.

12. Insert the switch through the hole as shown.



13. Insert the switch washer and lock washer onto the switch.
14. Thread the switch nut onto the switch.
15. Solder the three grounds from the Molex connector, the 2x4 header, and the 2-AA battery bay together.
16. Use heat shrink tubing around the soldered wire to prevent any shorts

IOIO board firmware

Materials

- IOIO board
- IOIO firmware v5 (https://github.com/ytai/ioio/tree/master/release/firmware/application)
- Male-male USB to Micro-USB connector

Instructions

1. Navigate in command line to: Desktop\IOIODude0100
2. Connect boot pin to GND on IOIO board.
3. Connect USB to PC. Make sure that the red and yellow LEDs are turned on.
4. Disconnect the boot pin from GND. The yellow LED should flash three times.
5. Go to the device manager to find the COM port the IOIO board is on.
6. To write new firmware, type "ioiodude --port=COM<number> --reset write App-IOIO0500.ioioapp
7. Disconnect the USB.

IOIO board mounting

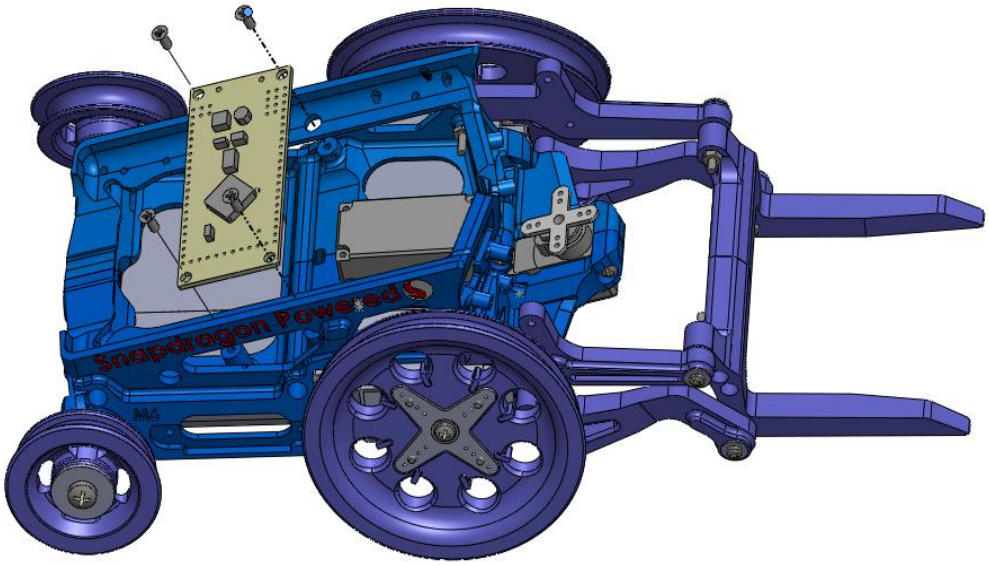


Figure 10 – IOIO board, exploded view

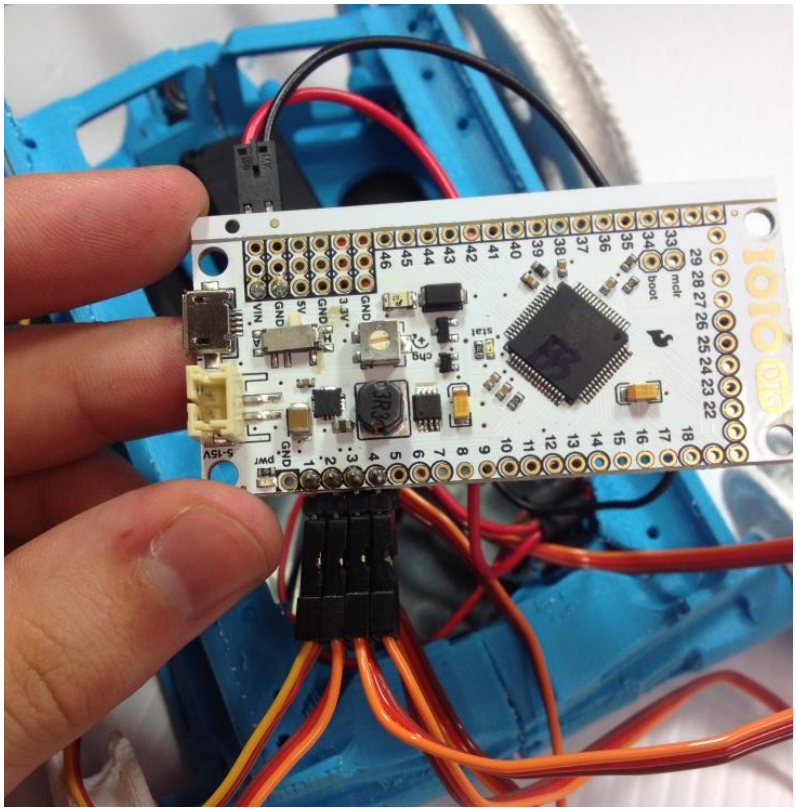
Materials

- 4X M3 pan head machine screws, 6-mm length
- IOIO board

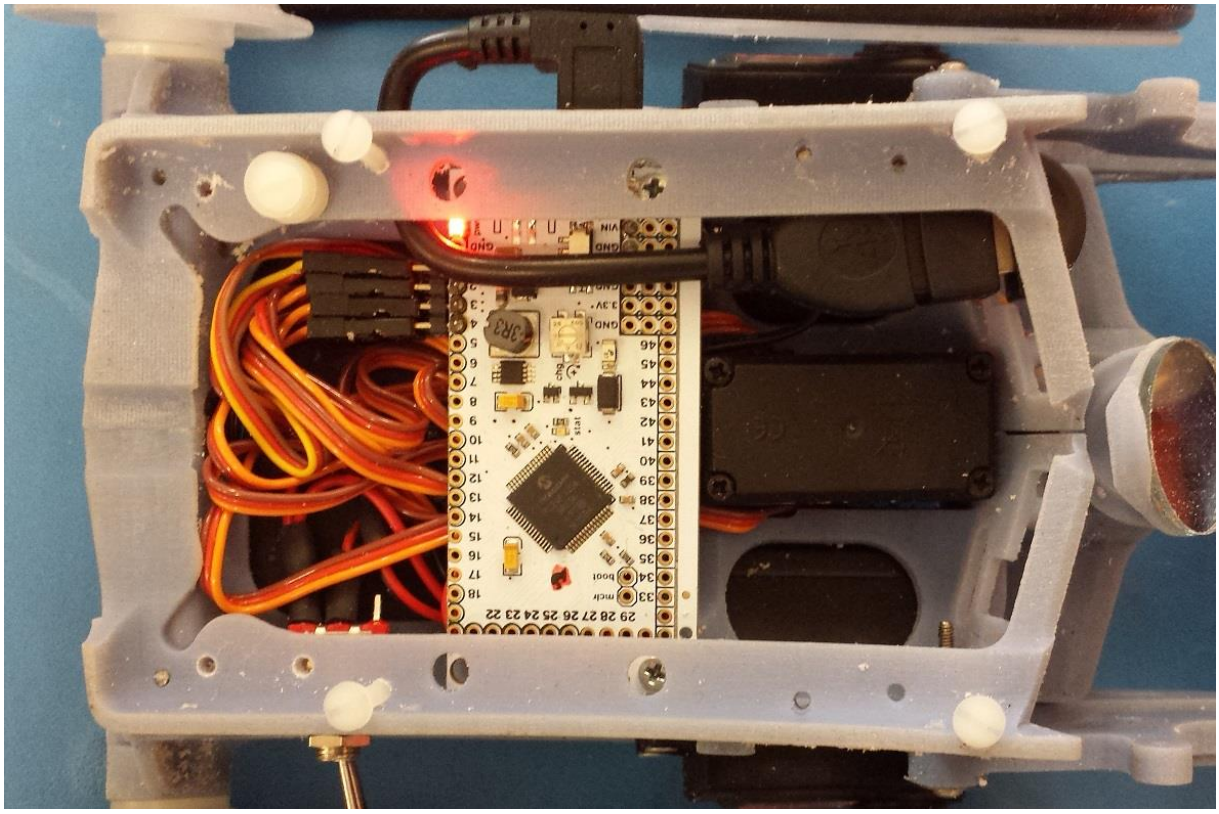
Instructions

1. Connect Molex connector to the 2-pin header on the IOIO board.

2. Connect the servos to the 4-pin header on the IOIO board in the following order:
   - Pin 1: Mirror servo
   - Pin 2: Left wheel servo
   - Pin 3: Right wheel servo
   - Pin 4: Forklift servo



3. With the IOIO board upright and the USB facing the left side of the frame, carefully tuck the wires towards the rear of the robot. Put the right IOIO logo side of the board under the phone cradle and in through the right frame slot (in front of the on/off switch) just enough to allow the board to be slid back through the left frame slot as shown.



4. Use M3 screws to secure the IOIO board to the Snapdragon Rover body.

Mirror mount placement

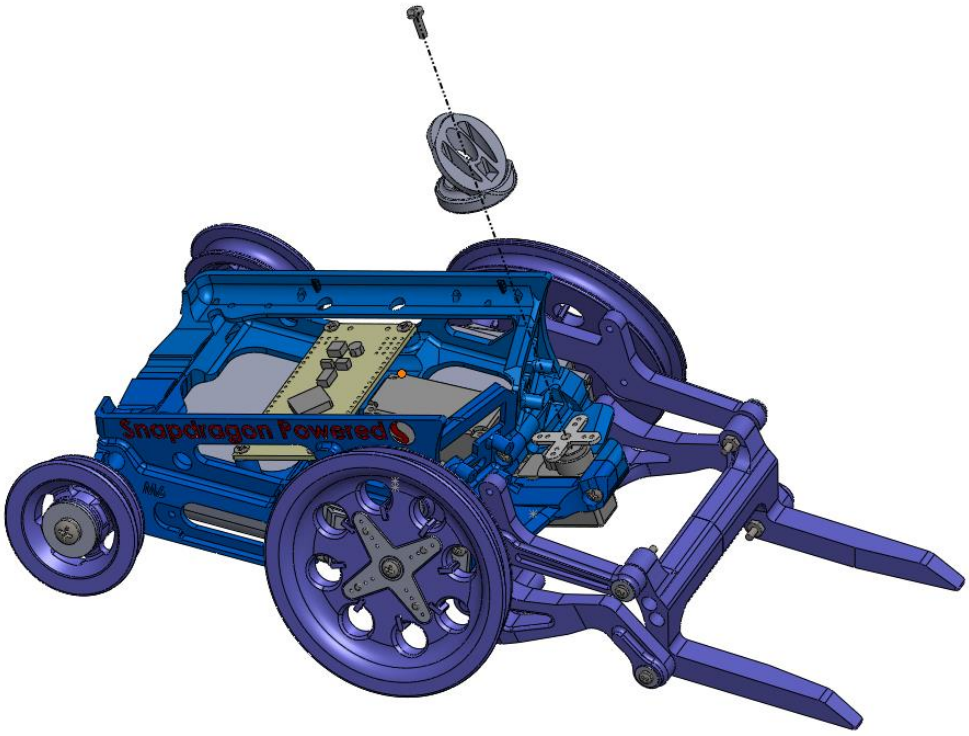


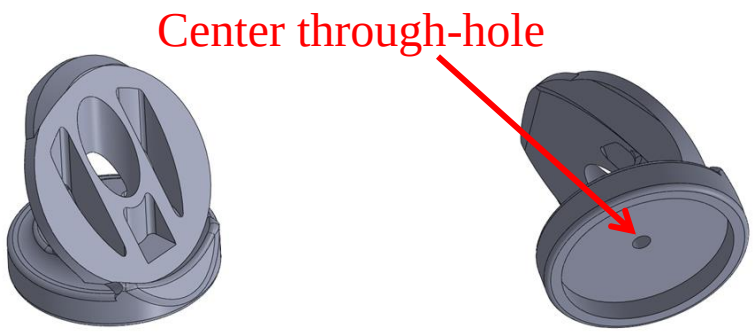
Figure 11 – Mirror mount, exploded view

Materials

- Snapdragon Rover mirror mount
- Mirror
- Turnigy TG9 9 g/1.7 kg /0.12 sec eco micro servo horn
- M2.5 pan head machine screw, length ()

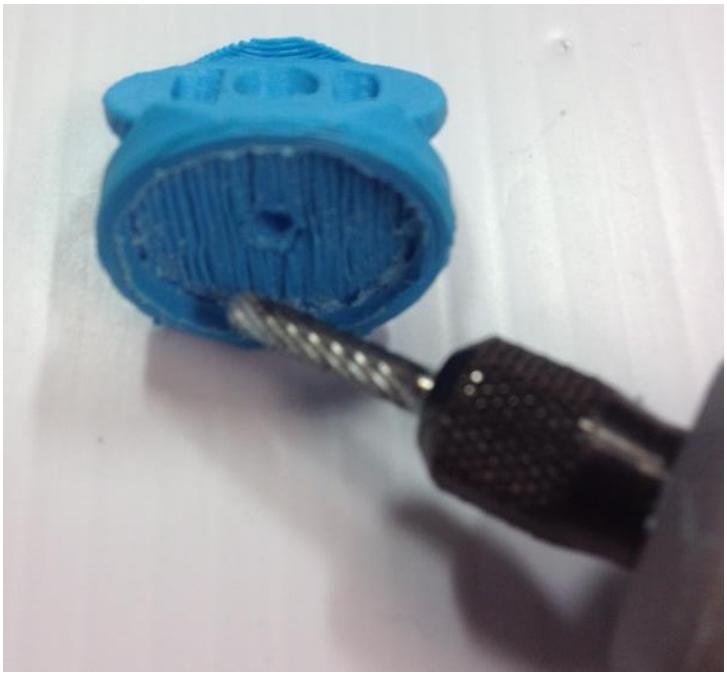
Instructions

1. Drill out the center through-hole in the mirror mount with the 7/64-inch drill bit.



2. Place the servo horn into the mirror mount.

3. The servo horn should have a sliding fit in the mirror mount. If it cannot be spun, then use a Dremel to thin the walls of the mirror mount to allow for a looser fit.

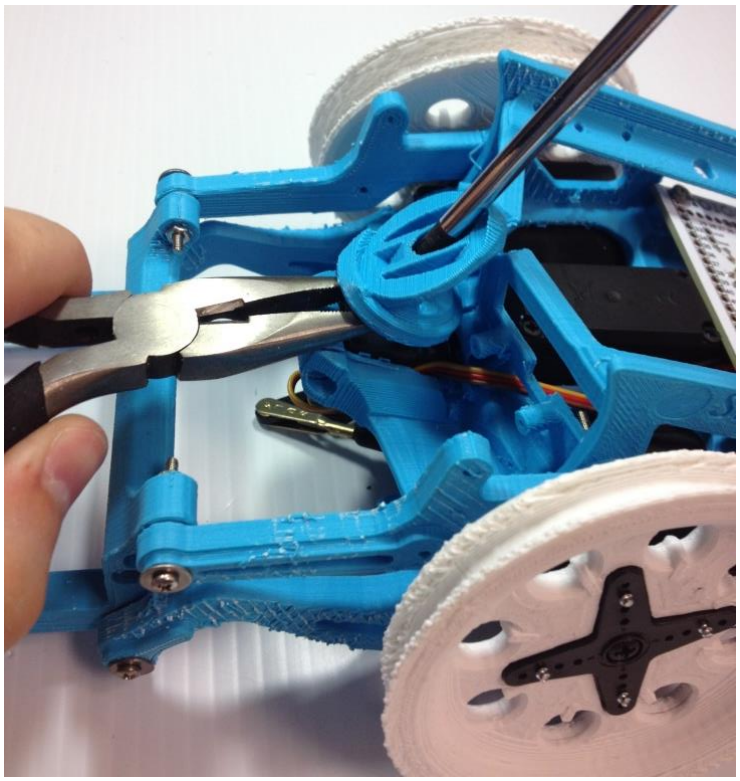


4. Attach the servo horn + mirror mount onto the servo.

5. Insert the screw into the hole in the mirror mount and thread it into the servo.

6. Thread the screw until the mirror mount is secure, but still capable of being rotated without also rotating the servo gears.

   NOTE: Avoid rotating the servo while threading the screw by using pliers to hold the horn as shown.



Servo calibration

Materials

- Android phone with Snapdragon Rover “MDR SimpleNavigator” app
- 5 AA batteries
- Bluetooth dongle
- Male-female Micro-USB to USB plug

Instructions

1. Plug the Bluetooth dongle into the female USB plug.
2. Plug the Micro-USB plug into the IOIO board.
3. Put the five batteries into the Snapdragon Rover battery bay.
4. Turn on the Snapdragon Rover.
5. Pair the phone with the IOIO board over Bluetooth.
6. Open the “MDR SimpleNavigator” app.
7. Select **Local** in the popup.
8. Both the mirror and forklift servo of the Snapdragon Rover should auto-rotate to their zero position.
9. The easiest way to attach the forklift horn to the forklift servo is to first make sure that the forklift servo is in the zero position.

Mirror placement

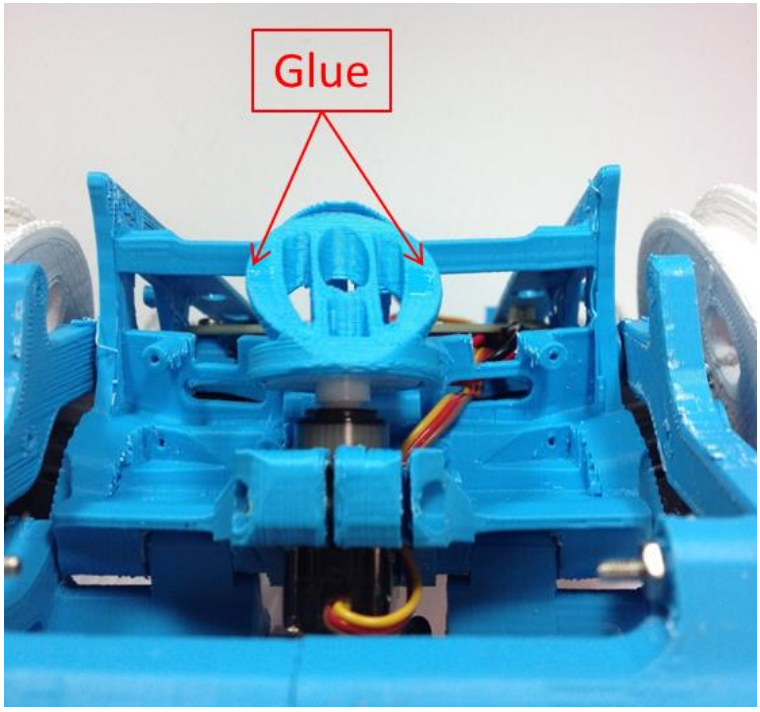
Materials

- Super glue
- Mirror

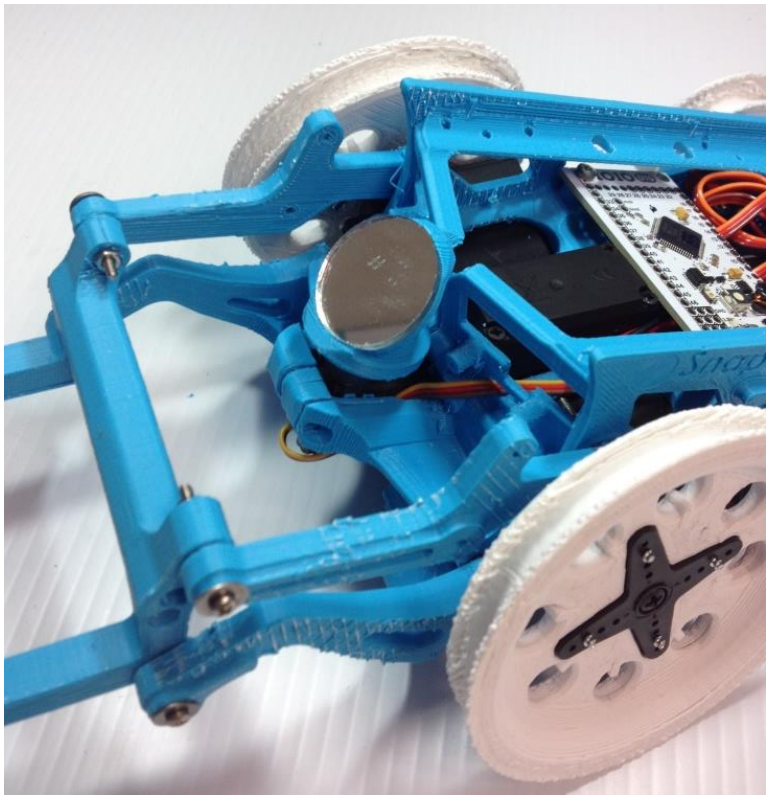
Instructions

1. Apply a small amount of glue or other adhesive to the sides of the mirror mount.

   NOTE: It may be necessary to remove the mirror at some point in the future, so using double-sided tape, rubber cement, or another easy-to-remove adhesive can be beneficial.



2. Snap in the mirror.



Treads

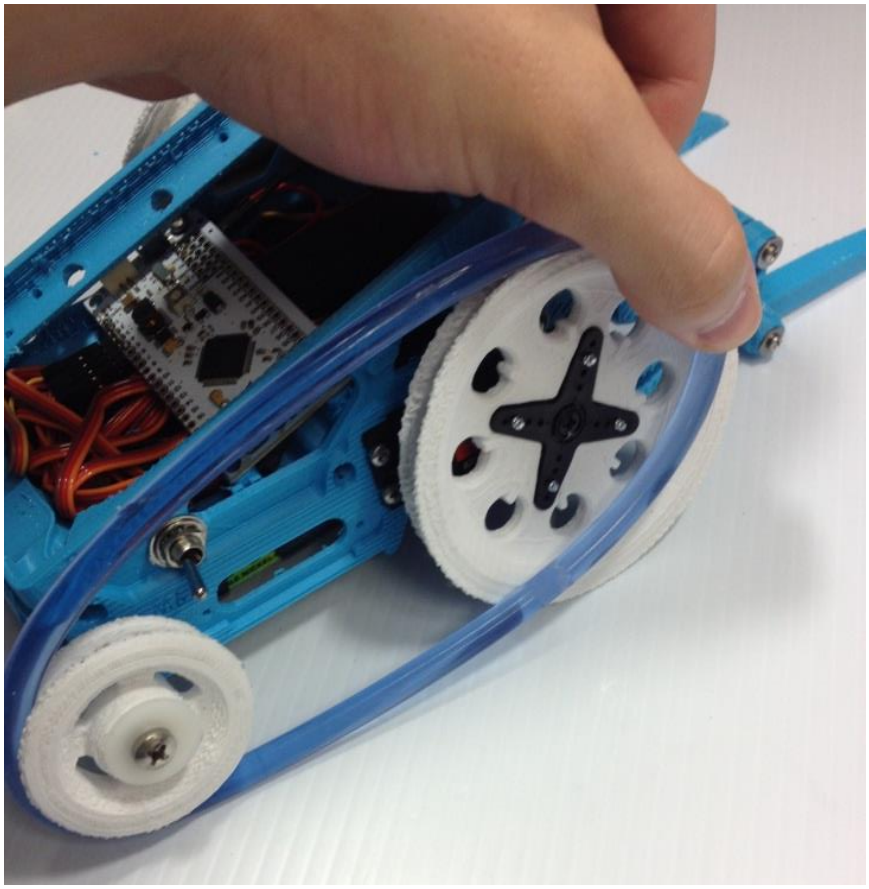
Materials

- 2X 112-mm ID x 6-mm O-Ring treads

  NOTE: The instructions show custom ¼-inch polyurethane treads.

Instructions

1. Put the treads on the wheels, starting with the back wheel.
2. Roll the treads over the larger wheels.



Configurations

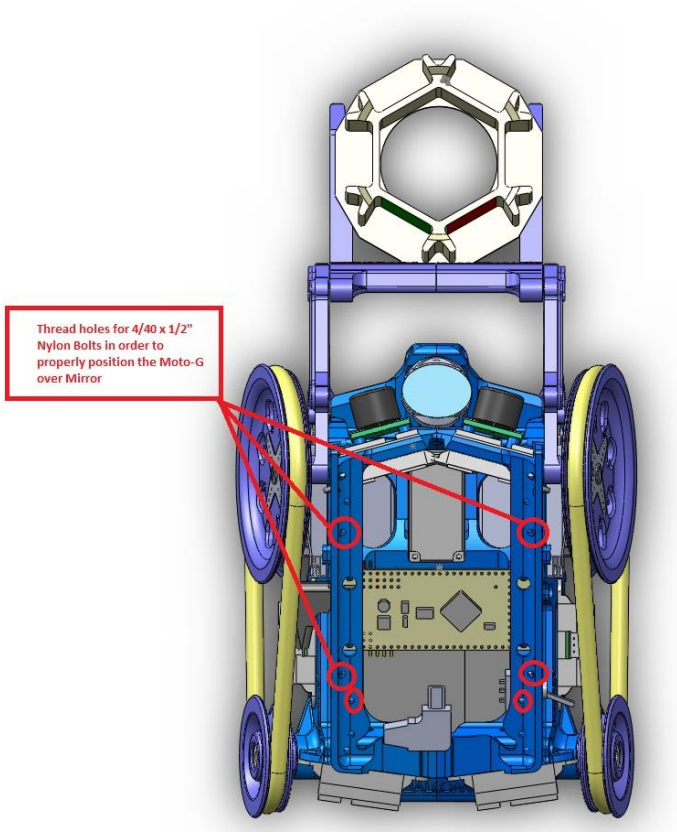
Materials

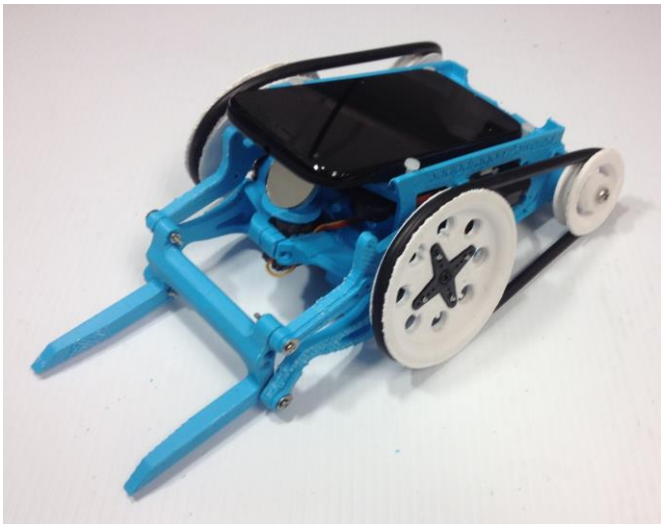
- 4X 4-40 nylon screws, ½-inch length
- 1X Motorola Moto G/Samsung Galaxy S4/IFC Development Board

Instructions

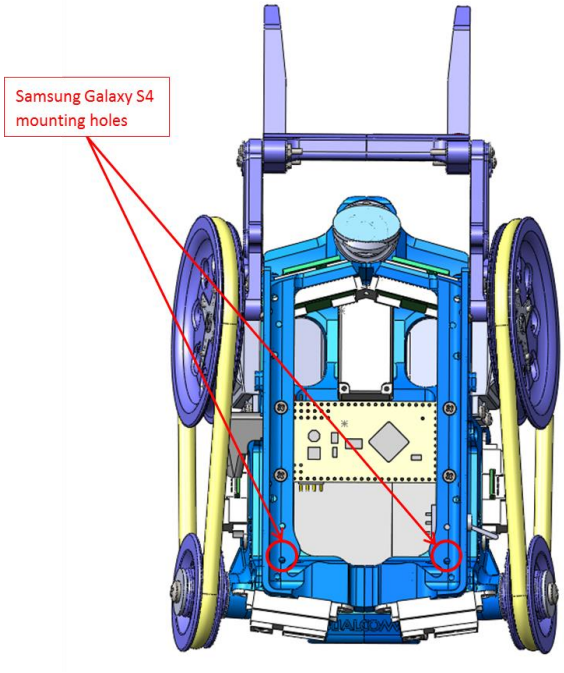
Depending on what is available, there are three different configurations of the Snapdragon Rover.

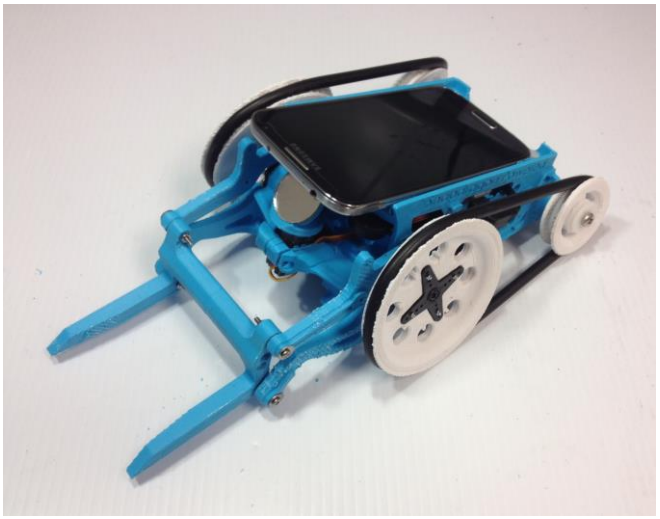
1. The **Moto G configuration** requires that all six nylon screws be threaded into the positions indicated.



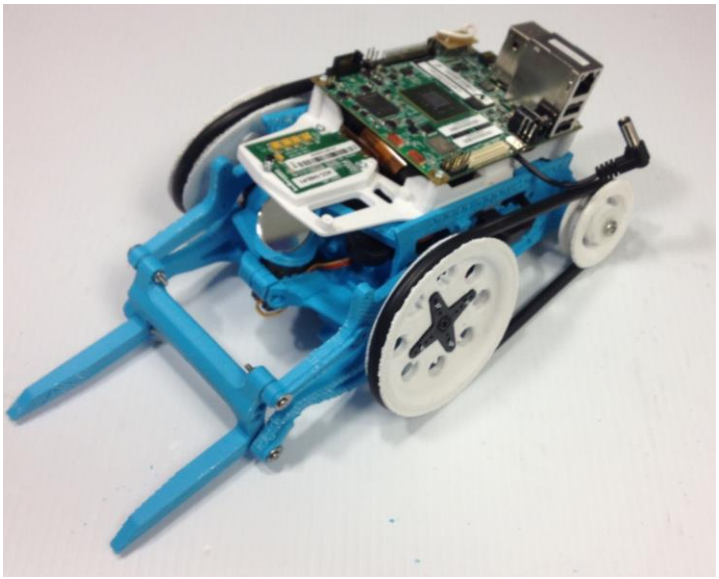


2. The **Samsung Galaxy S4 configuration** requires that two nylon screws be threaded into the positions indicated.





3. The **IFC Development configuration** requires no screws and snaps into the Snapdragon Rover as shown.



The IFC-6410 version requires a unique 3D printed backpack (white) that properly integrates five more AA batteries, a remote camera module, and a flat camera cable. The backpack CAD files are in the given folders. The build instructions and BOM for this version will be posted soon. For now, find out more about the IFC-6410, camera, and flat cable at Inforce: http://www.inforcecomputing.com/product/moreinfo/ifc6410.html