Trev: lessons learnt

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1. 50 km is not enough testing before a big trip.

32 kg tub chassis

20 mm thick aluminium foil honeycomb boards with fibreglass skins. Floor and front compartment reinforced with kevlar.

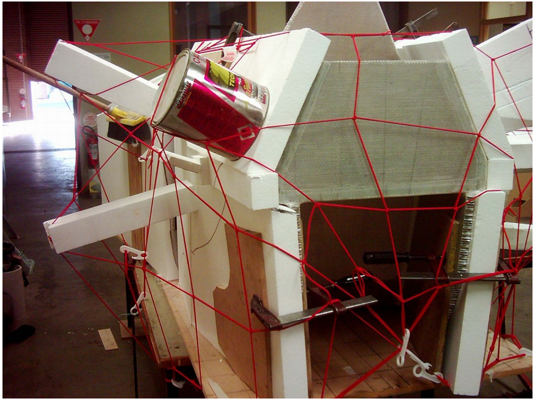
- ✔ Easy to build.
- ✔ No problems.

Non-structural foam body

Hand-carved polystyrene foam body with fibreglass skin.

- ✔ Low mass.
- ✔ Built without moulds.
- ✔ Good thermal insulation.

Non-structural foam body



- ✗ Tedious to build.
- ✗ Photographers leave elbow dents.

Moulded panels are more appropriate for a kit.

Acrylic canopy

Blown from aircraft-grade acrylic.

✔ Pillarless design gives excellent field-of-view.

✔ Side hinging and one-piece design gives good access.

✔ Much lighter than glass.

Acrylic canopy

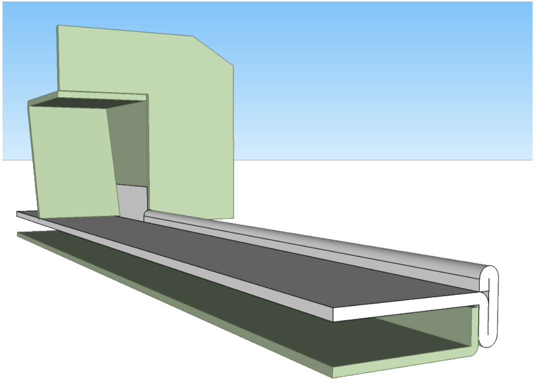
- ✗ Scratches easily. (But easily polished.)
- ✗ Needs a better seal and latching around the edge.
- ✗ The folding strut mechanism works well, but is untidy and rattles.
- ✗ Heavy to open with one arm (partly because we built up the edge to accommodate tall passengers).

Under-floor battery tray

The battery tray is made from 15 mm thick polypropylene honeycomb with kevlar skins.

- ✔ Low centre-of-mass.
- ✔ Air-mattress battery lifter.

Under-floor battery tray

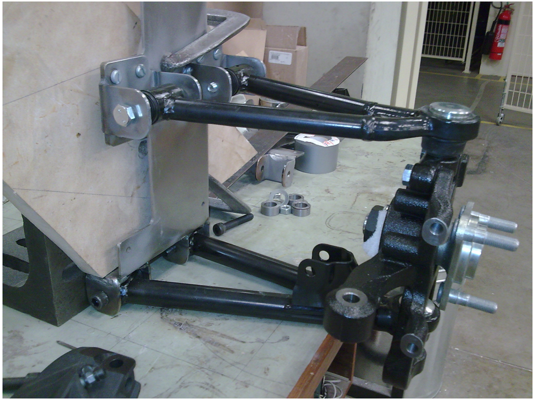


✗ Tub floor should be re-designed for an underfloor battery.

✗ Difficult to access while building and testing.

✗ High voltage connections to chargers in front compartment and motor controller under rear seat make it difficult to seal the battery tray.

Front suspension

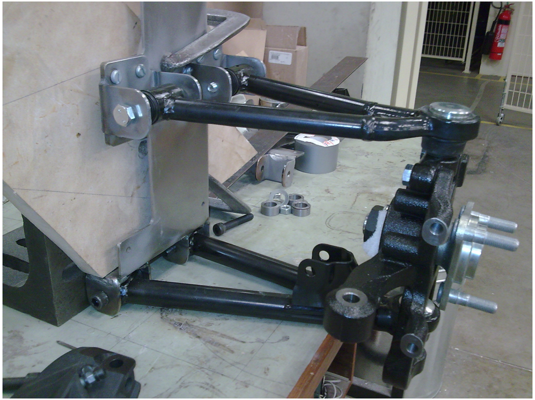


Unequal arm double wishbone suspension, designed to minimise track changes.

✔ Steel plates bolt onto the tub and wrap beneath the floor.

✗ Plates need additional vertical folds for stiffness, and better lower fasteners.

Front suspension



✗ Off-the-shelf uprights limit the steering angle.

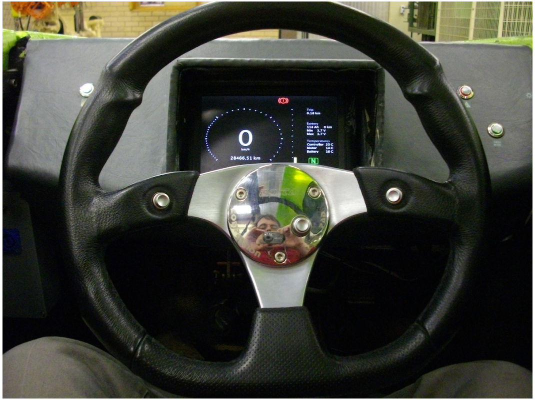
✗ Non-adjustable camber.

✗ Needs tuning to reduce body roll.

✗ Needs better noise isolation.

Next time we will design and manufacture our own.

Steering

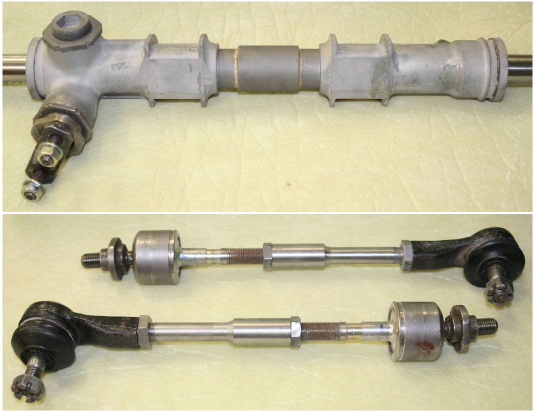


The steering rack is ahead of the front axle, which means that the steering arms point forwards and outwards. This works, but needs careful design.

✔ Small aftermarket steering wheel with collapsible boss.

✔ We don't need power assist.

Steering

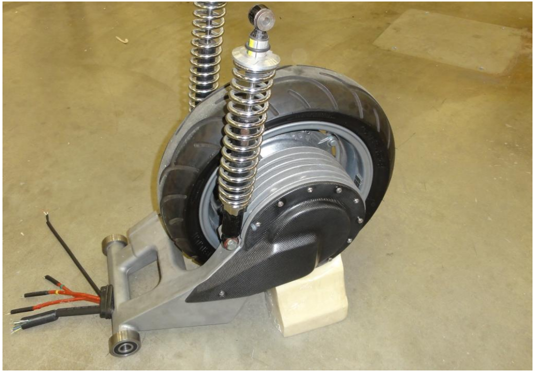


✗ Modified Diahatsu rack was difficult to fit.

✗ Off-the-shelf uprights could not accommodate the ideal steering arms—turning circle is large, steering is light.

✗ Self-centreing force is low.

Rear end



✔ Vectrix rear end was compact and easy to fit.

✗ Small motorcycle tyre.

✗ Tub should be designed so that the swing-arm pivot points are outside the car.

✗ Needs better noise isolation.

✗ Motor and reduction gear mass is unsprung.

Tyres

Trev does not need 165 mm wide tyres, but narrow car rims and narrow tyres with low rolling resistance are not available.

✔ Low-energy front tyres are barely worn after 30 000 km.

✗ Rolling resistance of motorcycle tyres is unknown, but likely to be poor.

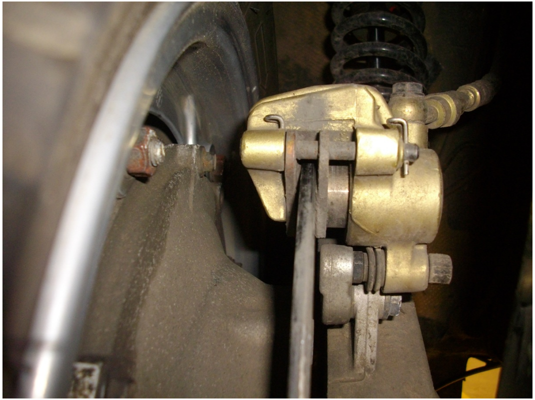
Brakes

Trev uses motorcycle disk brakes on all three wheels.

✔ 1 G deceleration, with no fading after 17 stops in rapid succession.

✔ No brake booster.

Brakes

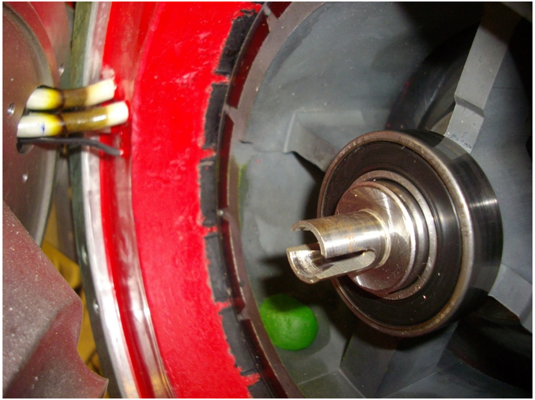


✗ You can hear the brakes! (No sound deadening, and not enough isolation.)

✗ Non-retracting calipers cause some brake drag.

✗ Regenerative braking is not yet implemented.

Motor and controller

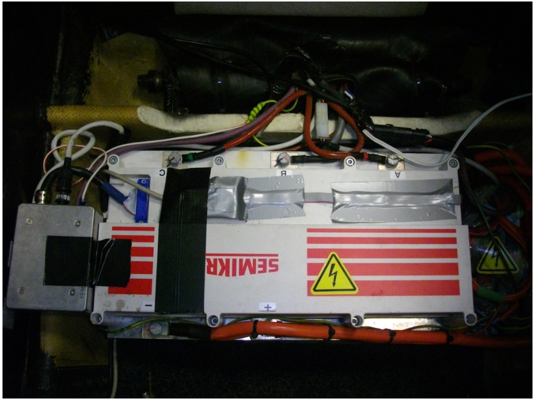


Trev has a Vectrix brushless motor with a Semikron IGBT power stage and a custom control stage.

✔ Power stage is robust.

✔ Air-cooled.

Motor and controller

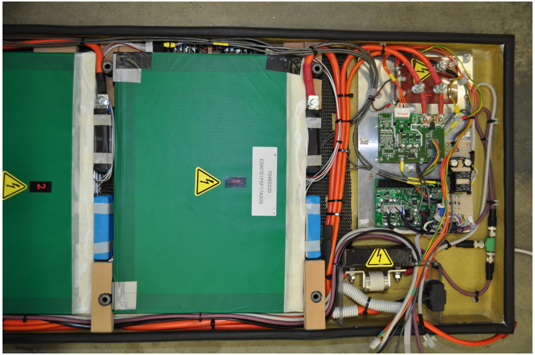


✗ Power stage is too powerful and too big (even after we hacked off half the heat sink).

✗ We need to improve our commutation (currently using simple 6-step control) and implement a more responsive torque control loop.

The motor controller should be in the battery tray, not under the rear seat.

Battery



Thirty-five Kokam 100 Ah lithium ion polymer cells, Elithion Battery Management System (BMS).

✔ Good specific energy: 160 Wh/kg.

✔ Low height: 50 mm.

✔ BMS worked well.

✗ Expensive cells: $30 000 for 13 kWh.

Charging

Trev had two Zivan chargers for Zero Race.

✔ Having the charging cable connect inside the cabin meant that the connector stayed dry and was obvious when plugged in.

✗ Low power factor means that the chargers draw more current than they use.

Charging

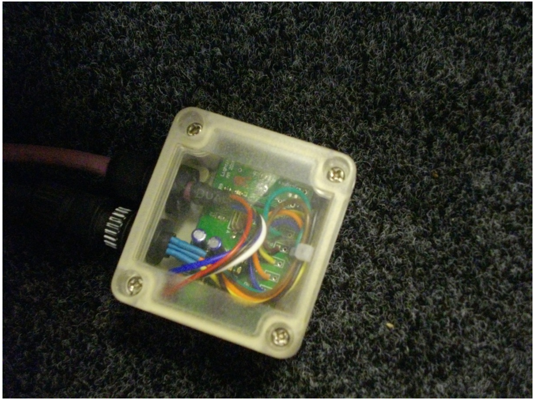
✗ Input current is not adjustable.

✗ No CAN interface.

✗ Battery management system cannot regulate charging current.

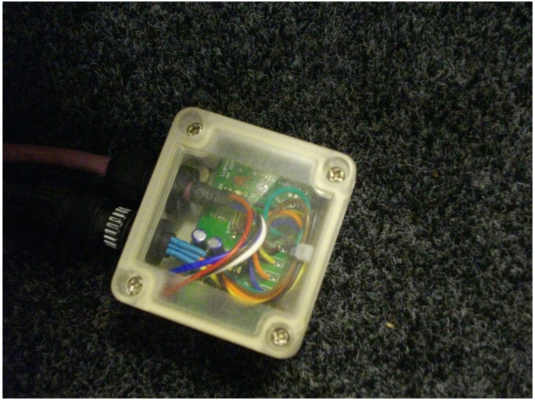
The ability to check charge status from your phone would be handy.

CAN bus



- driver control box (accelerator pedal, brake pedal, handbrake switch, light switches, horn and indicator buttons)
- battery management system
- motor controller
- dash display
- front left and front right lighting modules
- rear lighting module.

CAN bus



- ✔ Custom CAN nodes (for all but the BMS) were easy to build.
- ✔ Simplified wiring.
- ✔ Simple monitoring and data logging (CAN-USB to laptop).
- ✗ Expensive connectors (overkill).

Dash

Information was displayed on a 7" LCD screen from an AMOS 3000 12 V fanless PC with a solid-state drive, running TinyCore Linux. Software was written in Processing.

✔ Looks good, and easy to read in almost all lighting conditions.

✔ Easy to customise.

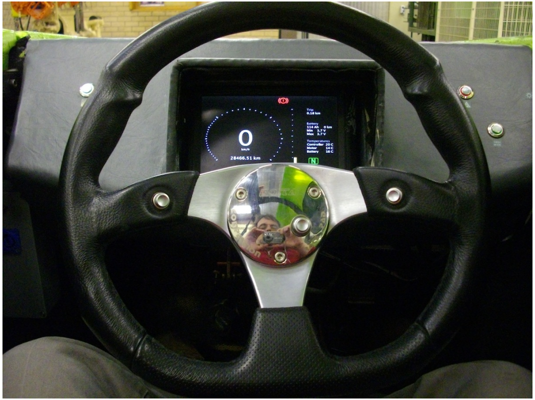
Dash

✗ Required a separate custom CAN gateway.

✗ Fifteen-second startup is too slow.

✗ Odometer value not always saved properly on shutdown.

Controls



- ✔ Backlit pushbuttons.
- ✔ Pushbuttons on the steering wheel for indicators and horn.
- ✗ Indicators not self-cancelling.
- ✗ The cable connecting to the steering-wheel buttons catches when the car is steered.

Comfort

✔ Aftermarket front seat is comfortable.

✗ Rear seat squab is too high—tall passengers do not have enough shoulder room, and we had to raise the canopy. Moving the motor controller and lowering the seat will fix this.

Comfort

✗ Needs controllable ventilation. Comfortable in cold weather if the vents are closed; hot inside if it is hot outside.

✗ Needs air flow on your face. (Fan?)

✗ The demister clears the front of the canopy, but not the sides.

Windscreen

✔ Light rain beads and flows off.

✗ The wipers work, but are ugly and scratch the acrylic.

We are still waiting for someone to design an effective, invisible, non-contact cleaning system.

Range

Predicted range was 260 km.
Maximum range was just over 250 km.
Reliable range was just over 200 km.

We need to do coast-down tests and constant speed tests to find the losses.

Range

Suspect:

- poor rolling resistance on rear tyre
- brake drag
- aerodynamic losses from 3-spoke wheels
- non-optimised motor control.

Over 95% of trips in Adelaide are less than 100 km per day.

Summary