Robot Platform Build Instructions

v1.0 - Oct. 3, 2016

Table of Contents

Tools & Materials Required

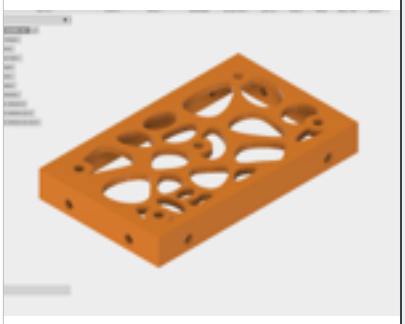
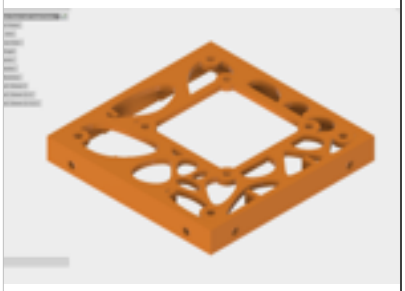
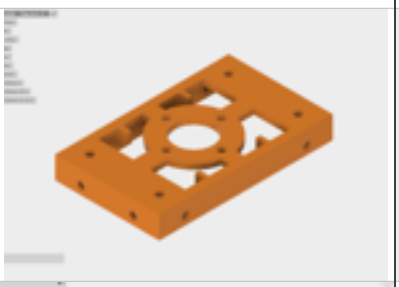
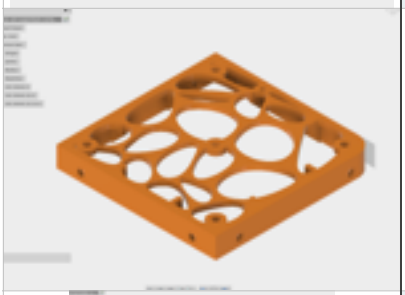
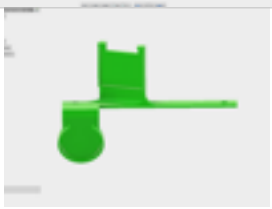
Supplies
- Printed pieces of the robot
- Motors, sensors, servos, etc
- Electronics boards
- *See the Robot Missions - Robot Platform Bill of Materials for the complete list*

Tools
- Phillips / cross slot screwdriver
- Needlenose pliers
- Xacto knife
- Hot glue gun & hot glue sticks
- Small allan key that works with the motor hub
- Piece of paper, pencil

Consumables
- Blue locktite
- Dual-lock (plastic velcro)
- Twist tie wraps

Robot Missions - Robot Platform 3D Printed Pieces

v1.0 - Oct. 8, 2016

	item	qty	file	instructions
	Base			
	Base middle	2	base/ base_middle.stl	
	Base motor	2	base/ base_motors.stl	
	Base flag post	1	base/base_flag.stl	
	Base corner	4	base/ base_corner.stl	
	Sensor attachments	2	base/ ultrasonic_sensor_ holder.stl	print one, and print the other mirrored

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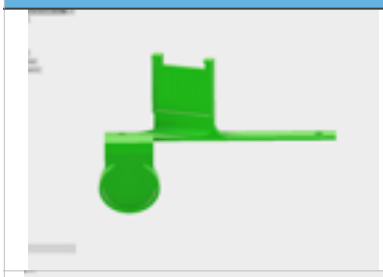
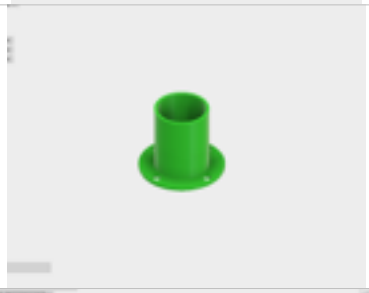
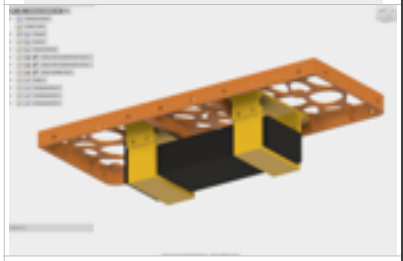
	item	qty	file	instructions
	Super bright led attachment	2	base/ led_attachment.stl	
	Flag post connector	3	base/ flag_adapter.stl	has to be printed on a 30 degree angle with supports as to avoid layer delamination if the robot falls backwards onto the flag post
	Battery holder mount	2	base/ batt_mount.stl	print one, and print the other mirrored
	Battery holder pieces	2	base/ batt_holder.stl	
	Drive System			
	Struts	4	drive system/ strut.stl	print two, and then print the other two mirrored

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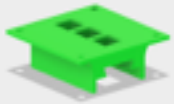
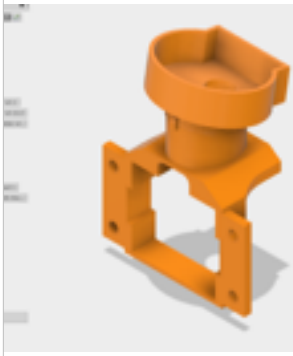
	item	qty	file	instructions
	Strut attachment pieces	2	drive system/strut_attachment.stl	
	Mounts	2	drive system/ mount.stl	
	Dovetail key	2	drive system/ dovetail_key.stl	
	Motor mounts	4	drive system/motor_mount.stl	

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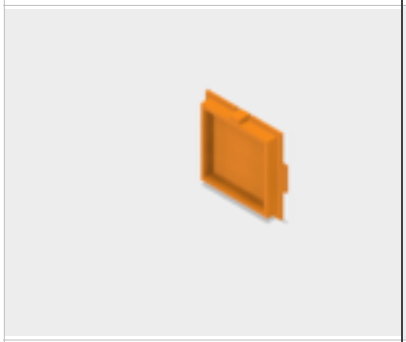
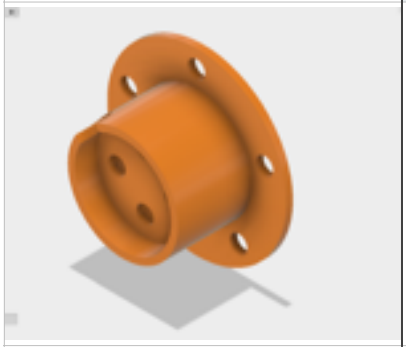
	item	qty	file	instructions
	Motor casing	8	drive system/motor_casing.stl	
	Motor enclosure	4	drive system/ motor_enclosure.stl	print with outer supports
	Enclosure back	4	drive system/enclosure_back.stl	
	Hub attachment	4	drive system/ hub_attachment.stl	print on 30 degree angle with supports

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	item	qty	file	instructions
	Inner wheel casing	4	drive system/ inner_case.stl	
	Flexible suspension	4	drive system/ flexible_piece.stl	TPU material, 3 perimeters, 30% infill
	Outer wheel casing	4	drive system/ outer_case.stl	
	Wheel	4	drive system/ wheel.stl	print without supports

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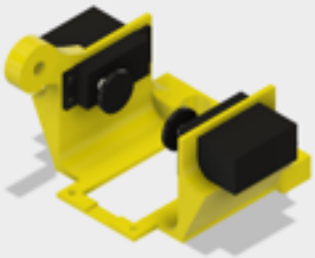
	item	qty	file	instructions
	Arm			
	Mount	1	arm/mount.stl	print with supports
	Servo arms	2	arm/servo_arm.stl	print one, and print the other mirrored
	First stage cover	1	arm/ first_stage_cover.stl	print with supports
	Dovetail M	1	arm/dovetail_m.stl	

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	item	qty	file	instructions
	Dovetail F	1	arm/dovetail_f.stl	
	Dovetail key	1	arm/ dovetail_key.stl	print with supports
	Second stage arms	2	arm/stage_arms.stl	print one, and print the other mirrored
	Stage connector piece	1	arm/ stage_connector.stl	

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	item	qty	file	instructions
	Stage cover	1	arm/ stage_cover.stl	
	Third stage arms	2	arm/stage_arms.stl	
	Stage connector piece	1	arm/ stage_connector.stl	
	Stage cover	1	arm/ stage_cover.stl	

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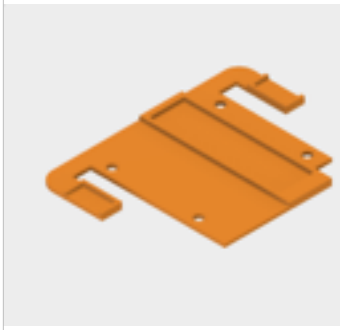
	item	qty	file	instructions
	End effector mount	1	arm/ end_effector_mount.stl	print with supports
	Scoop mount plate	1	arm/ scoop_mount_plate.stl	
	Scoop			
	Scoop to end effector mount	1	scoop/scoop_to_end_effector_mount.stl	

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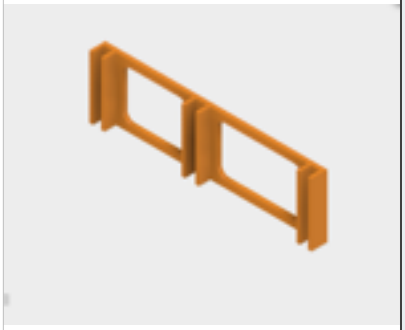
	item	qty	file	instructions
	Servo mount	1	scoop/ servo_mount.stl	
	Pivot left mount	1	scoop/ pivot_left_mount.stl	
	Pivot right mount	1	scoop/ pivot_right_mount. stl	
	Mount support beam	1	scoop/mount_support_beam.stl	

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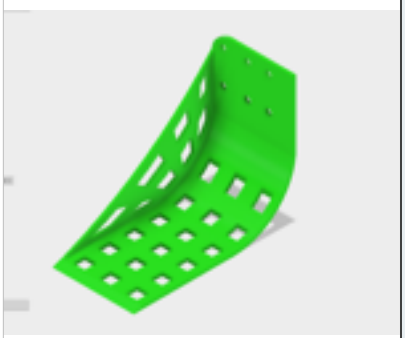
	item	qty	file	instructions
	Servo arm	1	scoop/ scoop_servo_arm. stl	
	Pivot support left (with curve)	1	scoop/pivot_left.stl	
	Pivot support right	1	scoop/ pivot_right.stl	
	Scoop half left and right	2	scoop/ scoop_half.stl	print one, and print the other mirrored

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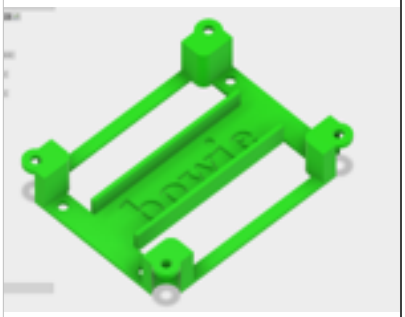
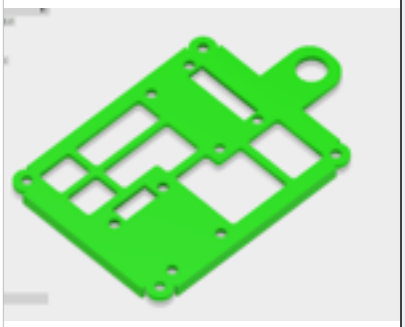
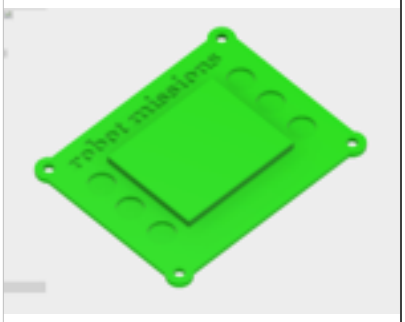
	item	qty	file	instructions
	Electronics			
	Board mount	1	electronics/ board_mount.stl	
	Sensor & Xbee plate	1	electronics/ sensor_plate.stl	
	Top plate	1	electronics/ top_plate.stl	
	Antenna holder	1	electronics/ antenna_holder.stl	

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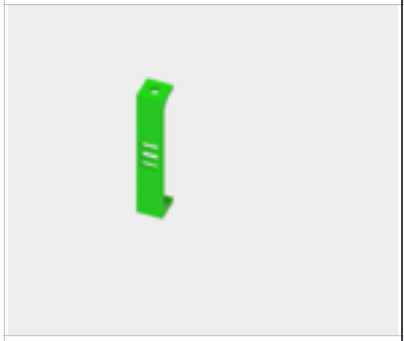
	item	qty	file	instructions
	Power supply area			
	Base to power supply area mount	1	power supply/ base_mount.stl	
	Bottom tray	1	power supply/ bottom_tray.stl	
	Bottom supports	8	power supply/ bottom_supports.stl	
	Middle tray	1	power supply/ middle_tray.stl	

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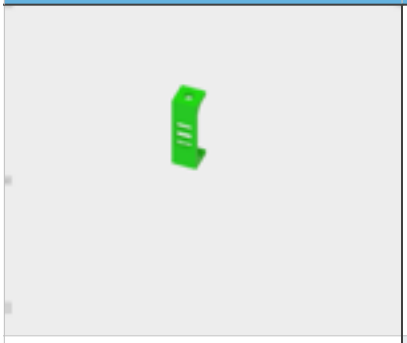
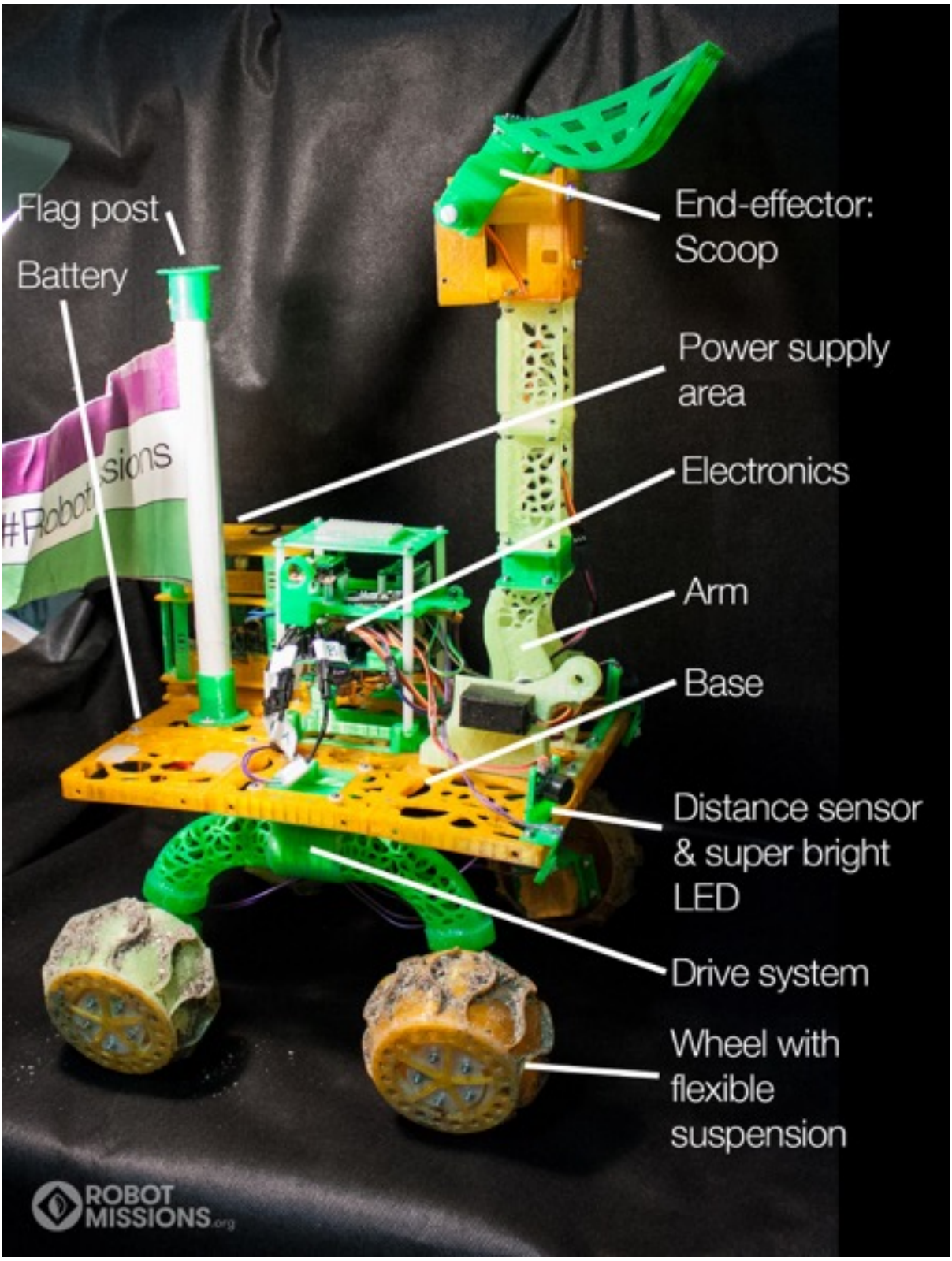
	item	qty	file	instructions
	Middle supports	8	power supply/ middle_supports.stl	
	Top plate	1	power supply/ top_plate.stl	

Sub-assemblies Overview



Base

The base is the main area of the robot. It will hold the electronics tower, the end effector mount, the drive system mounts, and sensors. It is comprised of 9 tiles assembled together to make a larger rectangle. This also contains an area at the back of the robot to hold the battery.

Pieces required

Base middle	2
Base motor	2
Base flag post	1
Base corner	4
Sensor attachments	2
Super bright led attachment	2
Flag post connector	3
Battery holder mount	2
Battery holder pieces	2

Hardware required

M3 10mm	24
M3 10mm	4
M3 10mm	4
M3 10mm	12
M3 Nuts, Washers	44
PVC pipes	2

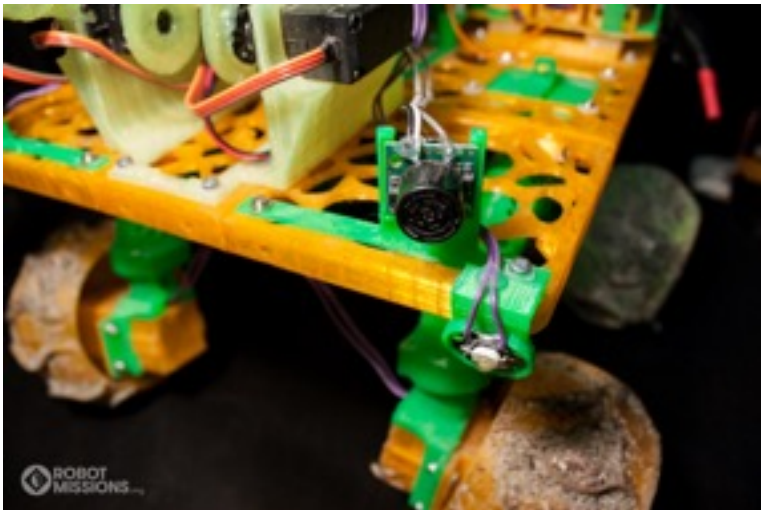
Base Assembly steps

1. Attach the base tiles together using two M3 screws on each side, except for the outside edge

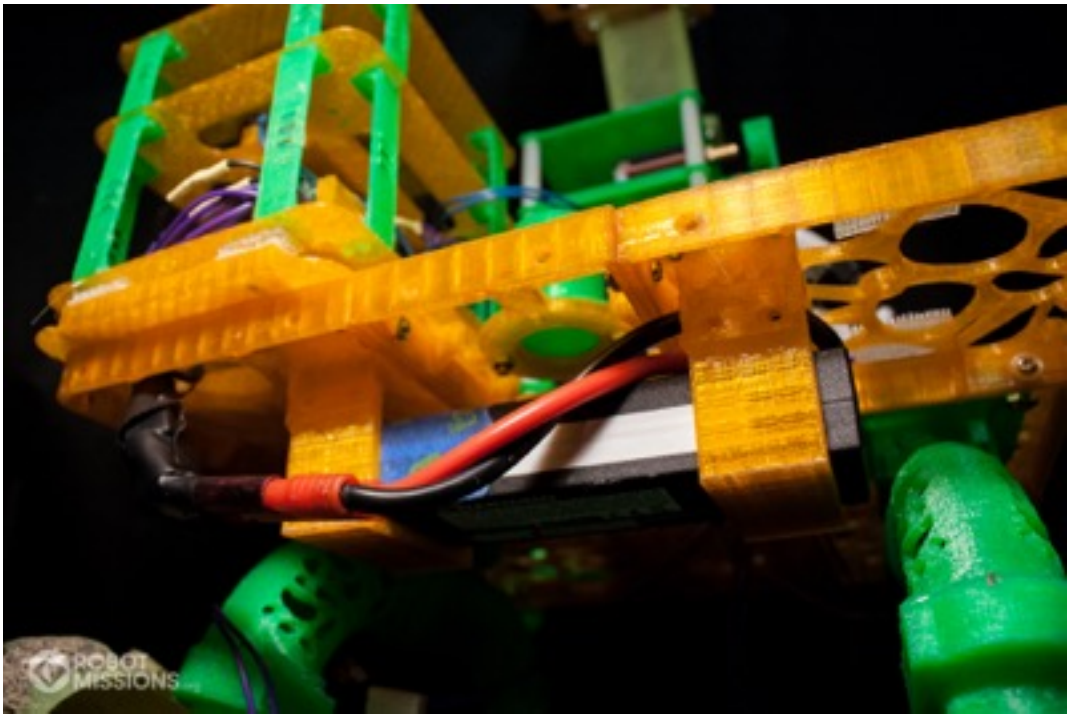
The base flag post piece will be at the back of the robot. The two base motor pieces are in the middle row on the left and right respectively.

2. Use adhesive to attach the super bright led piece to the sensor piece

3. Attach the assembled sensor piece on to the front of the robot, with the location for the ultrasonic sensor pointing outwards



4. Attach the battery holder pieces onto the back corner base tiles



5. Assemble the flag post by attaching the flag post connector to the base tile

6. Join two flag post connectors together, and add the two pvc pipes

7. Tape your Robot Missions flag to the post!

Drive System

The drive system is comprised of two struts that are joined together. The joining piece has a dovetail on it, which can slide in and out of the mount attached to the base. It is locked in place with a three pronged piece. At the end of each strut is the motor mount, where the motor housing goes. There is an attachment from the motor hub to the wheel. The wheel has a flexible inner piece to provide suspension. The drive system assembly is replicated twice, for both sides of the robot. The below lists are quantities for both assemblies in total.

Pieces required

Struts	4
Strut attachment pieces	2
Mounts	2
Dovetail key	2
Motor mounts	4
Motor casing	8
Motor enclosure	4
Enclosure back	4
Hub attachment	4
Inner wheel casing	4
Flexible suspension	4
Outer wheel casing	4
Wheel	4

Hardware required

M3 10mm	8
M3 10mm	16
Motor hub	4

M3 5mm	16
M3 10mm	20
M3 Nuts, Washers	44

Drive System Assembly steps

Repeat all these steps once for the other side of the drive system

1. Add both struts to the strut attachment pieces - make sure the extruded rectangle on the end of the strut is the same on both sides. This will be the inside direction. Use adhesive to secure in place

2. Add the mount to the base using M3 screws. The dovetail should be parallel with the outer edge of the base

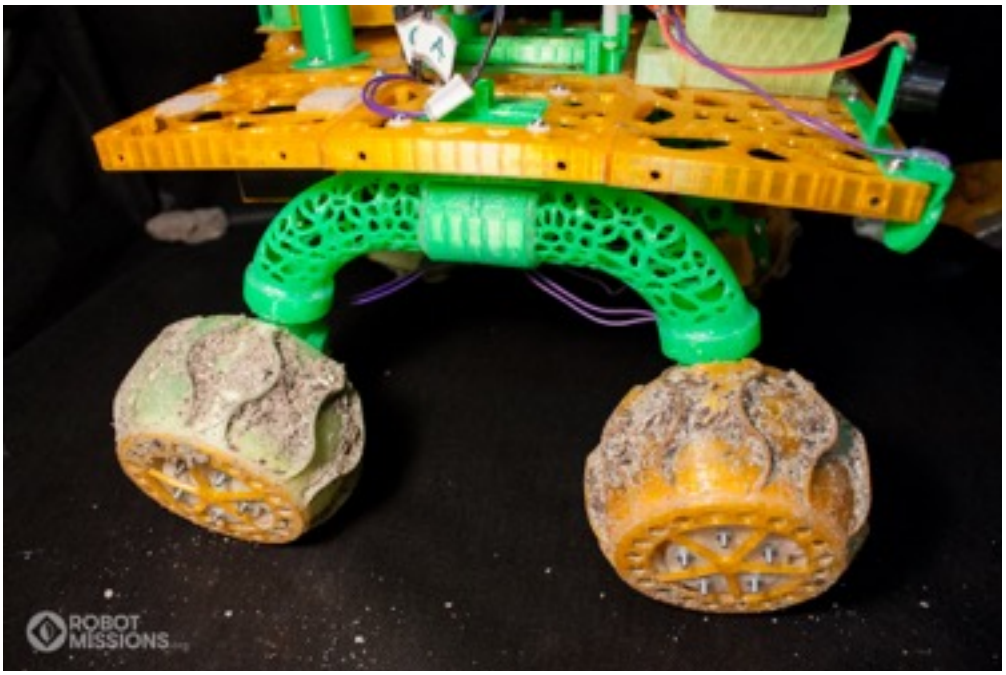
3. Add the motor mounts to the end of the struts. The extruded rectangle on the end of the strut will be flush with the proper place in the motor mount. Use adhesive to secure in place

4. Enclose the motor within both halves of the motor casing using adhesive

5. Insert motor casing into the motor enclosure, adding two points of adhesive to secure in place

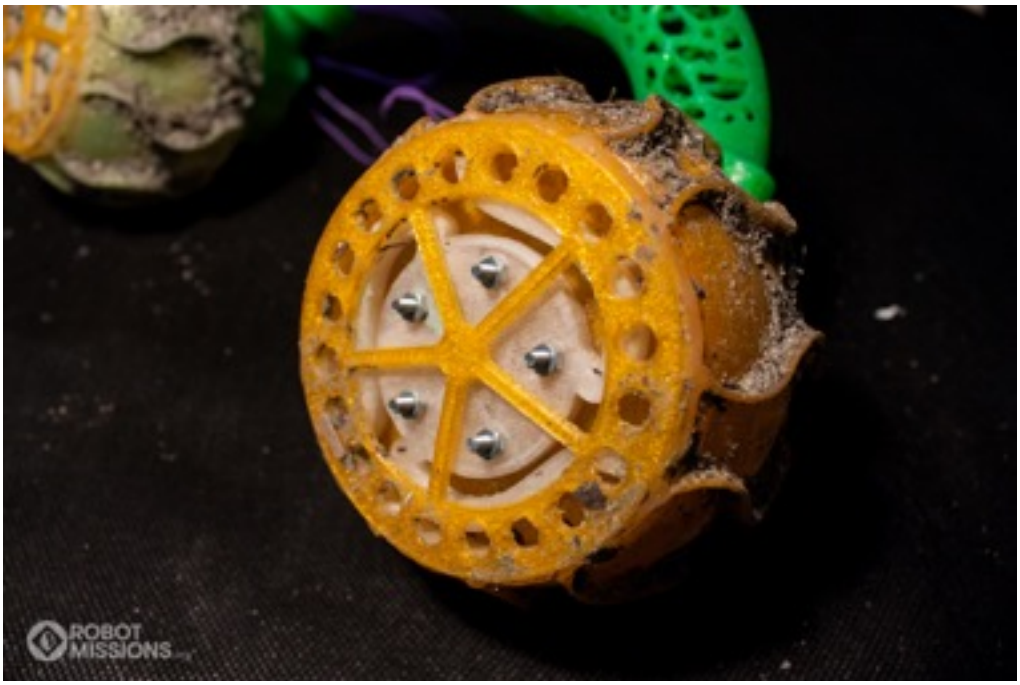
6. String the wires through the insert at the top of the motor enclosure

7. Attach the enclosure back with two points of adhesive on the small rectangular tabs



8. With the wheel, attach the flexible piece to the outer rim (as noted by the ~7mm extruded cylinder) using adhesive

9. Attach the outer casing using adhesive around the perimeter. The spokes should be between the circles



10. Add the motor hub to the motor axel. At this point, you might want to use the thread locker on the set screw of the hub

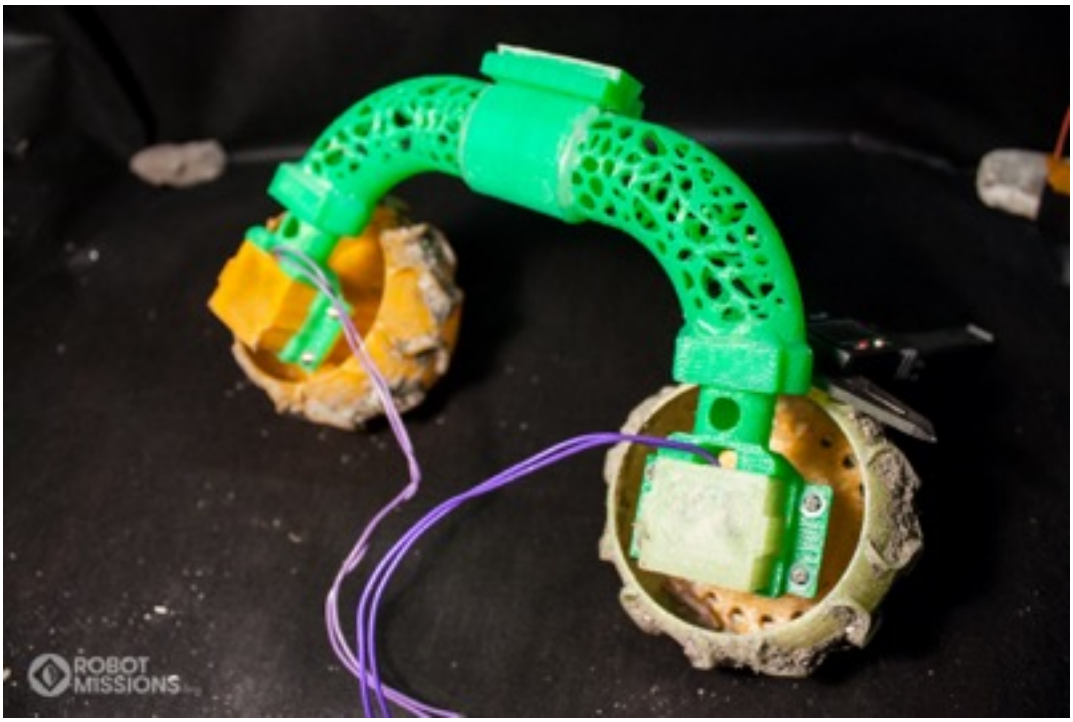
11. Attach the hub attachment to the hub with 5mm M3 screws

12. Attach the inner casing to the inside of the wheel using adhesive on the perimeter. The side that is entirely flat should be in contact with the flexible piece

13. Insert the motor with the hub attachment into the wheel to the area on the flexible piece

14. Use M3 screws to secure the motor and wheel together. The hex nuts will be on the outside. Note that this might require patience because of the tight area

15. Insert the motor assembly through the motor mount. Secure in place with M3 screws



16. Slide the drive assembly into the mount on the base, and secure in place with the dovetail key

Arm

The arm is mounted on the base of the robot and extends forward, with an end effector mounted on it. There are two servos used at the arm mount to provide adequate torque for lifting. The default end effector is a scooper. The scooper uses a servo to control the angle that it is pointing. The top of the arm is able to separate using a dovetail sliding joint for swapping modules and easier packing.

Pieces required

Mount	1
Servo arms	2
First stage cover	1
Dovetail M	1
Dovetail F	1
Dovetail key	1
Second stage arms	2
Stage connector piece	1
Stage cover	1
Third stage arms	2
Stage connector piece	1
Stage cover	1
End effector mount	1
Scoop mount plate	1

Hardware required (for both arm and scoop)

M3 10mm	4
M3 10mm	4
M3 10mm	

M3 10mm	4
M3 10mm	4
M3 10mm	8
1" Plastic binding post	12
M3 Nuts, Washers	2
	36

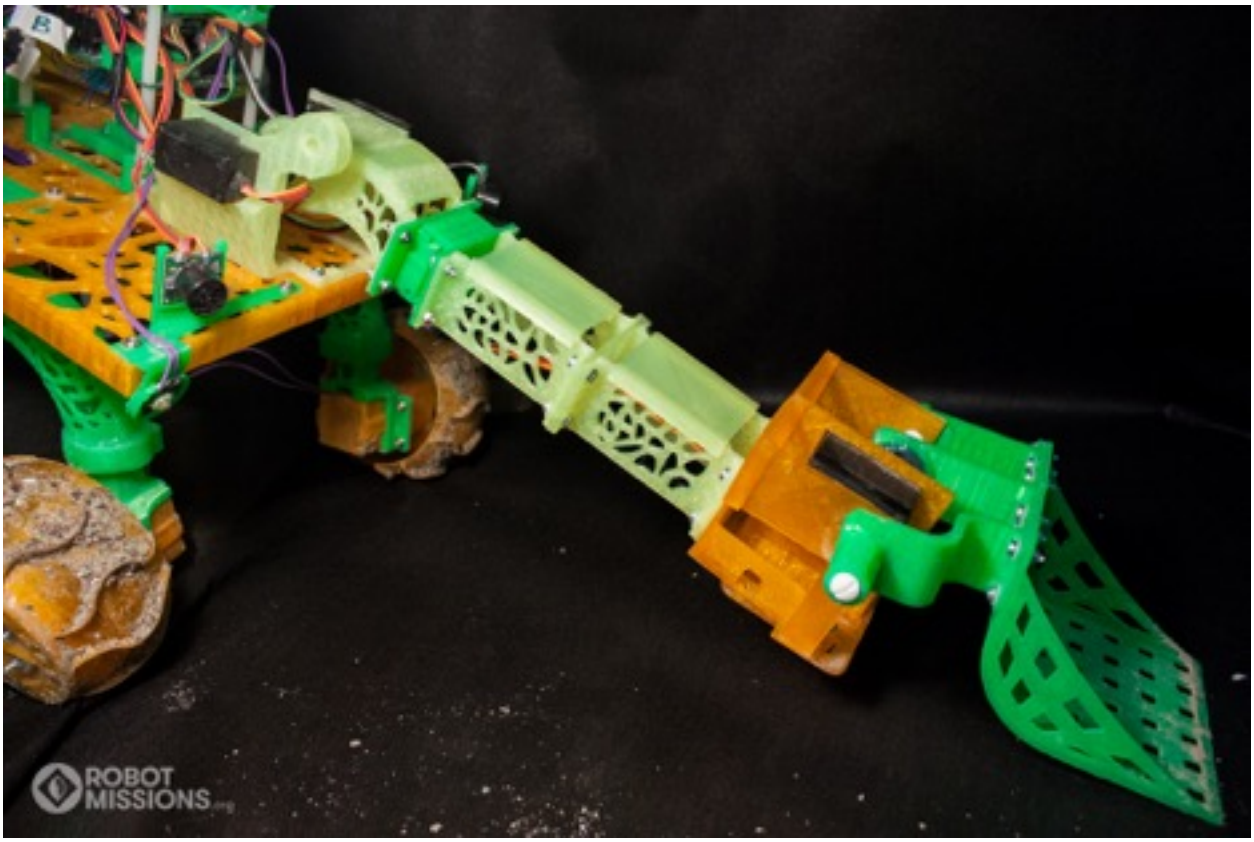
Arm Assembly steps

1. Add the mount to base using M3 screws

2. Insert the two servos through the mount. Servo horns point towards the front of the robot

3. Add servo arms to the servo horns - be sure to position the servos properly before doing so (ie, checking the minimum and maximum, and setting both servos to the same angle)

4. Add the first stage cover on top of the servo arms



5. Attach the dovetail F piece across the two servo arms using M3 screws

6. Slide the dovetail M piece and secure with the key

7. Attach the second stage arms to the dovetail M piece with M3 screws

8. Add the stage cover across the arms using adhesive

9. Add the stage connector piece and third stage arms using M3 screws

10. Now add the stage cover across the arms for the third stage using adhesive

11. Add the stage connector piece and the arm to end effector mount at the end of the third stage arms using M3 screws

12. Add the scoop mount plate to the end effector piece using M3 screws

Scoop

The scoop is mounted as an end effector on the arm. There is a servo mounted on it to control the pitch of the scoop. Two pieces extend from the scoop to serve as pivot point supports, keeping the scoop aligned as it is digging in to sand and lifting mass. The scoop itself has holes in it to let the sand filter through, but larger items will remain. It is assembled in two halves which are attached with an adhesive.

Pieces required

Scoop to end effector mount	1
Servo mount	1
Pivot left mount	1
Pivot right mount	1
Mount support beam	1
Servo arm	1
Pivot support left (with curve)	1
Pivot support right	1
Scoop half left and right	2

Hardware required

See the hardware required for arm

Scoop Assembly steps

1. Using adhesive attach the servo mount, pivot left support, and pivot right support to the 'scoop to end effector mount'

2. Install servo through the servo mount. Servo horn should be pointing towards the front of the mount - the area where there is less space between the end of the servo to the end of the mount

3. Add mount support beam behind the servo mount and pivot left and right support

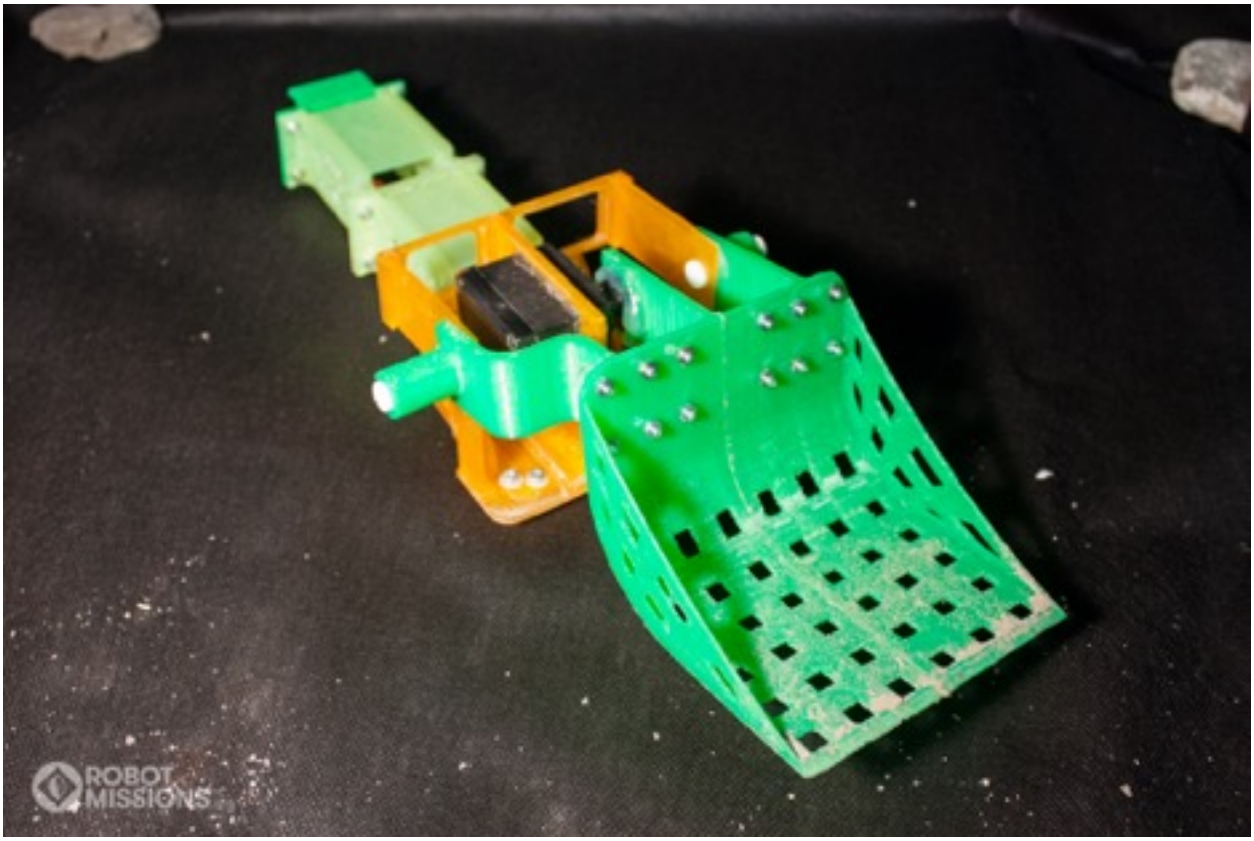
4. Assemble both halves of the scoop using a strong adhesive

5. Attach the pivot left mount, servo arm, and pivot right mount to the scoop using M3 screws

6. Attach servo arm to servo horn using adhesvie - be sure to set the servo position before doing so (ie, check the minimum and maximum)

7. Insert plastic binding post through the pivot areas, and secure in place with the other half of the binding post

8. Attach the 'scoop to end effector mount' to the scoop mount piece at the end of the arm using M3 screws



Electronics

The electronics tower is at the center of the base, an area that is less prone to damage. It consists of multiple layers of plates, using standoffs to connect the circuit board to the plates. The top plate can have dual-lock placed on it, so that different attachments can be added (for example: a GoPro).

Pieces required

Board mount	1
Sensor & Xbee plate	1
Top plate	1
Antenna holder	1

Hardware required

M3 10mm	4
35mm M3 standoffs	8
M3 5mm	4
M3 Nuts, Washers	4

Main Board Pin Assignments

To assemble the circuit board, please see the Project Description for the labeled diagram of the board. Use the Bill of Materials and Pinouts document to see what pin attaches to what.

Electronics Assembly steps

1. Install the M3 standoffs onto the board mount

2. Attach the board mount to the center tile of the robot using M3 screws

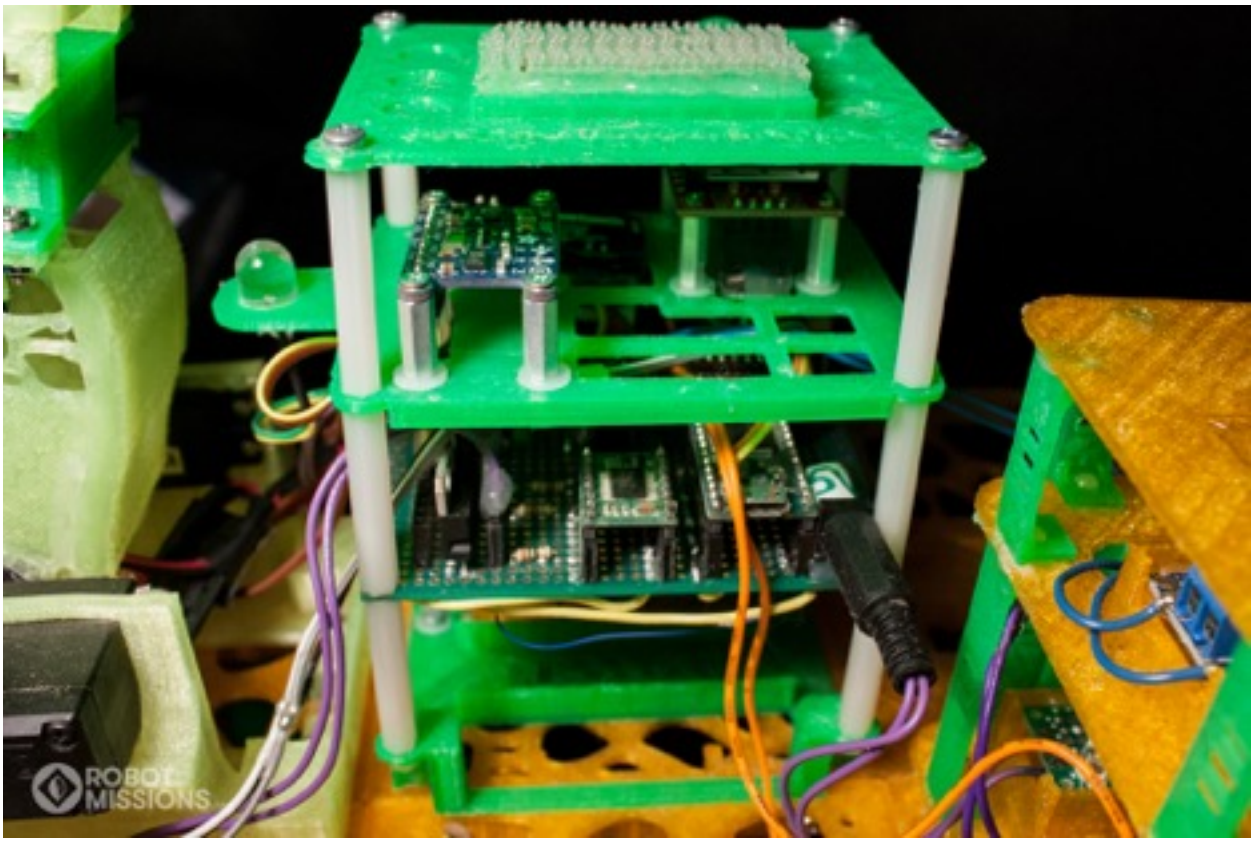
3. Add the main board to the standoffs, securing in place with 4 additional M3 standoffs

4. Add the sensors to the second plate

5. Add the second plate to the standoffs from the main board, use 4 additional M3 standoffs to secure in place

6. Attach the top plate to the standoffs using 5mm M3 screws

7. Add dual lock onto the extruded rectangle on the top plate



Power supply area

The power supply area holds the trays where the voltage regulators are placed for the power distribution on the robot. The sides are open to allow for air flow to keep the temperature down. If using this in a setting with younger kids who like to grab the robot, we would recommend attaching cardboard to the sides to prevent fingers contacting dangerous areas. The top plate has the power switch.

Pieces required

Base to power supply area mount	1
Bottom tray	1
Bottom supports	8
Middle tray	1
Middle supports	8
Top plate	1

Hardware required

M3 10mm	4
M3 10mm	8
M3 10mm	8
M3 Nuts, Washers	20

Power Supply Pin Assignments

Please use the Pin Assignments document to see how the various voltage regulators connect to each other.

Power supply area Assembly steps

1. Attach the mount to the base using the M3 screws. Two of the screws will be going through one of the battery holders

2. Use adhesive on the extruded rectangles to attach the mount to the bottom tray. Ensure the circles align properly

3. Install the voltage regulators in the proper tray area

4. Along the edges of the plate, attach the bottom supports using M3 screws

5. On the upper part of the bottom supports, attach it to the middle tray with M3 screws

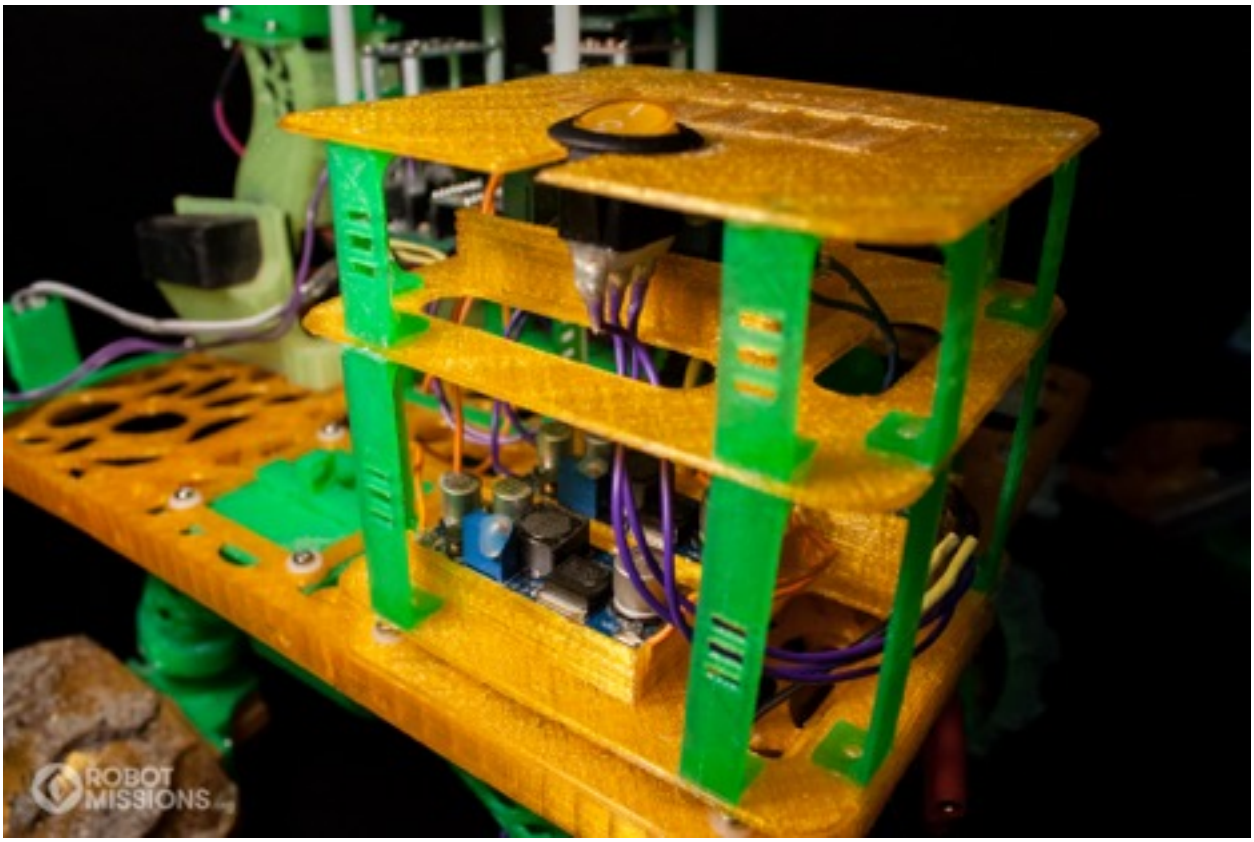
6. Install the voltage regulator in the proper tray area

7. String through the power switch through the openings

8. Along the edges of the plate, attach the middle supports with M3 screws

9. Attach the top plate to the upper part of the middle supports with M3 screws

10. Insert the power switch into the circular opening, secure with adhesive if necessary



Control Box

The control box is used to remotely operate the robot. Using the XBee, we can achieve far signal distance - rated to 1km, and we have tested it at 150m. There are 5 buttons for advanced functions. The control uses an off the shelf "Wii Nunchuck" (video game controller) that can be used one-handed, and has two buttons which control the arm and scoop pitch. These are placed in a cardboard box, where the extra space comes in quite handy in the field when storing debris or phones for remote viewing on a camera. Our current setup uses a derivative of the "RoboBrrd Brain Board", an Arduino 328.

Hardware required

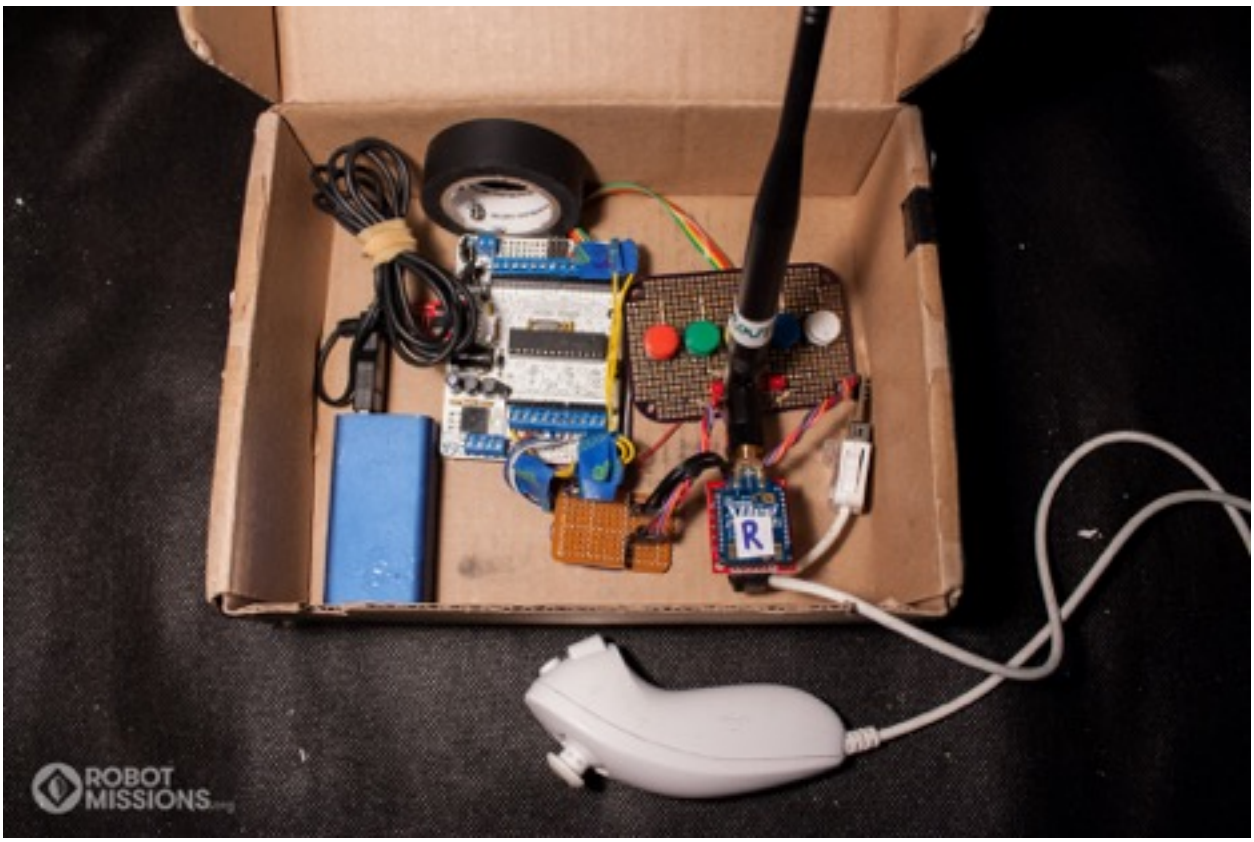
Cardboard box	1

Control Box Pin Assignments

Please use the Bill of Materials and Pinouts document to see what pin attaches to what.

Control Box Assembly Steps

1. Place electronics in box



GPS Unit

The GPS Unit is standalone within a hard water resistant case and can be attached onto the base of the robot using dual lock. This modularity allows for the GPS Unit to be taken on other adventures as well, such as a stand up paddleboard. The connector can be added from the unit to the robot to feed it the current latitude and longitude necessary for navigation to a waypoint. The coordinates are logged every 2-5 seconds to a file on the micro sd card.

Hardware required

Pelican 1010 case

1

GPS Unit Pin Assignments

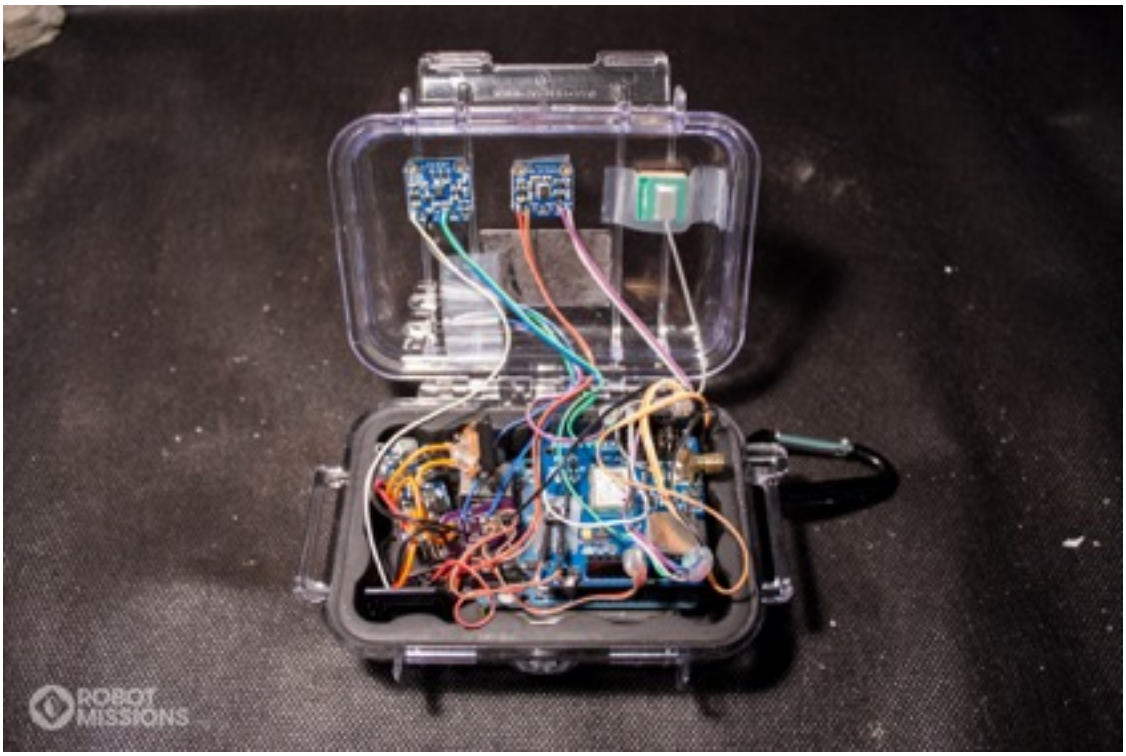
Please use the Bill of Materials and Pinouts document to see what pin attaches to what.

GPS Unit Assembly Steps

1. Attach a piece of cardboard to the battery. This is to prevent the sharp pins from the back of the Arduino poking at it

2. Place electronics in pelican case (cardboard side of battery is under the Arduino)

3. Tape the accelerometer, altimeter, and gps antenna to the top of the case



Disassembly & Packing

For disassembly and packing, we recommend following steps in this order:

1. Disconnect battery
2. Unplug all motor cables
3. Unplug end-effector / scoop servo connection
4. Remove dovetail key on arm
5. Slide out arm dovetail
6. Place arm aside for now
7. Slide out both drive systems
8. Place the extra supplies (batteries, cables, rope, etc) in the box along one of the edges
9. Place the base angled into the box, so that an open area forms where the extra supplies are
10. Put one drive system parallel to the base
11. Fit the other drive system perpendicular to this
12. Place the arm on top, angling the scoop inwards

It might take a bit of moving pieces around, but it should all fit within a 12x12x12" box.

We've found carrying the box with paracord the easiest and strongest way for carrying it with one hand.

Once you get to the location, unpack the box and re-assemble! The robot will be ready to go!