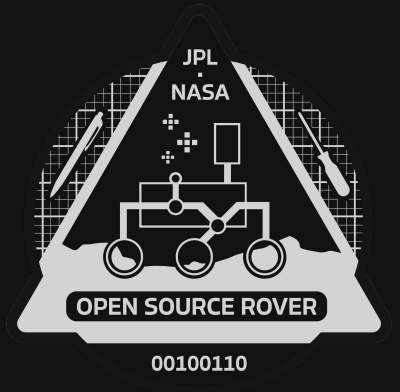
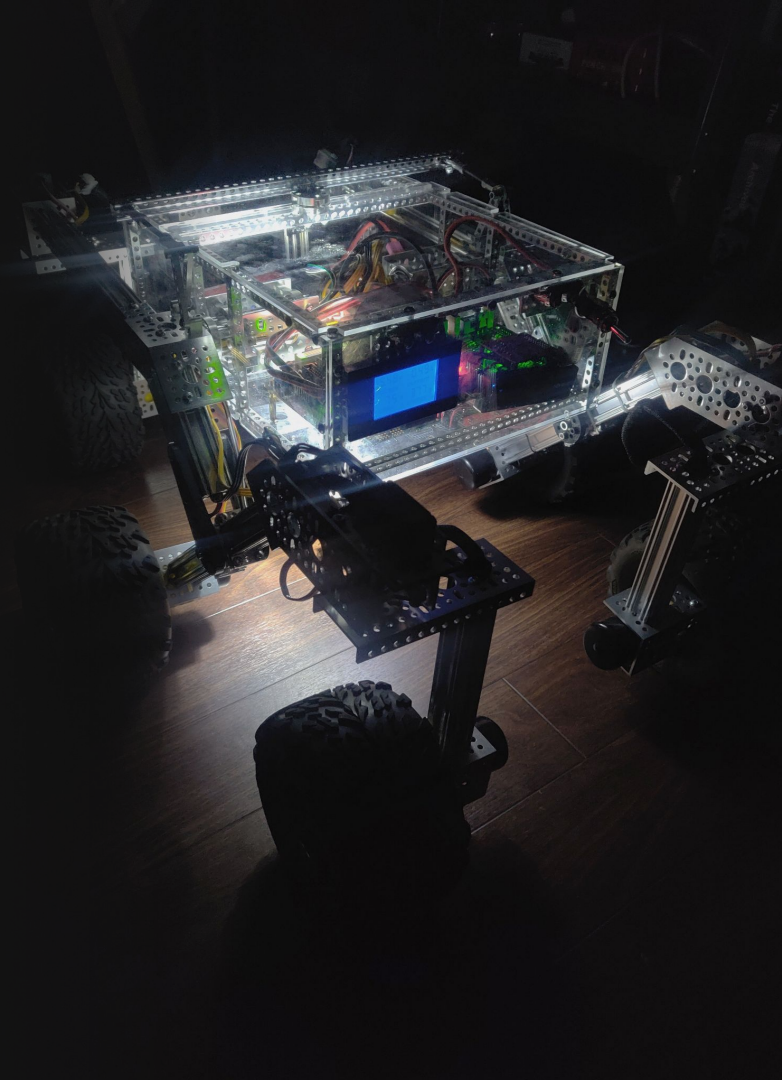


How to build a mars rover for earth



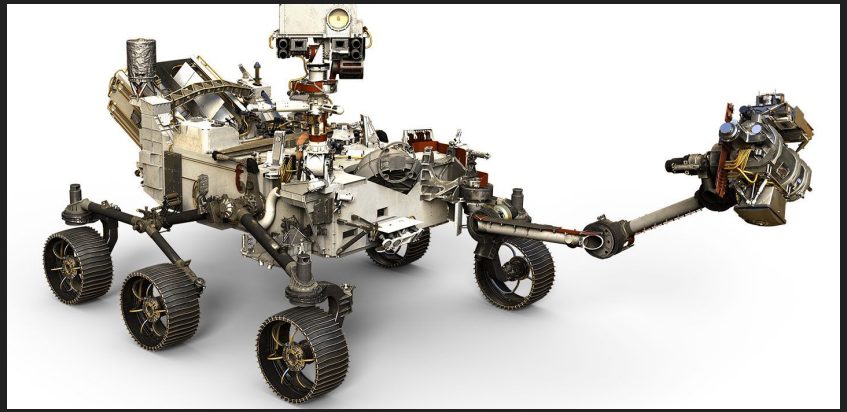
achille.fyi

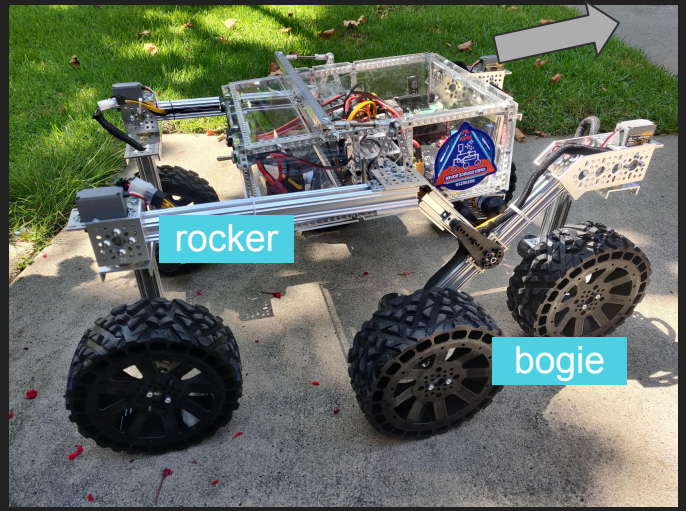
What is it?

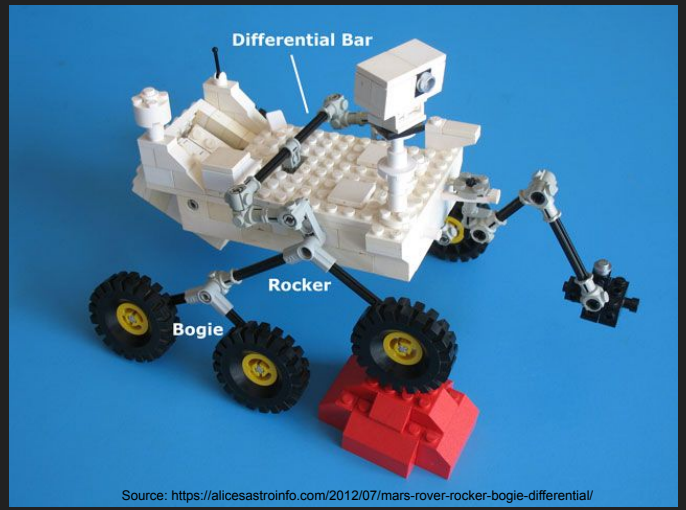
A build-it-yourself, scaled down replica of the Curiosity/Perseverance Mars Rovers, designed with (earth-based) education, academia, and hobbyists in mind.

2016: >$5k all custom, 2017: $3k, mostly off-the-shelf →open-sourced, 2023: $1.5k

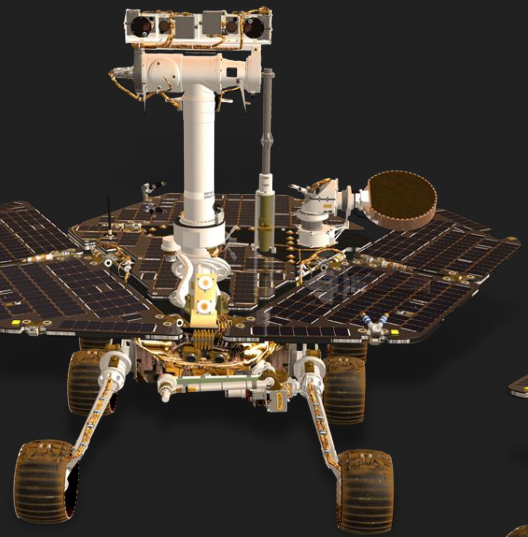
It is *not* an accurate replica. In fact it's purposefully different.

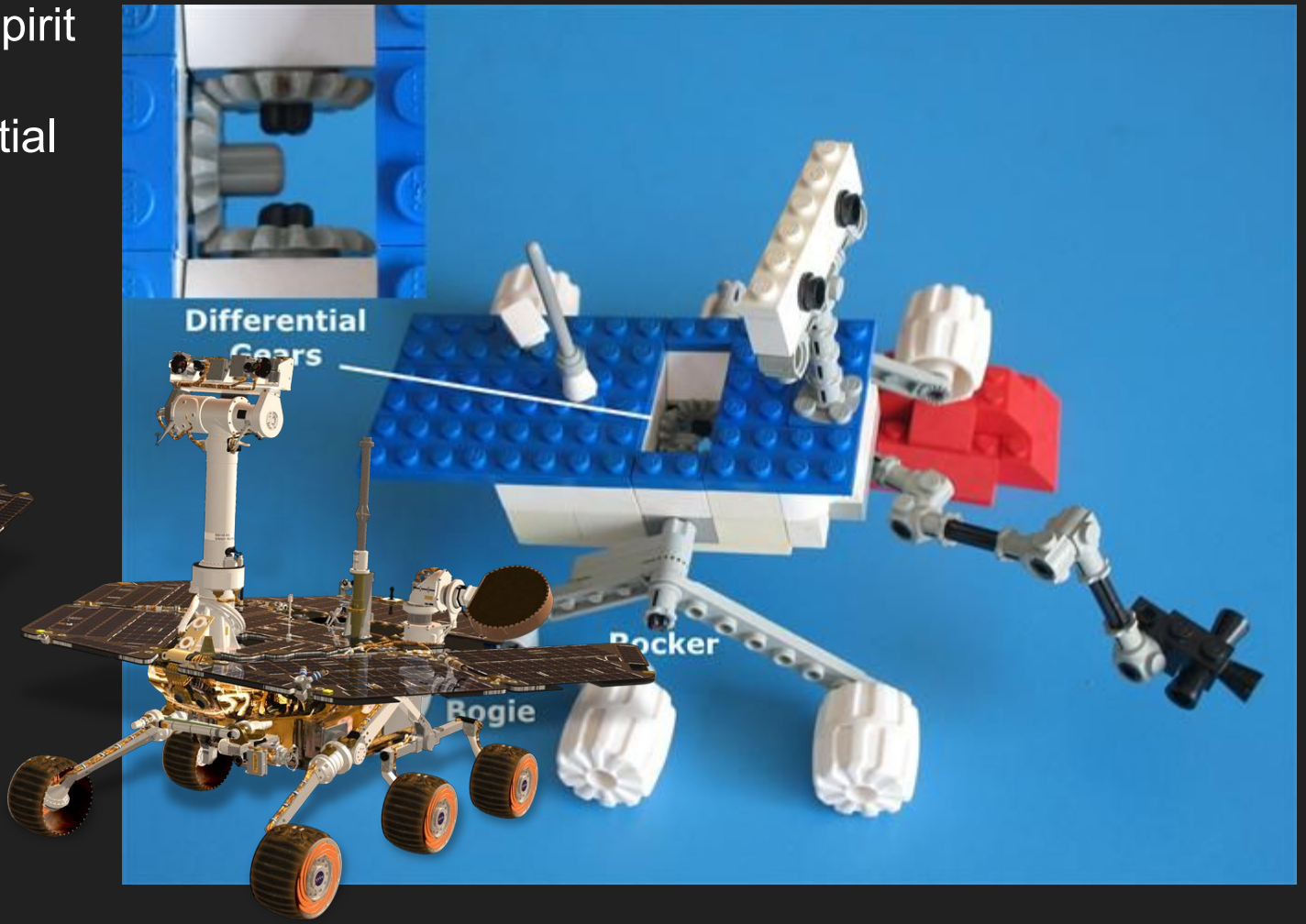




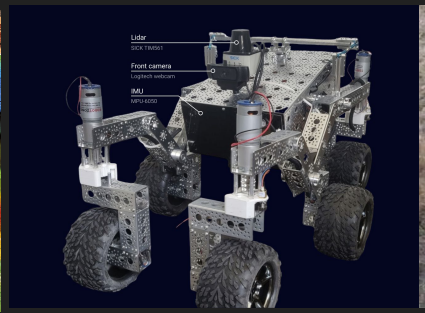


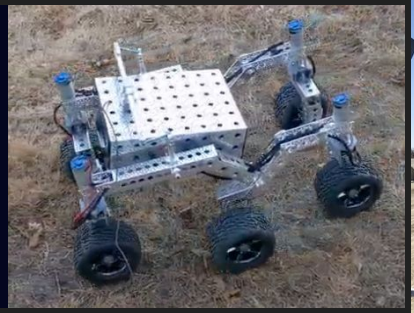
Why did the older Spirit and Opportunity Rovers use differential gears?

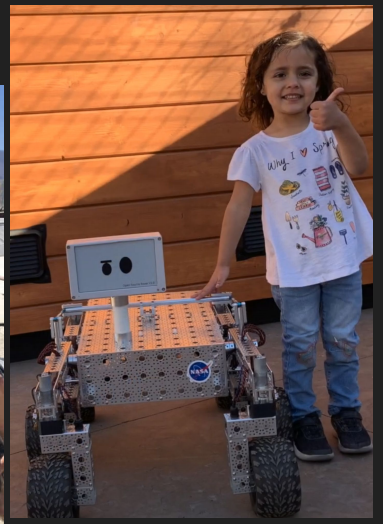


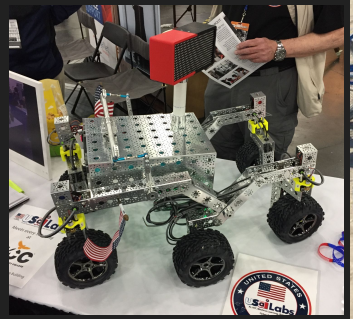


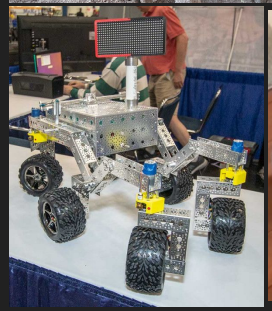
The first major OSR version (2017-2023)

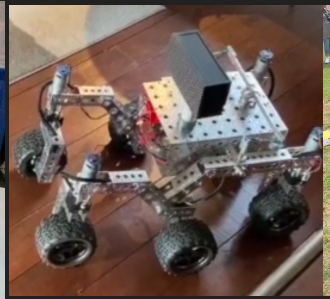


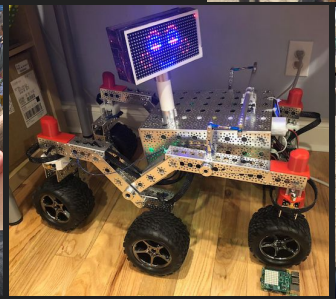




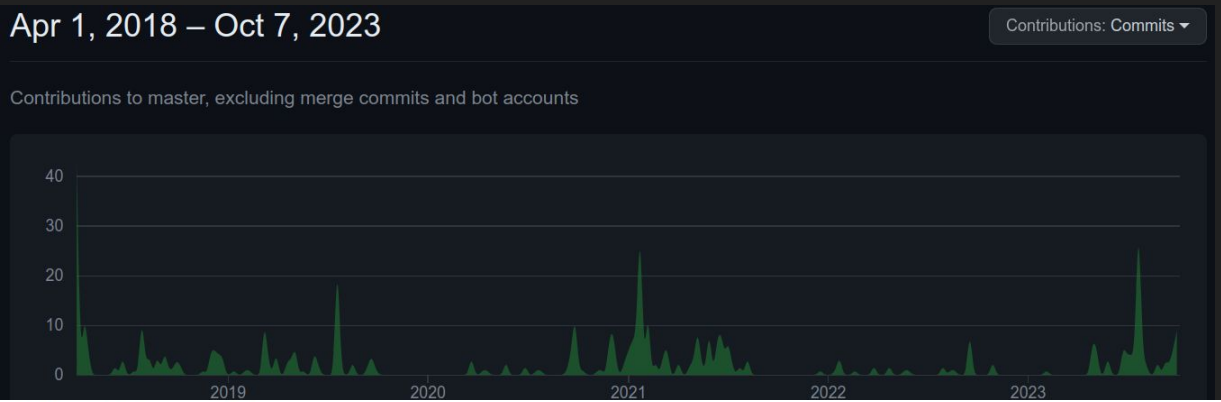




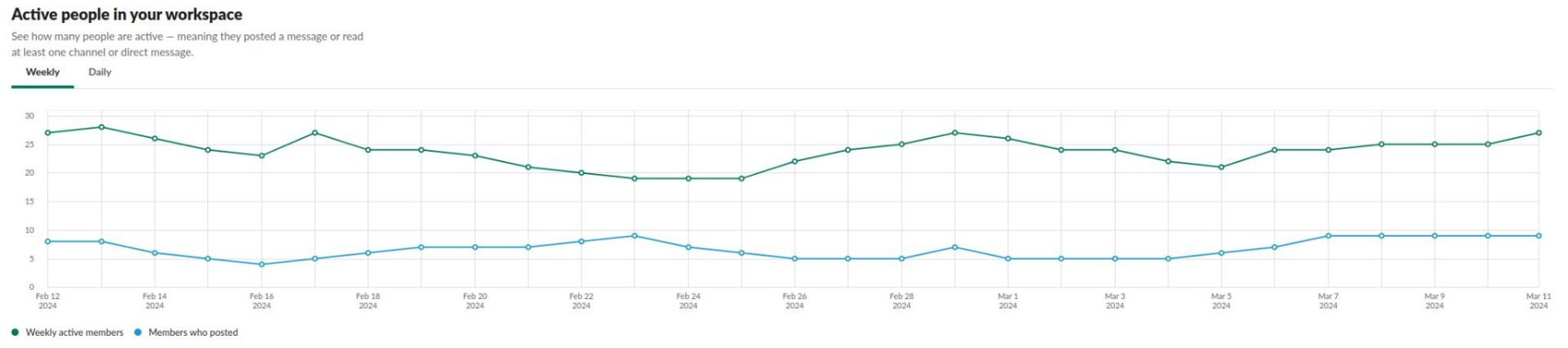




One of the most starred Open-Source Hardware projects of all time



Consistently active for 6 years



Other open source hardware projects

Chandandeep Singh • 2nd
Robotics Researcher
2d •

+ Follow

🤖 Open Source Robots for Learning Robotics 🤖
(Comprehensive list of ROS 2 resources:
Blog- ✅https://lnkd.in/eN4a-3qe
Video- ✅https://lnkd.in/eEupZs8W)

Discover open-source robots across various categories:
🔷 Rovers and Cars:
✅ TurtleBot - Low-cost personal robot kit: https://www.turtlebot.com/
✅ NASA Open Source Rover - DIY 6-wheel rover: https://lnkd.in/dTM-eKZX
✅ Sawppy Rover - 3D-printed Mars rover model: https://lnkd.in/dz3vB-yp
✅ DonkeyCar - DIY self-driving platform: https://lnkd.in/d7XDNJ45
✅ MORPH - Affordable robotics platform: https://lnkd.in/dwBrPzPA
✅ Linorobot - ROS-compatible ground robots: https://lnkd.in/dBsm4J6m
✅ MuSHR - AI research platform: https://lnkd.in/dsB2uTSu
✅ SCUTTLE - Low-cost mobile robot: https://lnkd.in/dWaGJVPv
✅ Mars-Rover - Open hardware and software: https://lnkd.in/d8EuJSVD
✅ OpenRobot - Smartphone-controlled car: https://lnkd.in/dMGXJjxZ
✅ OpenMower - RTK-GPS mower: https://lnkd.in/d_UUWDpV
🔷 Robot Arms:
✅ Dexter - Industrial robotics arm: https://lnkd.in/d543ie9f
✅ Reachy - Bio-inspired robotic arm: https://lnkd.in/ds46CVVC
✅ Faze4 - 3D-printable 6-axis arm: https://lnkd.in/dcPghi23
🔷 Quadrupeds:
✅ OpenDog - Quadruped robot: https://lnkd.in/d9SnJj6r
✅ Stanford Doggo - Agile research robot: https://lnkd.in/dgR-6FDj
✅ mjbots quad A0 - Small dynamic quadruped: https://lnkd.in/dq__7ypD
✅ Stanford Quadruped (Pupper) - Low-cost quadruped:
https://lnkd.in/dEB8hH6D
✅ Open Dynamic Robot Initiative - Modular Robot Architecture:
https://lnkd.in/d2rRrTc8
🔷 Open Source Sensors:
✅ OpenMV - Low-cost machine vision modules: https://openmv.io/

Ilir Aliu • 2nd
Robotics & AI: simplified by sharing tutorials, projects ...
1w •

+ Follow

20 Open-Source Robotics Projects 🦾

- ON GITHUB -

Here are 20 fascinating projects to accelerate your robotics knowledge and unlock valuable learning experiences:

1. ROSbot 2.0: An open-source mobile robot platform
https://husarion.com/

2. Magni: An affordable robotic mobile base with a 100kg payload
https://lnkd.in/ePXB-RZN

3. Bobble-Bot: A demonstration robot for learning principles of real-time control
https://lnkd.in/eM-XBNs2

4. ANYMal C: An autonomous four-legged robot
https://www.anybotics.com/

5. Stanford Doggo: An open-source quadruped robot
https://lnkd.in/eWYQcdPw

6. JPL Open Source Rover Project: An open-source 6-wheel rover based on the rovers on Mars
https://lnkd.in/eJg7WXNq

Perspective: other popular open-source robots

openrov-software Public

Meta project for all of the OpenROV Software projects

☆ 416 ⑂ 188

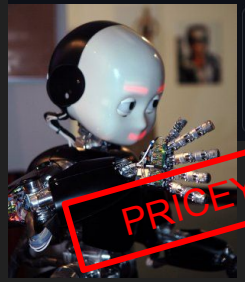
DISCONTINUED

openrov-hardware Public

Hardware for OpenROV. Include lasercut parts ar

☆ 193 ⑂ 116

DISCONTINUED



PRICEY

documentation Public

iCub Tech Docs

Ruby ☆ 23 ⑂ 31

cad-mechanics-public Public

Repository containing open parts of the CAD for mechanical design

Roff ☆ 15 ⑂ 4

Watch 52 Fork 103 Star 105

Code

About

The iCub Main Software Repository

openDogV3

openDogV3

CAD and Code for openDog V3.

I've included a Bill of Materials this time. BOM.ods, which is probably complete, I'll be adding to it if I remember anything else.

I used the AS5047 encoders in absolute position mode in this build. Check out the ODrive documentation for more info:

ODrive vel_limit and vel_limit_tolerance are set to math.inf within the ODrive tool which stops the motors disarming under certain circumstances. (You will have to do 'import math' first within the ODrive tool).

Menu options on the DogLCD are as follows:

0. nothing / default all power up
1. put motors into closed loop control
2. move legs outwards so they just clear the stand stirrups by 1-2 mm
3. move legs so both shoulder and knee joints are at 45° (the default positions shown in the CAD)
4. turn up motor position, velocity and integrator gains
5. Inverse kinematics demo mode for 6 axis of translation and rotation (also makes the legs slightly straighterCancel changes)
6. walking mode (same leg position as 5)
7. put the feet back into position so they rest on the stand stirrups

The remote now has a 'reverse' switch which reverses four axis of the remote so the dog walks backwards. This happens on the remote rather than in the dog's kinematics. There is also a motor enable switch which must be on for the dog to work.

Foot mould CAD is included for silicone rubber feet. I used a 25A Shore hardness Platinum cure silicone with pigment. Note that the Carbon Fibre foot tube is glued into the lower leg and foot insert to stop it rotating.

The parts are all printed in PLA. The larger parts are around 15% infill with 3 perimeters at 0.3mm layer height. The smaller parts such as the Cycloidal drive internals are 4 perimeters and up to 30-40% infill.

NO DOCS

DISCONTINUED

Spot_mini_mini: "Note: development for this project was haulted in November 2020 to respect my NDA with my employer."

Mars-Rover Public

Watch 35 Fork 93 Star 455

master 1 branch 0 tags

Go to file Add file Code

jakkra CAD: Fixes #27, unhide the arm in the model. 85823c3 on Oct 29, 2022 65 commits

About

3D printed and driveable Curiosity/Perseverance inspired Rover

ELEGOO-Smart-Robot-Car-Kit-V4.0

ELEGOO Smart Robot Car Kit V4.0

☆ 16 ⑂ 3

LEGO-Robotics Public

Mindstorms (RCX, NXT, EV3), SPIKE (Essential, Prime, Robot Inventor), BOOST, WeDo & other LEGO robotics platforms

Python ☆ 43 ⑂ 12

turtlebot Public

The turtlebot stack provides all the basic drivers for running and using a TurtleBot.

C++ ☆ 282 ⑂ 313

INDOORS ONLY

turtlebot3 Public

ROS packages for Turtlebot3

Python ☆ 1.2k ⑂ 931

11 OML + Gradle + SPARQL + R

This page introduces one way to seamlessly connect openCAESAR processes using the R.

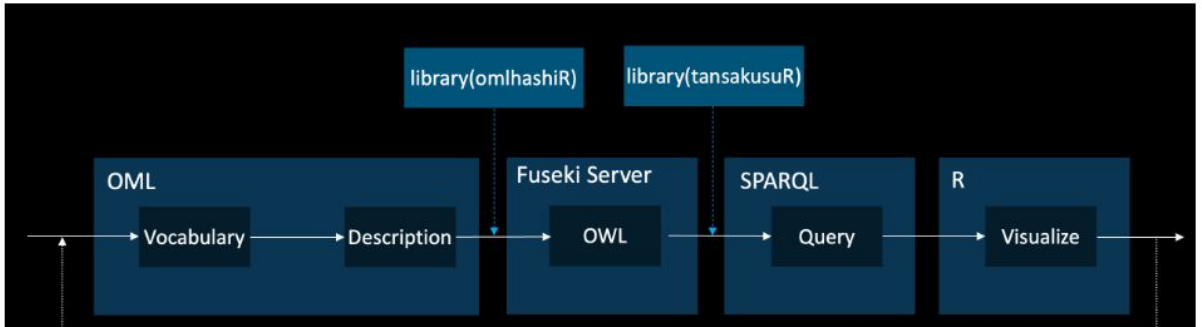
OML projects created by openCAESAR are Gradle projects that have OML analysis tools configured as Gradle tasks in a build.gradle script. A user can invoke Gradle tasks from a console/terminal session using the Gradle Wrapper Command-Line Interface (e.g., ./gradlew owlLoad). The supported OML editors such as OML Rosetta and OML Luxor allow invoking those Gradle tasks using a UI.

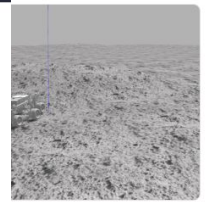
In the MBSE practice using openCAESAR, the vocabularies are described to answer analysis questions. Typically, the process is iterative. Build OML vocabularies and descriptions, write queries in the SPARQL language for analysis, and modify the model based on the query results in an exploratory manner.

We introduce two packages to improve the reproducibility of the exploratory modeling process with documentation tools such as R Markdown and Quarto.

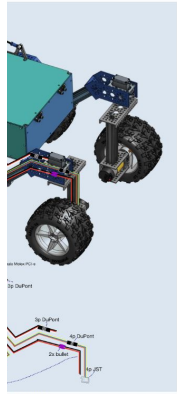
- omlhashiR
  - We use a package omlhashiR as a wrapper to run Gradle tasks of OML projects from R.
- tansakusuR
  - We use a package tansakusuR as a wrapper to send SPARQL codes to the endpoint of OSR Model from R.

By using the “omlhashiR” and “tansakusuR” packages, workflows can be seamlessly connected.





ending on your skill level with crimping.



de is identical.

Recipe for an active & thriving open source (hardware) community

SAUT-A (Wall-E)

Ingredient 1

excitement

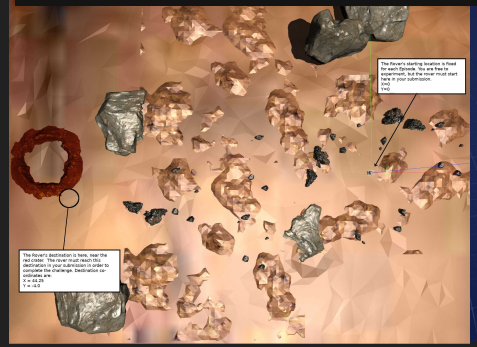
How do you get there?

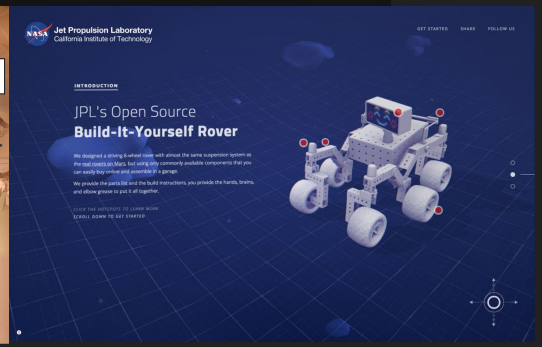
- Give talks, show live demos, and show what you could build
- **Always be launching** some new feature, mod, update

Always Be Launching

AWS JPL OPEN SOURCE ROVER CHALLENGE

aws | Jet Propulsion Laboratory





Today's launch!

HACKADAY

HOME BLOG HACKADAY.IO TINDIE HACKADAY PRIZE SUBMIT ABOUT Octo

OPEN SOURCE ROVER GETS AN UPDATE FOR EASIER BUILDING

by: Lewin Day 9 Comments

September 16, 2023

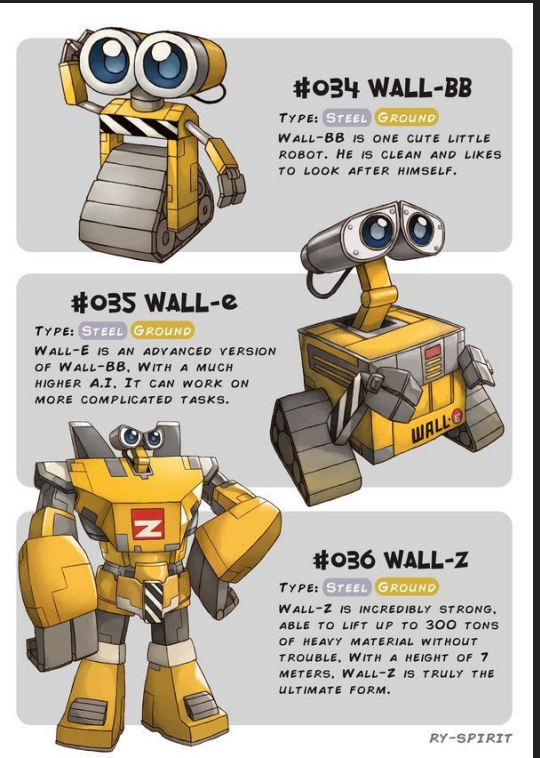
Achille Verheye
Post to Anyone

This just in: This Mars Rover is fed up with looking at more rocks 😤

it wants to contribute to society for real and do something useful - so I'm teaching it to do the laundry with its new roof rack 👕🧺. Unlike the Perseverance rover I don't want it to drop 'samples' on its way to the laundr room though 🧦🥰

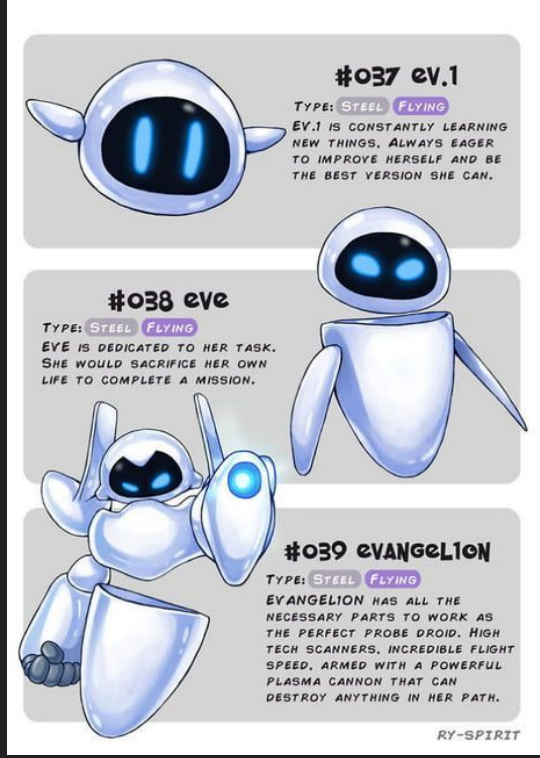
open source hardware

OSHW US002551



Ingredient 2

continuous improvement

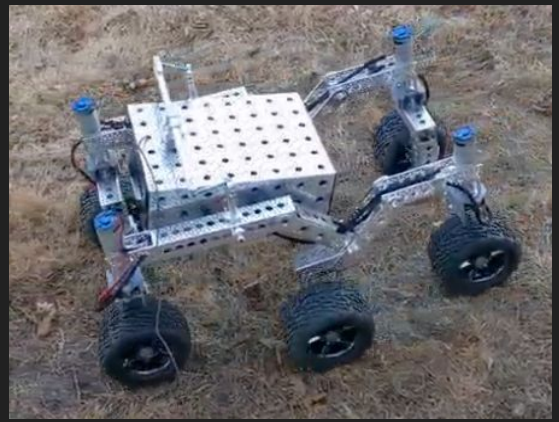


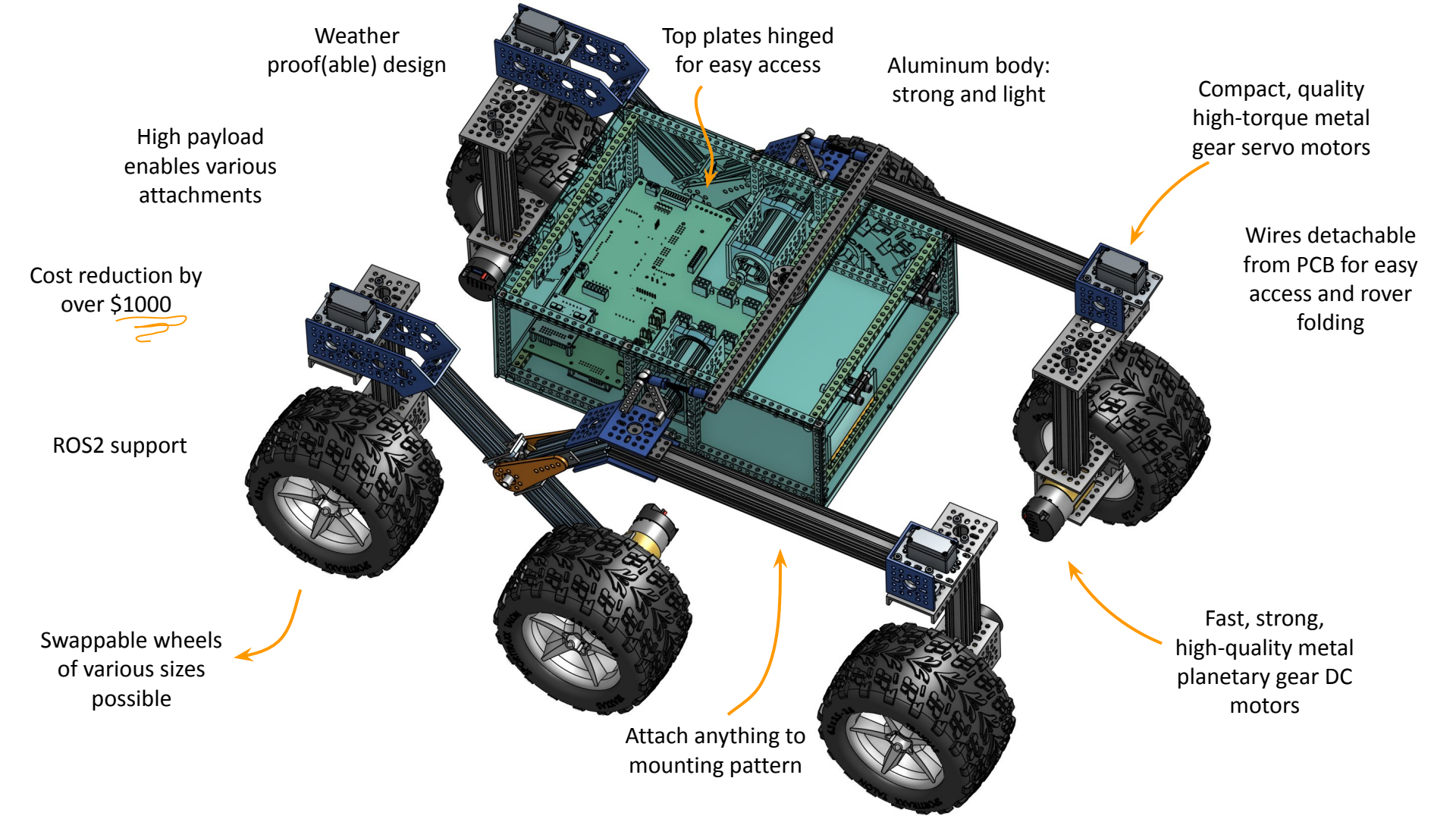
Open-Source Means Ever-improving

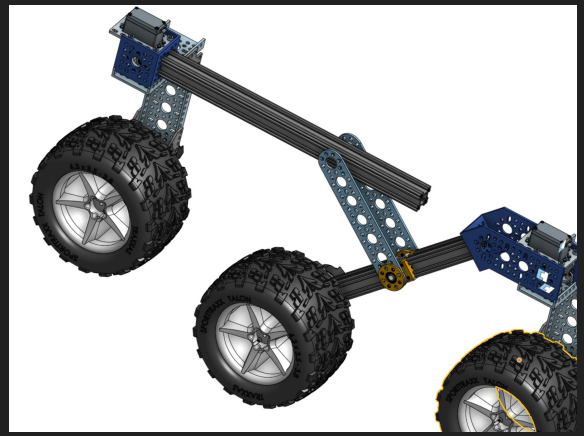
2021

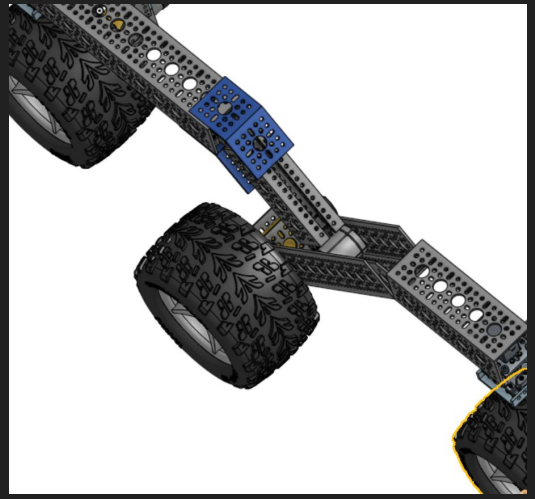
The current design:

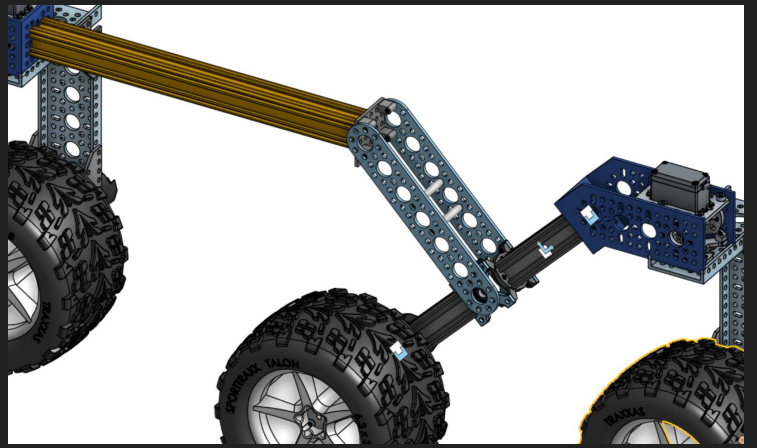
- Is awesome and a great starting point + many lessons learned!
- Pricey: ~$2,500
- Many vendors, sourcing parts is long and arduous
- Requires off-the-shelf parts, machining, and 3D printing
- Hard to access electronics inside
- Not weatherproof → can't drive on sandy, wet, dirty ground
- Assembly is long and complicated
- imperial…

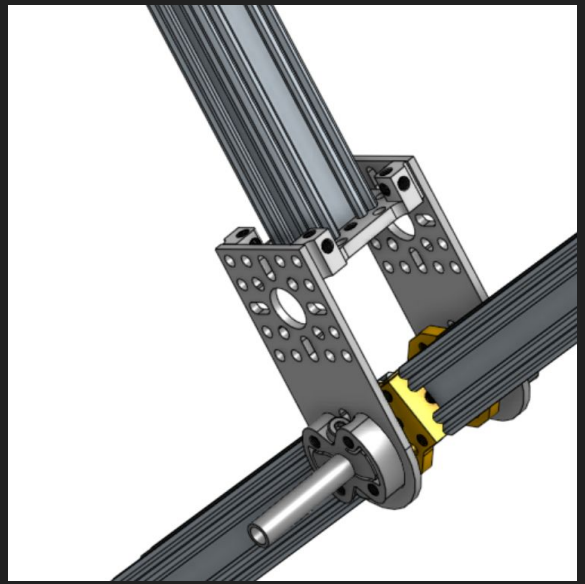


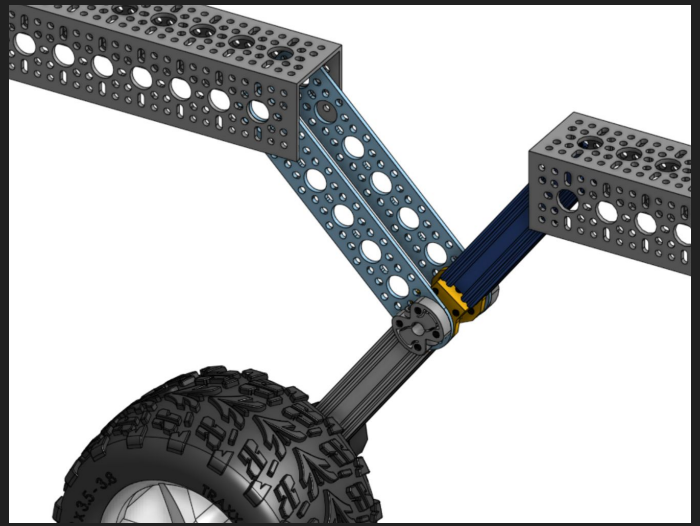

Weather proof(able) design
Top plates hinged for easy access
Aluminum body: strong and light
Compact, quality high-torque metal gear servo motors
High payload enables various attachments
Wires detachable from PCB for easy access and rover folding
Cost reduction by over $1000
ROS2 support
Swappable wheels of various sizes possible
Attach anything to mounting pattern
Fast, strong, high-quality metal planetary gear DC motors

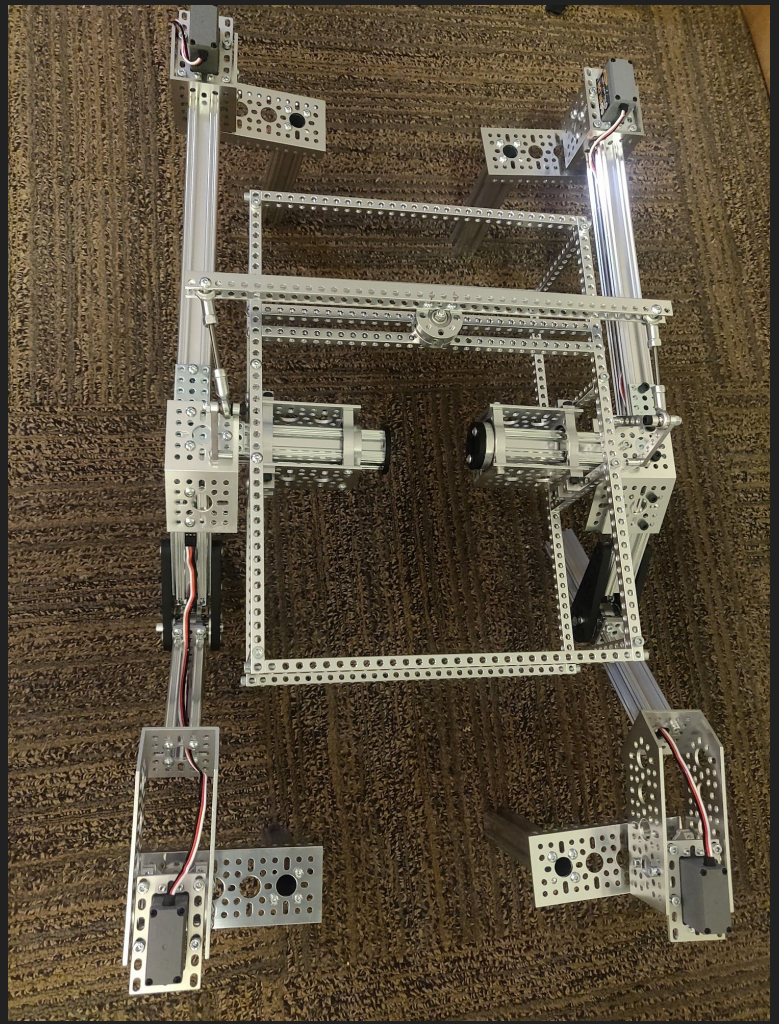


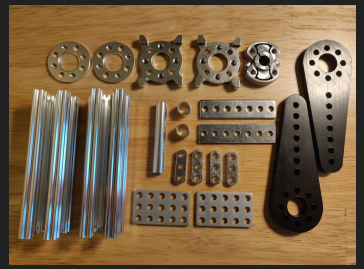


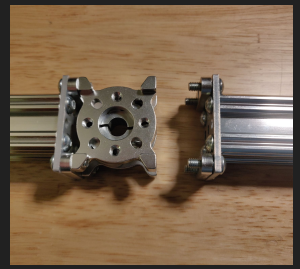


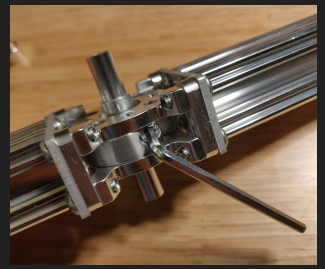


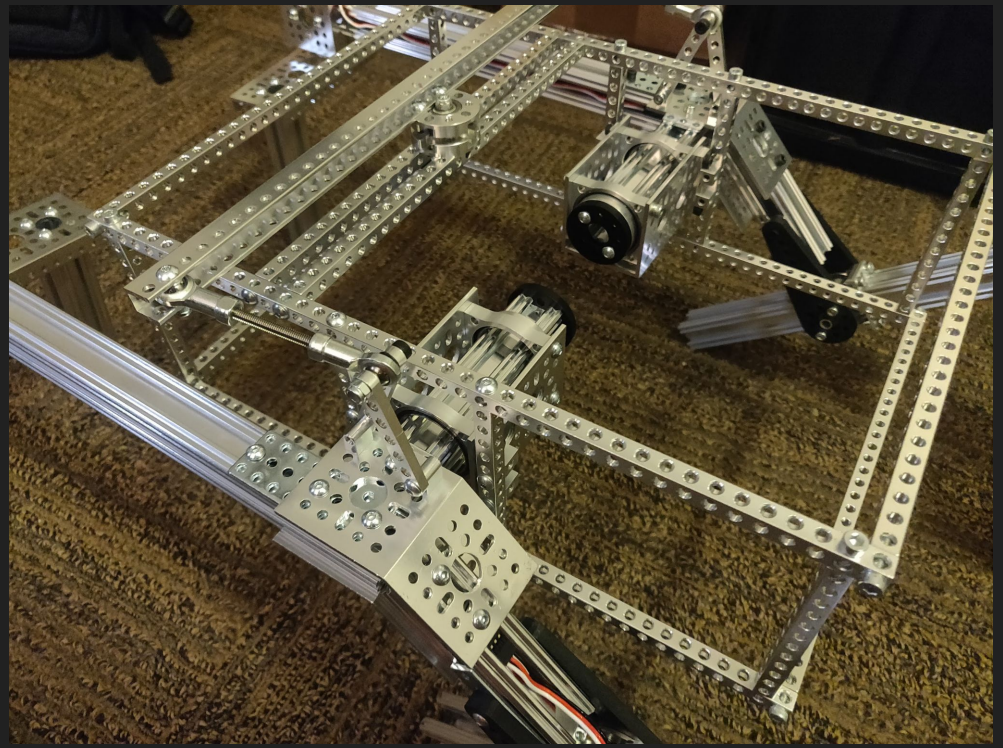






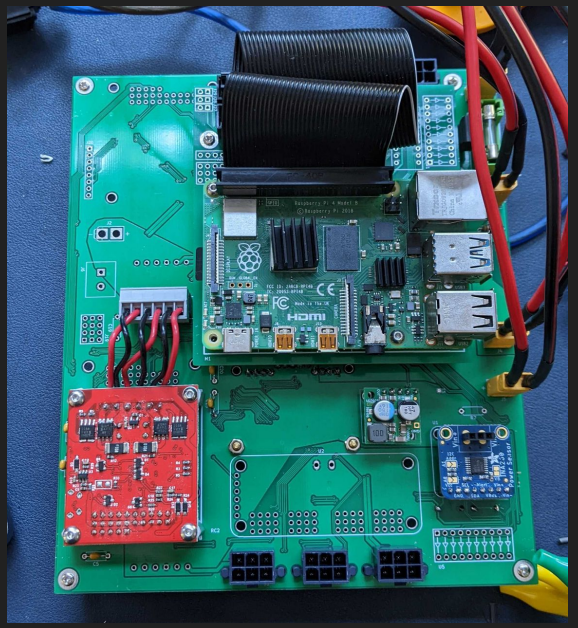


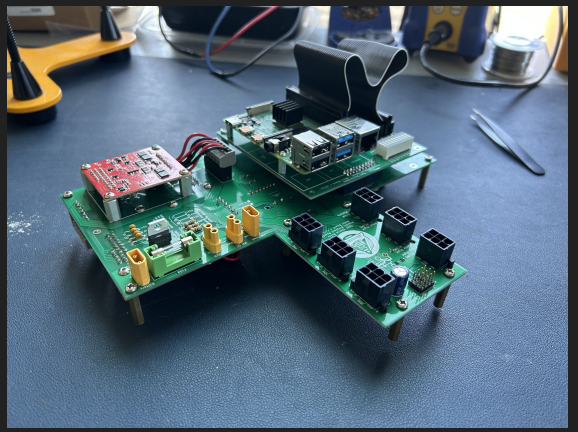




Redesigned PCBs

- 2 boards: motor and brain board → reduced board complexity + future proofing
- Detachable connectors rather than screw terminals
- Added INA260 (blue) to monitor battery input current
- Various LEDs for voltage bus status, serial RX/TX activity with the motor controllers
- 4x GPIO outputs from the RPi
- Servo controller has spare outputs available (more LEDs?)





Keeping the change going

- Lower resistance to change
  - Someone posts a question on Slack → many replies → suggest creating a PR for solution
    - Lead the way
  - Offer contributors with track record to join maintainer team
  - Pull requests: eternal balance in speed vs quality for larger improvements
    - Make tickets for future work
- Maintainer meetings
  - Massive speedup + accountability
  - Keep them light and fun
- Cheerleader to rally the troops
- Everyone’s a volunteer

Ingredient 3

this one weird trick will surprise you

Relentless focus on docs

Use a multimeter to test the voltage between test points T4 ("swt_out") and T2 ("Batt-"). This shou
power supply/battery (14.8V)

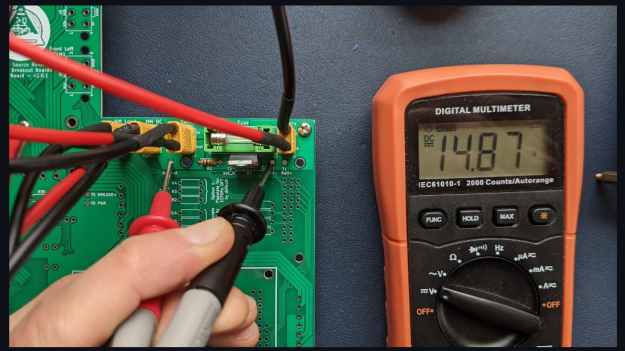


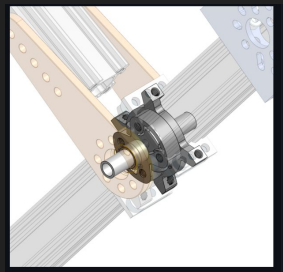
Figure 3.8: Testing the voltage between T4 and T2

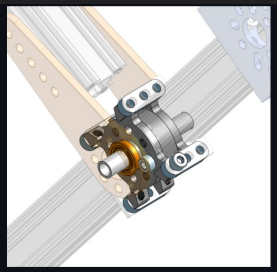
Also check the voltage shown by the multimeter. This should show the same voltage as well.

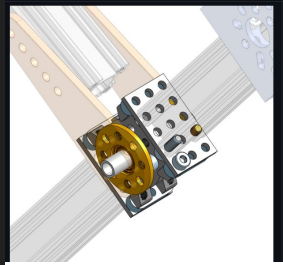
Include plenty of pictures
Include testing practices and common mistakes

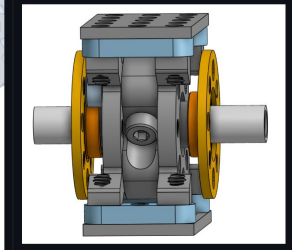
subassembly	nb	length	type	purpose	multiplier	total
wheel	4	10	either	motor - channel	6	24
wheel	3	10	button	bracket - vert. extrusion	6	18
corner	3	10	button	vert. extrusion - low channel	4	12
corner	3	10	button	low channel - servo shaft	4	12
corner	3	10	either	servo bracket - rocker	4	12
corner	3	10	either	servo bracket - rocker	4	12
corner	6	6 or 8 or **10**	button	servo - channel	4	24
rocker-bogie	8	12	socket	rocker-bogie joint	2	16
rocker-bogie	8	**10** or 12	socket	rocker-bogie joint - extrusion	2	16
rocker-bogie	13	8	socket	rocker-bogie - body-axis	2	26
rocker-bogie	2	6 or **8**	socket	rocker-bogie - diff pivot	2	4
rocker-bogie	8	8	socket	rocker-bogie joint	2	16
rocker-bogie	4	10	socket	rocker-bogie joint	2	8
rocker-bogie	4	10 or **12**	socket	diff pivot - rocker-bogie	1	4
rocker-bogie	4	**20** or 22	socket	turnbuckles	1	4
rocker-bogie	2	6	button	diff pivot shaft - bearing	1	2
body	28	16	socket	structure	1	28
body	34	16	button	body plates	1	34
body axis	4	18 or **20**	socket	axis - body	2	8
body axis	8	**6** or 8	button	bearing - channel	2	16
body axis	2	6	either	axis cap	2	4
hinges	2	**6** or 8	button		4	8
hinges	2	6 or **8**	either		4	8
hinges	2	14 or **16**	either		4	8
hinges	1	10	button		4	4

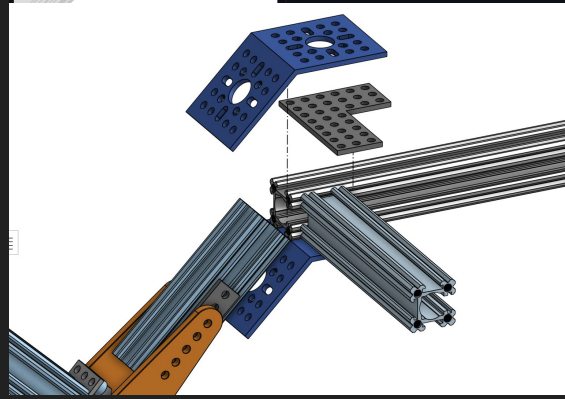
Instructions down to the screw level





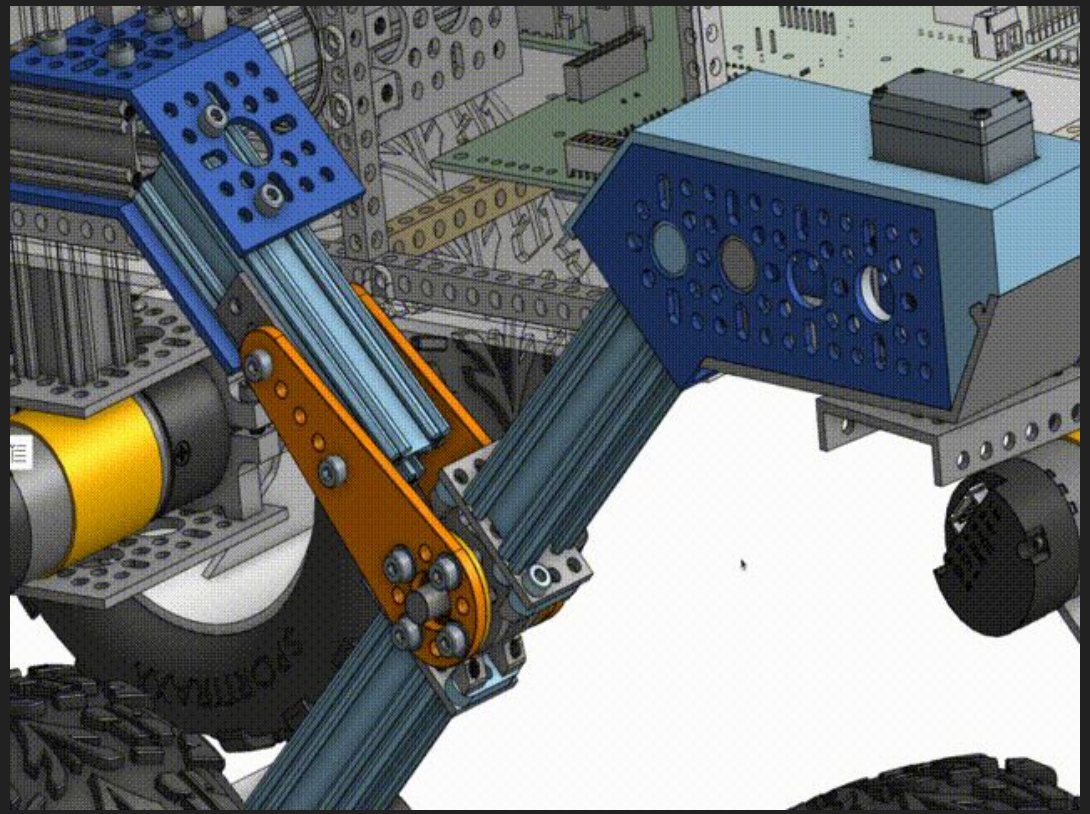






Step-by-step assembly

Combining good docs and ever-improving is hard



Design for less documentation.

Use tooling like OnShape. Still have pictures of the real result but we need fewer.
Point to external instructions, e.g. RPi install

What building one looks like: ordering parts

- Order parts from GoBilda
- Upload component list to Digikey
- Order PCB (group order!)
- Order laser cut parts for body or cut yourself
- Order specialty components: battery, Raspberry Pi, gamepad
- Optionally get tools you don't have access to: soldering iron, crimper, hex keys, multimeter

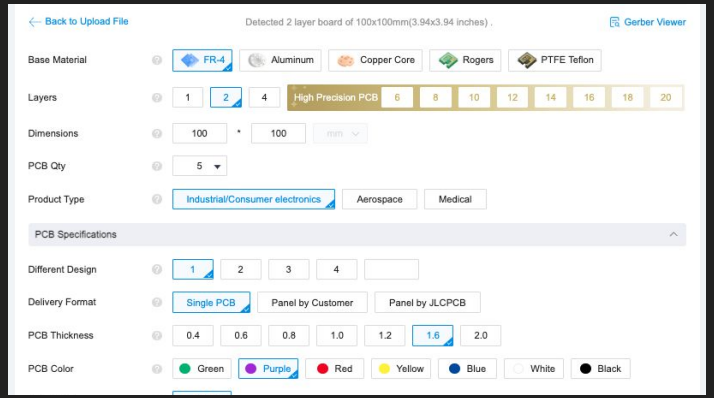
Parts for corner assembly

short name	link	cost per part	total # req	total cost
144mm goRail	1109 Series goRAIL (144mm Length) - goBILDA	$5.49	4	$21.96
4 Hole U channel	1121 Series Low-Side U-Channel (4 Hole, 120mm Length) - goBILDA	$5.99	4	$23.96

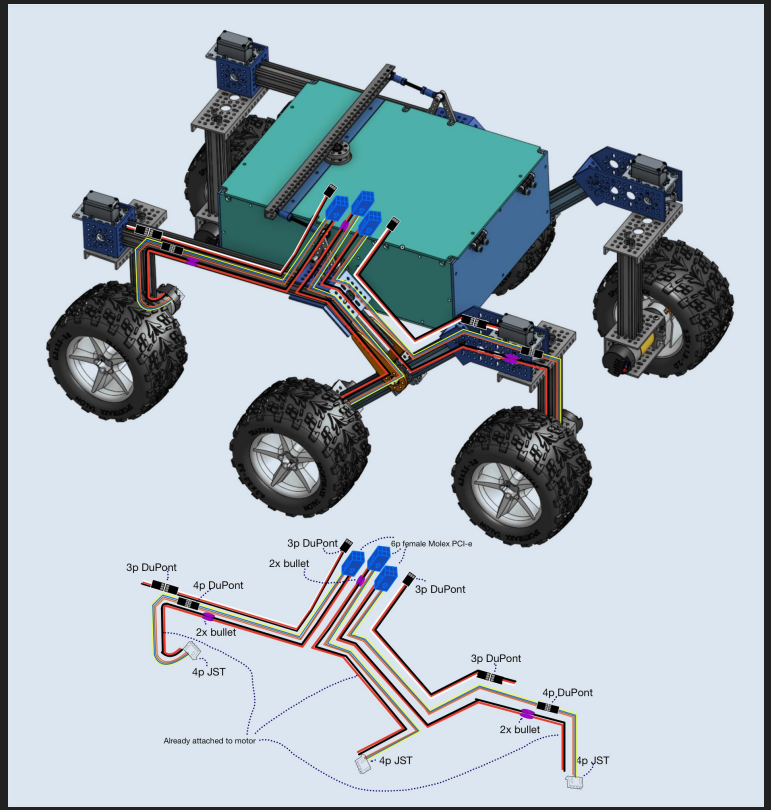
Cost to build these assemblies: $11.48 * 4 assemblies = $45.92

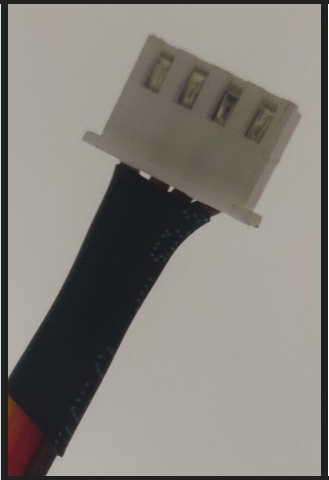
Parts for rocker bogie assembly

short name	link	cost per part	total # req	total cost
1hole uchannel	1120 Series U-Channel (1 Hole, 48mm Length) - goBILDA	$3.69	2	$7.38
servoblock	ServoBlock™ (Standard Size, 25 Tooth Spline, Hub Shaft) - goBILDA	$29.99	4	$119.96
servo	2000 Series Dual Mode Servo (25-2, Torque) - goBILDA	$31.99	4	$127.96



What building one looks like: wiring

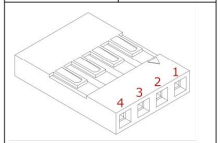




Corner Encoder Extension Cable (x4)

Diagram

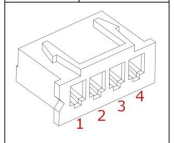
DuPont		
DuPont	male	4-pin
5V		1
GND		2
EnA		3
EnB		4



Dupont Pinout

W1		
4x	22 AWG	36.0 cm
DuPont:1:5V	1:RD	Encoder-JST:4:5V
DuPont:2:GND	2:BK	Encoder-JST:3:GND
DuPont:3:EnA	3:BU	Encoder-JST:2:EnA
DuPont:4:EnB	4:WH	Encoder-JST:1:EnB

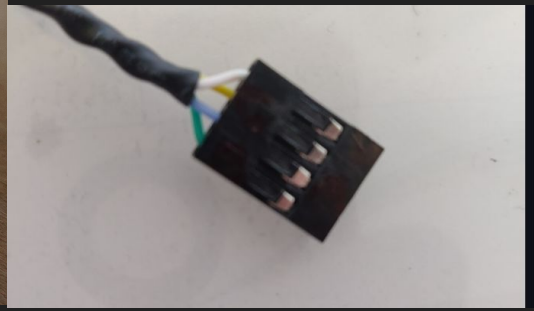
Encoder-JST		
JST-XH	female	4-pin
1		EnB
2		EnA
3		GND
4		5V

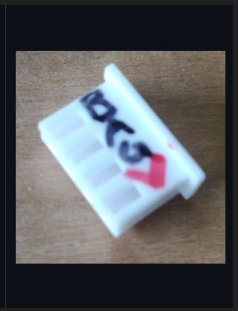


JST-XH Pinout

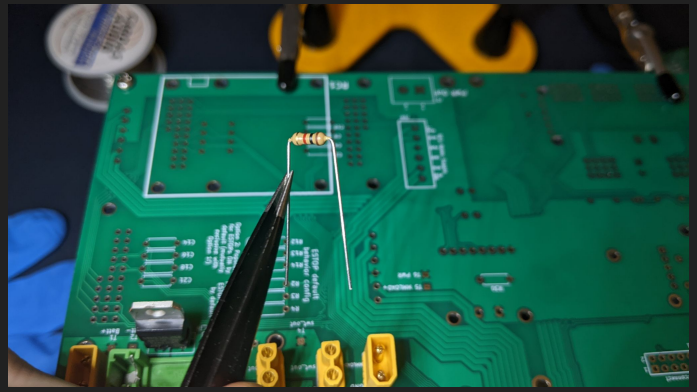
Bill of Materials

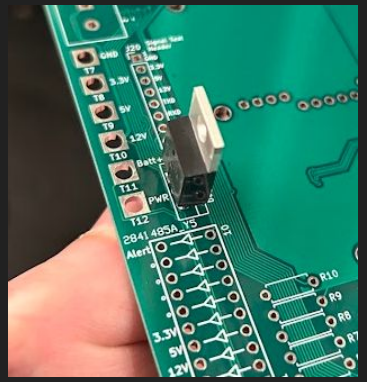
Id	Description	Qty	Unit	Designators
1	Cable, 4 x 22 AWG	36.0	cm	W1
2	Connector, DuPont, male, 4 pins	1		DuPont
3	Connector, JST-XH, female, 4 pins	1		Encoder-JST

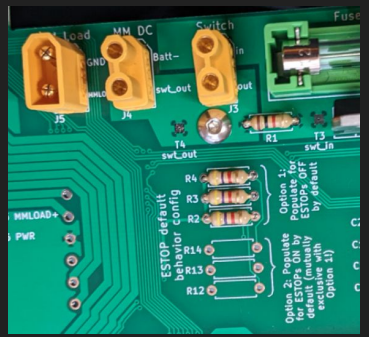


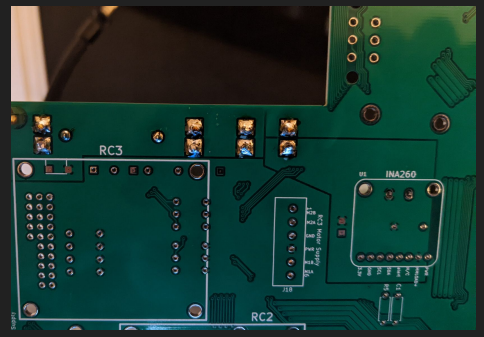


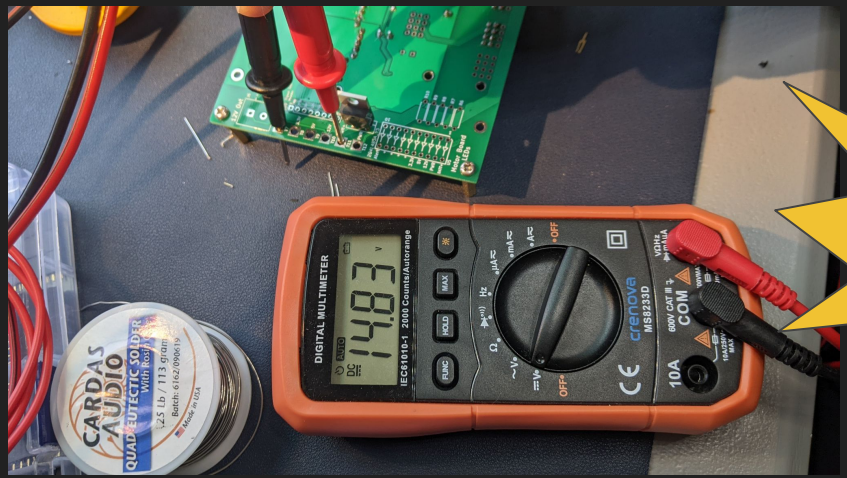
What building one looks like: PCB assembly & soldering



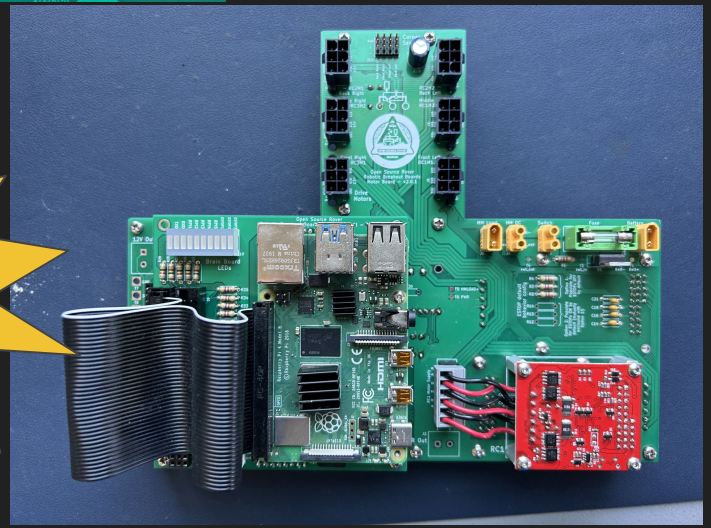




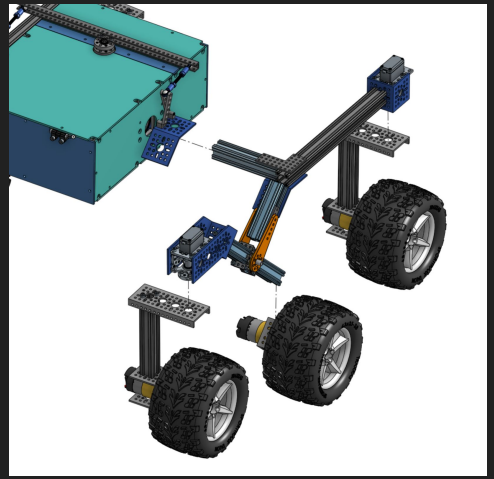


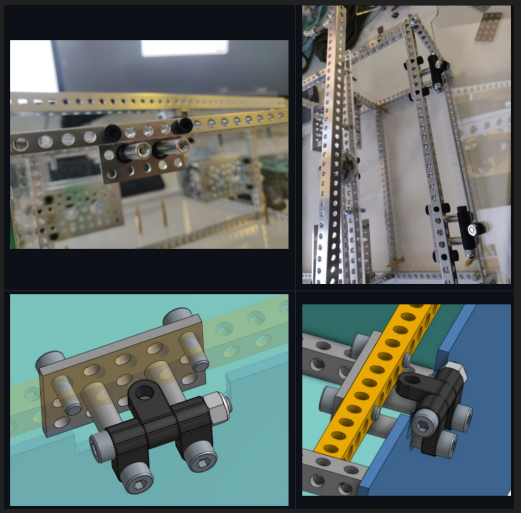


over 60 pictures!



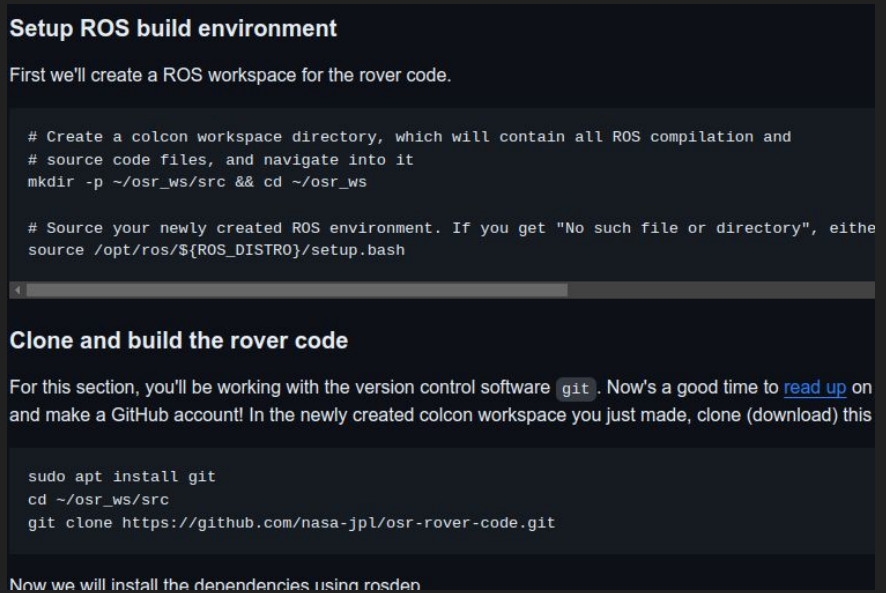
What building one looks like: mechanical assembly





What building one looks like: software

1. Installing Ubuntu on the Raspberry Pi
    a. Other distros may also work - at your own risk - minimize instructions and simplify support
2. SSH into the RPi
3. Installing ROS 2
4. Compiling the code
5. Testing I2C/serial connections
6. Calibrating and configuring your rover
7. Running!
8. Systemd service



Setup ROS build environment

First we'll create a ROS workspace for the rover code.

```
# Create a colcon workspace directory, which will contain all ROS compilation and
# source code files, and navigate into it
mkdir -p ~/osr_ws/src && cd ~/osr_ws

# Source your newly created ROS environment. If you get "No such file or directory", eithe
source /opt/ros/${ROS_DISTRO}/setup.bash
```

Clone and build the rover code

For this section, you'll be working with the version control software `git`. Now's a good time to read up on and make a GitHub account! In the newly created colcon workspace you just made, clone (download) this

```
sudo apt install git
cd ~/osr_ws/src
git clone https://github.com/nasa-jpl/osr-rover-code.git
```

Now we will install the dependencies using rosdep

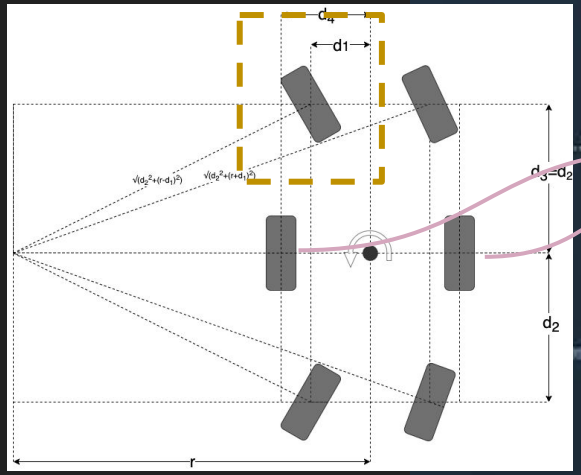
Profit!

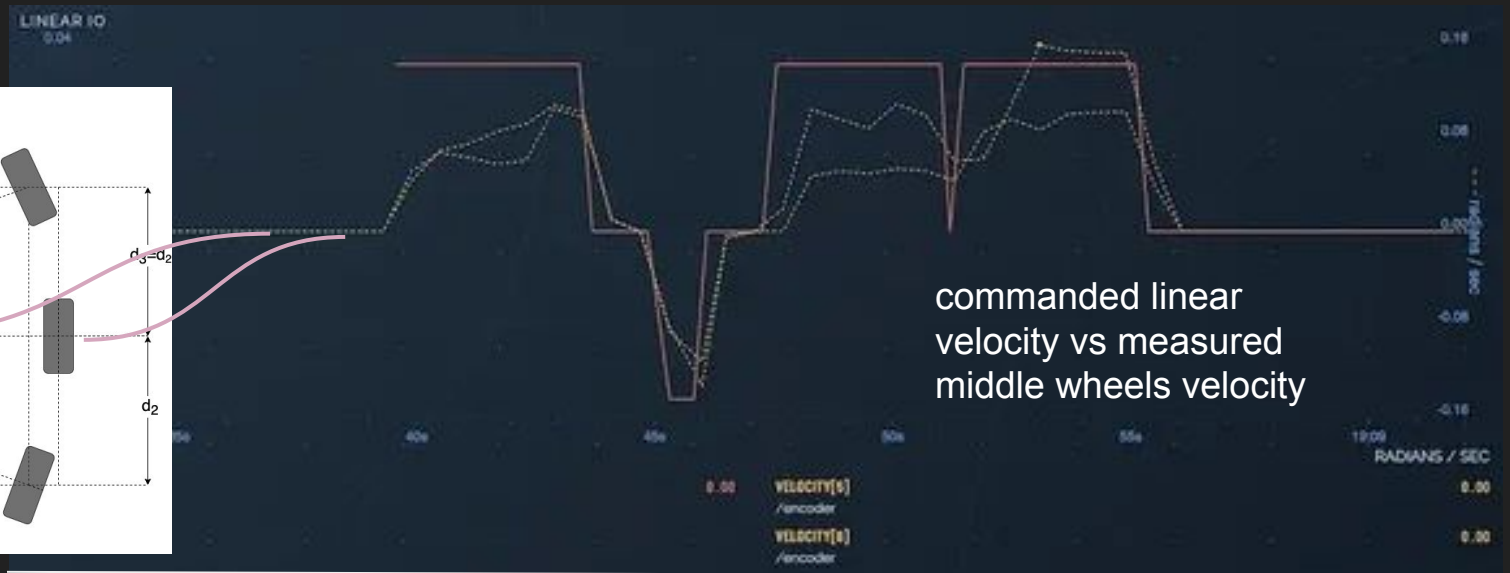
→ a gentle intro to full stack robotics in just a few weeks

→ just the start

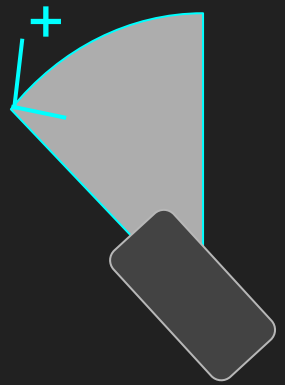
Ingredient 4

teach others



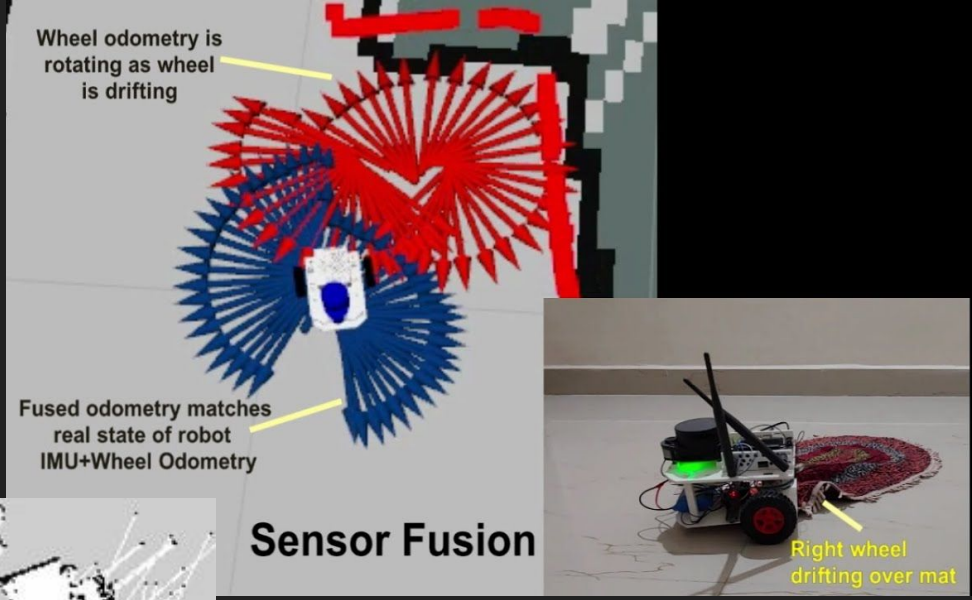


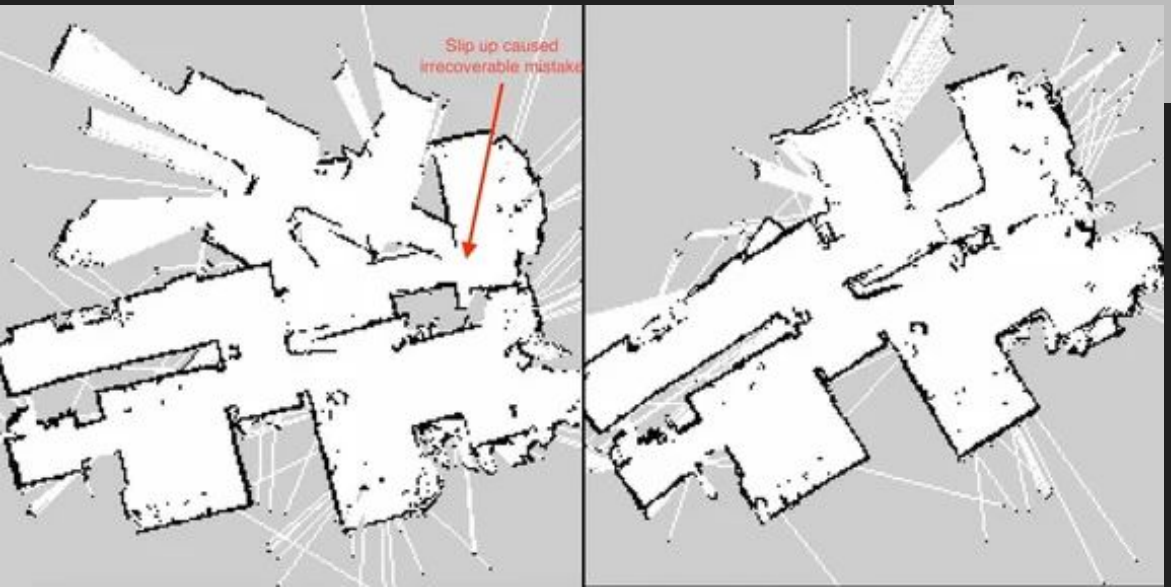
commanded linear velocity vs measured middle wheels velocity



commanded angular velocity vs front left wheel angle

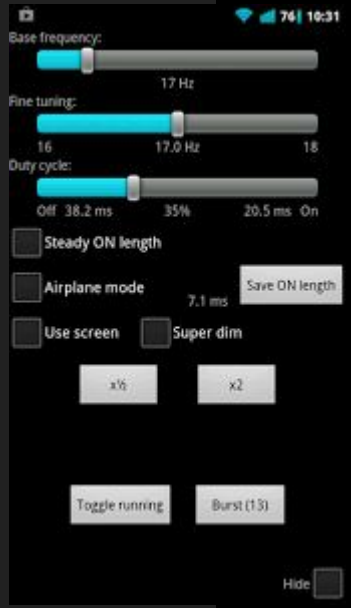
SLAM:
Build a map of our environment so we can navigate in it





Is my robot actually going as fast as I told it to?


NEIKO
TEST
MEM


74% 10:31
Base frequency:
17 Hz
Fine tuning:
16
17.0 Hz
18
Duty cycle:
Off 38.2 ms
35%
20.5 ms On
Steady ON length
Airplane mode
7.1 ms
Save ON length
Use screen
Super dim
x½
x2
Toggle running
Burst (13)
Hide

Result

profit

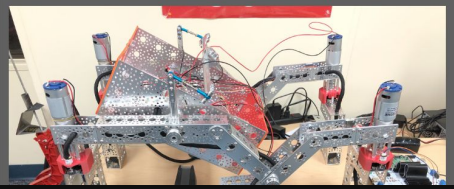
@jerrydon1085 1 month ago

Great video! Ordering Parts now... Silly Digikey is importing the "Index" field as the "Quantity" for the BOM. Thanks for version!

Reply

• 2 replies

I think my students are more excited than me. This is a wonderful project for high school students. Thanks you all for your collaborations.



@mohamedmostafasadeck5 1 month ago

wow, that's awsome
Go Ahead 👋👋👍

Reply

@chubbyzombie666 1 month ago

13 subscribers and I'm the first one to click LIKE. This robot is super cool, I just subbed and hope you got links below. elogoo smart car parts and sheets of plexy glass. Thoughts?

1 Reply

Hey Achille, just wanted to drop by and say I hope I'm not causing too many headaches with the myriad suggestions and git issues I've opened 😅

The OSR is the kind of project I've wanted to sink my teeth into for years, so I've been very excited as I've been working on building mine, seeing all kinds of potential upgrades and improvements

Mr Roboto says:

September 16, 2023 at 10:48 am

My kids and I built an equally capable one for ~$100.

It’s not all sunshine and roses

spending cuts, no obligations, slow progress, parts unavailable or discontinued, unresponsive partners, frustrating dead ends, thanklessness, …

What will you build?

Autonomy
Robot arm for picking trash
Remote teleoperation
Combine with a UAV
Head/display
Run F-prime on the OSR
Build kits (3D printing)

Maintainers

Meet fortnightly, answer questions, design next-gen rover, make improvements, fix bugs, …

Why become a maintainer? Learn from others, help others, build out your resume

- @ericjunkins: made the first version of the OSR as an intern at JPL, mostly electrical & mechanical
- @Achllle: mostly mechanical & software
- @dcschooley: mostly electrical
- @apollokit: mostly electrical & software
- @abust005: new member!
- Lan Dang: JPL liaison and builder

All in their spare time

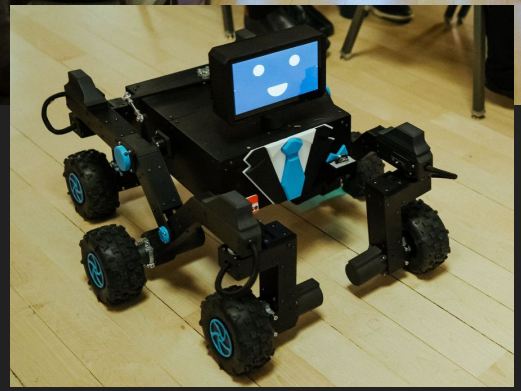
Join us!

- Marketing, social media
- Researchers in outdoor or space robotics
- Builders & hobbyists
- Documentation wizards

Thank you!

This just in!

💍



Congrats, Eric!