A (truly) low-cost line-following Robot for School and University STEM activities

Designed in collaboration with BEng Electronics students
as a Birmingham City University
“Student Academic Partnership”

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Aim

To encourage more young people to study engineering by engaging them with STEM activities through the design, building and programming of robots.

Objectives:

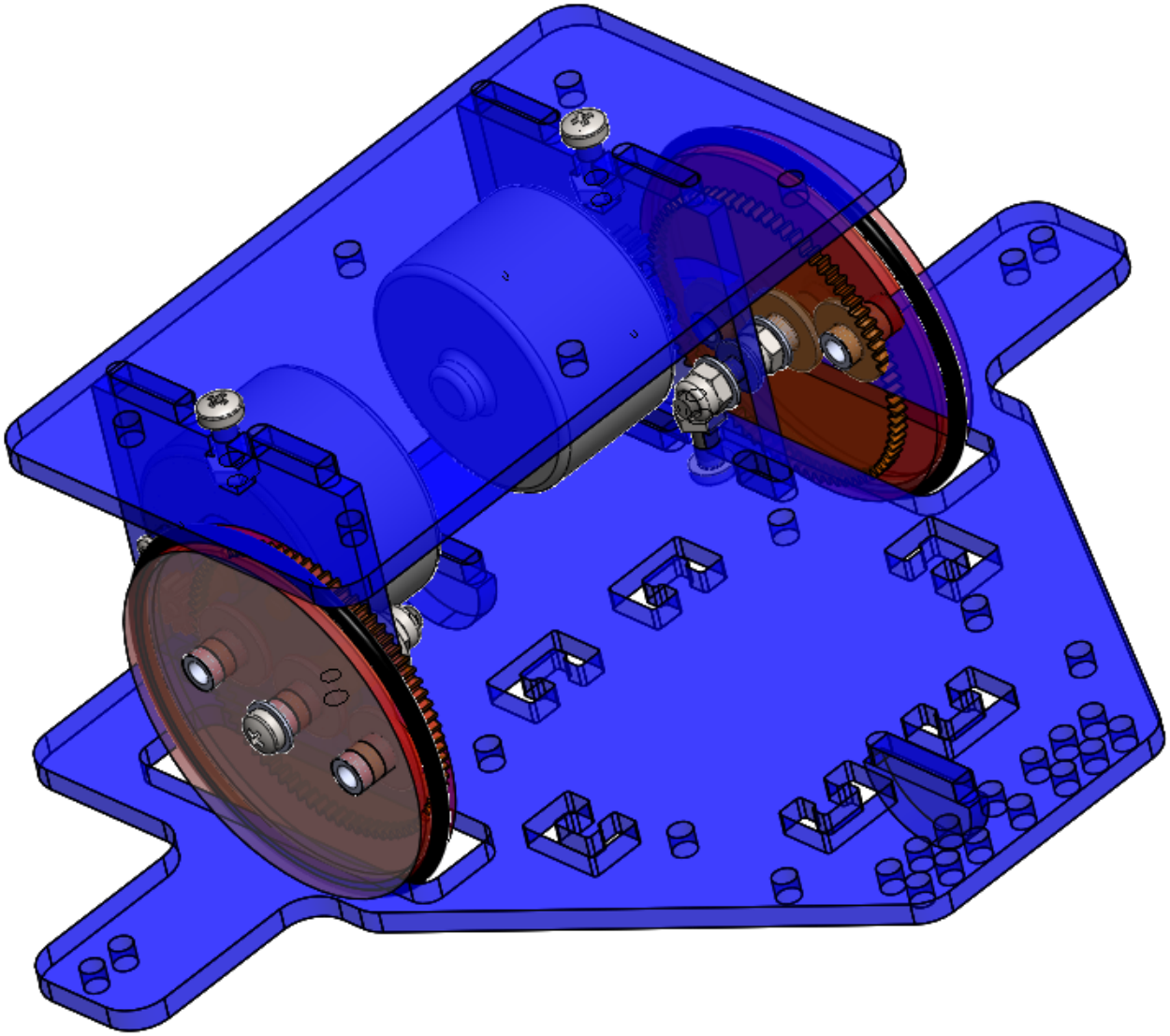
1. Design a very low-cost robot kit for school and university use that can enter the Line Follower competition at Birmingham TechFest.

2. Develop materials (design and teaching notes, circuit designs, algorithm and code examples) to support schools and universities in the use of the robot.

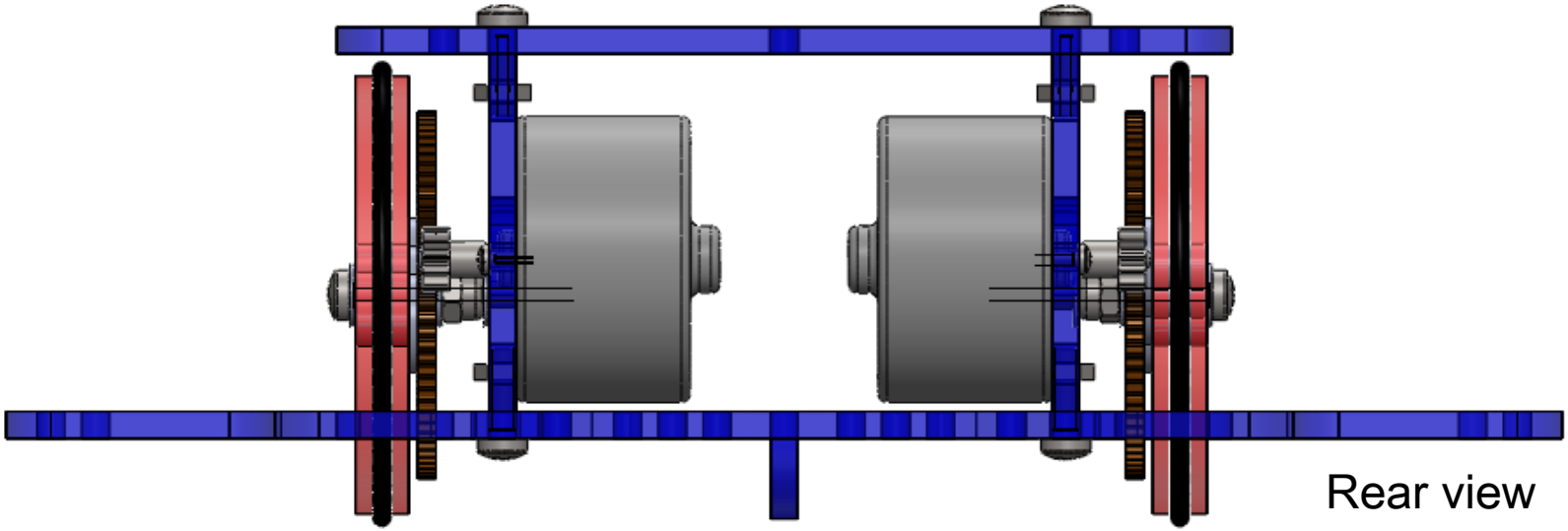
3. Provide materials ‘open-source’ to appropriate schools throughout the UK.

4. Provide the space and competition tracks for a large-scale event at Birmingham TechFest 2012

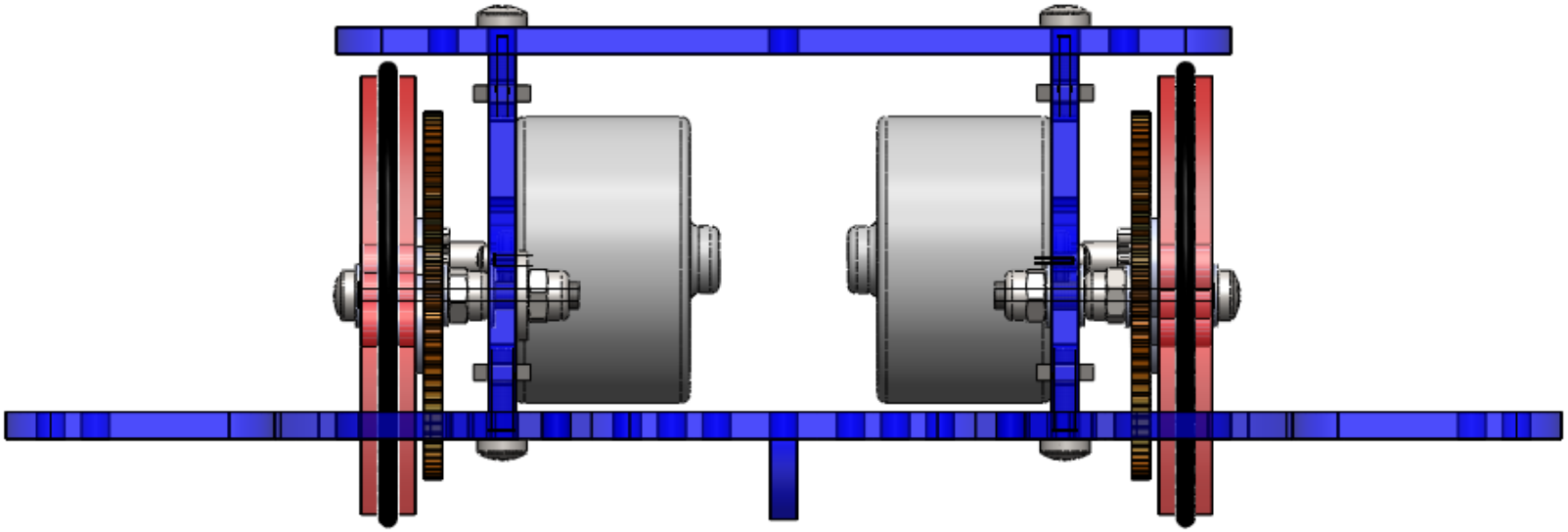
LaserLine – a (mostly) laser-cut line follower



LaserLine – a (mostly) laser-cut line follower

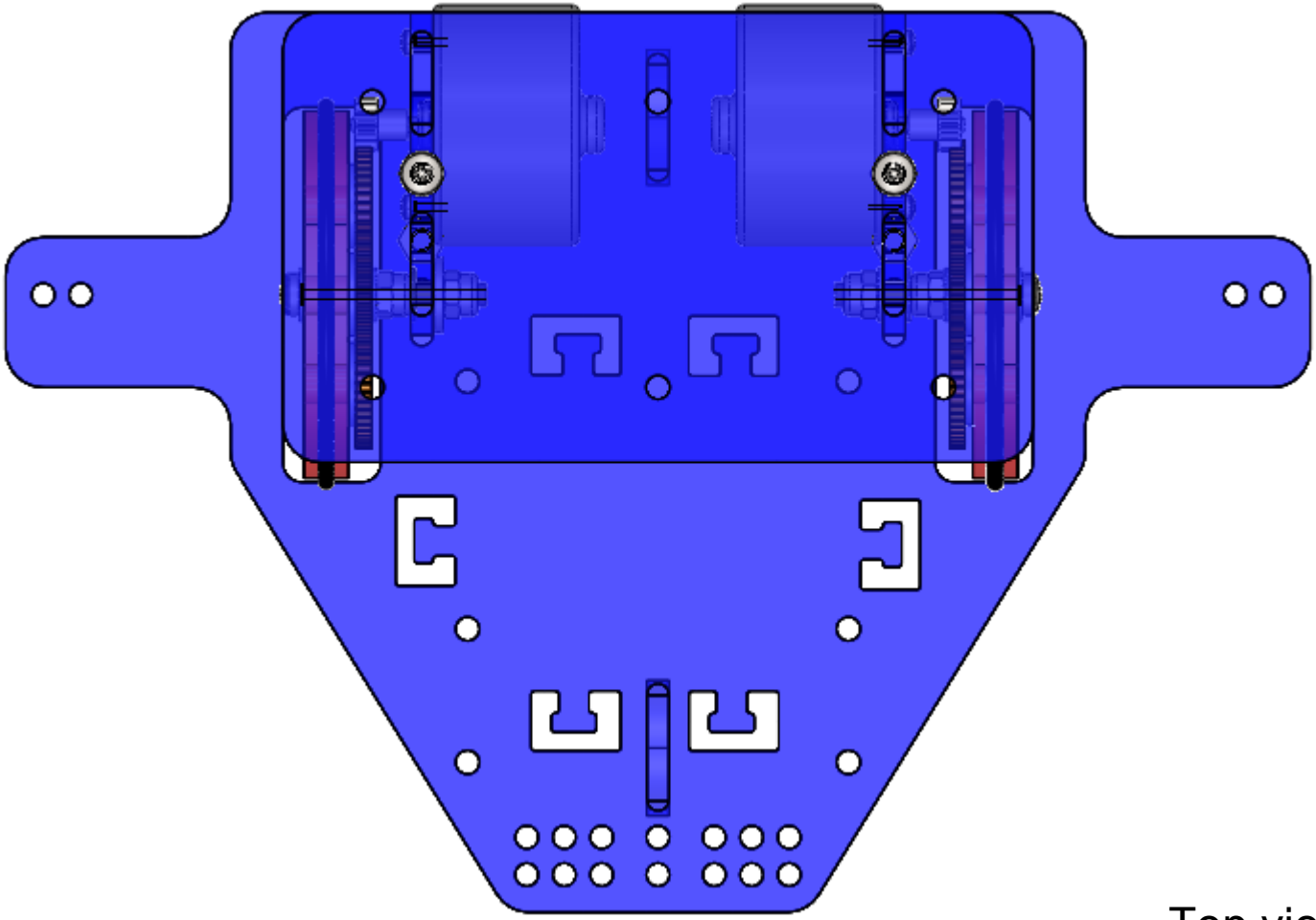


Rear view



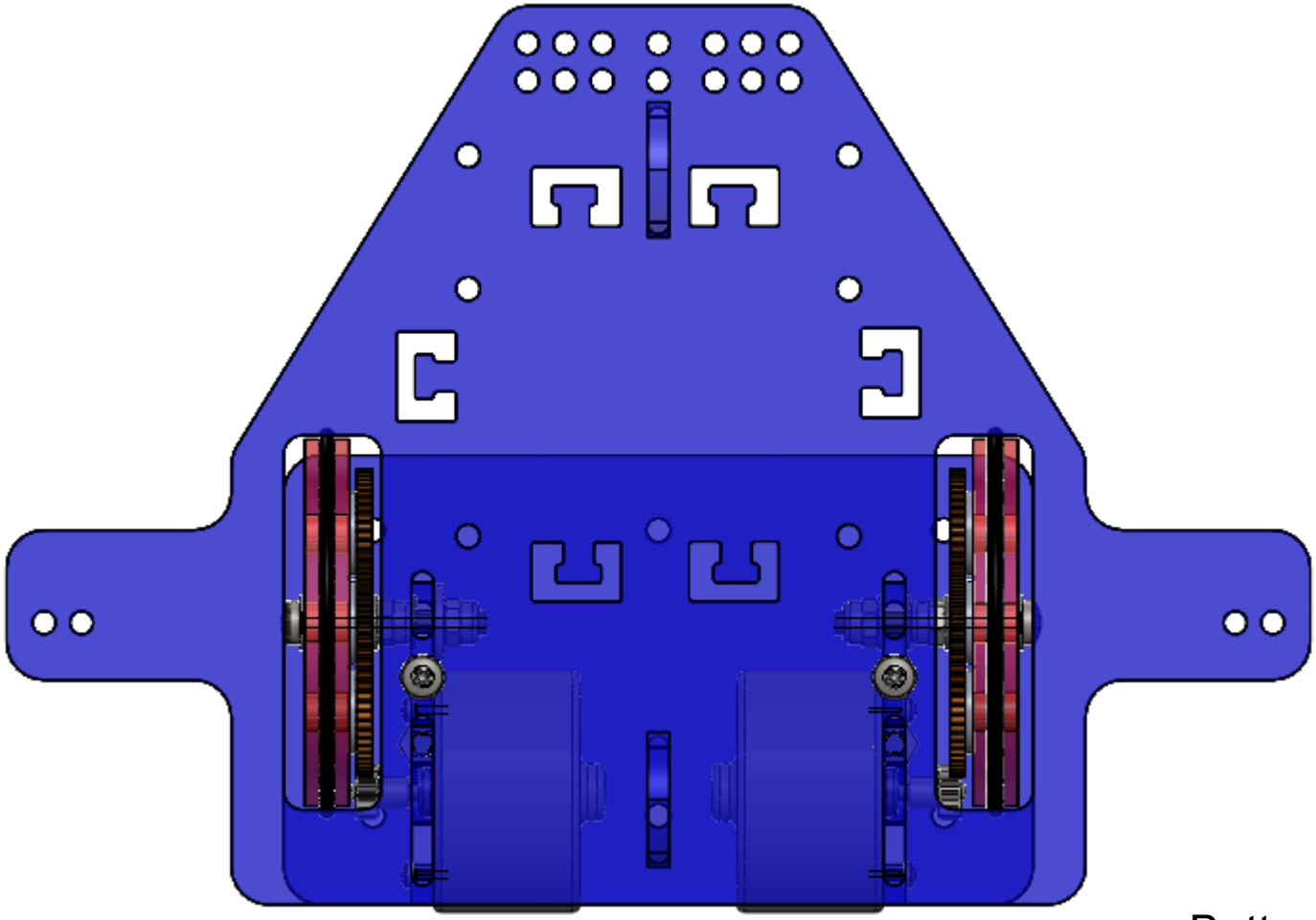
Front view

LaserLine – a (mostly) laser-cut line follower



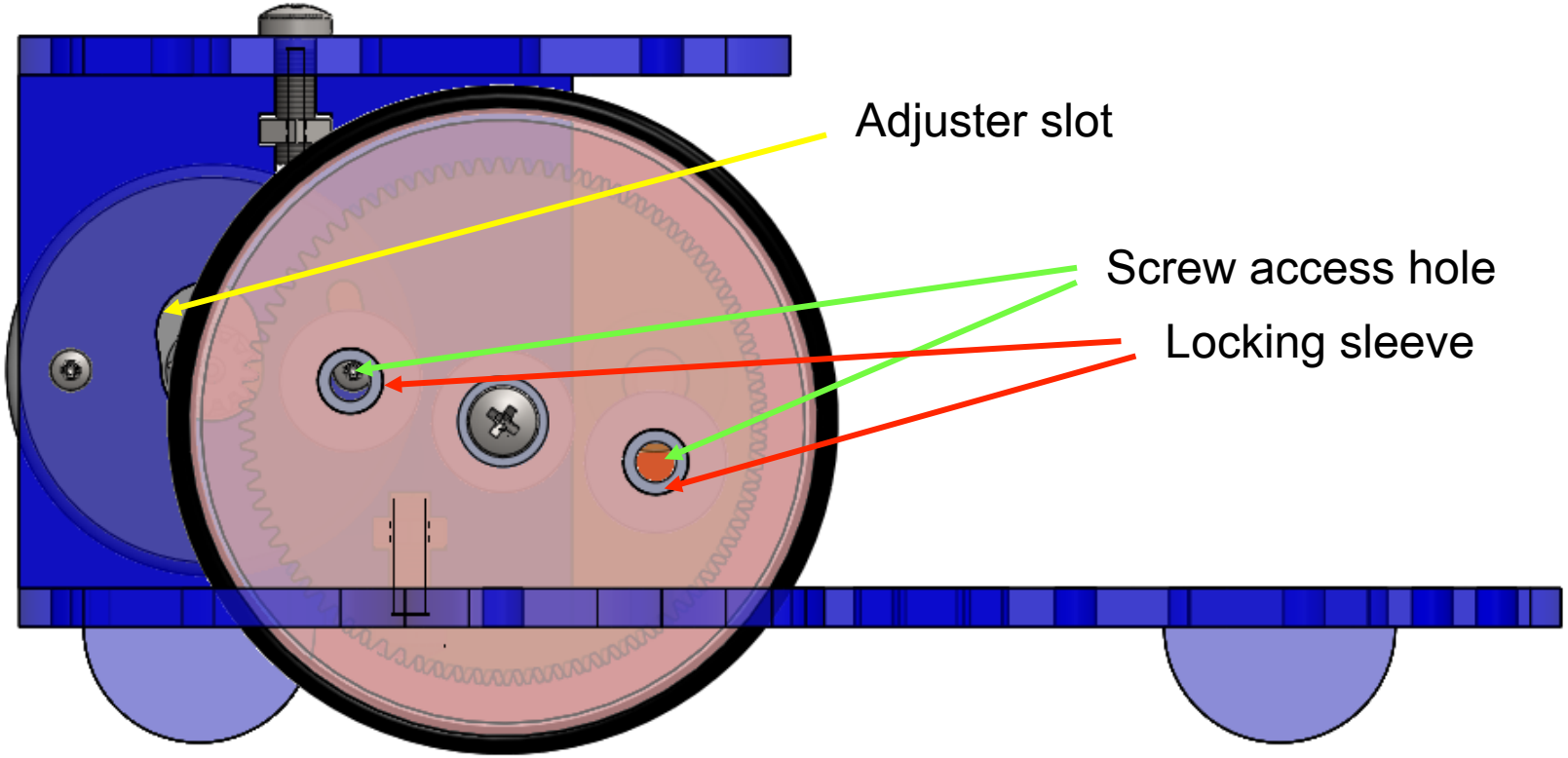
Top view

LaserLine – a (mostly) laser-cut line follower



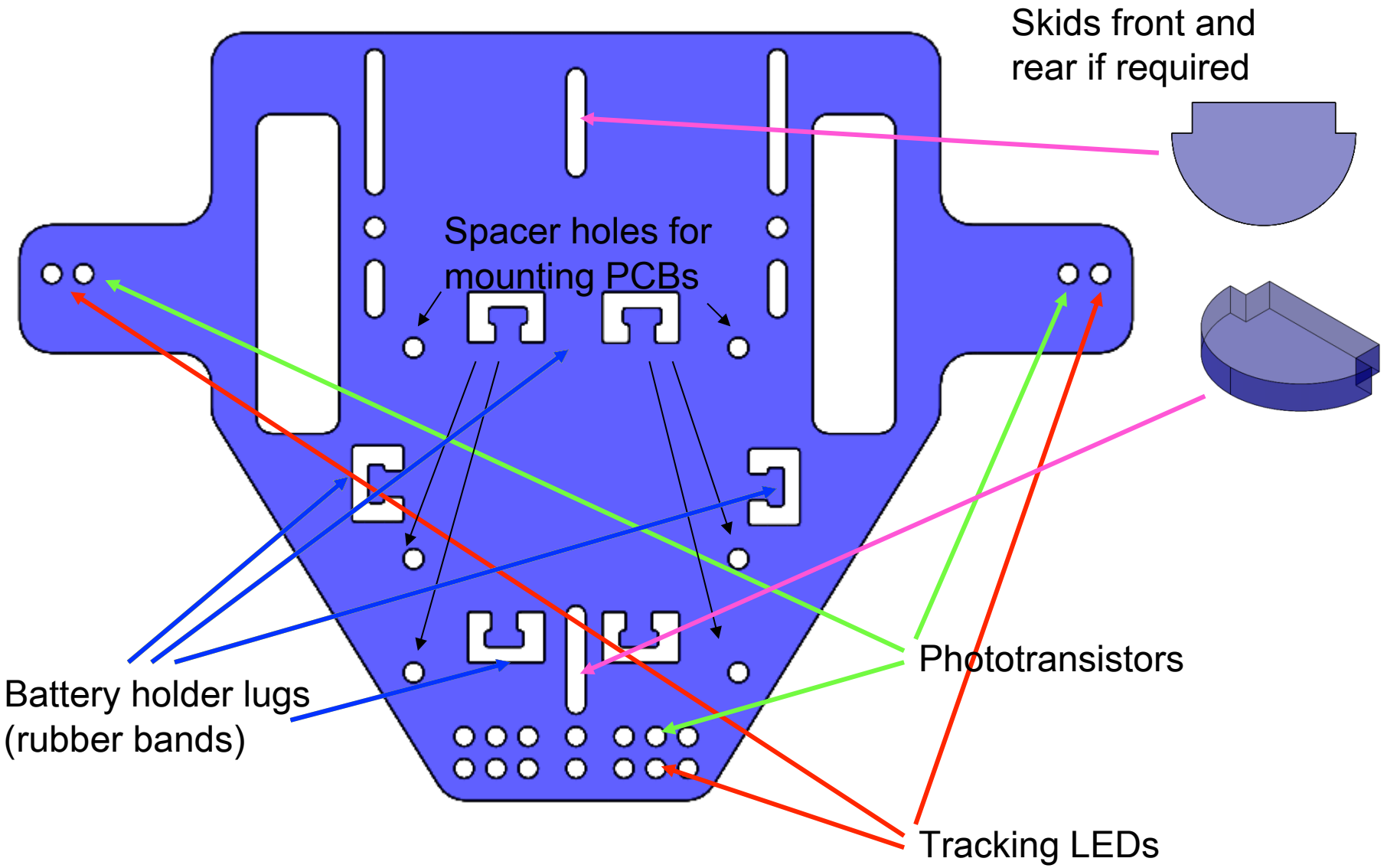
Bottom view

LaserLine – a (mostly) laser-cut line follower

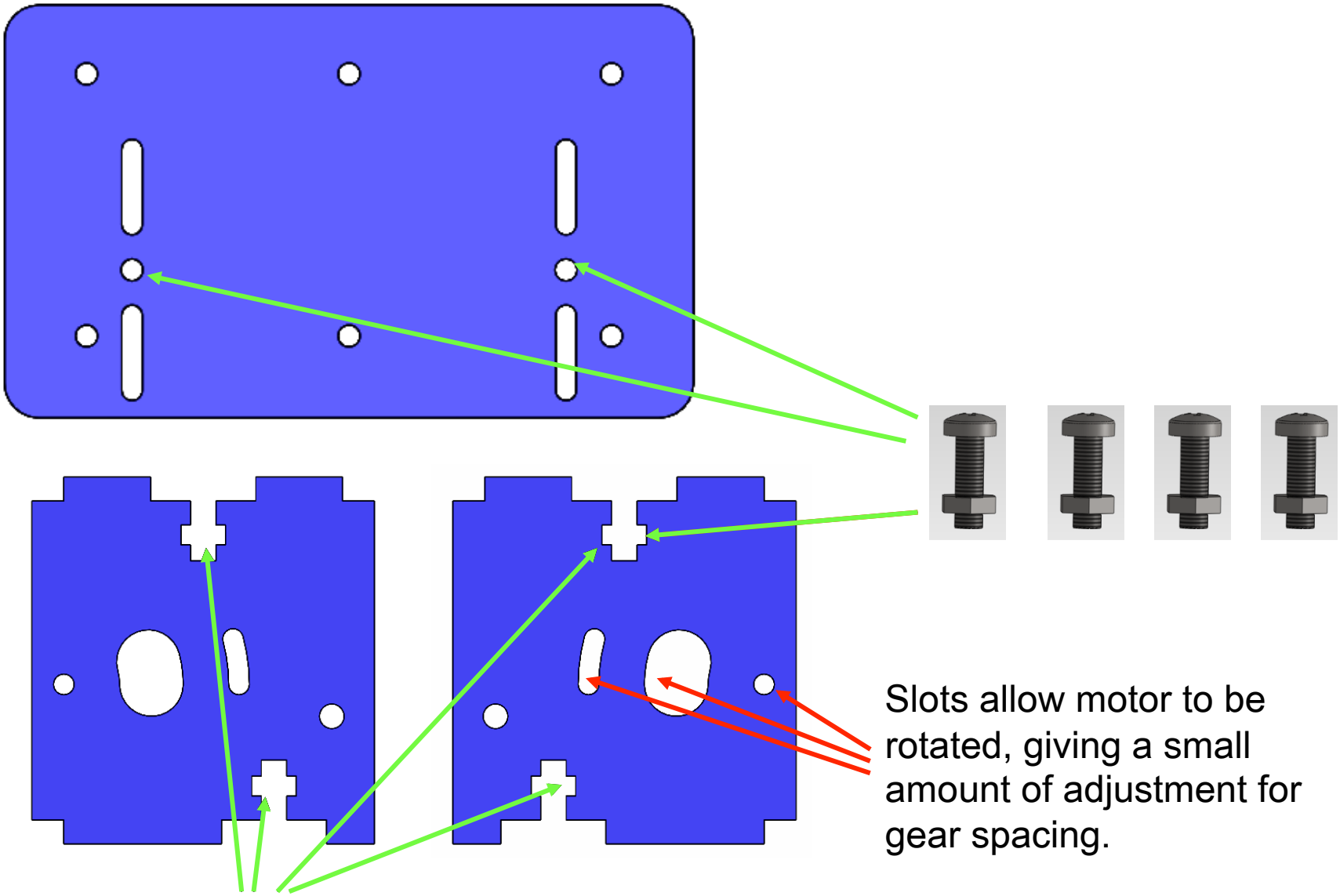


Side view showing adjuster slots for gear spacing, plus dual-purpose locking sleeves/access holes to lock the wheel components together while also giving easy access to the motor retaining screws.

LaserLine - Chassis Components (1)



LaserLine - Chassis Components (2)



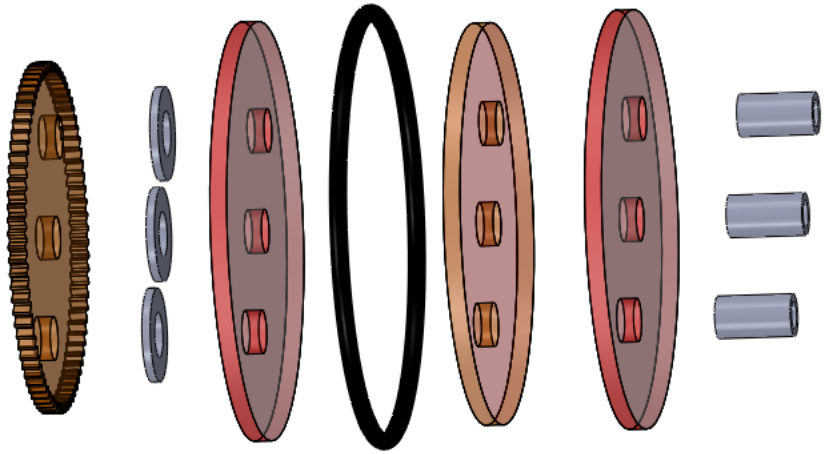
LaserLine assembly

LaserLine Wheel and Stub-Axle Assembly

Wheels and Gear

2 - 49mm x 2mm perspex discs
1 – 47mm x 2mm perspex disc
1 - 80 x 2mm x 0.5mod perspex gear
3 – M5 nylon washers
3 – M3 x 9mm nylon spacers
1 – 50mm O-ring

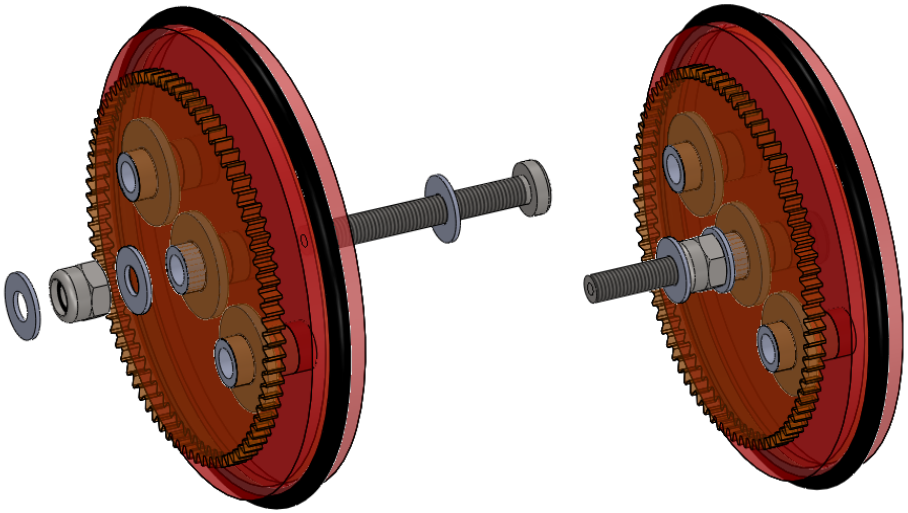
The spacers are pushed through the three discs to hold them together to form the wheel (glue may be required). The M5 washers fit over the spacers to space the spur gear away from the disc. The O ring tyre slips onto the rim.



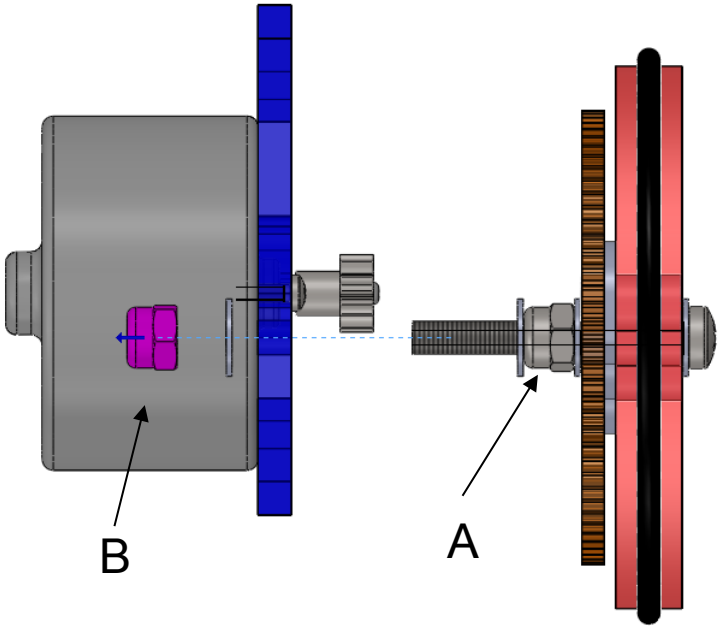
Stub-axle assembly

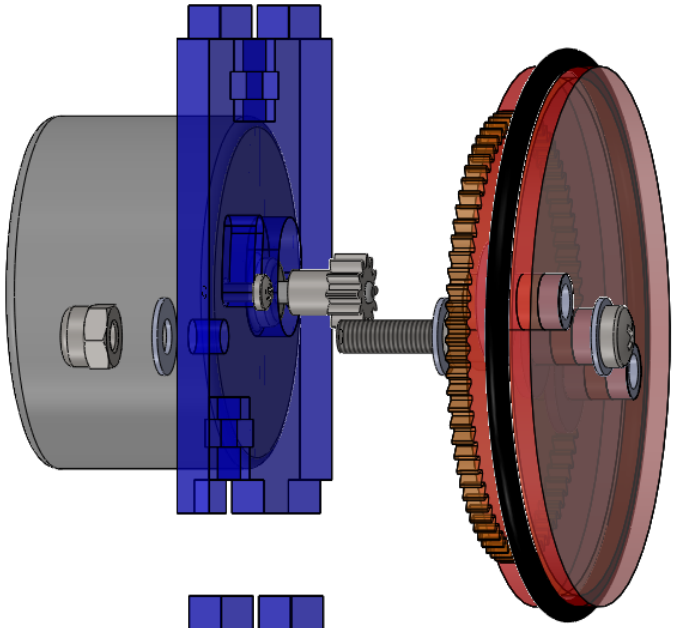
3 – M3 nylon washers
1 – M3 x 20mm machine screw
1 – M3 locknut

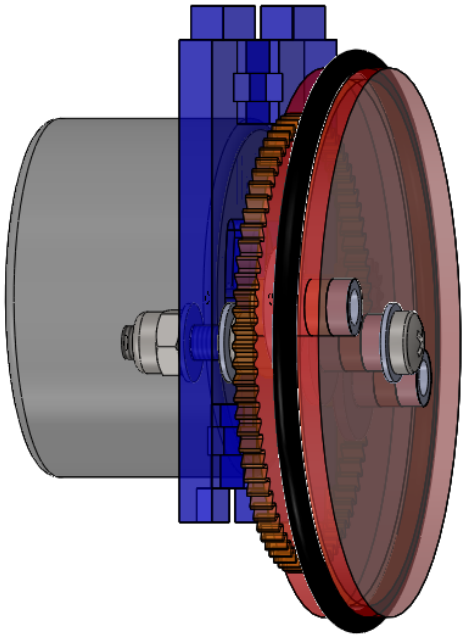
The stub-axle is a 25mm M3 screw with washers and locknut as shown.



LaserLine Drive Train Assembly





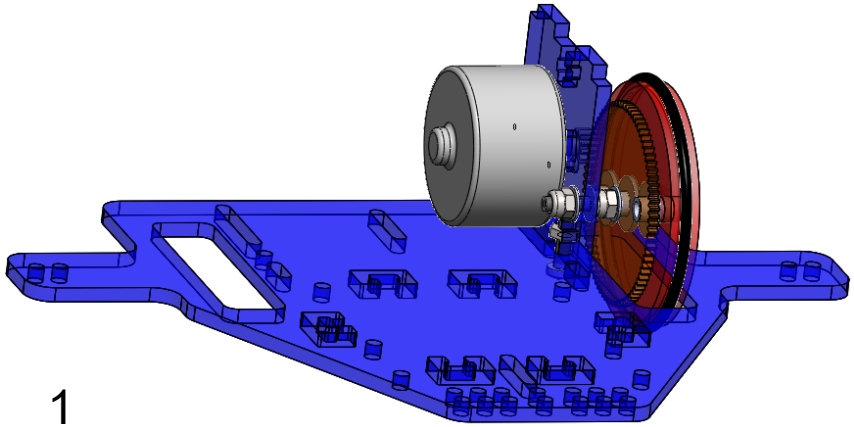


Drive train assembly –

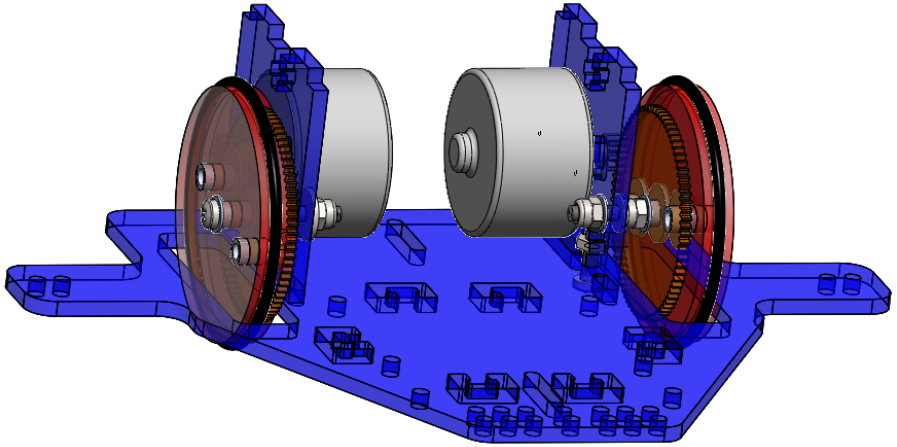
The wheel is set to rotate freely using the lock-nut A

The wheel assembly is then fixed to the motor plate with lock-nut B.

LaserLine Chassis Assembly



1



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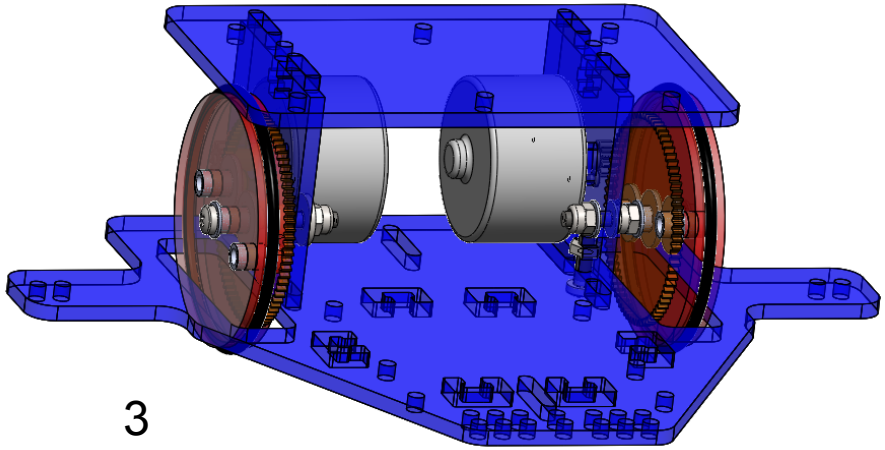

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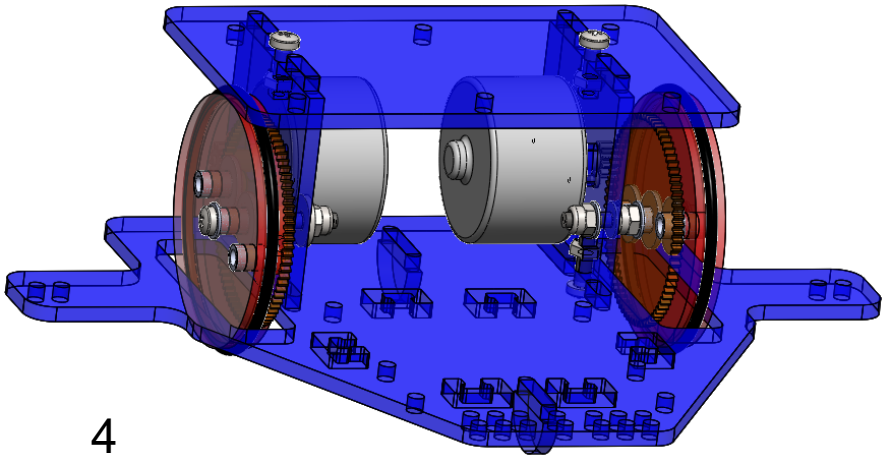

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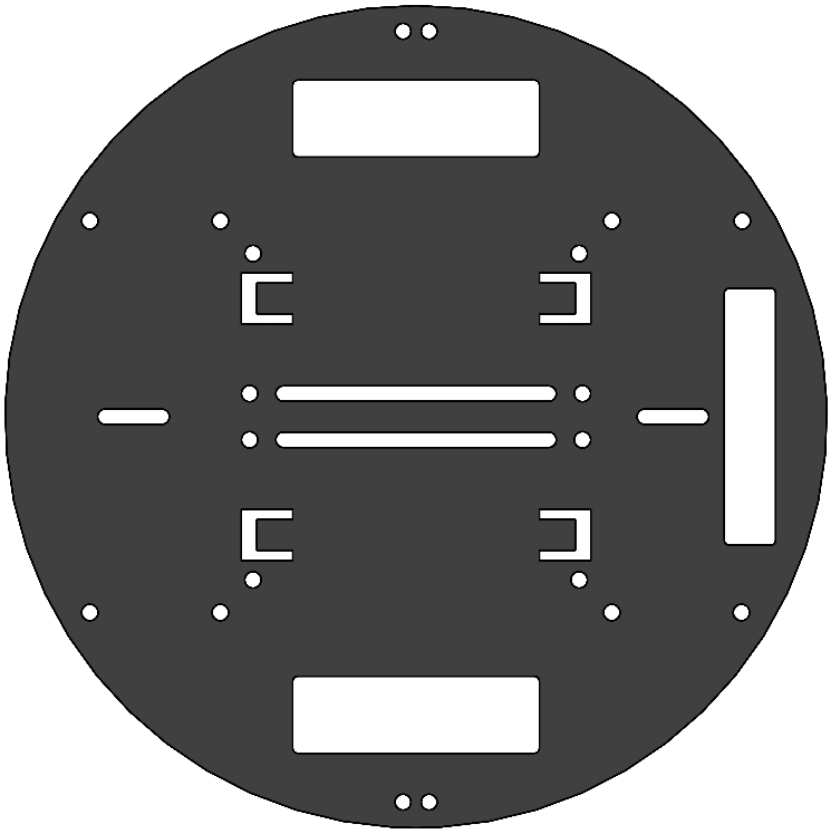
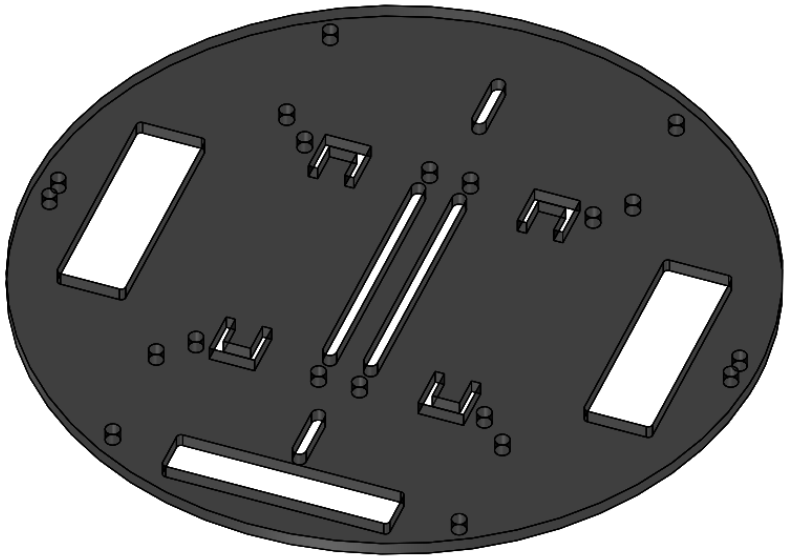
A stepper-motor line-follower

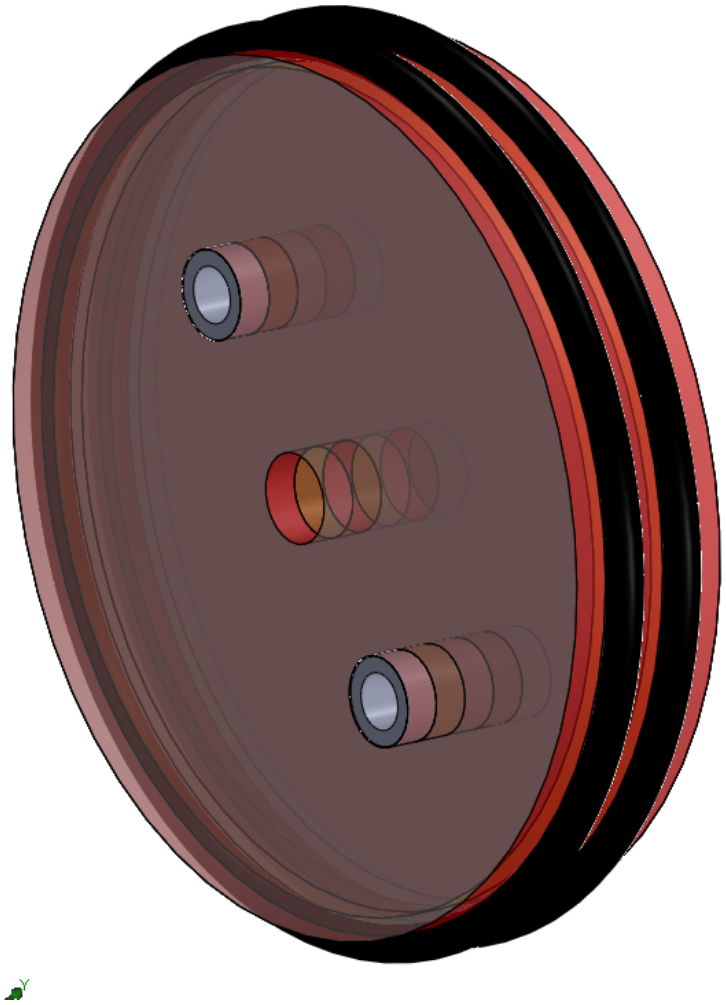




Circular base, Inboard motor-mounts:

less chance of damage to marker sensors, easier to pick up, stronger ‘box’ assembly

Double-ring wheels



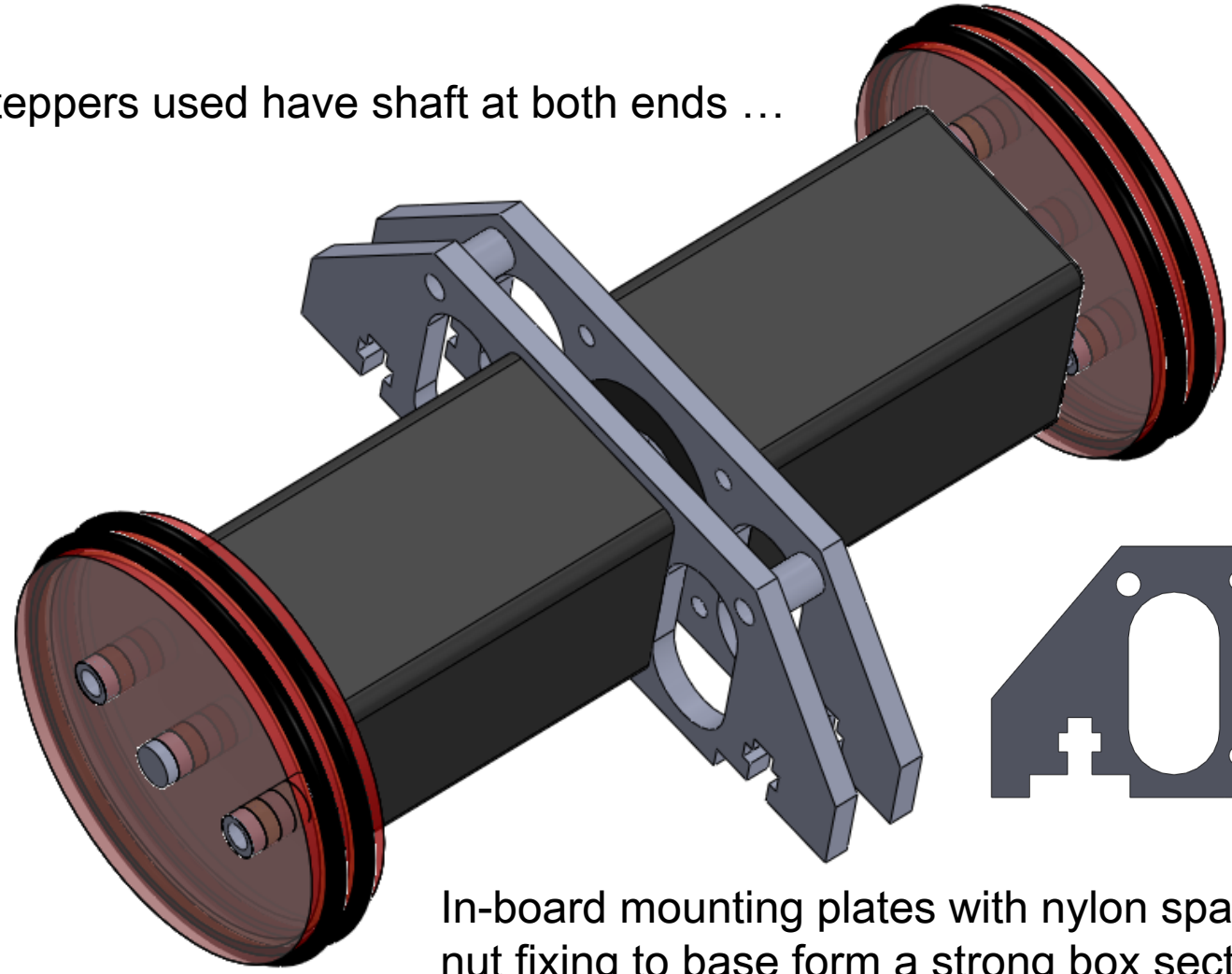
Same design for wheels but using 2 O-rings with 3 large and 2 smaller 2mm thick discs for 10mm wheel thickness.

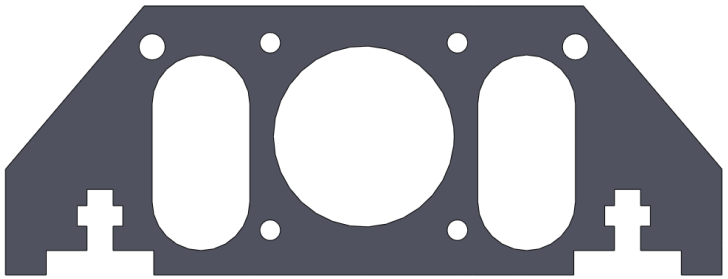
Off-the-shelf 10mm nylon spacers used to locate the discs, but this time not for the bore ….

… the wheel is bonded directly to the stepper motor shaft with cyanoacrylate glue.

Stepper motor drive assembly

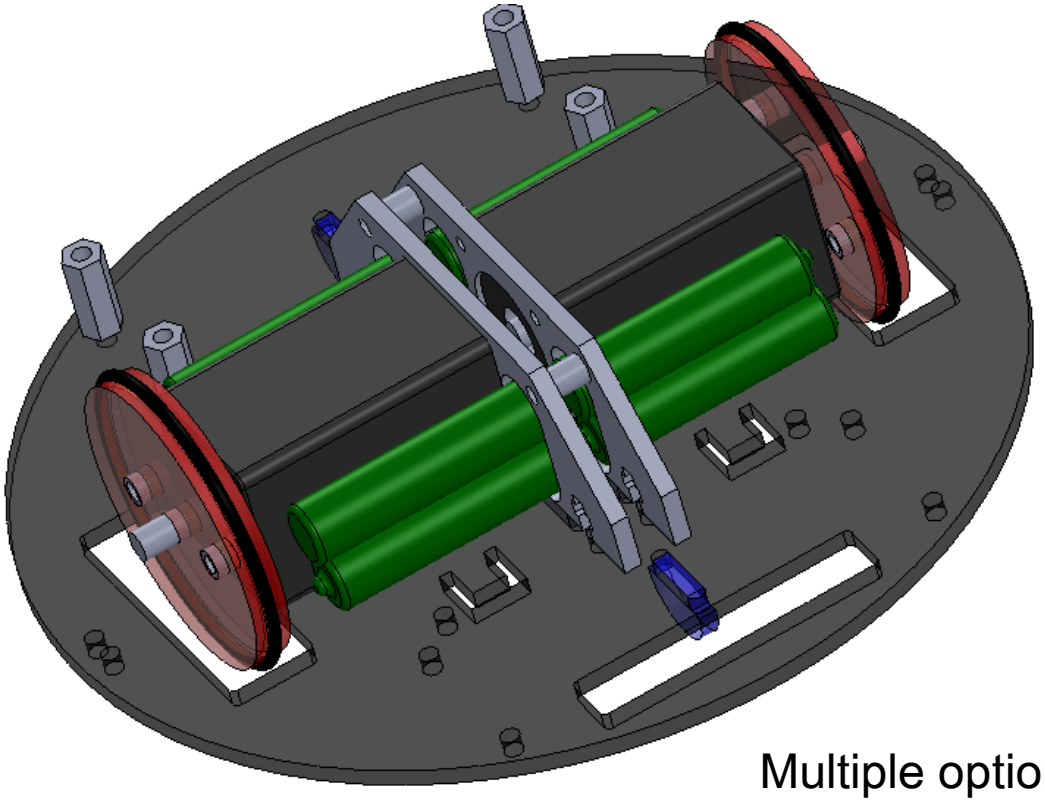
Steppers used have shaft at both ends …

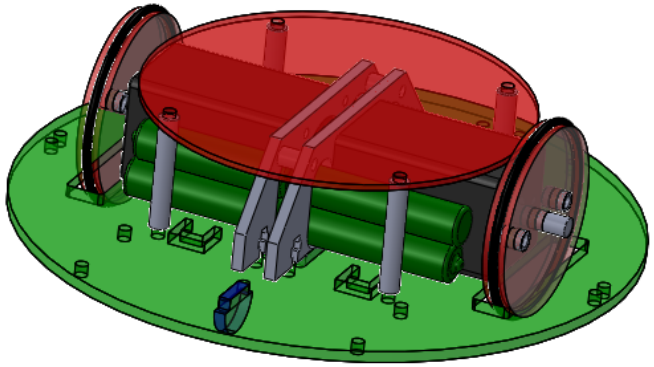




In-board mounting plates with nylon spacers and captive nut fixing to base form a strong box section from 3mm perspex. Holes in brackets hold batteries in position.

Stepper Line-Follower Chassis





Multiple options for PCB mounting

Elastic bands for battery fixing

Marker sensors on wheel axis

Slot allows for optimisation of sensor height

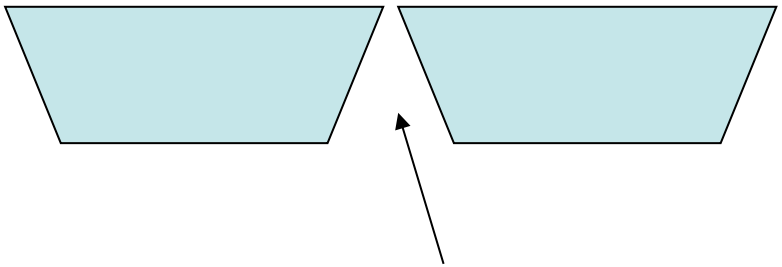
Hints and Tips for Laser Cutting

1. A laser cutter is not a saw …..

   cut width changes with depth ➔ tapered cuts

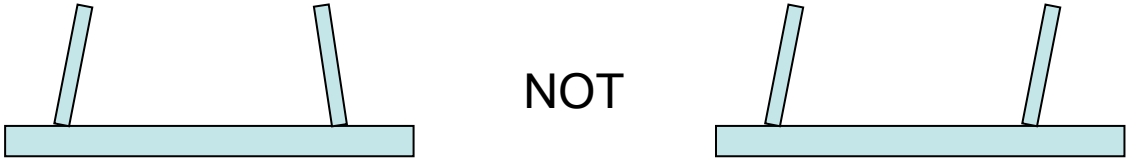
   cut width and depth change with material ➔ variable cutout sizes

   cut width and depth change with focus ➔ variable cutout sizes



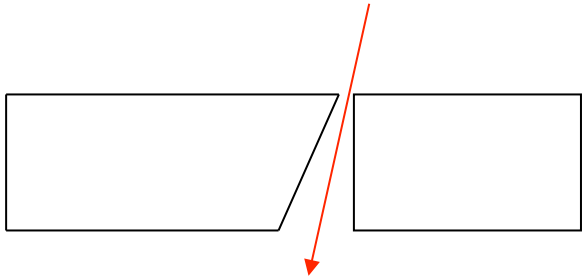
Vaporised material ➔ taper cut

Cut mirror images of mirrored assemblies … ensures that taper is opposite and can ‘cancel’ out.



Hints and Tips for Laser Cutting

Regular re-alignment of the laser mirrors is required:



Taper will be offset if the beam is not vertical
Cutting power will be reduced
Assemblies will be mis-aligned

Important to design and cut a test piece to ensure alignment is correct

Materials

So far the only plastic that does not give us significant problems for the thicknesses I need (2mm and 3mm) is cast perspex:

Extruded perspex suffers from stress cracking …

Polycarbonate/Lexan, PVC, nylon melt and/or char

➔ excessive smoke and fumes, gas and material ignite …..!

Thickness of sheet materials can vary considerably …

so design for ‘loose’ joints that can be mechanically fixed/tightened where possible

Summary

- Reproducible quality with well-specified materials
- Requires a change in design thinking to maximise potential
- Brings low-cost and consistency to robot designs
- Currently these designs are in use at Schools and University