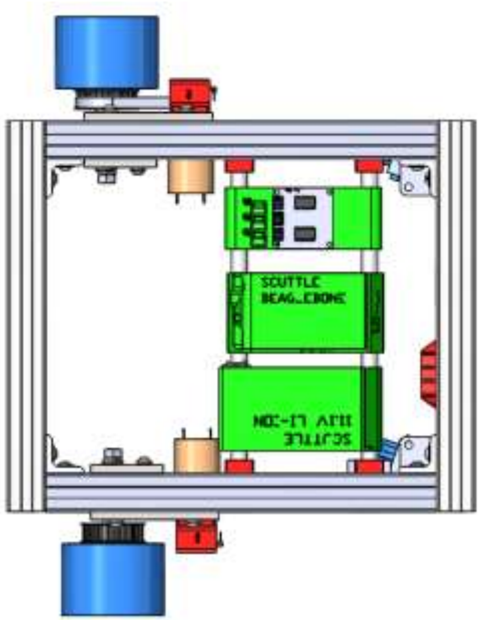


SCUTTLE Assembly & Parts Guide

revised 2020.09.14

SCUTTLE Assembly

Playlist

3D Models

Assembly instructions are provided in the SCUTTLE youtube playlist. There’s also testing, programming, and demo videos (more than 80 in total).

We recommend you use the wiring diagrams for assembling electronics and the youtube videos for the hardware.

The CAD model on GrabCAD.com shows how all components fit.

Motor

12v dc motor
with gearbox

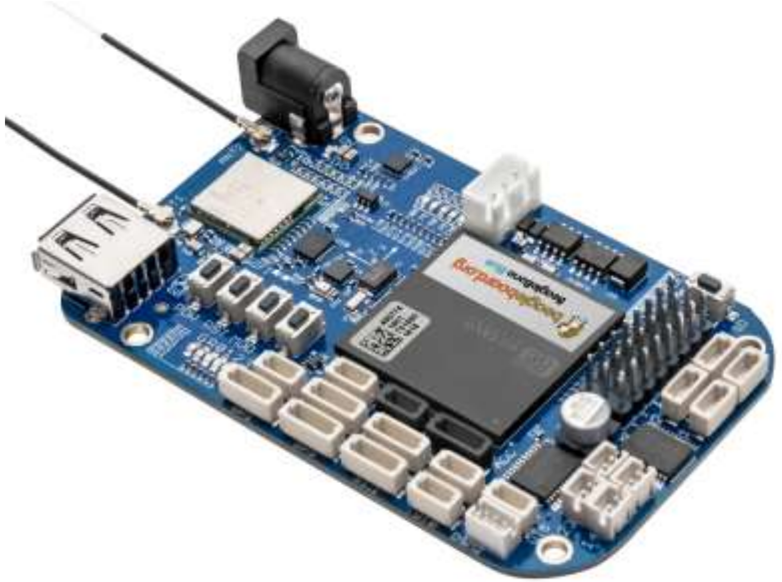
Scuttle has two motors for driving the rear wheels. Each is a 12v DC motor with a gearbox that reduces the output speed to 200 RPM. The 6mm shaft is offset by 7mm from the centerline of the motor, which helps raise the clearance of the motor housing from the ground in the robot chassis. Three M3x10 screws fasten the motor to the motor plate.

The motor leads must be soldered to wires of 18 AWG or larger.

Alternates: you can find other versions of this motor with different speeds. The 250RPM version, has higher speed and lower torque.

Converting to brushless is an exciting option but it requires both hardware and software adaptations.

Embedded Computer – Beaglebone Blue



Beaglebone Blue

The beaglebone Blue is an embedded Linux computer with extra robotics features such as built in motor drivers and dual WiFi modules, power management and servo ports.

More resources:

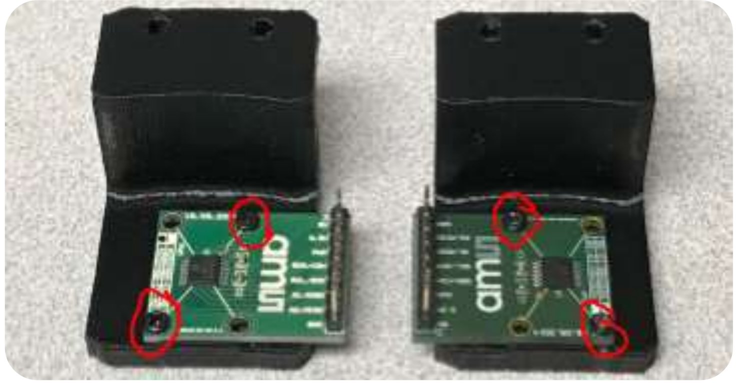
- Beaglebone Blue Wiki
- Beaglebone Blue Specification Sheet
- Beaglebone Blue Schematic
- Summary Video in 1 Minute

Alternates: you can also use Raspberry Pi or other single board computer (SBC).

Other modules will require separate purchase of:

- Power regulator
- 2^{nd} Wifi Dongle
- Servo driver (if used)

Encoders



Left and Right
Encoder Brackets

Two AMS AS5048B encoders are required for SCUTTLE, with one at each motor pulley. Some details:

- They are actually angular position sensors. They return a degrees value from 0 to 360.
- It communicates over I2C. The left-hand encoder is addressed as 0x40 and the Right-hand encoder is addressed as 0x41, assigned by pullup pin.
- They measure the rotation of the motor pulley, and the software adjusts for 1:2 wheel:motor turn ratio

There is one standardized encoder bracket used for right and left (as of version 2.4). The sensor is paired over a diametric magnet, mounted at the end of the motor shaft.

Resources for the encoder:

- AMS AS5048B Datasheet

Dual Motor Driver

Motor Driver

A number of motor driver options are available. The standard choice is HW-231 motor driver which uses the NXP MC3386 H-Bridge. The ground is connected directly to the battery pack and it accepts two input pin pairs as PWM channels.

Resources for the motor driver are here:

- MC3386 [Datasheet]

Alternate: the ever-common L298N will also work for driving the motors, but it will not drive enough current for full output of our motors. It's an option if you're just learning and want to save money.

Battery Pack

Version 1 Battery Pack with Cover Removed

The battery pack is a 3-cell lithium ion pack with a nominal voltage of 11.1v (3.7v per cell) combined with a few off-the-shelf parts and a 3D printed case. The capacity is 3400 mAh (we verified!) And they have enough capacity to drive SCUTTLE for several hours.

With additional actuators, a significant payload, or demanding sensors such as the SICK LIDAR, it is advised to add more capacity to the robot. The cells must not be drained below 2.8 volts each to prevent damage.

Resources for the battery pack are here:

- Panasonic NCR18650B datasheet
- Battery Cell handling and protection youtube video
- Instructions: Battery Cell supplemental info
    - shows more on assembly.

Alternate: our next favorite cell is undergoing testing and it's the LG HE4. We discovered it by this comparison video. It has a lower cost and nearly-equal performance.

LIDAR (optional)

SICK TiM561 LIDAR

SCUTTLE has been enhanced with a lidar manufactured by SICK sensor company. This lidar performs laser-based ranging in 270 degree plane at 0.33 degree resolution, 15 times per second! The USB interface is used to communicate to the microprocessor and the power is directly provided by the 11.1v battery pack.

Resources for the LIDAR unit are here:

- Pysicktim python library on Github
- Operating instructions from SICK
- Technical information from SICK

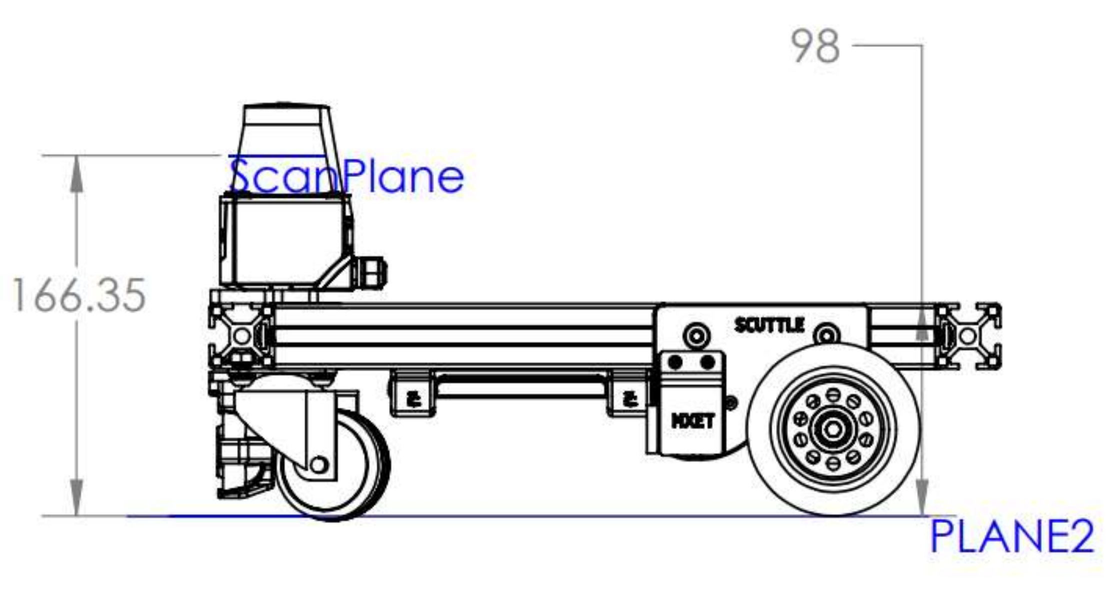
Alternate option: first of all, LIDAR is not a requirement. Slamtec RPLIDAR A1 is compatible with SCUTTLE but has not been tested yet.

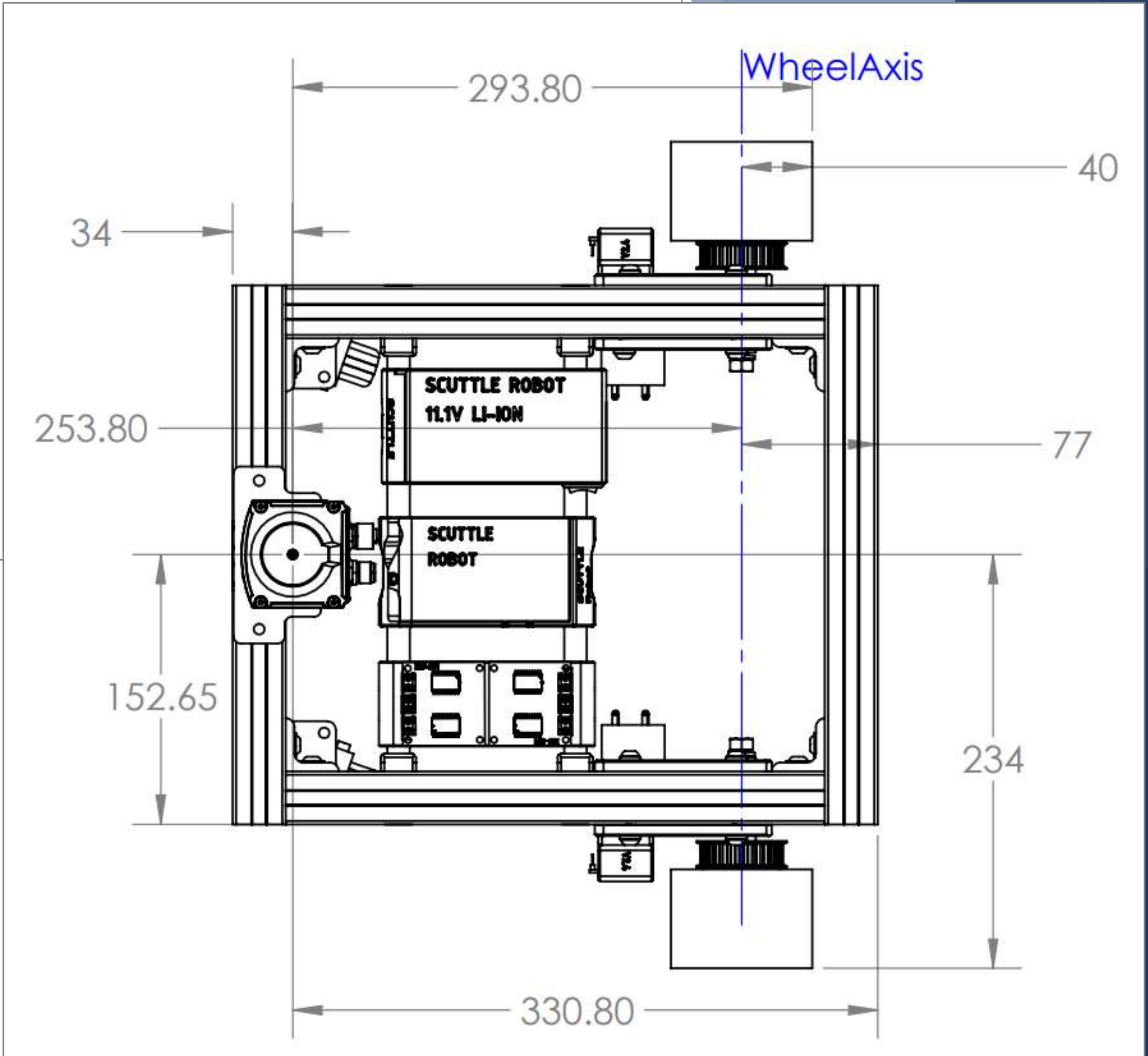
Important links:
Datasheet from SICK
User Manual from SICK
Software maintained by SICK on GitHub
Software library applying TiM561 to Python (pysicktim)

LIDAR (continued)

SICK TiM561 LIDAR

Dimensions and basic mounting configuration shown.





USB Camera

Microsoft Webcam

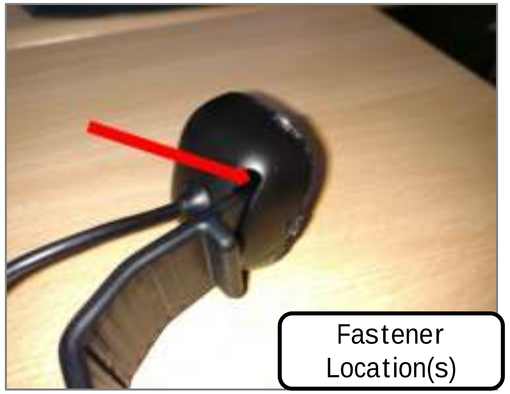
The integrated USB camera is a Microsoft LifeCam HD-3000. On the robot, we remove the camera's mounting bracket and inserted the camera into a 3D printed bracket.

Resources for the HD-3000 Camera are here:

- LifeCam HD-3000 datasheet
- Camera Supplemental Info sheet shows how to remove the flexible grip and infrared filter

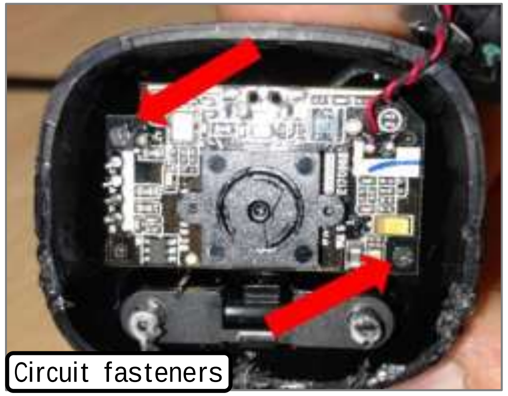
Alternate options have been successfully tested including Logitech C270 & WyzeCam with webcam firmware. Some will work with no changes to software, and some will require minor changes

USB Camera – Infrared Conversion



Fastener Location(s)

Pry here



Circuit fasteners

1.
After removing the IR filter, you can still use the camera to process visible light. The vision program in this manual is executed with no IR filter. It is the only way to see the beacon containing IR LED's. Remove the two screws on either side of the flexible tab in the first picture. You must rotate the tab to the left to access the right, and vice versa.

2.
The camera front shell can be removed with a light prying force, near the arrows.

Next, unscrew the circuit board (two screws).

3.
• Use a small PH1 screwdriver. Do not get any dust on the sensor. With all the cables still attached the board should be in a facing-down position.
• Get a sharp knife or pointed tool. The IR filter is on the sensor facing side of the lens. It reflects red. Be careful: it's glass and brittle. Cut from the edges of the filter towards and through the plastic ring. This way you will have some gaps to jam your knife in and pry the IR filter out more or less in one piece.
• Pry the filter out. Be careful not to scratch the underlying lens.
• Reassemble Lens and board, but don't close the case yet.
•Adjust the lens. When you look at the assembled lens you will notice it looks a bit like a triangular screw. And that's what it is. Get some pliers and gently, carefully adjust the lens to make up for the changed focal length. Don't scratch the lens with the pliers. Open a webcam app and look at an object at 1-2 meters distance. Turn the lens a little each way until you find the right direction, then continue until you see the best focus.

4.
Removing the Flexible Grip
This grip will need to be removed to mount the camera on the robot. The figure below shows the parts which hold the grip inside the camera.
1. Spring clip
2. Pin
3. Flex grip
In order to remove the flex grip, you'll open the camera, remove the circuit board (two screws) which holds the camera sensor, and then use a small flat screwdriver to remove the silver clip (part no.1) which will allow the pin (2) to fall out and then the grip (3) to be removed.

Pin components of the flexible grip.

Ultrasonic Sensor

HC-SR04 Ultrasonic Ranging Sensor

The ultrasonic sensor is for range-finding. It's an optional item to support autonomous driving and obstacle avoidance.

There are versions of this board which require 5v (more common) or only 3.3v (less common). If your board requires 5.0v then power will need to be drawn directly from the power port on the beaglebone.

Resources for the HC-SR04 are here:

HC-SR04 [Datasheet]

Alternate options include IR rangefinders or full-on LIDAR. Both have been successfully tested.

Power Connector

Anderson Powerpole Connector Housing

Our Anderson Powerpole (APP) power connector is fairly new in the market and gaining popularity. It's carefully chosen with these metrics in mind:

- Easy for students to crimp, no soldering
- High Current (15, 30, and 45A)
- Modular, for expansion
- Affordable

Many power electronics, such as radio-controlled cars are using gold-plated barrel connectors. You can use any connector that supports sufficient current but this is our favorite.