Designing and building a modular tracked vehicle

Using an affordable, off-the-shelf, tracked robot chassis, let's build a 3D-printable modular tracked vehicle (MTV) that's easy to attach future upgrades to

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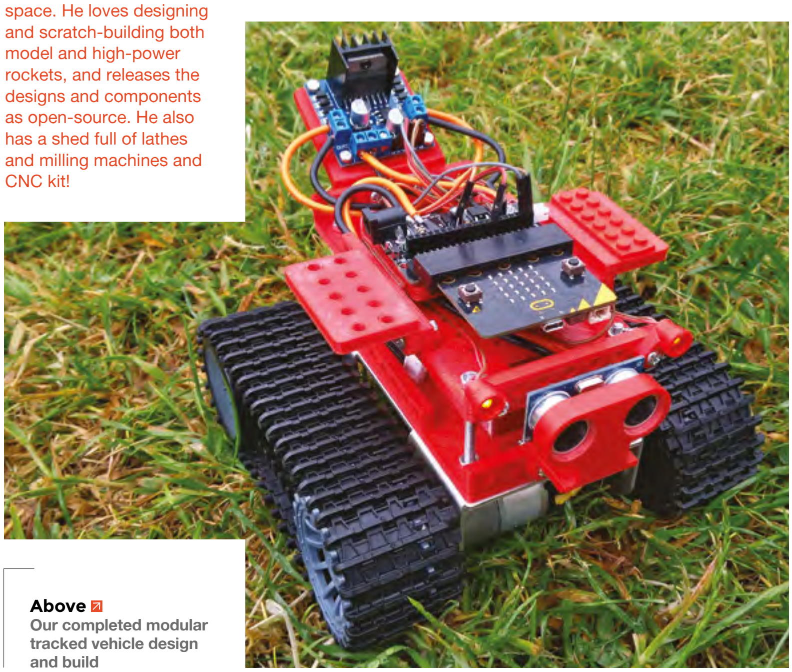
Jo Hinchliffe is a constant tinkerer and is passionate about all things DIY space. He loves designing and scratch-building both model and high-power rockets, and releases the designs and components as open-source. He also has a shed full of lathes and milling machines and CNC kit!

At around £20 to £25, this chassis kit is often described online as a 'tank crawler chassis'. It arrives with a metal chassis, two geared DC motors labelled for 350 rpm at 12 V, a set of drive wheels with some drive hub mounts, two non-driven/idler wheels, and some tracks. Also included is a bag of assorted nuts, bolts and washers, some tools, and a battery box designed to take two 18650 cells. Noticeably, having bought two of these kits, no instructions are supplied for the chassis kit, so we had to use some trial and error to explore the best way to assemble it. You can download the designs for our upgrades from **hsmag.cc/mtv**.



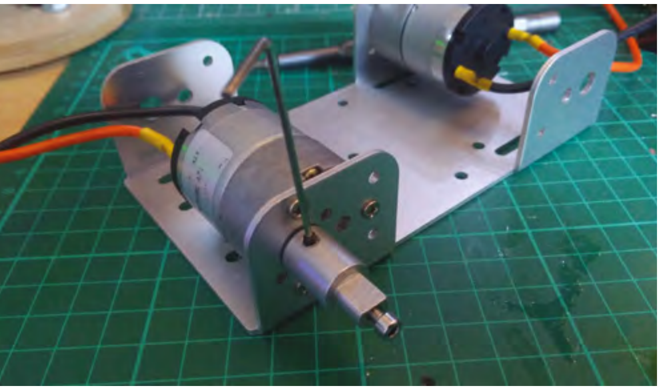
Above Our completed modular tracked vehicle design and build

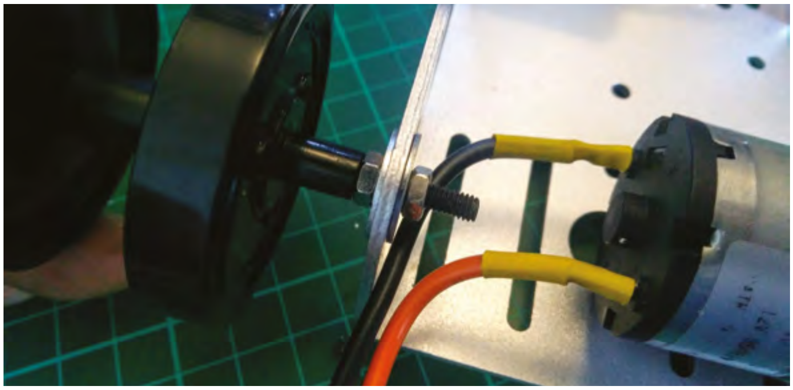
Looking at the metal chassis, each side has two mounts: one with nine holes, and one with five holes. We realised that the nine-hole mount was the only one that had the correct holes to mount the motors; this meant that the motors are diagonally opposite each other, in turn meaning that there are some issues around symmetry in the build already.

We attached the two motors to the chassis with three of the M3 screws each, and then, using the small grub screws and the supplied Allen key, we attached the aluminium hub adapters onto the shaft of the motors. Next, we added the driven wheels, which were a good fit, onto the hub adapters, keyed into position with a flat section, and pulled onto the hub adapter with an M3 bolt (**Figure 1**).

MAKING TRACKS

The idler wheels are interesting in that it's not particularly clear into which hole on the chassis mounts they are designed to go. There are a couple of candidate holes. The first we tried is the hole that is closest to the diameter of the long semi-threaded bolt that acts as an axle for the idler wheel. We tried this first using a nut and washer on both the outside and the inside of the chassis mount to create a fixed axle, carefully locking the nuts in a position that allowed the idler wheel to spin, but not be so loose as to be able to move too much up and down the axle. Skipping ahead slightly, once we had added both idler wheels using these holes and added the tracks, we realised that although the tracks were parallel to the chassis sides, they were offset front to back. So looking from



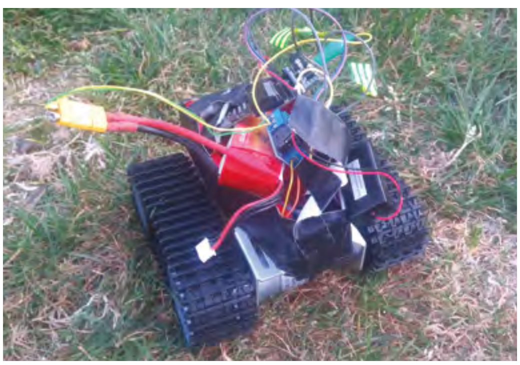


above, one set of tracks was around 10 mm extended beyond one end of the chassis, while the other set of tracks was extended the same amount off the other end. It definitely looked odd, and we worried that it might affect the tracking of the vehicle.

LET'S COBBLE AND TEST!

We cobbled together some drive electronics and gaffer-taped them on to test (**Figure 2**). While we were still unhappy with the way that the tracks looked, it did track correctly and drove well. However, we decided to strip the tracks and idler wheels off and tried to reconfigure them. We ended up using the much larger holes on the five-hole mount tabs, and discovered we could get the tracks to align not perfectly, but much better. We also realised that clamping the axle bolt using the large washers through the larger hole meant that we could slacken the idler wheel axle, and it could move within the larger hole to allow the tracks to be loosened for removal without having to split the tracks (**Figure 3**).

As we mentioned earlier, once we had the tracks and motors in place, we soldered some wires to the motors (**Figure 4** overleaf) and quickly cobbled together some running gear, a micro:bit in an RKub2 breakout board, an L298N motor driver, and a 3S 2200 mAh LiPo battery. We used a slightly modified version (**Figure 5** overleaf) of the micro:bit code that we used to control the :MOVE mini MK2 robot in our *Working with micro:bit radios* article in issue 30.



While this looked like an abomination, it allowed us to test the chassis to see how it ran – it also helped us consider the design. We realised that this chassis was very capable and can move quite quickly and accurately – it is also pretty good across some quite rough terrain and can certainly traverse short grass, gravel, and more. Another useful thing we realised was that if the centre of gravity wasn't particularly →

MAKING TRACKS

Whichever option you choose in terms of the idler wheel axle position, you'll have to shorten the supplied tracks by removing some links. To do this, we need to remove the pins between some links. For this, you will need a thin pin-type tool. We found a tool originally designed to be an insert pin to release a mobile phone SIM card cover that worked – a drawing-pin with the point filed off would also work. Once we discovered that one end of the track link internal pins was knurled and one wasn't, we could remove pins fairly easily – but until that point, this was a very frustrating task!

The tip we can share is that, as you can see in the image below, if you push your tool against the track pin from the side where the pin ends on the inside of the track and the pin link is lower than the edge of the track, you are pushing the pin out in such a way that the short knurled (and therefore slightly wider) section of the pin is pushed out at the other end first. Trying to push the thicker knurled end through the track link holes doesn't work. We removed one pin and then wrapped the track around the idler and powered wheel to work out how many links to remove, and then we removed them. Once we were happy with the track lengths, we pushed the pin back in.

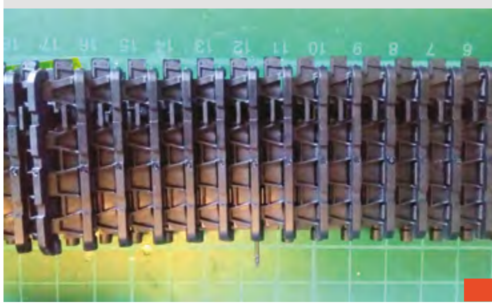


Figure 1
The motor and hub mounted. The chassis mounts feature lots of holes, some of which are used, and some of which aren't

Figure 2
A horridly cobbled and gaffer-taped ten-minute prototype was put together to allow a test-drive of the chassis which informed our design ideas for the modular mount system

Figure 3
The idler wheel mount with the axle clamped into the larger of the available holes using the four larger washers

YOU'LL NEED

- A 'tank crawler chassis kit'
- Soldering iron and some wire
- Access to a 3D printer
- Some M4 threaded bar
- Some M4 and M3 nuts and bolts
- L298N motor driver and a micro:bit

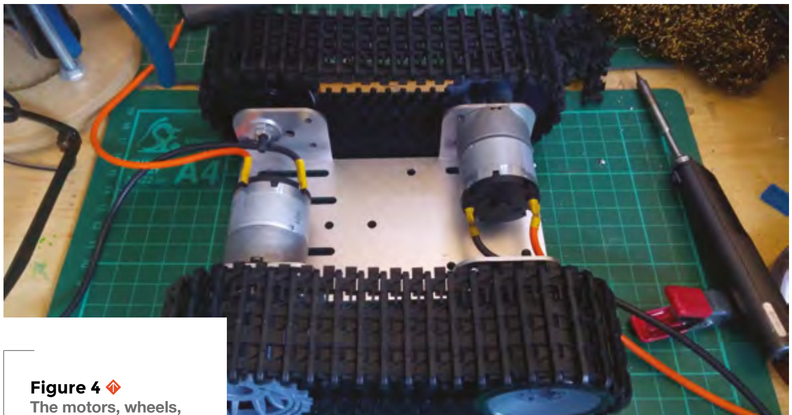
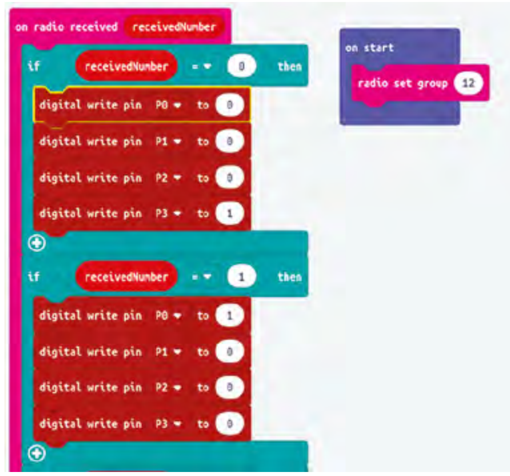


Figure 4
The motors, wheels, and tracks mounted, and wires soldered to the motors

Figure 5
We used the code featured in the *Working with micro:bit radios* article, replacing the servo blocks with 'digital write' pin blocks. Pins 0, 1 and 2, 3 are attached to the motor control pins on the L298N – writing one pin high and one low makes the motor rotate one way or the other

central, it was prone to tipping front to back when going over an incline. As the 2200 mAh battery is by far the heaviest component, we realised our design had to hold this centrally in place, and as close to the chassis as possible.

Measuring up the dimensions of the chassis and noting the positions of the slots, we used FreeCAD to design the lower tray first. We added our 10 mm-spaced hole rails on the front and the edges. We also added some raised ridges inside to ensure our 2200 mAh cell stayed in a precise central position. We



decided that the end of the chassis with the larger circular hole was going to be the back, and that we would run the motor wiring up through that hole. Therefore, we decided to leave a larger area around the hole and under the area of the battery open to allow wires to be routed through (**Figure 6**). After printing, we attached the lower deck using some short lengths of M4 threaded bar we cut to around 50 mm, with a nut under the chassis and a nut on top of the lower deck.

The upper deck is the same overall dimensions as the lower deck, and also has the side mount 10 mm-holed rails in the same relative position to the lower one, but is peppered with more 10 mm-spaced holes. We also designed a larger slot into each end of this deck to allow for the routing of cables. The gaps between the side rails and the front and back rails on both decks were also for if we needed to route cables around the outside of the decks, but we might get rid of these in a future revision as we haven't used them. When fitting the upper deck (**Figure 7**), we used a couple more nuts as this allowed us to experiment with different heights for this deck. However, we might replace this system with

MODULAR TRACKED VEHICLE

Thinking about our design, we wanted to create some upper sections that mount onto the chassis that could hold the electronics, but that could grow and change, and we could add and remove components and experiments. Realising this, the modular tracked vehicle project was born! We decided that we would include a lot of mounting holes and that, wherever possible, they would be spaced at 10 mm between centres. This means that when designing additional modules, we can add 10 mm spaced mount holes and know we can mount it in a variety of positions. We settled on the hole diameters to be roughly equivalent to M4 – we actually drew most of the holes in FreeCAD to be 4.2 mm diameter. The reason for this is that then they can be used as a through-hole for an M4 bolt, but also this is a good diameter to use if we wanted to use a brass thermal insert nut with an internal M3 thread. This gives us options to be able to still use the 4.2 mm holes, even if the back of the hole is covered or inaccessible.

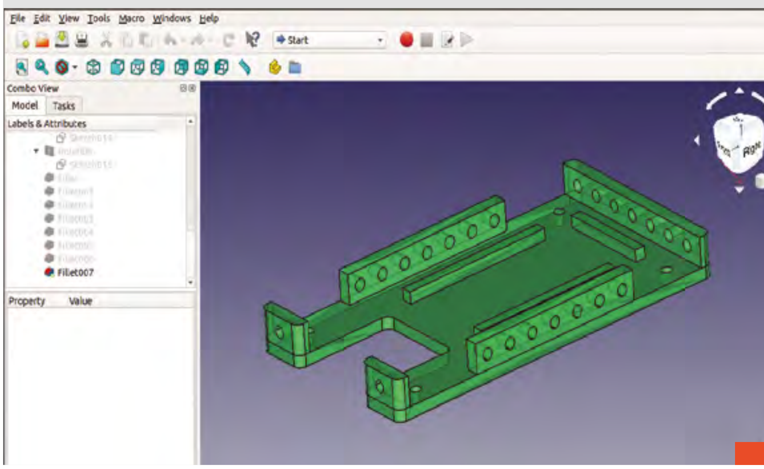
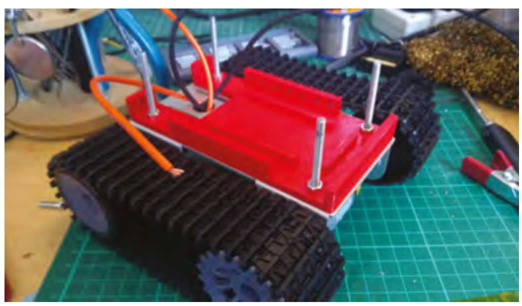


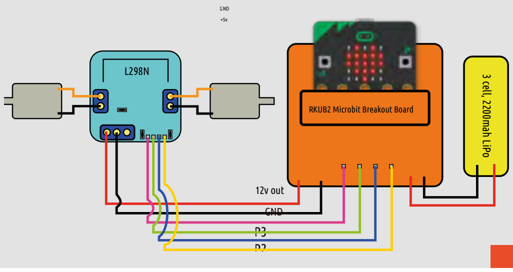
Figure 6
Our lower deck design, printed and bolted onto our chassis



WIRING

We are more focused on sharing the mechanical design aspects in this tutorial, and we may well change the control system in the future. The micro:bit and L298N motor controller setup is pretty basic. There's no proportional control for the motors – they are simply switched on or off. That said, the image to the right shows the main connections, and there are plenty of tutorials online to show you how to use the micro:bit and the L298N, such as this great primer by Les Pounder: **hsmag.cc/UVBUTz**.

We used the RKub2 breakout for the micro:bit because it can be powered directly from a three-cell LiPo battery – it regulates power to the micro:bit and offers a 12 V, 5 V, and 3.3 V output. This is useful because we ran our motors and L298N off the 12-volt (or in our case 11.4 V) rail, and the LED headlights were connected via a 150 ohm resistor to the 5 V rail. It also breaks out all the micro:bit pins as we needed one more than the three available if attaching directly to the micro:bit.



some cut lengths of aluminium tube slid over the 4 mm threaded rods to act as standoff spacers, as this would make it quicker to disassemble and reassemble.

The first add-on modules we made for the MTV consisted of a couple of bolt-on platforms that could hold the electronics in place. For now, we have built this version using the micro:bit and L298N motor driver, and so we designed with those in mind. We wanted to see what it was like to mount something at an angle, so the first module we designed was a 45-degree mounting plate, into which we added the mounting holes for the L298N – this was attached to the back of the upper deck. We mounted the micro:bit and RKub2 breakout panel onto a flat module panel that could be bolted flat onto the upper deck, which is a simple solution. We could have mounted it to the side rails, or indeed created an L-bracket mount to mount it rising up vertically. The RKub2 board has the frustration that when soldered together, the mounting holes on the PCB are all partially obscured by the components, so we ended up using some double-sided tape to stick the board to the mounting panel.

LET'S ACCESSORISE!

Next, we wanted to design some more accessories to explore how we might add modules to the MTV. First up, we added some LED headlights consisting of a 3D-printed mount that could contain a 3 mm LED, which we used a spot of hot glue to retain into the print. We then designed and printed a holed 45-degree L-bracket that could be used to side mount accessories, and then a similar bracket with no holes. The no-holed 45-degree bracket was used because we had some Lego-compatible tape that we added, meaning that Lego or Lego-compatible items could be built onto it. Finally, while we haven't had a chance to wire this up and write some code for it yet, we designed a mount to be able to add an HC-SR04 ultrasonic sensor. □

HOLDING THE BATTERY

We 3D-printed a small pressing foot that could be threaded onto an M3 bolt and held in position with a locking nut that would act to clamp the LiPo battery down into its bay. We used our thermal insert rig (a modified soldering iron rigged onto a Dremel drill press accessory) to heat and push an M3 thermal insert into a central hole on the upper deck. Assembling the clamp through the threaded insert, we now had a nice clamp that held the LiPo in place securely.

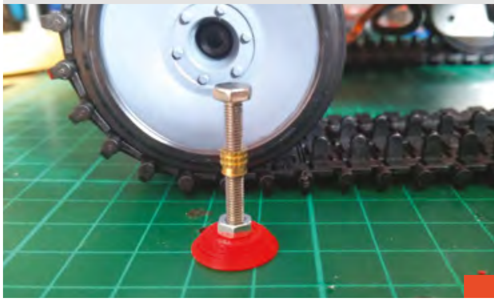


Figure 7
Top deck fitted after printing

Below
Lots of accessories added to the upper and lower deck, but still plenty of room to mount more