ID HONOURS PART 2: DESIGN RESEARCH AND PROTOTYPING

nomadA

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PROJECT:

WORK-FROM-ANYWHERE CARAVAN-

MOBILE REMOTE WORKING ENVIRONMENT

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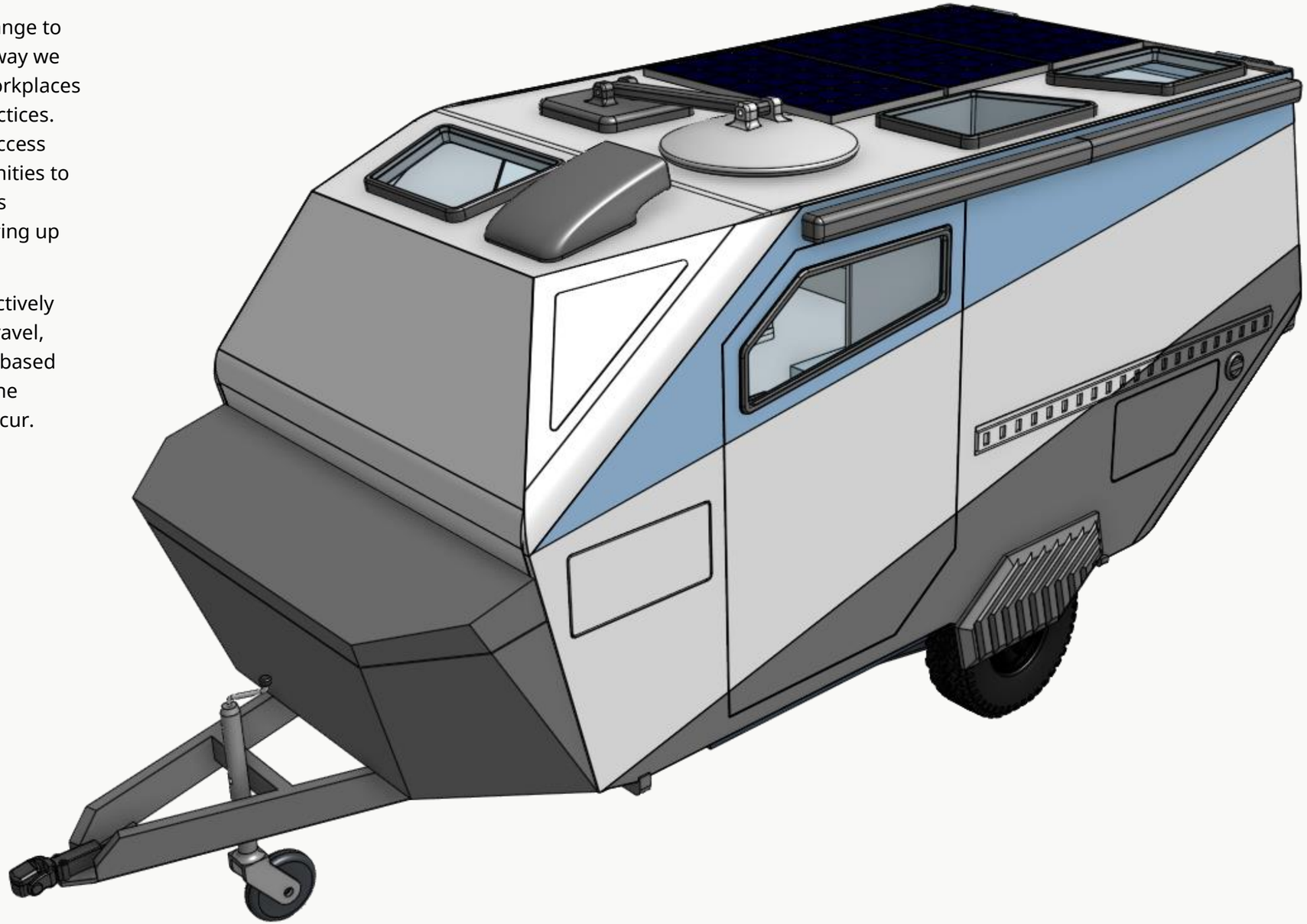
Abstract

The COVID19 pandemic has brought massive change to the way we work and travel. A major shift in the way we work has been seen in the large shift to home workplaces and widespread adoption of flexible working practices. Along with emerging low-cost satellite internet access technologies, this has greatly expanded opportunities to work remotely. Restrictions to overseas travel has encouraged many Australians to look locally, driving up demand for local, nature-based tourism.

NomadA is an off-road capable caravan that effectively facilitates the combination of remote work and travel, increasing the frequency and duration of nature-based travel experiences as well as greatly expanding the locations in which remote work can effectively occur.



Design Development

INTRODUCTION

Research into current trends within the caravan and recreational vehicle market such as consumer and manufacturing. Within caravan manufacture, issues with a large proportion of current caravan construction have shown a trend of many failures related to inefficient manufacture, as well as outdated design and construction techniques. Factors that contribute to this include the prevalence of small-scale manufacturing operations that rely on high skilled labour.

The COVID19 pandemic has brought massive change to the way we work and travel. A major shift in the way we work has been apparent the large shift to home workplaces and increase in flexible working opportunities. This, along with emerging internet access technologies, has greatly expanded opportunities to work remotely. Restrictions to overseas travel has forced Australians to look locally, driving up demand for local based tourism. With Ute and SUV sales higher than ever and interest in nature-based caravan travel, a gap to create a product to meet the needs of this emerging demographic has been identified.

Gap/trend focus

Increasing demand for nature-based local travel & remote working spaces

Goals for this project include:

- Improving employee wellbeing in a remote work environment
- Expanding the locations in which remote work can effectively occur.
- Provide an affordable and mobile work environment.

Design question

How might we….

re-imagine a mobile environment

to improve the experience of remote working?

SURVEY

Introduction

A survey was created to gain insight into the lifestyles and mindsets of people that value nature-based travel and work remotely, as well as drive the size, feature and budget constraints for the Caravan/Vehicle design.

The aim of this survey was to identify priority features as well as pain points, beliefs and attitudes of those wanting to travel whilst working remotely.

Baseline questions were taken to establish the viewpoint of the survey respondent.

Likert scale used to provide more objective data that gives a point of comparison between different data points as well as being easily understood and relatively quick to complete.

The survey was then posted to 7 Facebook groups after admin approval, these groups included:

- Vanlife Australia
- Caravan & Camping Australia
- Caravanning with Kids Australia
- Self-Build Campervans (Vanlife Australia)
- Planning a Lap of Australia - Hints and Tips

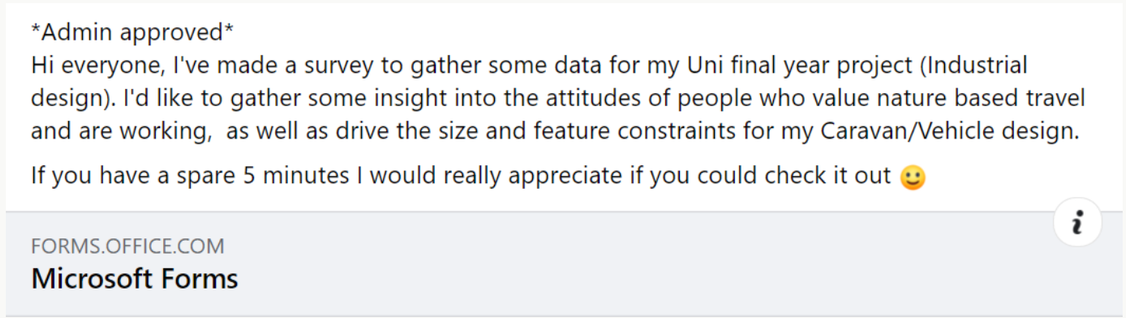


Figure 1 Facebook group post (2021) by Callum Poon
https://www.facebook.com/ (various groups)

Although the Facebook groups all included more than 12,000 members each, the visibility of the post was relatively low and a total of 16 responses were recorded.

The full results of the survey can be viewed in appendix A.

DESIGN REQUIRMENTS

The following summarises the findings and design requirements gained from the survey:

Remote working requirements:

- Ergonomic seating
- Natural light
- General storage space
- Consideration of the use of conference tools

Packaging requirements

- Protection from weather – rain/cold/wind/heat
- Ability to sleep 2 people with a fixed or low effort bed setup
- Ease of camp/accommodation site setup
- Ease of packing for a trip
- Ability to be self-sufficient for 6-7 days (power, water, food)
- Ability to sleep 2 people
- Cooking facilities
- Easily towable by a large SUV
    - less than 2700kg gross mass [fully loaded], less than 2200kg tare [empty]

Although expanding and folding features such as a pop top and fold out beds are compact and can add functionality to a smaller space, a number of disadvantages make them unsuitable for the vehicle I wish to design. These include: lack of insulation, potential for mould & leaks and setup difficulties. From the information gathered in this survey and talking to a caravan repair expert, a decision was made to avoid this type of design.

Bed layout

Having a fixed bed that requires minimal or no setup was required as it was found to be a high priority for almost all of the survey respondents.

This was also backed up by the experience of many caravan & vanlife YouTube channels that I watched, which featured those with experience living in campervans and caravans. Many of those with a bed that required over 2 minutes of setup would commonly leave the beds permanently set up.

Design criteria

PACKAGING OPTIONS

Campervan/expedition vehicle

Advantages:

- Able to travel into cities easily
- Does not require towing
- Quick setup time

Disadvantages:

- Lack of mobility when set up at campsite/remote working location as the vehicle cannot be separated from the campsite

Figure 2 Roadtrip van (2021) by Daniel J. Schwarz https://unsplash.com/photos/SQpl_GGORl4/info

Cost:

Large vans are expensive to buy, maintain and run. E.g., 2021 Mercedes sprinter 4x4 (vehicle only) starts from $67,990, commonly over $120,000 when fitted out. As this would be an additional vehicle, costs such as registration, insurance and maintenance would need to be factored in as well.

Camper trailer

Advantages:

- Lightweight & compact size
- Easily made to handle rough terrain

Disadvantages:

- Very poorly insulated
- Long setup time

Cost:

Camper trailers are relatively affordable, typically ranging from $10,000 for a more basic setup, to $60,000 or extreme off-road versions.

Figure 3 Camper trailer (2019) by Brendan Batty https://www.carsguide.com.au/adventure/advice/australias-top-6-forward-folding-camper-trailers-73470

Towable Caravan

Advantages:

- Flexibility to upgrade car and caravan independently.
- Cheaper to maintain
- Easier to insulate
- Better road comfort (car suspension is typically more refined than commercial vehicle/van suspension)

Disadvantages:

- Less convenient to haul around due to size and weight
- Difficulty navigating around tight areas and reversing

Figure 4 Full size caravan (2020) from Australian Motor Homes & Caravans http://www.australianmotorhomes.com.au/new-caravans

Cost:

Cost ranges from $50-100 thousand for a typical full-sized caravan from 14ft-22ft (4260-6700mm) long.

Design criteria

LEGAL DIMENSION REQUIREMENTS

Vehicle Standards bulletin VSB1 outlines the requirements that trailers of less than 4,500kg must comply to in Australia.

Max width:
2500mm including all exterior mounted components.

Max height:
4300mm

Max length
12,200mm total length

USAGE FACTORS

This vehicle is intended to serve as a base for remote work to be undertaken alongside nature-based travel and intended for free-camping use rather than stays at caravan parks. This will support the emerging hybrid work schedule and a growing lifestyle choice.

The following factors should also be accommodated for:

- Capable of 1-week trips off the grid
- Sleeping for 2 including indoor and outdoor workstations
- Priorities:
    - Ease of setup
    - Ergonomic seating
    - Natural light
    - Increasing length of trips

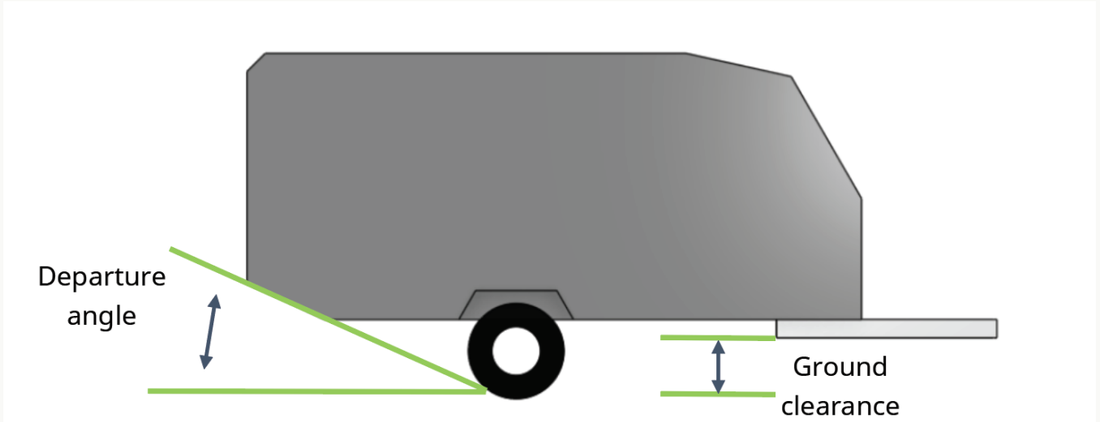
With the emergence of accessible satellite internet, this vehicle would not be limited to traveling within populated areas with traditional internet access. This means that the restriction to possible destinations is now much less restrictive, and a vehicle accommodating remote work using this technology is not bound to the same restrictions.

OFF ROAD FACTORS

Ground clearance

Off road caravans typically have **at least 300mm** of ground clearance to its lowest point, with more capable vehicles boasting over 500mm of ground clearance (Patriot Campers, 2019)

Departure angle – this is where most caravans will get hung up on when the rear end of the caravan touches the ground. Typical off-road caravans feature a **departure angle of 20-30deg** (AOR, 2020), but caravans that are more capable feature a departure angle over 40deg.



Overall size

Width of a typical full size caravan ranges from 2300-2400mm, however, full sized caravans that are off road orientated typically reduce the width to under 2200mm as this allows accessibility to more off-road tracks.

The overall length of the caravan affects the vehicles turning circle, and increasing the length also increases the caravan's overhang, which negatively affects departure angle. Off road caravans have a body that is typically less than 18ft (5486mm)

The height should ideally be as close or lower than the vehicle towing it. A typical off road 4x4 vehicle has a height around 2000mm, and when loaded up with roof accessories such as a rooftop tent, the total height is closer to 2500mm.

Due to the tighter spaces in which vehicles travel within an off road environment, the caravan A-frame must allow adequate space for the tow vehicle to turn.

SIZE CONSTRAINTS

Interior space

This caravan needs to accommodate standing inside. With this in mind, anthropometric data was looked at to set an interior height that would accommodate a majority of people.

Anthropometric data (Tilley, A. R., & Dreyfuss, H. ,1993)

99 percentile man: 1920mm

90 percentile man: 1846mm

50 percentile man: 1755mm

Given that excessive height will hamper this vehicle's ability to transverse more difficult terrain, the minimum interior height is set based on a 90th percentile man, and given that men are statistically taller than women, this would accommodate at least 90% of the population.

Interior height: **1850mm**

Exterior size constraints

As the Caravan is designed to incorporate satellite internet access technologies, this will enable remote work to be done far away from caravan parks and in locations that are more difficult to reach.

Considering this, off-road caravan dimensions were evaluated, and the constraints are set as per the figures below:

Overall height: 2800mm

Overall width: 2200mm

Overall body length: 5200mm

Functional requirements

- Must be towable
- Must include a doorway to enter vehicle
- Includes sleeping space for 2 or more
- Includes 2 or more ergonomic workstations

Objectives

- Enables users to effectively expand locations in which remote work can effectively occur
- Suitable for renting out via peer-to-peer services
- Easy to operate and use for unfamiliar parties

Constraints

Must fit to the following size constraints:

Less than 2200kg tare weight (unloaded)

At least 80mm of suspension travel

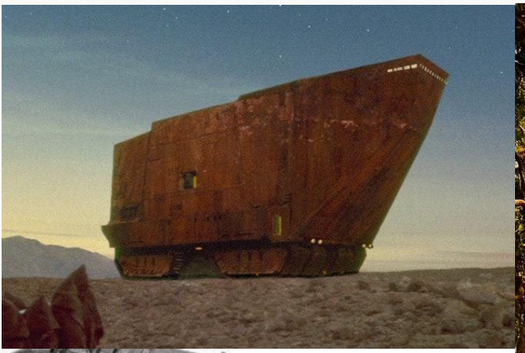
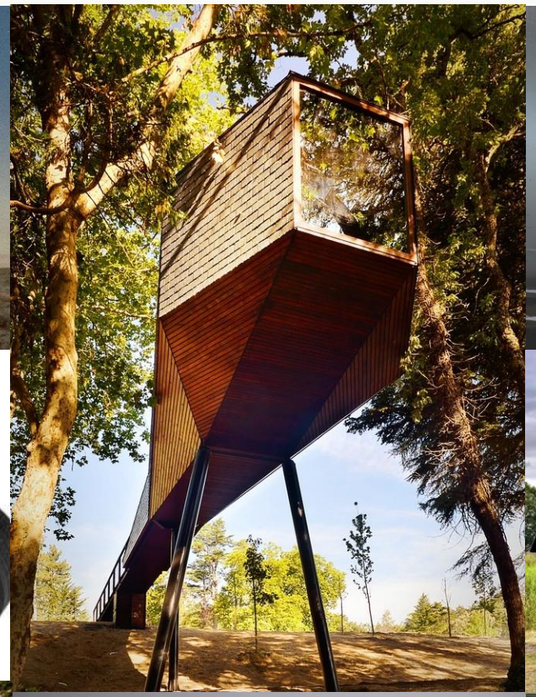
At least 20deg departure angle

Doorway must be on passenger side of vehicle as a legal requirement.

Exterior shape – mood board

As this caravan would be used very differently from caravans currently on the market, the exterior shape would be important to visually distinguish its utility from current designs.

Considering the Australian caravan manufacturing environment, the shape would also need to be easily manufacturable by smaller manufacturers.





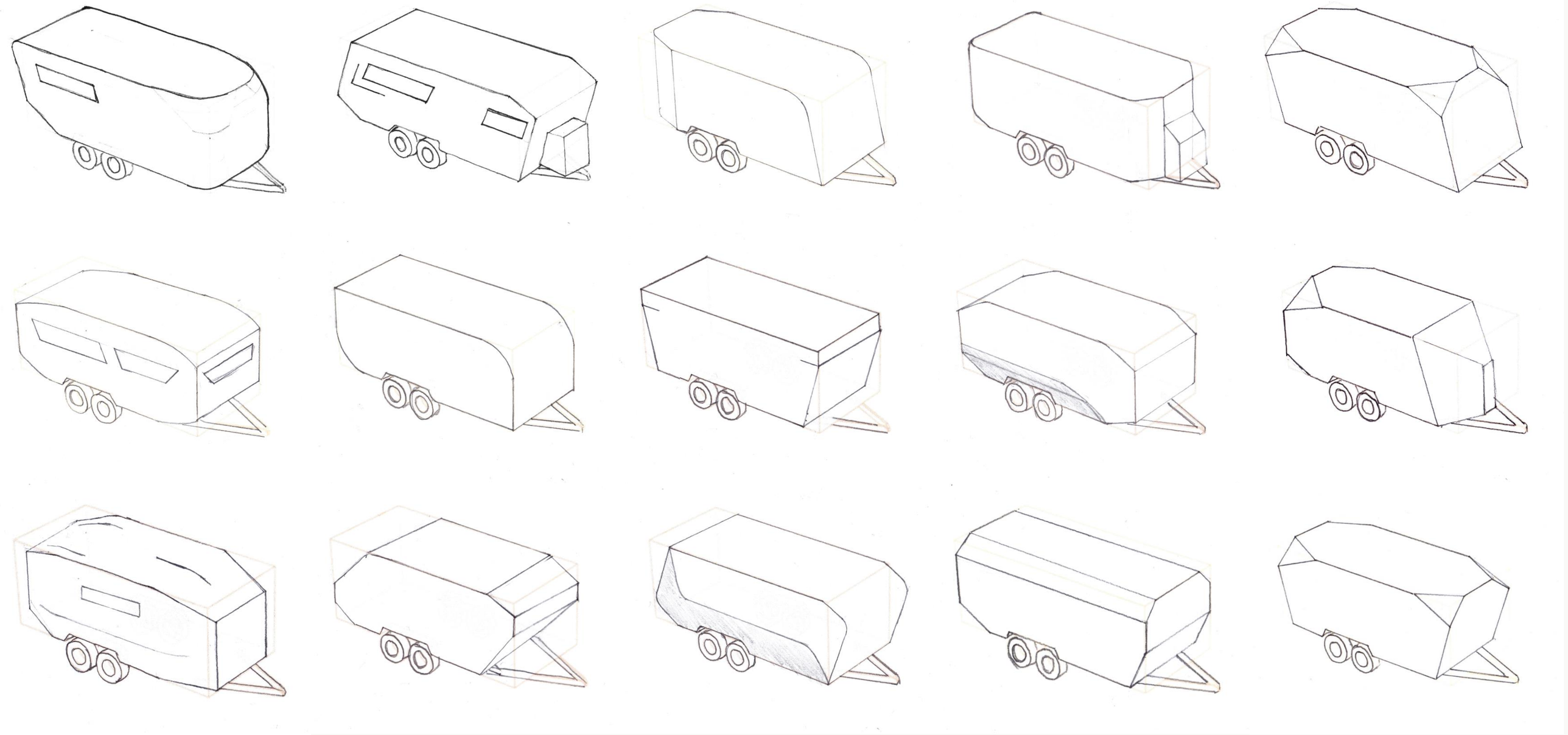





Outer shape ideation

An exterior box shape outlining exterior dimensions was used to guide the shape of the package, and different shapes were sketched.

A box shape of dimensions 2150H, 2400W and 5500L (18ft), which was later revised to be smaller and include only 1 axle.

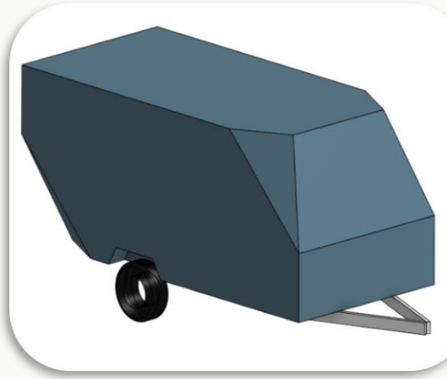


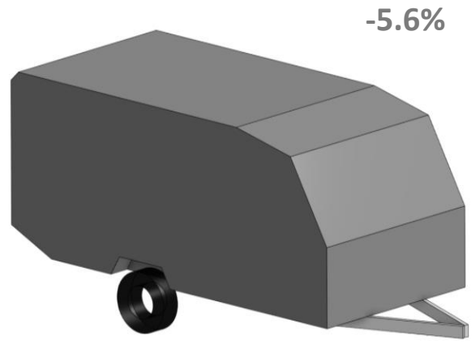
Exterior selection options

Narrowing the design options left the following 6 options. Referring back to the personas, no.3 and no.5 were chosen as they are more distinctive from current caravan designs, which would differentiate it to traditional products

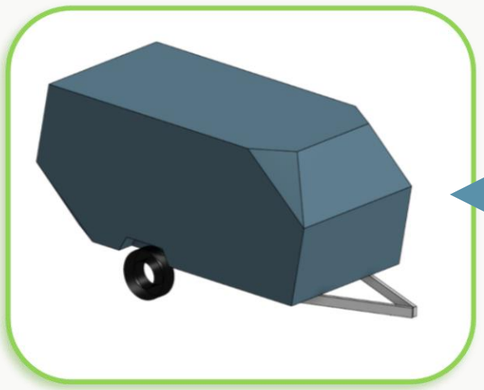
To analyse the space loss from the various shapes, some of these models were drawn into CAD. Compared to the shape of a traditional caravan, no3 and no6 did not lose more than 2.2% of the volume.

No5 results in a more usable interior space, as the roof does not encroach as much into headroom. As well as including more interior volume, it was the chosen exterior shape.



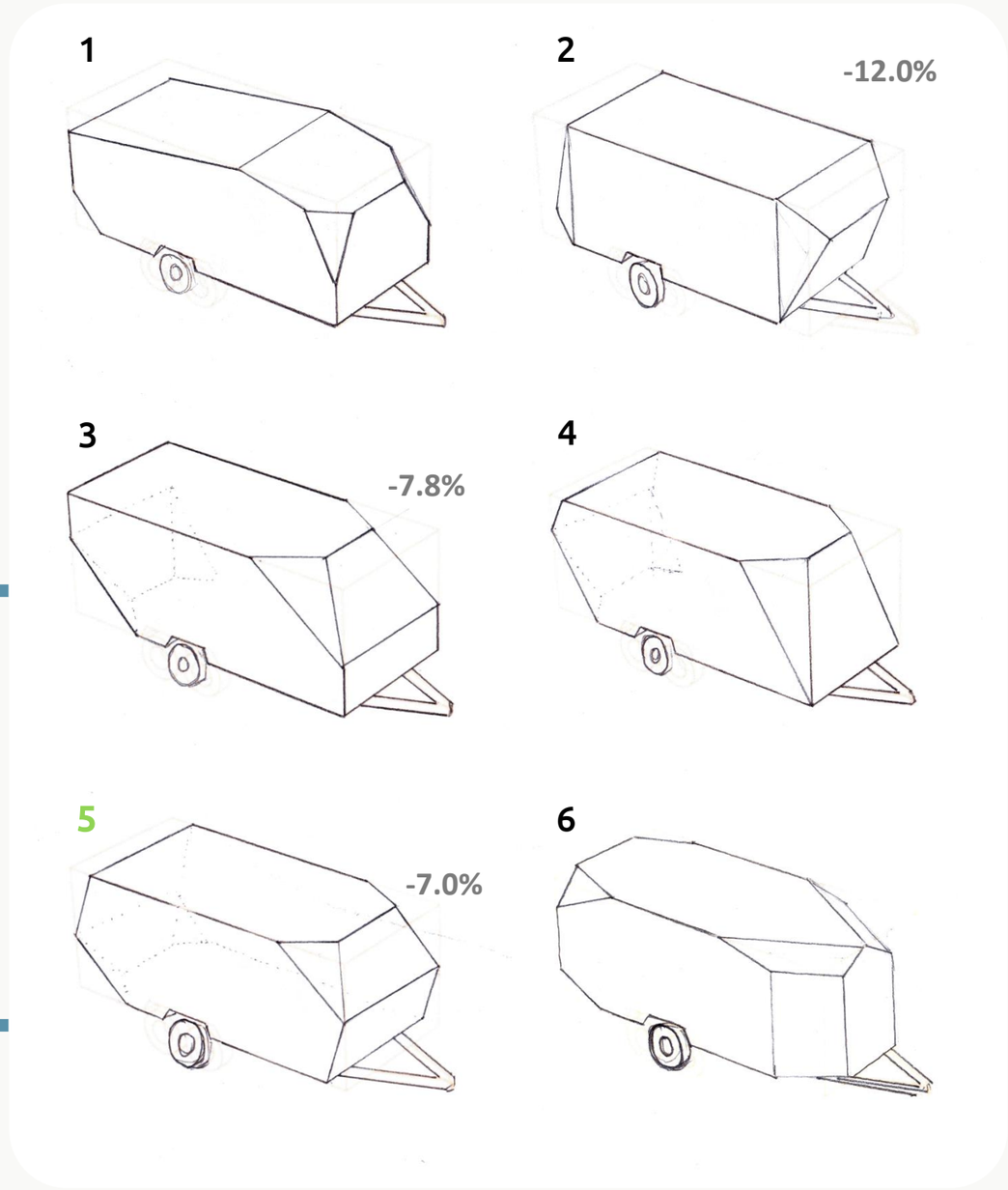


Traditional caravan shape



CHOSEN DESIGN

% Loss in volume compared to rectangular prism



Exterior – Composite panels

Fiberglass/polyurethane foam composite panel is currently used extensively to manufacture the shells of most modern trains and truck bodies. Due to its excellent thermal insulation properties, relative toughness and light-weight construction, it is also an excellent material for use in a caravan.

Superior insulation properties means that the caravan will be more suitable for use in a wider range of climates and its light-weight nature means that either more payload can be carried or less powerful vehicles are able to tow it.

The fiberglass/polyurethane foam composite panel is able to “bend” using relief cuts, similar to how plywood can be bent using a similar technique (see Figure 5). This allows the side panels of this design to be one piece, increasing strength and reducing the assembly needed.

These panels would then be bonded to the chassis and the other panels, which is the same method in which modern trains and trucks are built with when using similar fiberglass/polyurethane foam composite panel.

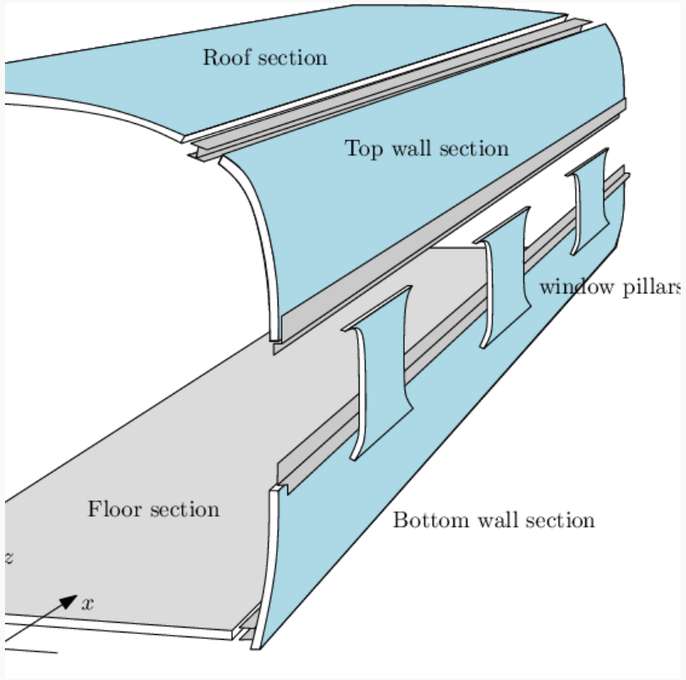


Figure 6

Figure 5 fiberglass/polyurethane foam composite panel with kerf cuts

https://www.semanticscholar.org/paper/Light-weighting-Methodology-in-Rail-Vehicle-Design-Wennberg/5348b12579789b2fb9ab7fbb0fb0a9a2cf6d9c28/figure/0

CAD – Exterior panels

Sheet metal tools in Onshape were used to create the exterior panels. These can then be CNC cut from fiberglass/polyurethane foam composite panel. This sets the interior constraints and allows the interior layout to be visualised more accurately.

As CNC machines are readily available and accessible for most smaller caravan manufacturers, this technique of manufacturing allows for an assembly process that is more straightforward, decreasing the reliance on skilled labour and opportunities for error, whilst also increasing precision.

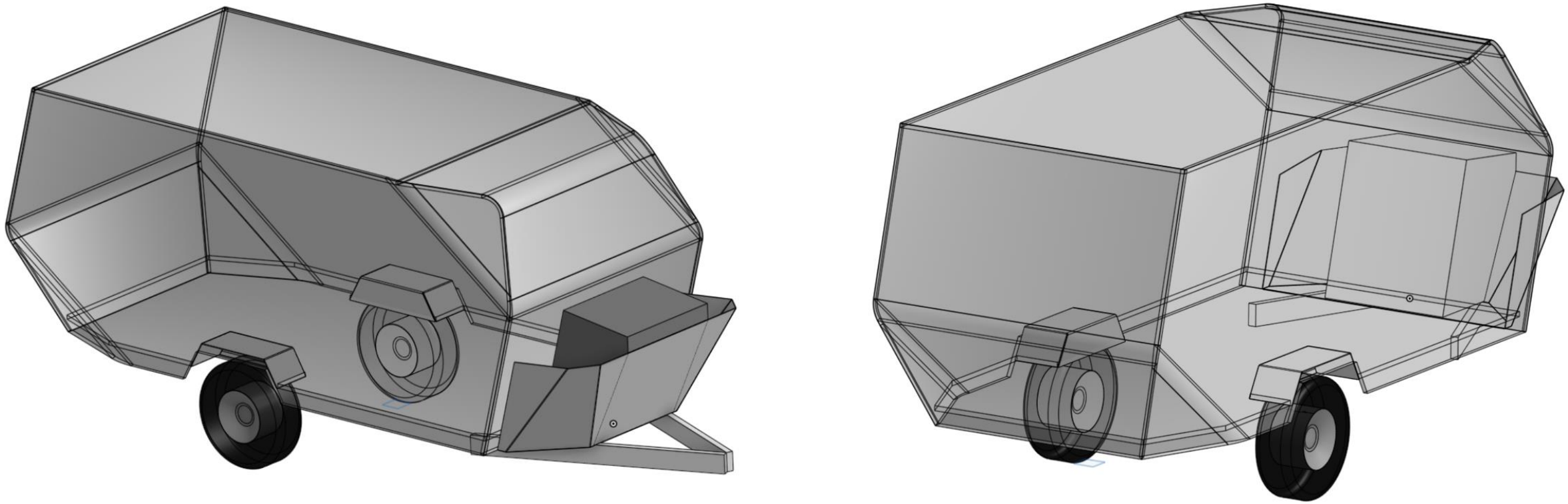
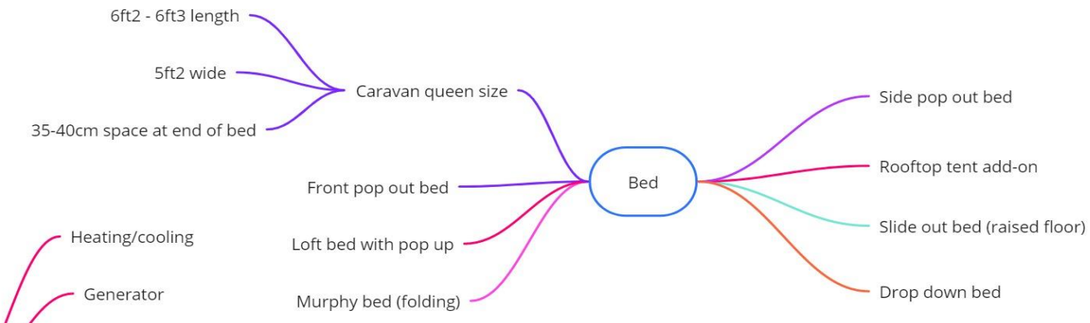
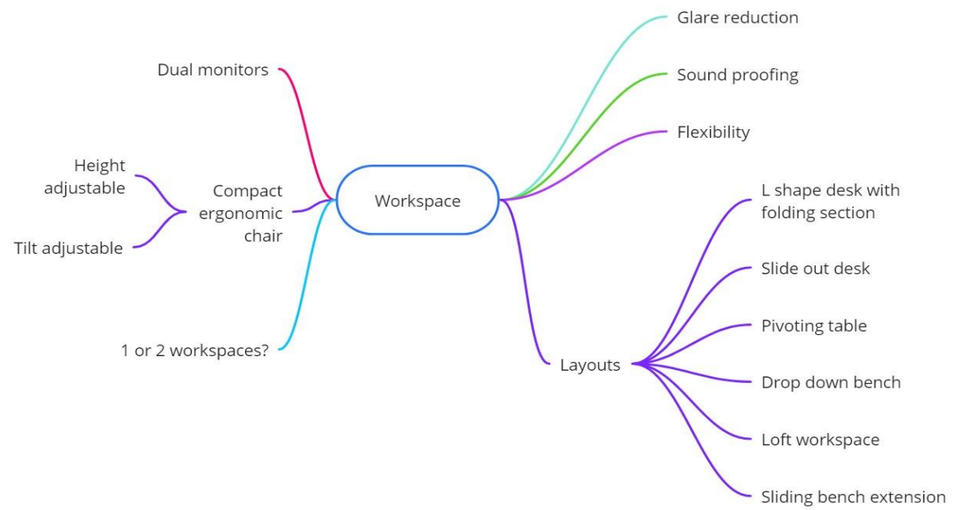


Figure 7 CAD model of exterior panels in Onshape

Brainstorming

Feature, sleeping arrangement & workspace ideas





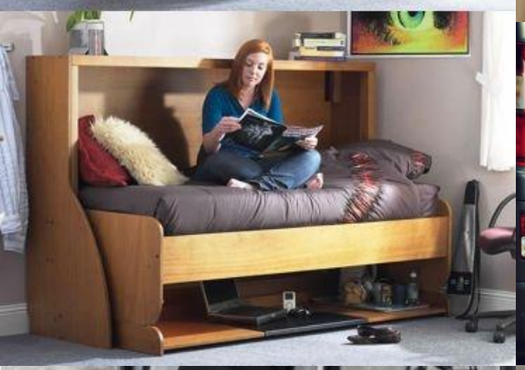
Mood board – Use of small spaces









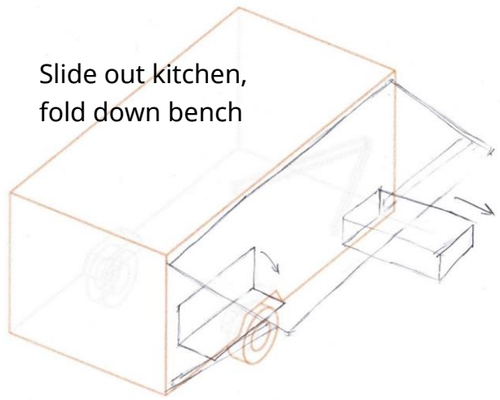




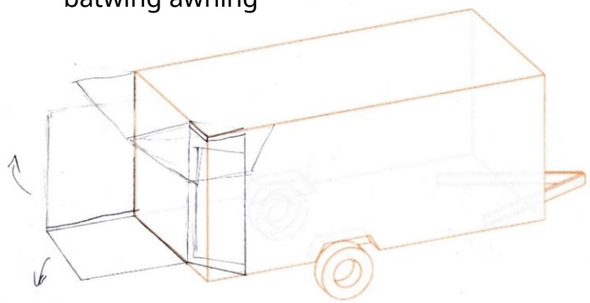

Sketching – Exterior space solutions

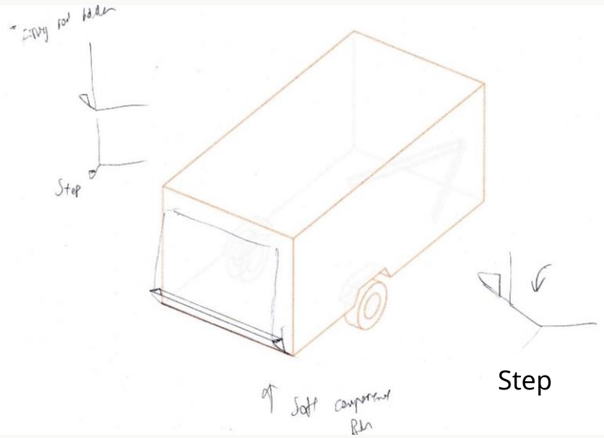
Using an outline of a CAD body of the exterior dimensions, several space and storage utilisation ideas were sketched.

Slide out kitchen,
fold down bench



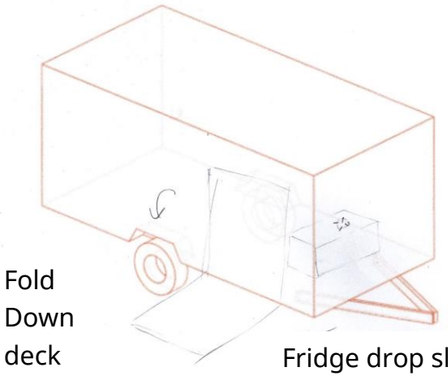
Fold out deck,
batwing awning





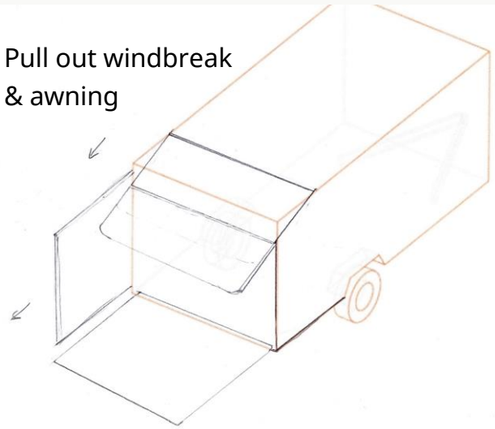
Step

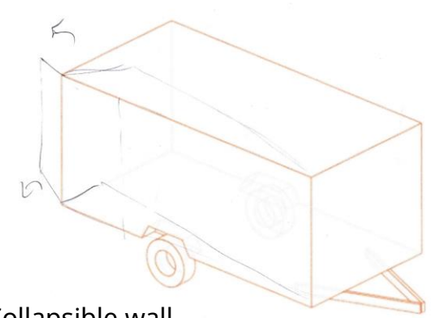
Fold
Down
deck



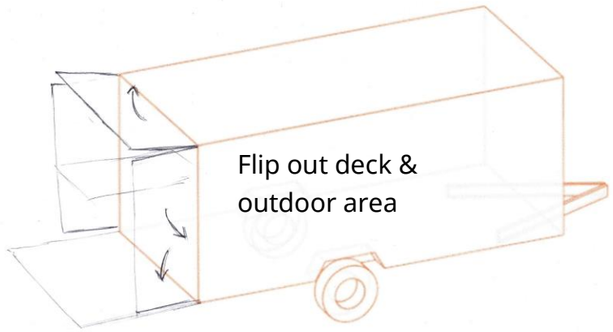
Fridge drop slide

Pull out windbreak
& awning



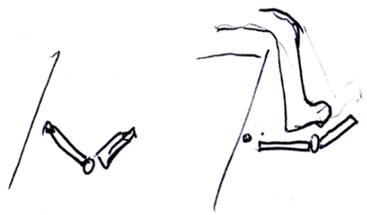


Collapsible wall
section

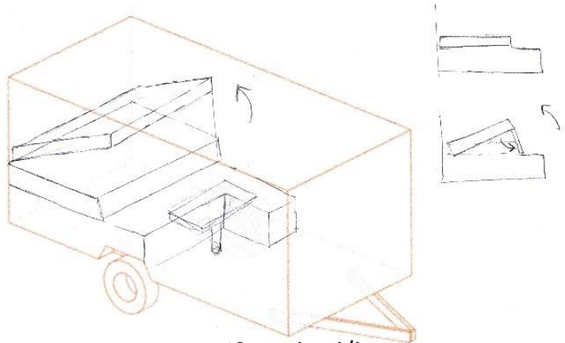


Flip out deck &
outdoor area

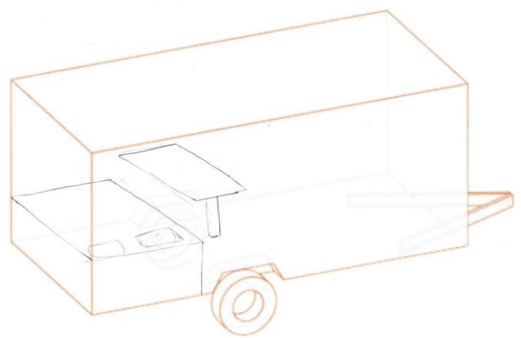
Rear drop down
footrest



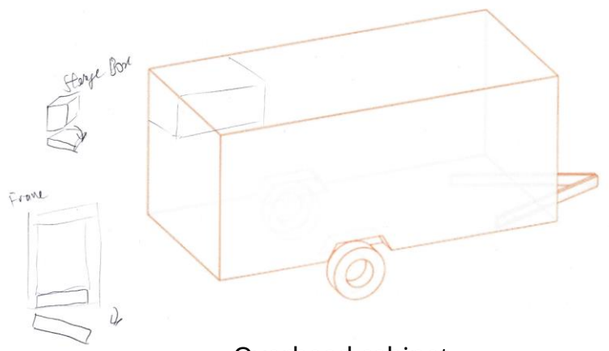
Sketching – Interior space & storage solutions



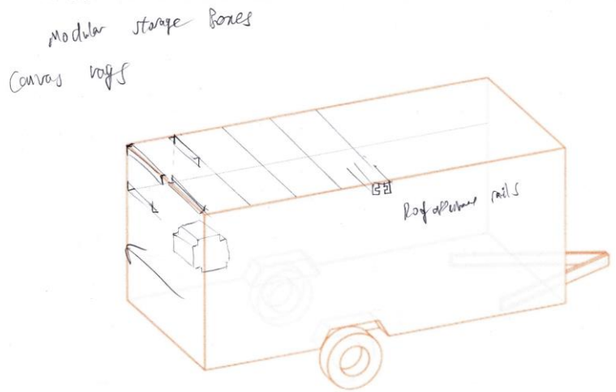
Lift up bed/lounge backrest



East-west bed configuration

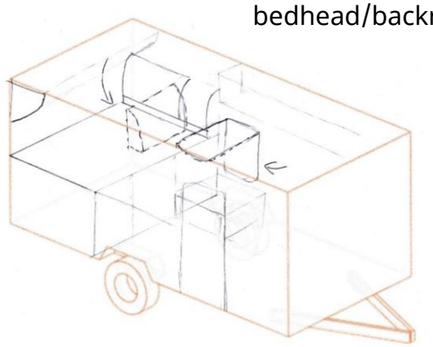


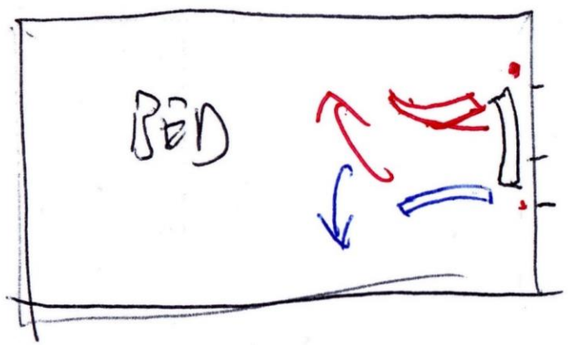
Overhead cabinet – storage underneath



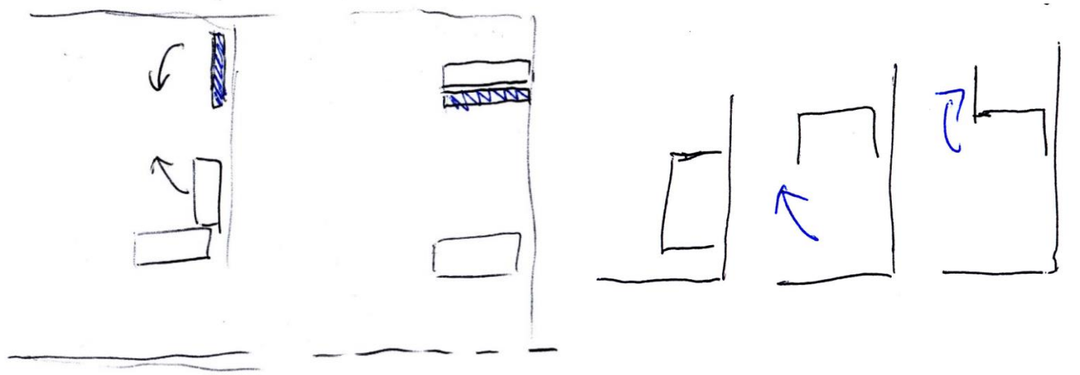
Modular storage boxes

Swing out bedhead/backrest

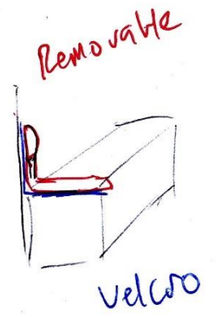




bedhead/backrest



bunk mattress



Movable backrests

Sketching – layouts

1:25 blank floorplans were printed on A4, and different layouts were sketched to scale, to gain an understanding of how the space could be used, and different elements arranged. Consideration was made to avoid placing the bathroom above a wheel well as it would result in insufficient height for a shower.

#1

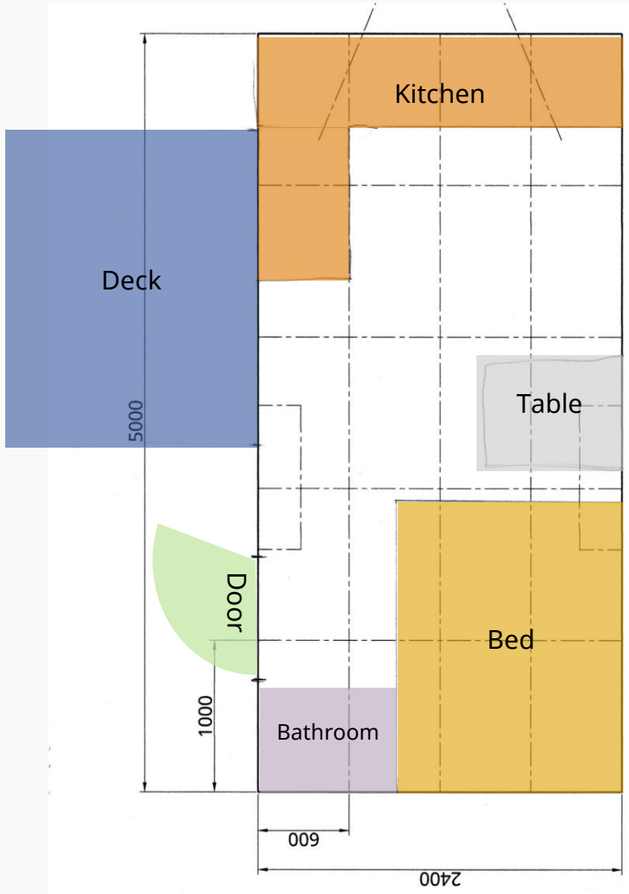
The rear door in option 1 results in narrow walkway areas , however the deck being on the passenger side as well results in this being suitable to bring to traditional caravan parks.

#2

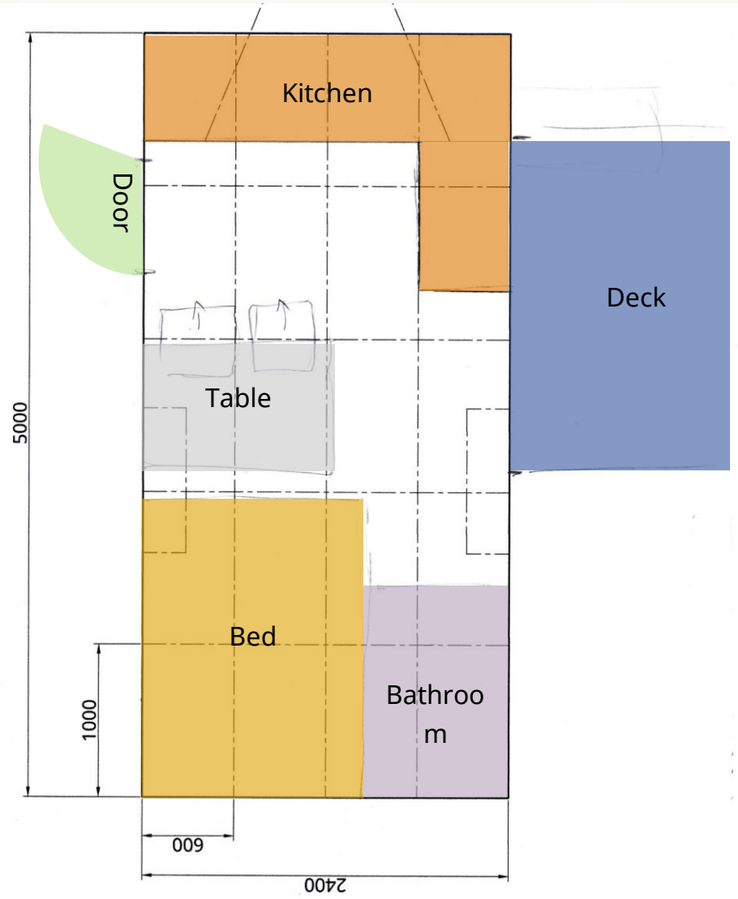
Very open feeling front section – lots of natural light from door and deck.

#3

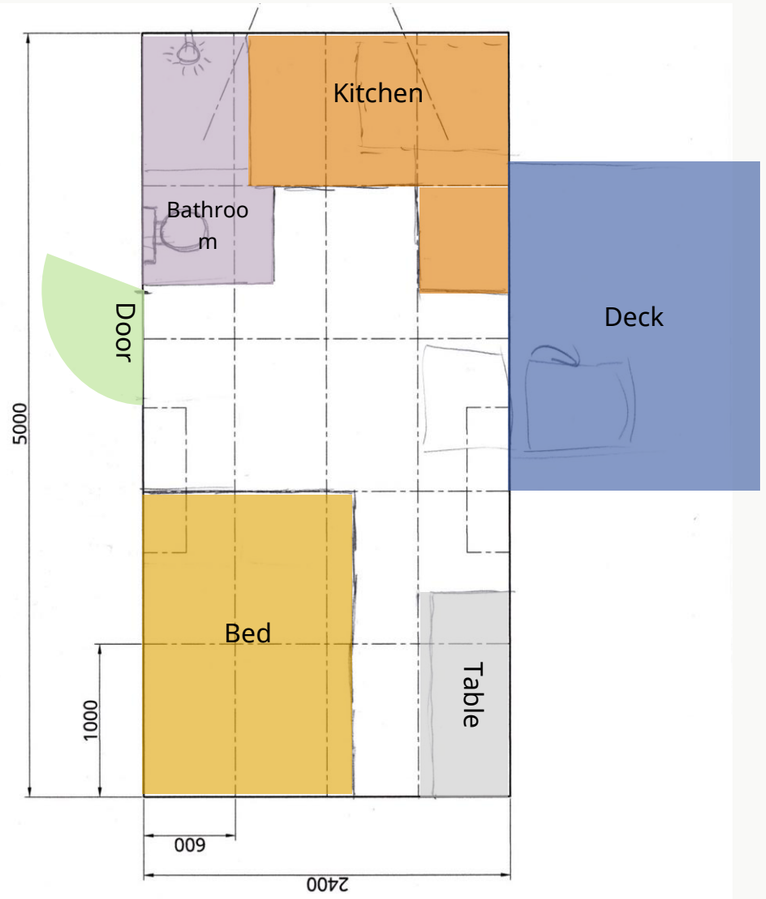
Bench depth may not be usable, non-existent dining area due to one sided table in rear cnr.



#1



#2

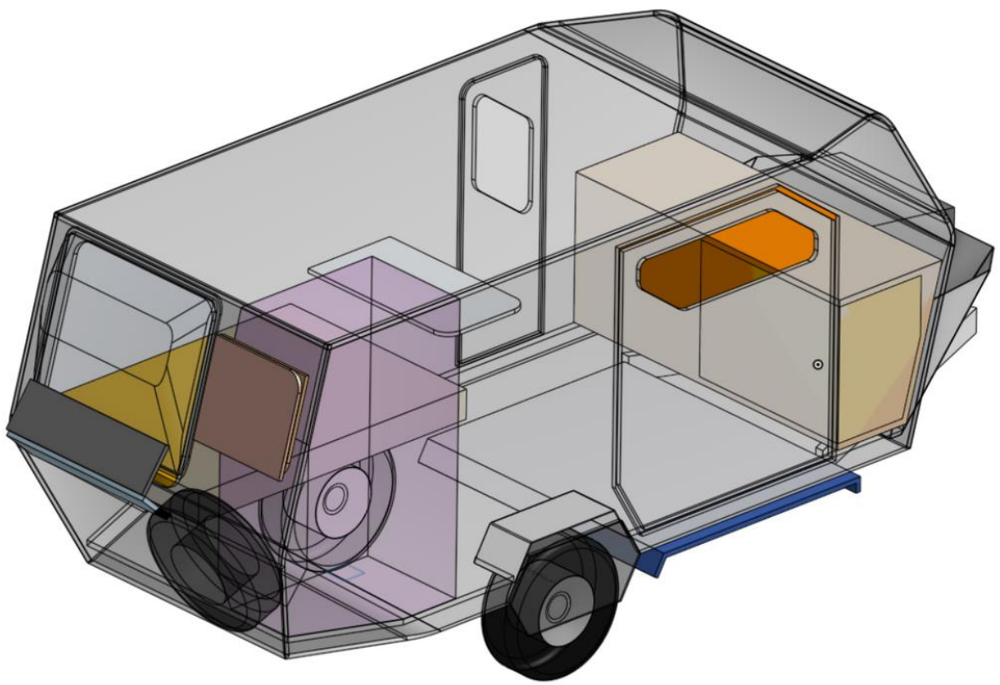


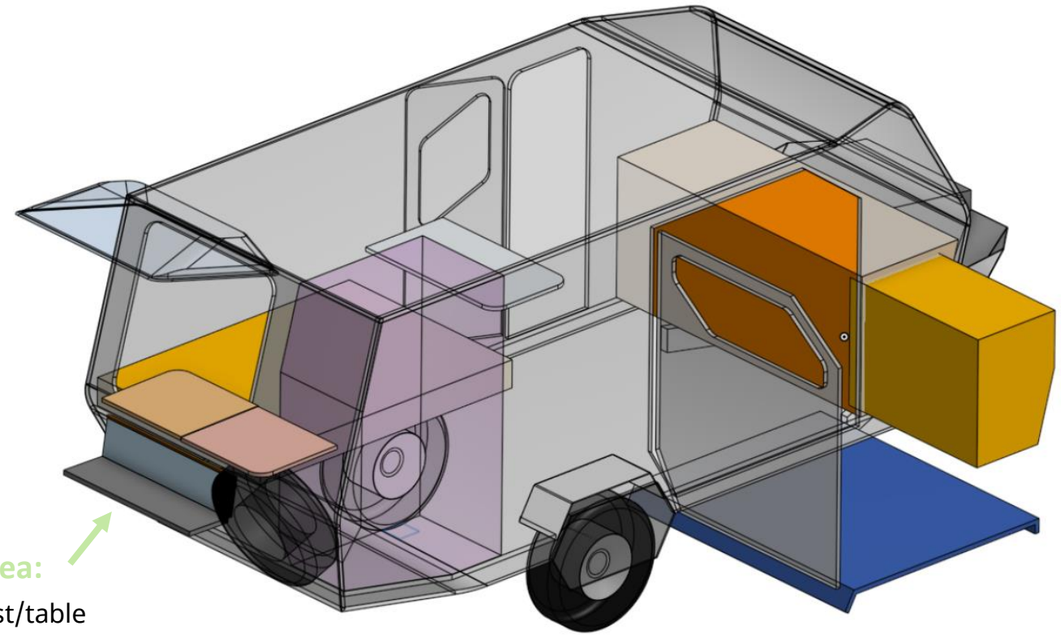
#3

CAD – visualising space in 3D

Referring back to the design criteria & personas, #2 was chosen as the most suitable iteration.

To refining the layout further, the various spaces were put into 3D, so that it could be visualised how these spaces interact as a whole.





Rear seating area:

Fold down footrest/table

Lift up window

Bed/slide out kitchen	Bathroom – toilet/shower	Kitchen	Deck

Methods of Testing,

Evaluation & Validation

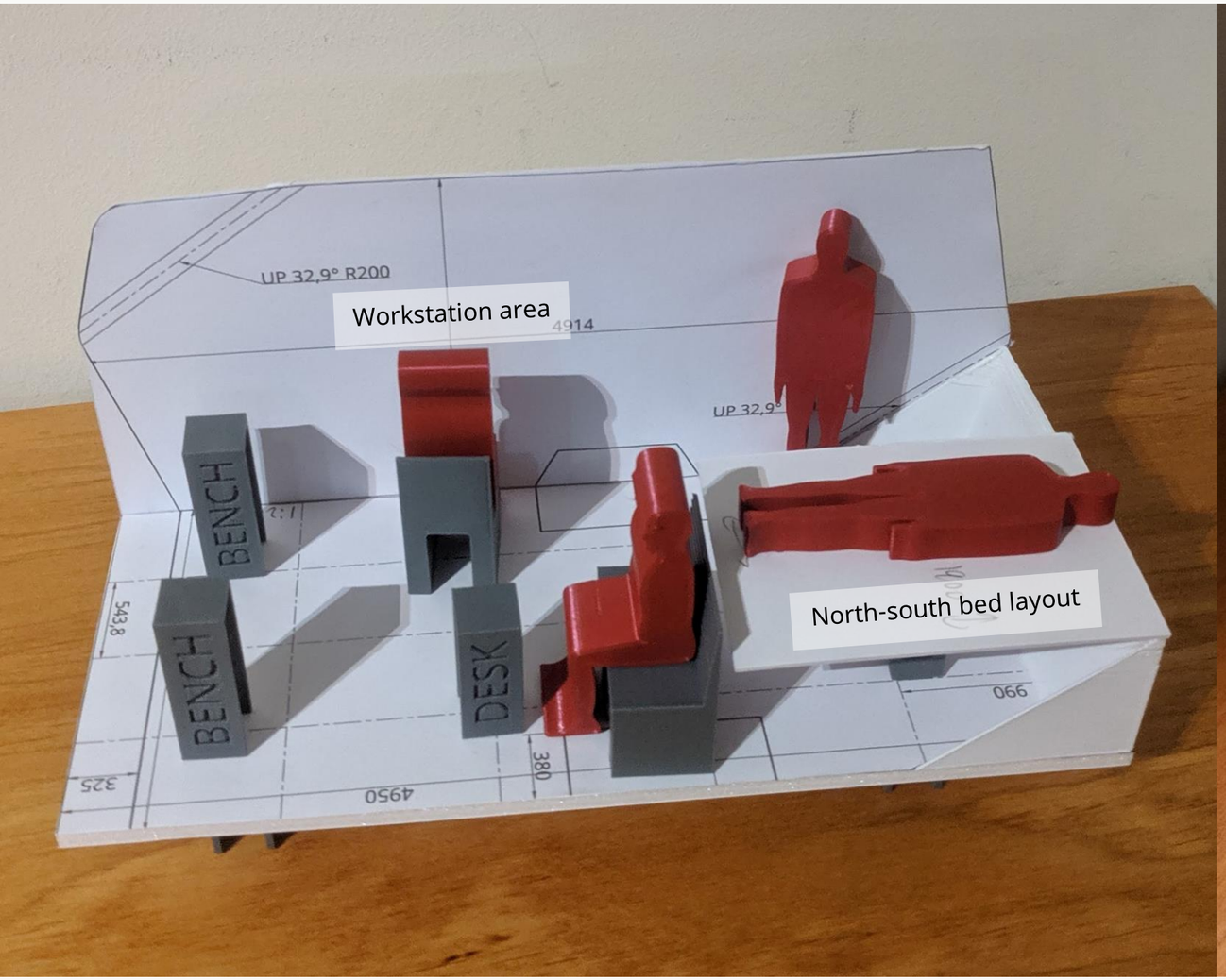
Scale Prototyping

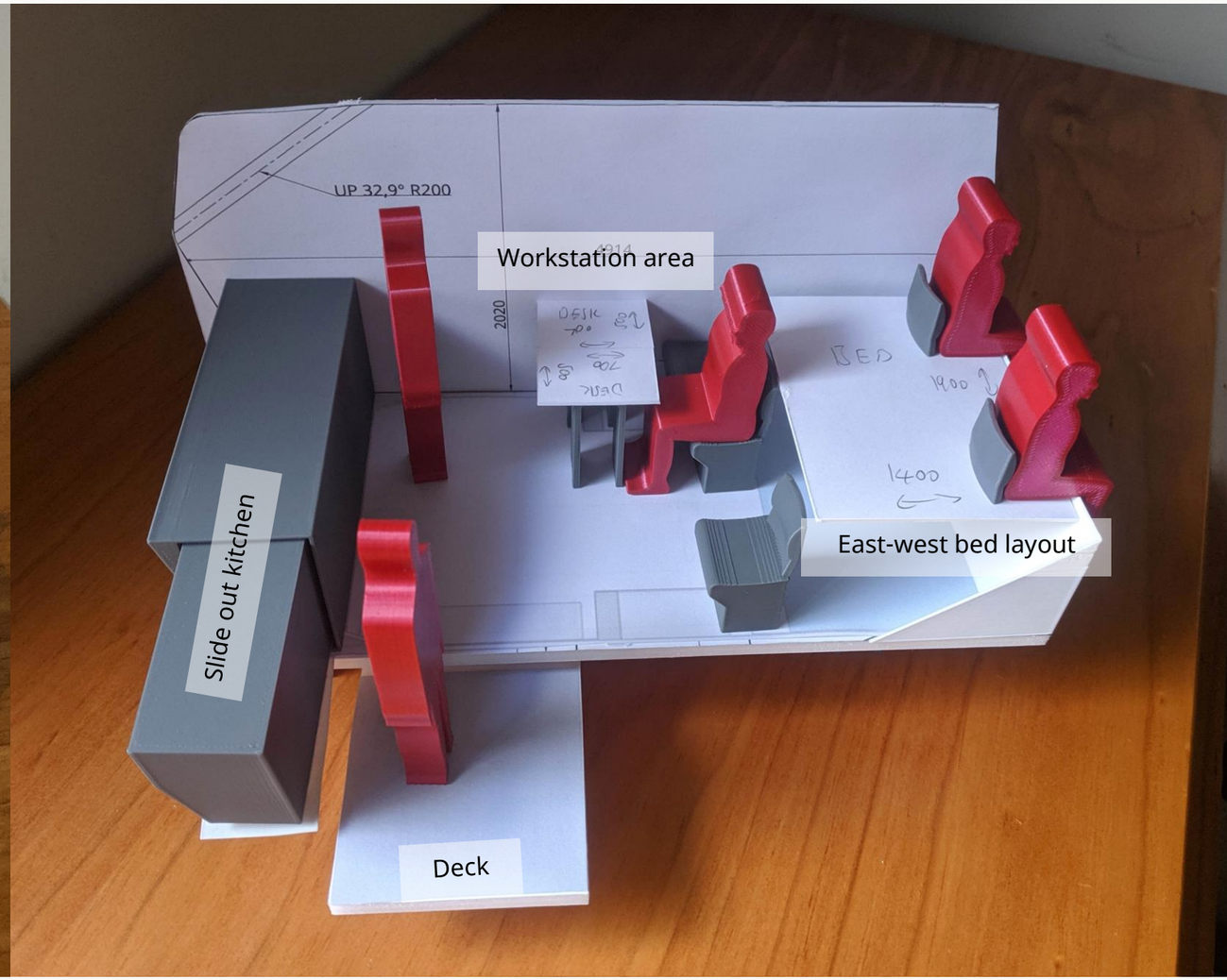
A 1:20 scale model of different elements in the design was produced using the initial CAD model.

Scale and labelled blocks were 3D printed to represent the following elements, with the heights based of ergonomic guidelines.

- Floor (floor of vehicle @ 760mm from ground)
- Bed (top of bed @ 780mm from floor)
- Desk (700mm – based off ergonomic working guidelines)
- Bench (900mm – based on Australian standards for kitchen benches)
- Chair/seating (420mm – Australian guidelines)

To gain an accurate sense for the scale and size of what it would feel like in such a space, simplified standing and sitting person models were produced based off a 50th percentile male.





Space validation

To understand the use of space within a small living space, existing caravans were analysed. This was done in conjunction with the scale prototyping to validate the usefulness and ergonomics of the dimensions in the various areas.

See appendix B for measurements.

The height of myself would also need to be considered, with my height of 1750mm matching closely with a 50th percentile male (1755mm).

Outcomes:

Refinement of space dimensions for: toilet & shower, lounge & seating, table space, bed clearance & walkway space.

Figure 10 measuring head clearance space

Figure 9 Analysing table space

Figure 8 Measuring shower space

Design Evaluation

After referencing back to the personas and how the target user would use the interior and exterior spaces, the following changes will be implemented:

Entry door

Removal of smaller entry door, large door for deck opening used as main door and swapped to passenger side. This was done to increase wall space and free up more space inside the vehicle.

Bed

Bed rotated to east west configuration (body facing width wise) to use less space lengthwise and allow rear bed seating area to extend full width. This also required the spare tyre to be relocated from the rear wall to underneath the rear floor.

Rear bed workstations

Current design of fold out footrests difficult to use as they need to be folded down before the rear lift-up window can be raised. This will be changed so that it can be folded up after the rear lift-up window is raised, to ensure ease of use.

Front window

A front window was added in the kitchen area to increase natural light when cooking or preparing food. This was later removed based on expert advice as it is extremely susceptible to damage from rocks during travel.

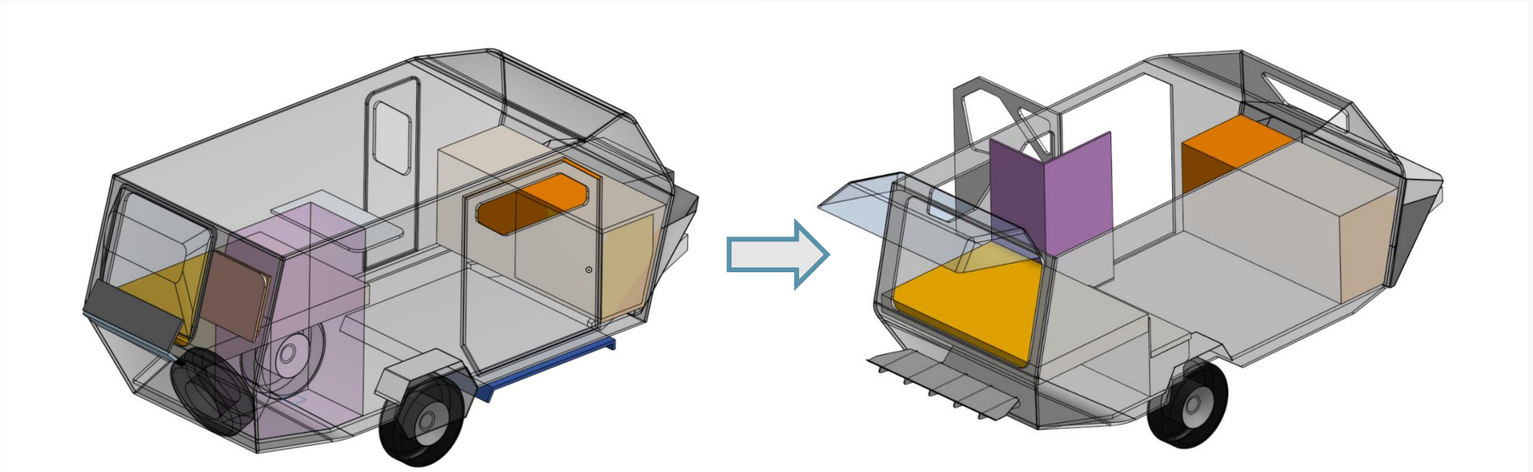


Figure 12 Preliminary design

Figure 11 Refined design

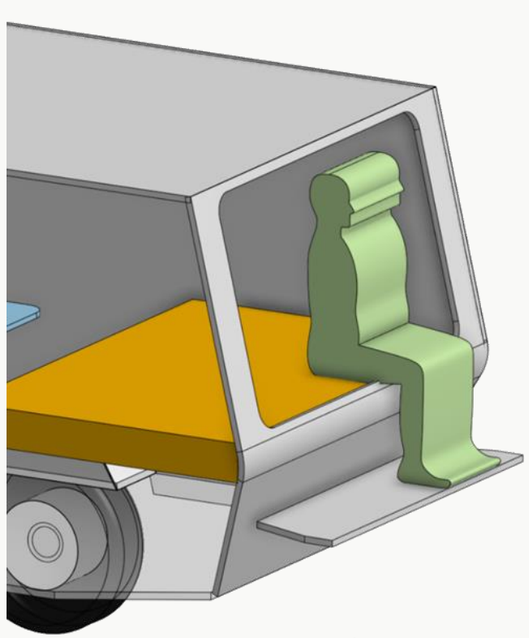


Figure 14 Rear workstation

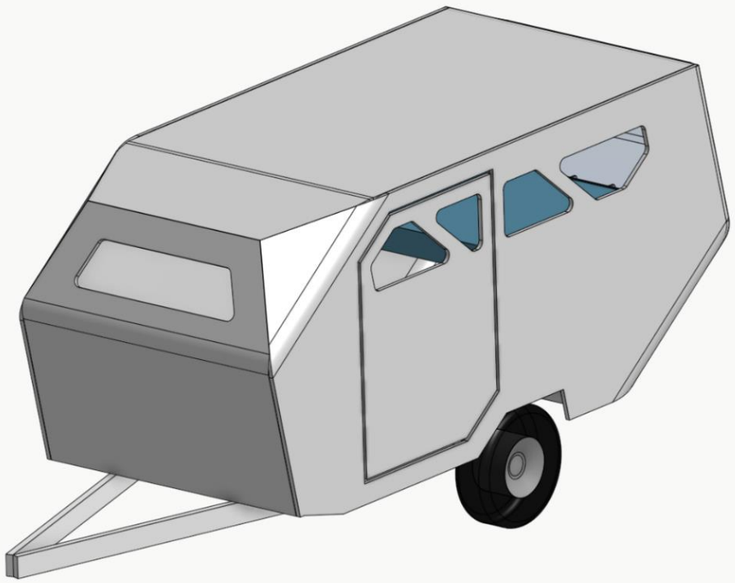


Figure 13 Exterior development

Shower

Shower space taken out of the inside, replaced with outdoor fold out shower tent. This is due to the unusable space it occupies and possible introduction of mould inside the living space. Based on survey results, the importance of having a shower was low, but as this vehicle is designed to be used in a free camping usage scenario, the 1 week stays this is designed for will mean that access to shower facilities will be essential. Hotter weather generally sees the need for more frequent showers so moving it outside does not see major usability drawbacks.

Exterior size

As an area inside does not need to be allocated for a shower and the bed switched to an east-west configuration, the body of the vehicle was further shortened to 4725mm (from 5m)

There are many advantages to reducing overall size, such as: decreased weight & turning circle as well as increased departure angle and manoeuvrability.

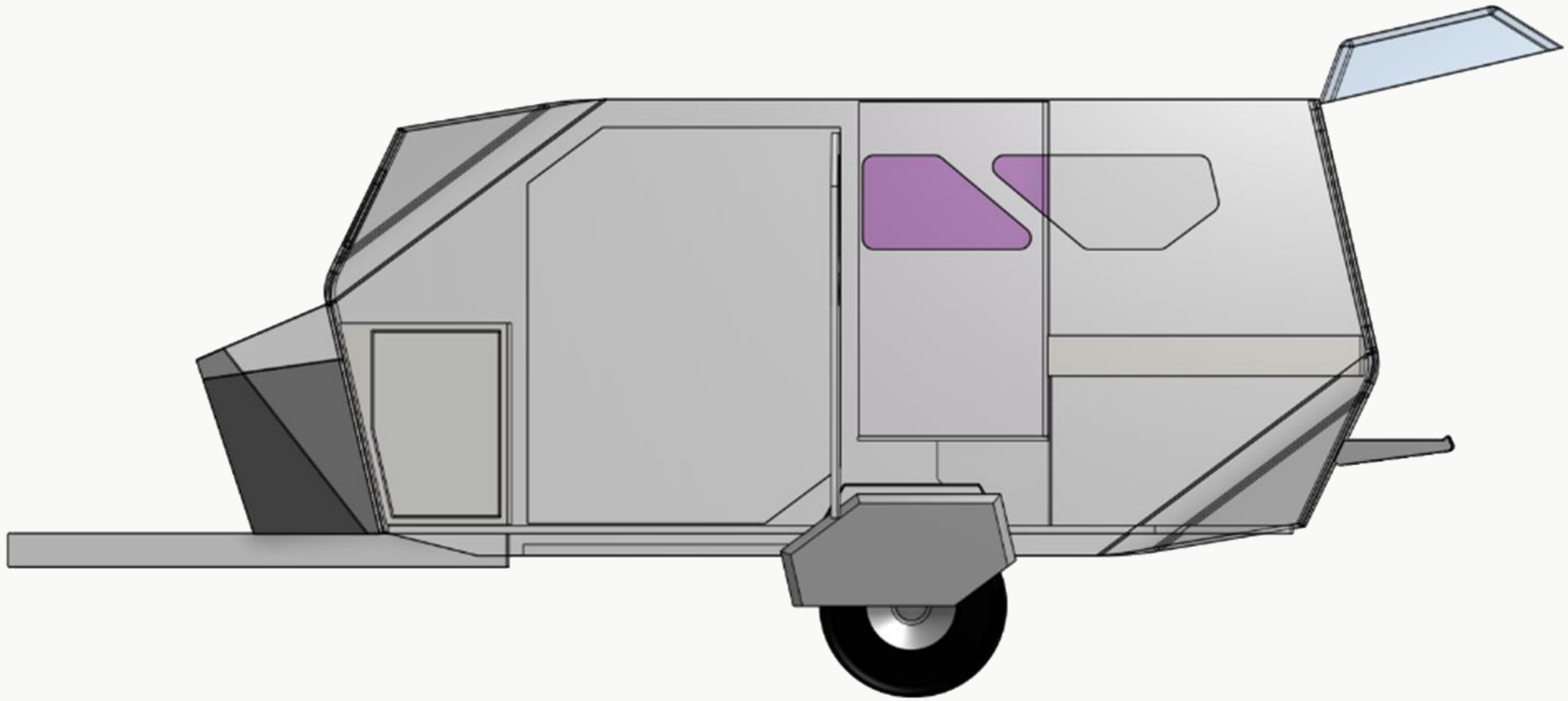


Figure 15 Refined design – side profile

Ergonomic considerations

Ergonomic standards such as the National Occupational Health and Safety Commission's ergonomic principles guidelines as well as Australian standards for kitchen heights were referenced in setting table heights and dimensions.

Non-adjustable chair considerations

Seat depth: 380-480mm

Seat width at least 450mm

Seat height 420mm

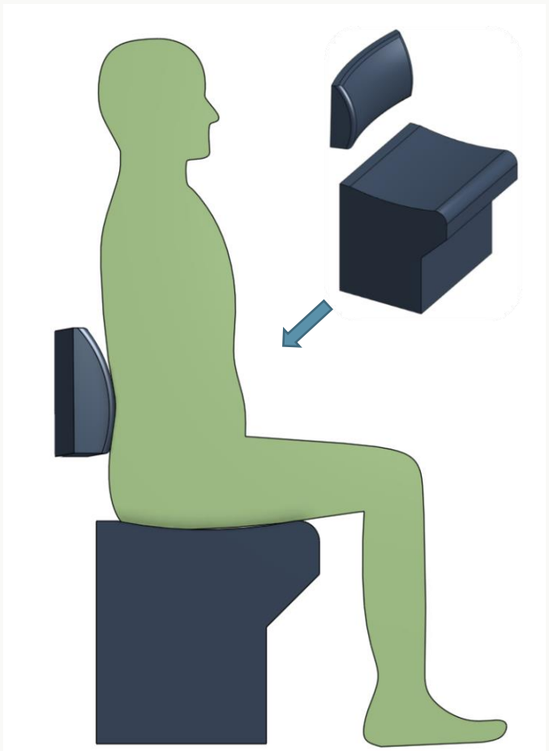


Figure 17 Chair base and lumbar support design with 50th percentile male (2021) by C. Poon

Lumbar support area between 200mm to 250mm from top to bottom

- Centre of lumbar support area between 190mm to 220mm above seat
- Lumbar support area vertical convexity approx. 250mm radius
- Backrest width at least 360mm
- Backrest angle between 100 and 105deg

Rounded front edge of seat to avoid pressure on the underside of the thighs.

Based on these considerations, an ergonomic chair base and lumbar support non- adjustable CAD model was created (see Figure 17)

Office desk design

Desk top surface height between 680-720mm

Adequate clearance for legs under the desktop and sufficient space to comfortably stretch legs

Depth at least 600mm

Desk width at least 1000mm

Rounded edges of all corners of the front edge of desk top

A flat smooth surface so that the keyboard and mouse can be used on the same level

Scalloped desks that contain a cut-out illustrated Figure 16 provide more opportunities for forearm support, more

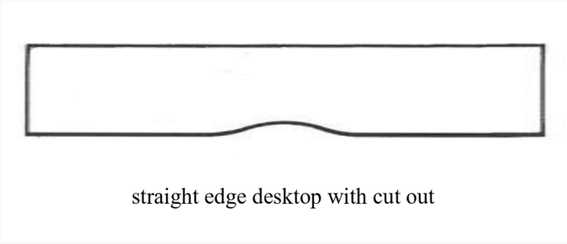


Figure 16 Examples of scalloped desktop (2012) by Worksafe QLD

acceptable reach zones and better work postures when using multiple screens.

When using laptop computers for significant periods, it is recommended that full sized keyboards and mice are used, and components such as laptop stands be used (Worksafe QLD, 2012).

Figure 18 Table space in a typical caravan

Lumbar support design ideas

To ensure proper ergonomic support for longer sitting periods in the various workspaces of the vehicle, lumber support is necessary. As there are 2 main workspace areas inside the caravan, these lumbar support sections would need to be easily deployed at those locations.

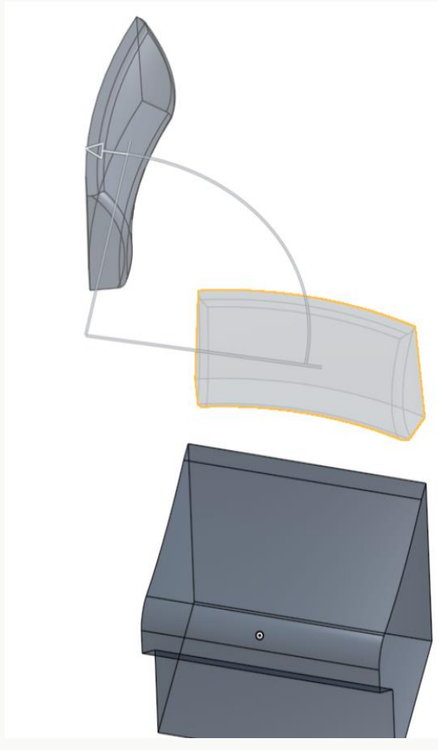
The bed area cannot feature a fixed backrest as it is around the same area as the middle of the bed, this is where a vertical or horizontal axis pivot would be required.

The following diagrams illustrate the methods in which this could be deployed:

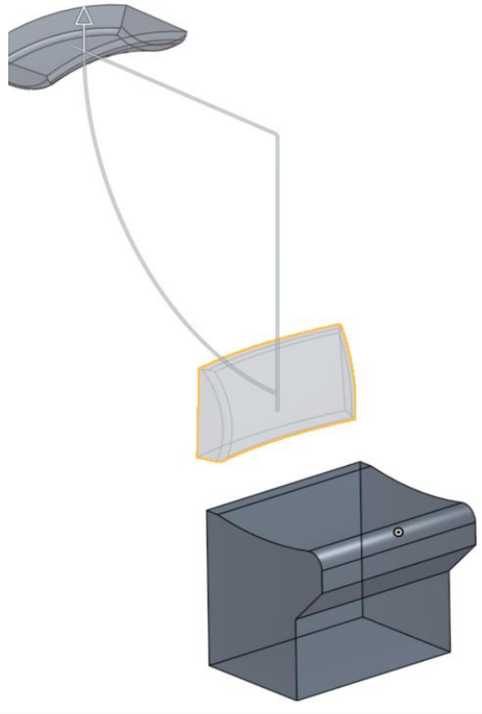
Using a vertical axis pivot would also mean that this could become the bedhead.

The horizontal axis pivot would result in more length head to toe on the bed but will be a potential head hazard as the bed area does not have an excess of height.

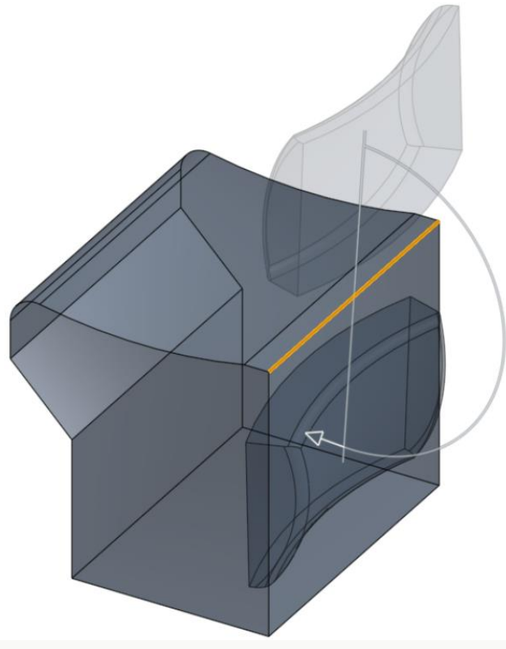
The backrest section could be attached to different areas of the vehicle using hook and loop (Velcro), increasing flexibility whilst reducing weight.



Vertical axis pivot



Horizontal axis pivot



Folding backrest

Feature Considerations

Features and appliances for current commercially available caravans & off grid van conversions were compared and analysed. Specifications were set based on being sufficient for 1 week off grid whilst accommodating remote work. These features and appliances were set based on research as well as consultation with industry experts.

WATER

Water storage is a typical amount that would last 2 adults 1 full week, with shower usage every 1-2 days. Electrical usage has been calculated based on expected usage, for full calculations, refer to appendix C.

Multiple containers for water storage are essential so that there is redundancy in the case of damage, and to reduce substantial weight transfer whilst driving. As water storage is one of the heavier items, it is critical that it is stored as low as possible as well as central to the axles to improve driving dynamics.

Water: 168L minimum (12L per person, per day)

Figure 19 Typical Caravan fresh water tank (2020) by One stop caravan shop

HEATING/COOLING

Cooling will be omitted for a variety of reasons:

- Polyurethane foam/fiberglass composite has excellent thermal insulation properties
- Aircon on roof adds extra height to vehicle, aircon on side wall reduces interior space
- Aircon system typically weighs ~40kg and is in a high location (bad for weight distribution)
- Very high power usage requires more batteries - $$$

Figure 20 Caravan Air conditioner (2020) by Caravans Plus

2x 9kg gas cylinder holders (gas is still much more energy efficient than batteries, good for heating & cooking)

Gas (LPG) energy density =

7500Wh/kg (including bottle weight - 9kg gas bottle)

Lithium-ion battery current energy density =

100-265Wh/kg

Hot water system for cooking and showers

ELECTRICAL

Inverter – 1500W

Provides 240V power to charge laptops or other devices.

Figure 21 Redarc 1500W 12V pure sine wave inverter (2020) by Redarc

Lithium batteries – 300A

Figure 22 Lithium battery (2021) enerdrive B-tec

Battery management system (BMS)

Figure 23 Batteryplus battery management system with solar regulator (2021) by BMPRO

Solar panels 400-500W total

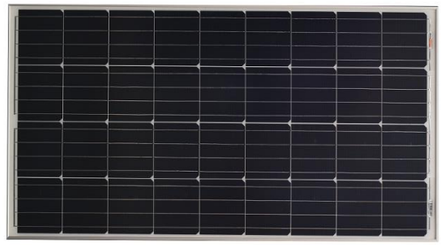


Figure 24 150W 12V mono solar panel (2019) by Arizon

Breakaway

Brakes caravan in case of detachment, legal requirement

DC-DC charger

to charge batteries when driving

Reverse camera

assist in reversing caravan

EXTERIOR

Outdoor shower tent – fold out

Figure 25 shower awning (2021) by BCF

Awning – at least 2m shade length

Figure 26 Caravan awning (2021) by Caravan RV Camping

Satellite internet dish

Figure 27 Starlink satellite dish (2020) by SpaceX

Windows

integrated flyscreens & blinds

Ventilation fan/rangehood

Allows the generation of positive pressure to reduce dust when travelling

Increased ventilation to keep cool

Could be used as rangehood to reduce cooking smells

Figure 28 Maxxfan Deluxe with rain dome (2021) by Outback Equipment

OTHER

Toilet

Composting toilets do not require emptying for 2-3 months, liquids are able to be emptied anywhere, separating liquids and solids reduces smell.

Stovetop

2 burner stove

Fridge

60-90L storage, dual zone

Figure 30 Engel 75L dual zone fridge/freezer (2021) by Snowys

Heater

Gas powered heater, safe to use indoors

Figure 29 Gas powered caravan heater (2020) by Truma

Cost estimation

The cost to build such a caravan was estimated.

Item	Description	QTY	Cost per item	Total cost
Appliances				
Ventilation /rangehood fan	Maxxair fan deluxe	1	$450.00	$450.00
Fridge	Engel MT-V80FC Combi Fridge Freezer 75L	1	$1,919.00	$1,919.00
Hot water	Hot water unit with ~20L capacity	1	$400.00	$400.00
Stove	2 burner stove	1	$250.00	$250.00
Heater	Gas heater - Truma Varioheat	1	$1,900.00	$1,900.00
Cabinetry				
Rear lounge		1	$300.00	$300.00
Side lounge		1	$500.00	$500.00
Flip bunk bed		1	$800.00	$800.00
Slide out kitchen		1	$750.00	$750.00
Kitchen cabinetry		1	$1,500.00	$1,500.00
Bed supports & under storage		1	$1,000.00	$1,000.00
Chassis & attachments				
Chassis	150x50x2.5 RHS main sections, galvinised steel	1	$10,000.00	$10,000.00
Suspension	Assymetrical link	1	$6,000.00	$6,000.00
Jockey wheel	250mm Al-KO jockey wheel	1	$144.00	$144.00
Slide out deck		1	$4,000.00	$4,000.00
Wheel wells		2	$120.00	$240.00
Wheels & tyres	incl spare	3	$250.00	$750.00
Hitch	DO35 off road hitch	1	$475.00	$475.00
Water tank - 36L		2	$60.00	$120.00
Water tank - 45L		2	$75.00	$150.00
Water tank - 90L		1	$100.00	$100.00
Front garage box		1	$1,000.00	$1,000.00
Gas bottles	9Kg gas bottle	2	$30.00	$60.00
Interior				
Interior lighting	LED strips & downlights	1	$150.00	$150.00
Mattress	Queen mattress	1	$500.00	$500.00
E-track	3m lengths	3	$39.00	$117.00
Rear workstation backrests	Clip into e-track	2	$300.00	$600.00
Ergonomic backrests	with velcro	4	$100.00	$400.00
Storage crates		4	$40.00	$160.00
Smoke detector		1	$30.00	$30.00
Carbon monoxide detector		1	$30.00	$30.00

Item	Description	QTY	Cost per item	Total cost
Panels				
Panel pack	29mm panels - side walls, roof, front & rear walls	1	$7,500.00	$7,500.00
Flooring	34mm floor panel	1	$1,000.00	$1,000.00
Plumbing				
Kitchen sink		1	$150.00	$150.00
Taps		1	$50.00	$50.00
Toilet	Natures head composting	1	$1,590.00	$1,590.00
Shower		1	$400.00	$400.00
Water pump		1	$135.00	$135.00
Misc pipes & fittings etc.		1	$200.00	$200.00
Exterior				
Roof hatches		3	$300.00	$900.00
Windows		2	$400.00	$800.00
Rear large hatch		1	$1,600.00	$1,600.00
Fold down footrest		1	$750.00	$750.00
Door hardware		1	$500.00	$500.00
Wheel cover/recovery boards		2	$600.00	$1,200.00
Water filler		1	$50.00	$50.00
External shower	Black External Shower Box - Watermarked	1	$100.00	$100.00
Shower Awning	Nomad shower tent awning with roof	1	$280.00	$280.00
Main awning		1	$900.00	$900.00
Satelite internet	Starllink base cost	1	$809.00	$809.00
Taillights		1	$1,000.00	$1,000.00
Wiring	Assorted electrical wiring	1	$150.00	$150.00
Electrical				
Inverter	REDARC 1500W 12V pure sine wave inverter	1	$1,178.00	$1,178.00
Battery management system	INC solar regulator - BMPRO 35HA II	1	$965.00	$965.00
Lithium batteries	Lithium lab 150AH battery LL12150P	2	$1,450.00	$2,900.00
Solar panels	CAMEC 150W 12V SOLAR PANEL	3	$360.00	$1,080.00
DC-DC charger	MiniBoost DC–DC Smart Battery Charger	1	$275.00	$275.00
Brakeaway	trailsafe breakaway	1	$185.00	$185.00
Reverse camera	Safetydave reversing camera	1	$260.00	$260.00
			Grand Total	**$61,702.00**

Design Outcomes

Outcomes overview

SCALE MODEL

A 1:10 scale model will be produced to demonstrate the aesthetics and functionality of the product

3D printed chassis with workable suspension

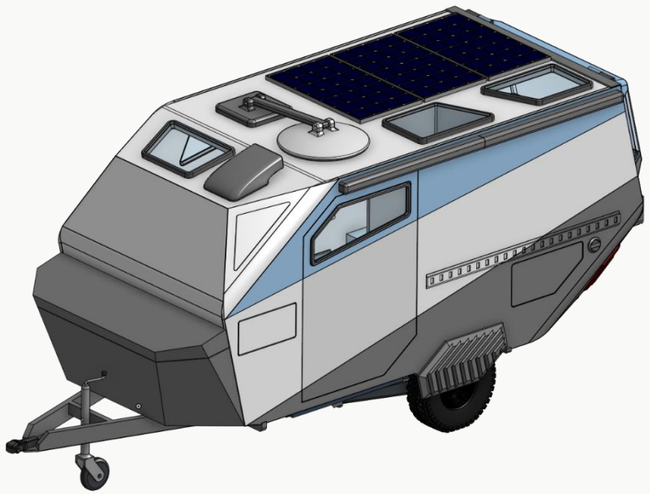
3mm acrylic laser cut panels with removable roof

Rear hatch in clear acrylic & 3D printed frame

3D printed furniture components – slide out kitchen etc

Velcro rear lumbar support sections

Lagun mount table mounts 2x at rear, 2x at lounge, 1x at LH wall



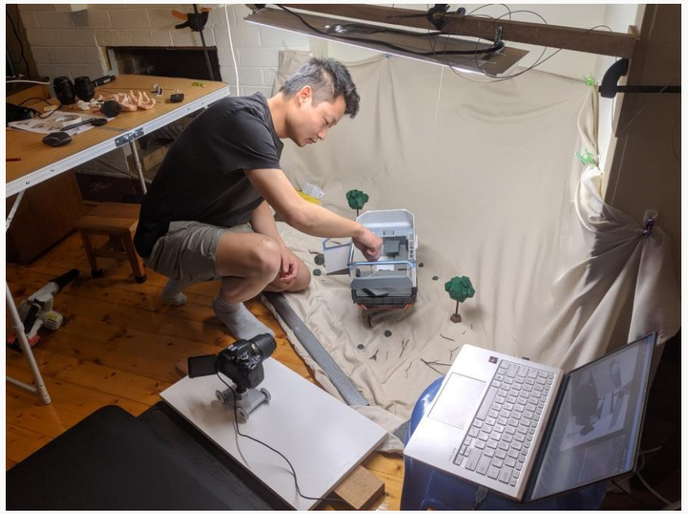
VIDEO

As I was making a detailed scale model, it was decided that I would produce a stop motion video. An initial rough storyboard was produced to outline an overview of elements that could be included in the video (see appendix E).

To reduce complexity and make this feasible to do in a short time, non-posable low poly characters would be used, as well as basic props.

Filming inside would reduce weather and light variability, which is especially critical when shooting stop motion.

A 3D printed camera dolly is used for sweeping shots so that a smooth movement can be produced.



RENDER

Rendered in-context hero shots produced using Key shot.

Scale model build process

As the walls were made using CAD sheet metal tools, these were exported and used to laser cut 3mm white acrylic. Windows were cut out of 2mm clear acrylic.

Figure 33 Laser cut acrylic components

Engineering drawings created in CAD used to mark the locations of bend lines.

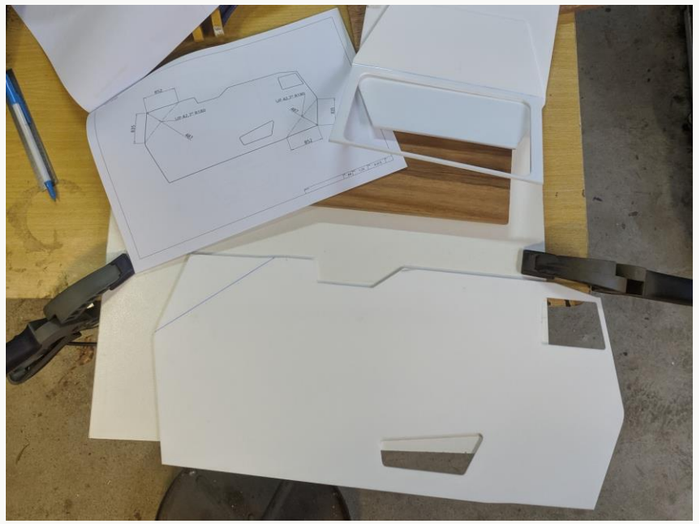


Figure 34 Engineering drawings used to mark bend lines

A 10mm slot was cut into a piece of chipboard and a heat gun used to form the acrylic into a bendable state.

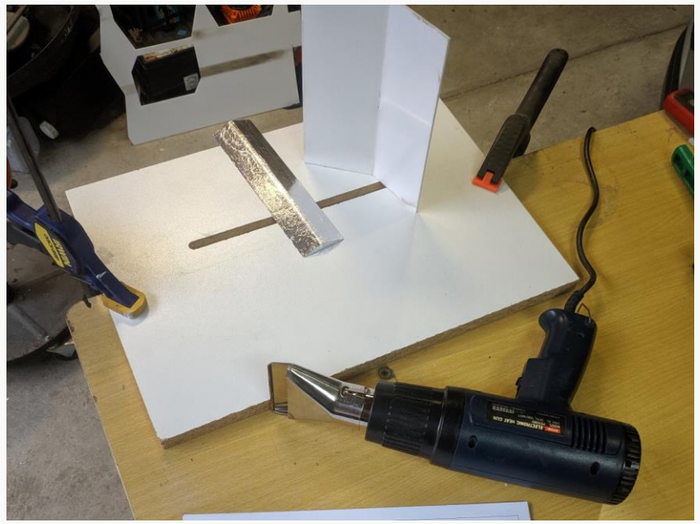


Figure 32 Acrylic bending setup

Bend angle jigs were drawn in CAD. These were then printed in PETG and coated with foil tape for heat resistance.

Figure 35 Bend angle jig

Over 100 parts were printed in over 10 different colour filaments, totalling to 300-350 hours of print time and 4-5kg of filament used. Print files were tracked using excel.

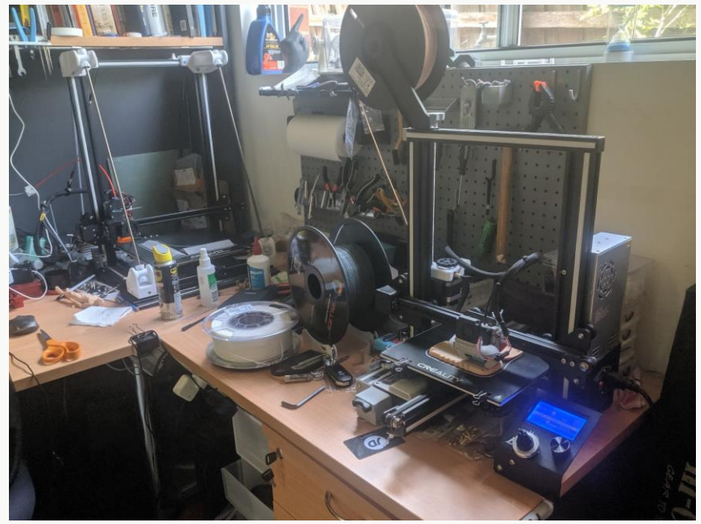


Figure 31 3D printer setup in my room

The chassis was split into 3 sections to fit on the print bed. The middle section took 4h to print.

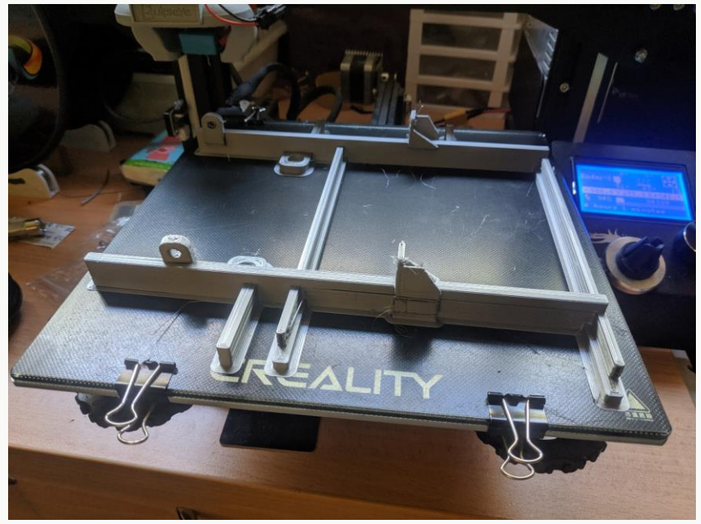


Figure 36 Middle Chassis part

Alignment holes were designed into the chassis sections so that 2.4mm aluminium welding rod could be used to add strength and help alignment of the pieces. Epoxy was used to glue the sections together.

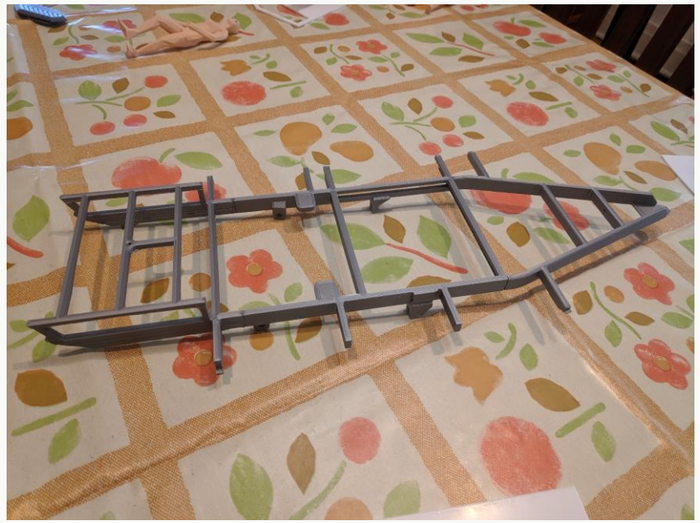


Figure 38 Assembled chassis

The front wall is bonded to the kitchen. Aligning parts were designed in the chassis so that the side walls sit at the correct height.

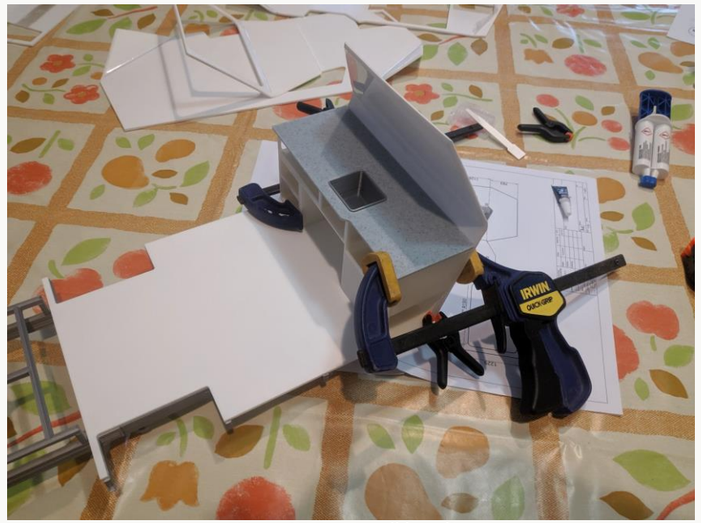


Figure 37 Front wall bonding

As the bend angles weren't 100% accurate, there were gaps between some of the panel joins, most notably at the front top corners.

Figure 41 Wall assembly

The kitchen benchtop is printed out of marble PLA

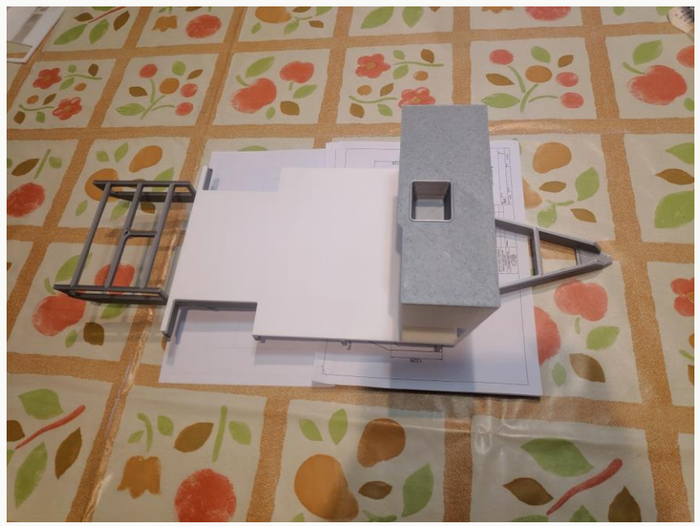


Figure 39 Floor & kitchen assembly

The rear wall is then bonded to the chassis and side walls.

Figure 40 Rear wall bonding

Small cnr supports were printed and bonded using epoxy.

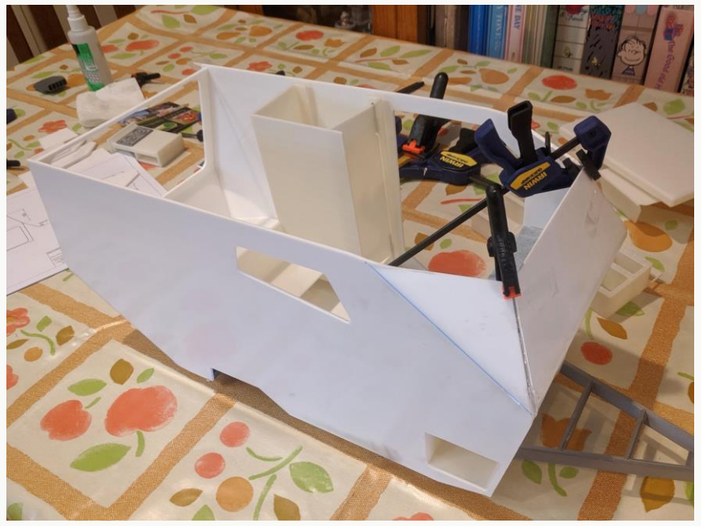


Figure 42 Filing front cnr joins.

E-track sections glued to walls. Attachment sections included a magnet glued into the rectangular slot.

Rear swingout backrests use 2.4mm aluminium tig welding rod to allow rotational movement.

Figure 43 E-track sections & rear backrests

Over 100 3d printed parts printed!!

Figure 44 Dining table converted to assembly area/mess zone

Bed and lounge cushions were upholstered using a fake leather vinyl. This was stapled into the plastic.

Figure 45 E-track sections & rear backrests

Vinyl graphics applied to the walls, the front top cnr filled with white silicone.

Figure 46 Graphics attached & front top cnr gap filled

Suspension parts drilled and taped.

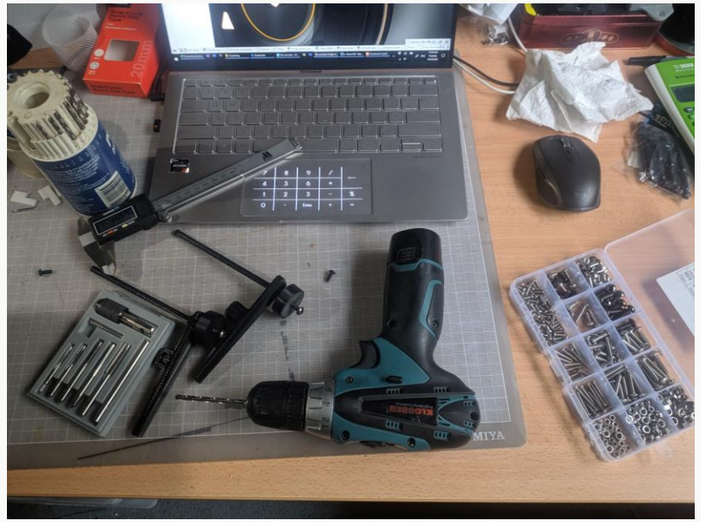


Figure 47 Drilling & tapping 3D printed parts

Front suspension mounting points broke so steel brackets were made.

Figure 48 Fitting suspension

Windows stuck to window frames and panels using PVA glue as it dries clear.

Figure 49 Windows & hatch fitting

Main door fitted using hinged nylon RC hinges.

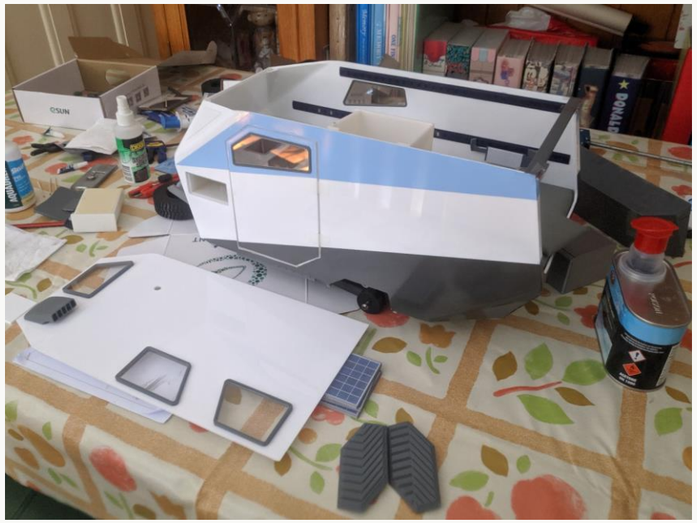


Figure 51 Door fitment

Rear hatch window attached using 2.4mm ally tig rod.

Figure 50 Rear hatch & side awning fitment

3D printed wheels and tyres. Rims painted using silver base coat and dusting of black to create a dark metallic grey.

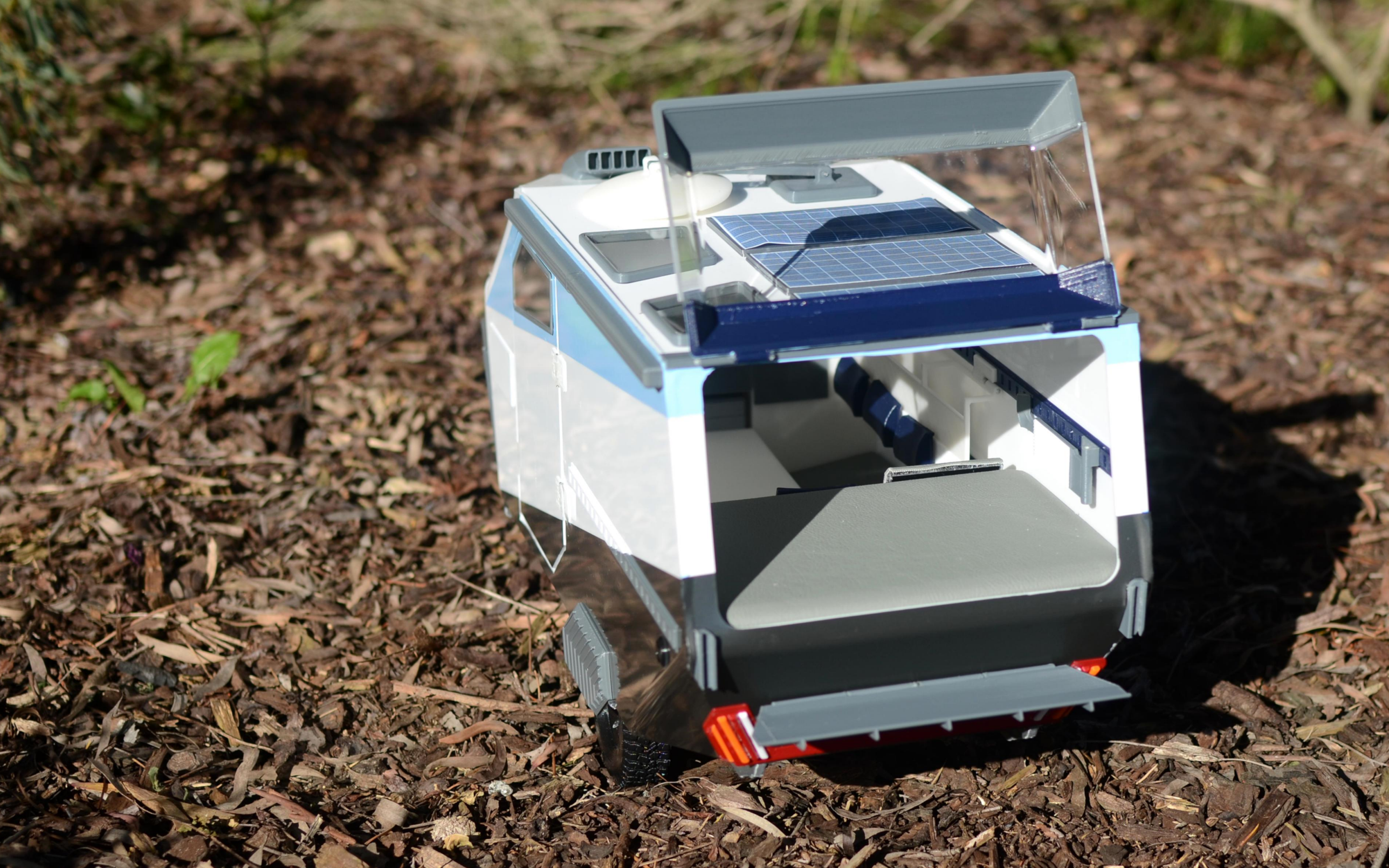
Figure 53 Windows & hatch fitting

A pack of Low poly people in different poses was purchased from CG trader. To be used in stop motion video.

Figure 54 Printing of Low poly people

Figure 52 Low poly people cast

Scale model – Final result



Video – Refined storyboard

Scene 1:
Sounds: electrical noise from dishwasher or washing machine, Minecraft villager sound before thought bubble

Set: inside, laptop & desk

Sitting inside, remote work on a computer, thought bubble pops up – person wishes they were outside in nature.

As the model was still under construction when developing this storyboard, the storyboard is shown with a matching view of CAD and how a low poly person will interact inside the scene.

Scene 2:

Sounds: birds chirping

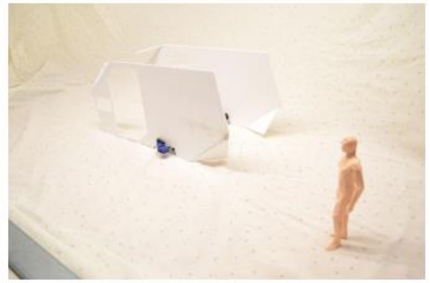
Set: 1:10 vehicle prototype (open roof), low poly trees in background

Deck opens, step comes out, person steps into vehicle, demonstration of different features

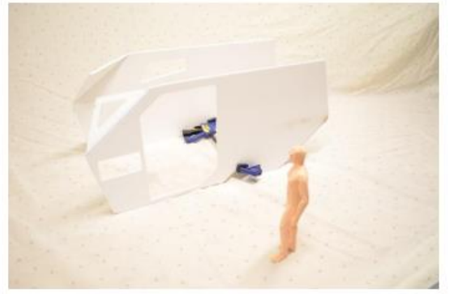
Features shown: Lounge work area, rear hatch work area, toilet, indoor & outdoor showers, outdoor area with awning, outdoor kitchen, campfire by the background.

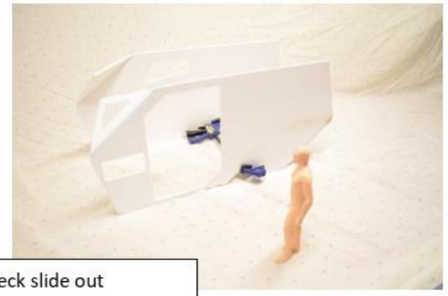
Scene 3

Rotating 1:10 prototype hero shot (with roof)

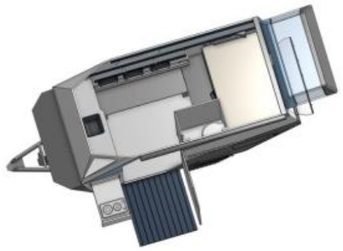


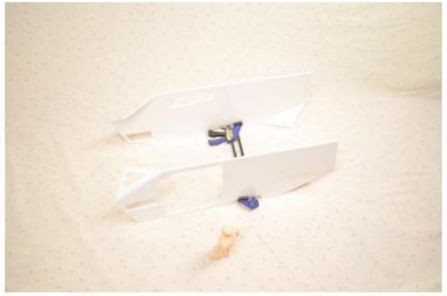
PAN – rear window & footrest opens





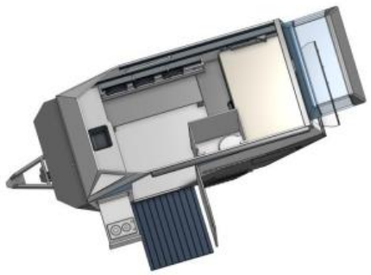
Door & deck slide out

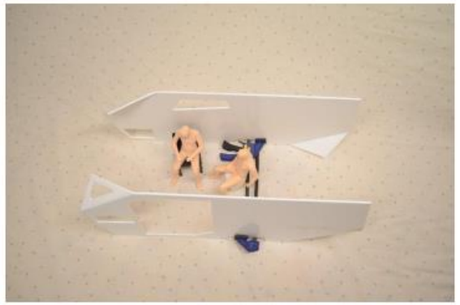


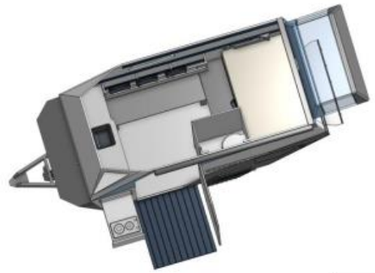


Scene 4

People inside demonstrating use of inside workstations



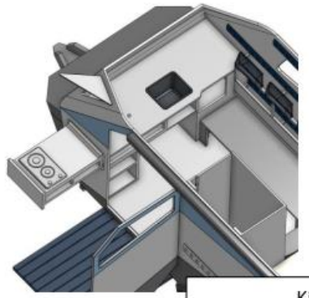


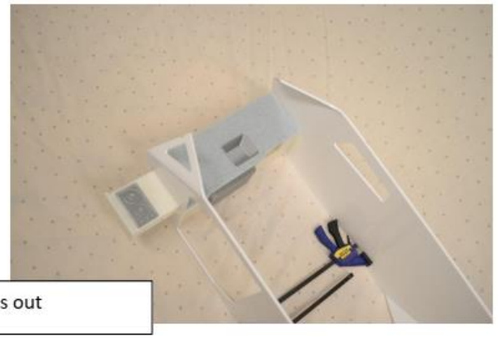


Backrests come out

Scene 5

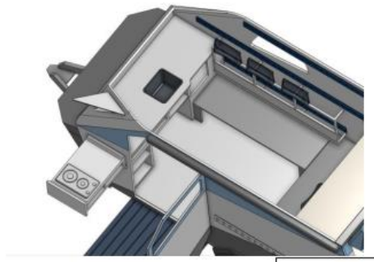
People demonstrating rear bed workstations

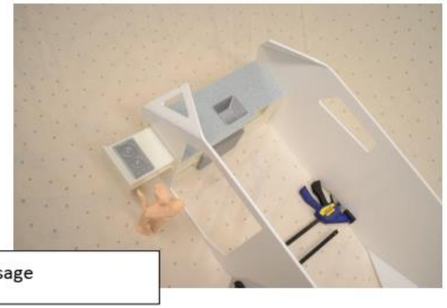




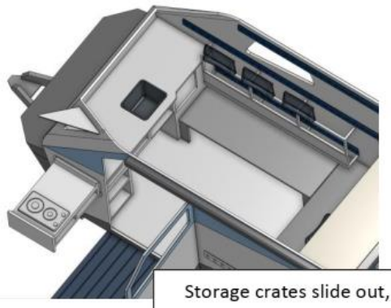
Kitchen slides out

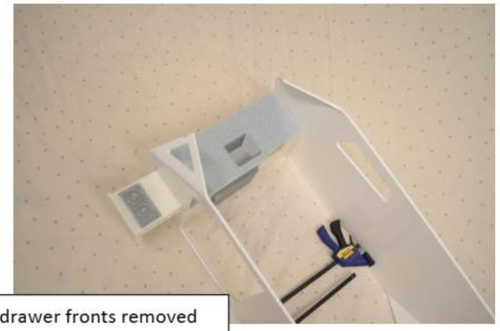
Scene 6
Kitchen usage demonstration





Kitchen usage



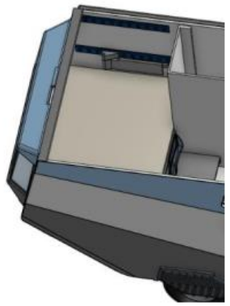


Storage crates slide out, kitchen drawer fronts removed

Scene 7
Relaxing in the evening by the campfire

Scene 8
Sleeping

Fade out



Video – Set & props

Figure 60 Cast & crew

Figure 59 Props

Figure 58 Yum Yum Pasta sauce (chopped 3D printer fillament)

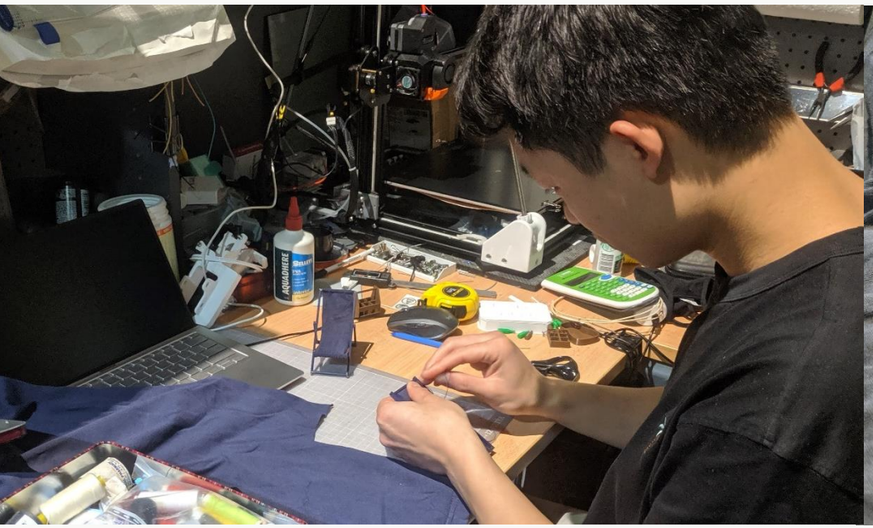


Figure 57 Sowing old t shirt as folding chair material

Figure 56 Finished folding chair

Figure 55 Low poly trees and filming setup

Video – equipment & setup

Dragonframe software was used to capture the stop motion footage. An older Nikon D5100 was used with the standard 18-55mm kit lens in most scenes, except for the off-road scene, where a 40mm macro lens was used.

A 3D printed camera dolly was used for sweeping shots.

Overall, roughly 1000 frames were taken.

Video was exported out at 8 frames/second.

The standing characters could for the most part stand up without assistance, but blu-tack was used when they couldn't and also for other items.

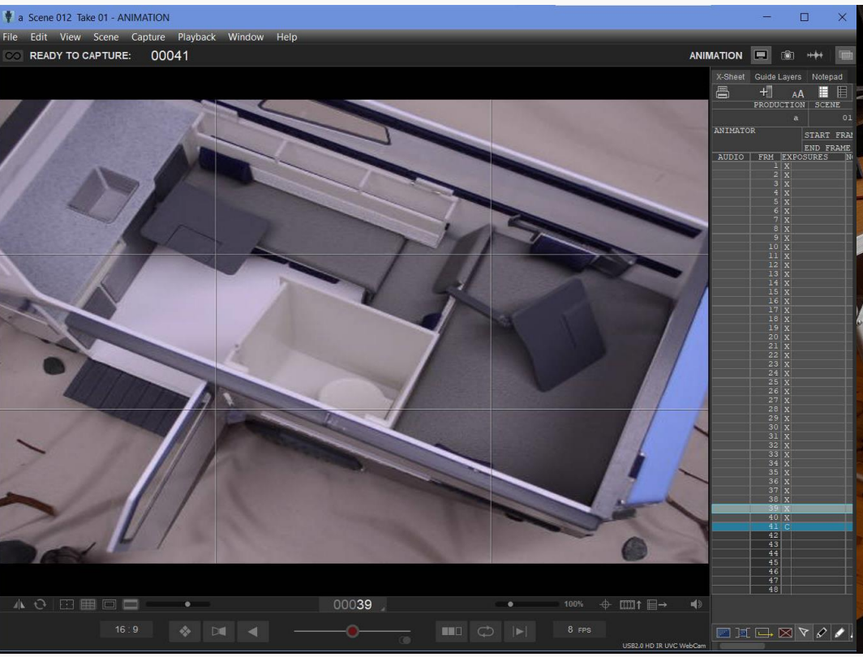


Figure 62 Dragonframe software

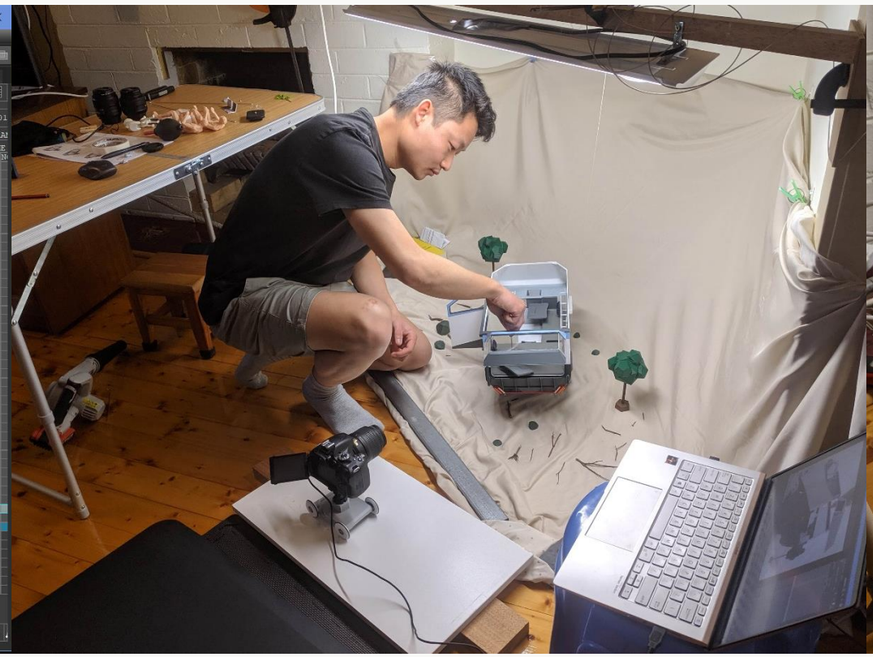


Figure 63 Stop motion filming

Figure 61 Final scene filming setup


nomadA

nomadA

Final specifications

OVERALL DIMENSIONS:

Length: 4750mm

Width: 2100mm

Max height: 2873mm

Internal height: 1887mm

Weight: ~2200kg tare

Plumbing

Front tank: 90L

Side wing tanks: 36L x2

Central wing tanks: 45L x2

Total fresh water storage: 207L

Total grey water storage: 45L

Hot water system

12V water pump

Internal shower

Electrical

1500W inverter

300A lithium battery capacity

420W solar

Reverse camera

Maxxfan ventilation fan

Starlink satellite internet dish

Kitchen

75L dual zone fridge

Dual burner gas stove

Other

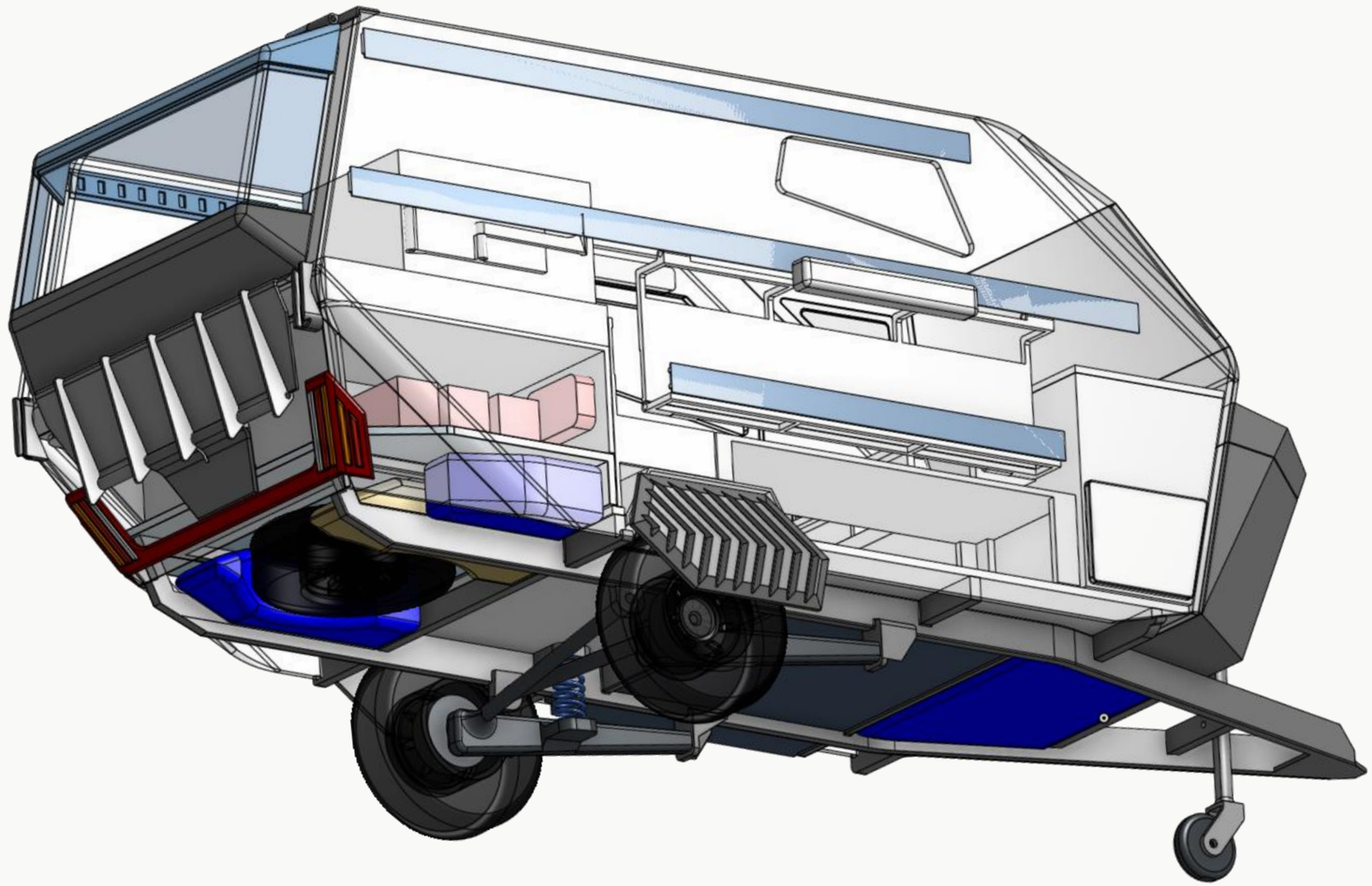
Composting toilet

DO35 off road hitch

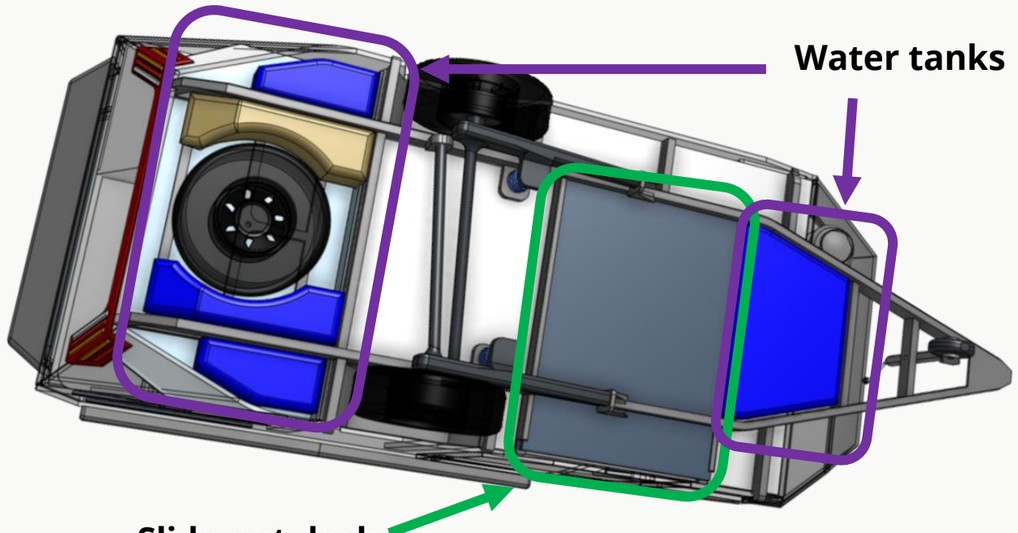
External shower box

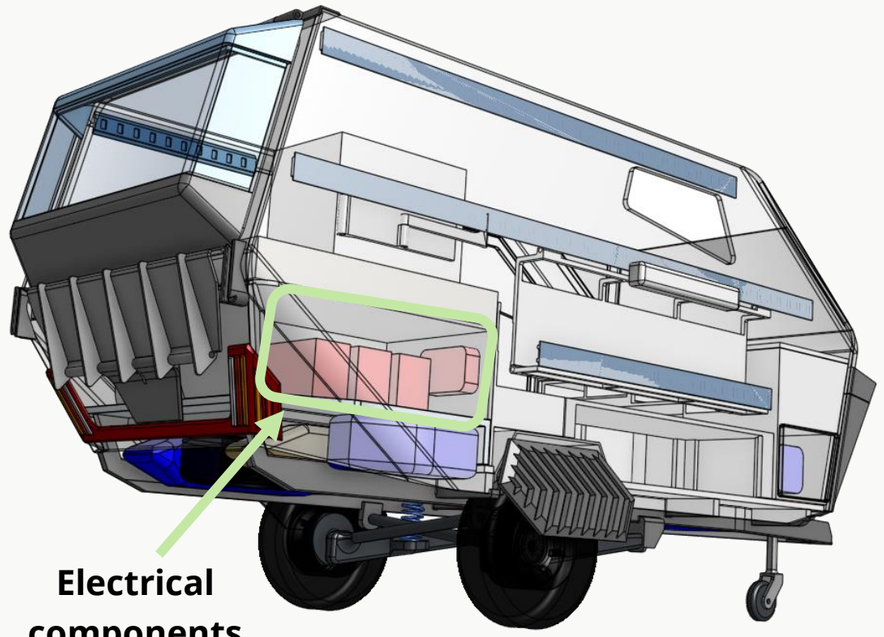
Shower tent/awning

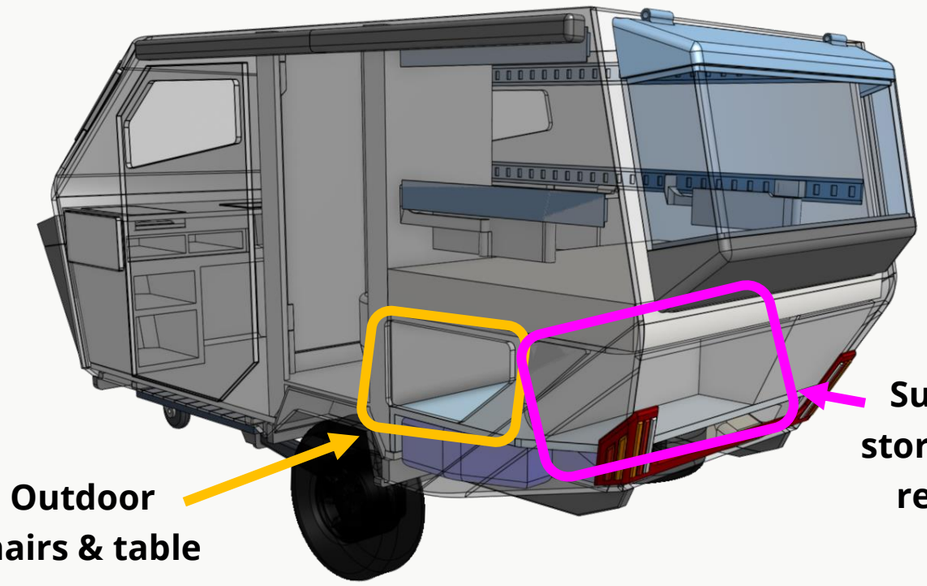
3m main awning

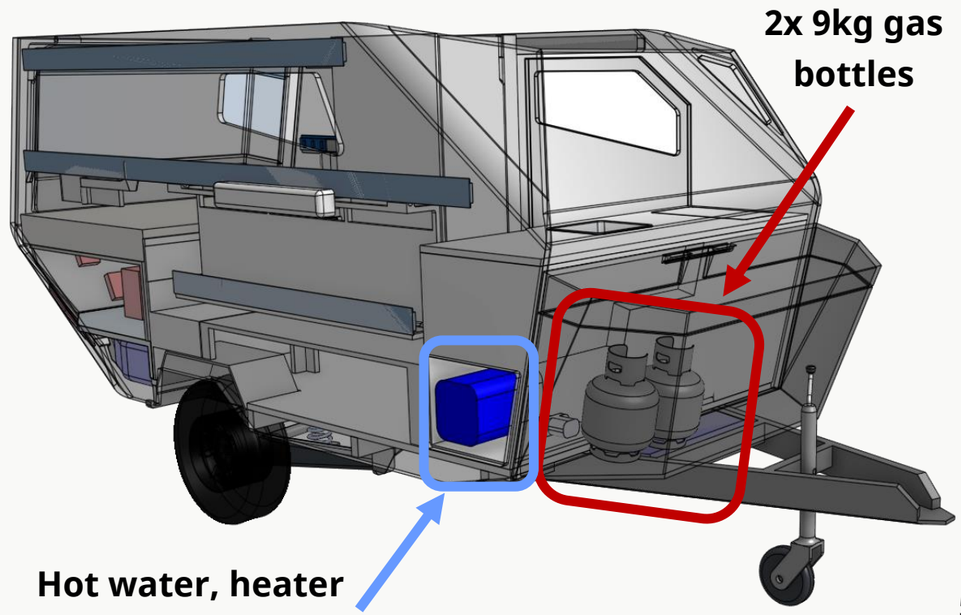


Storage overview

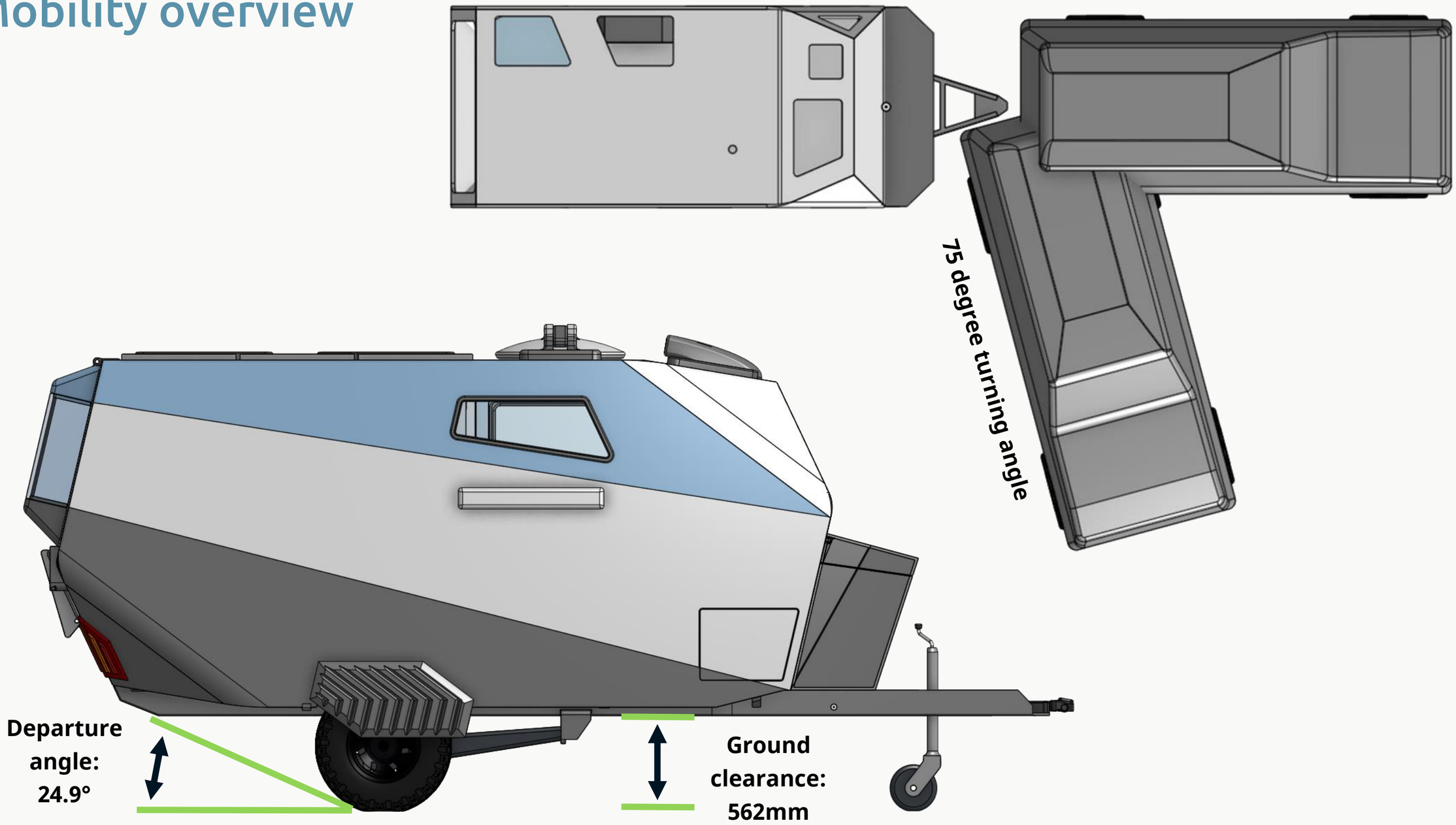








Mobility overview



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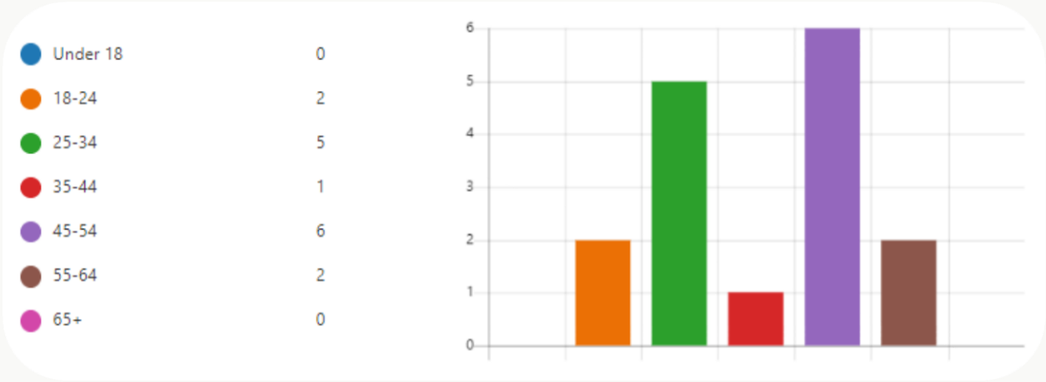
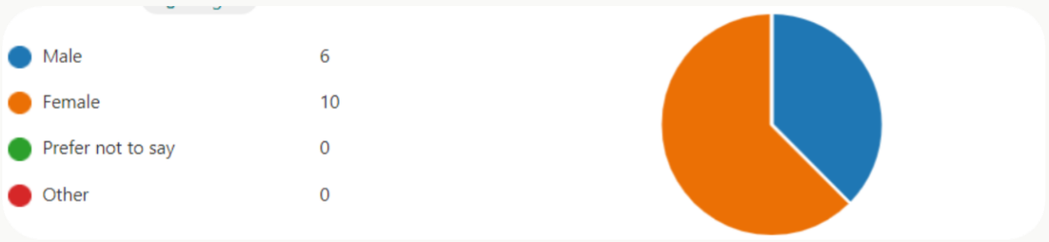
Appendix

A. FULL SURVEY RESULTS

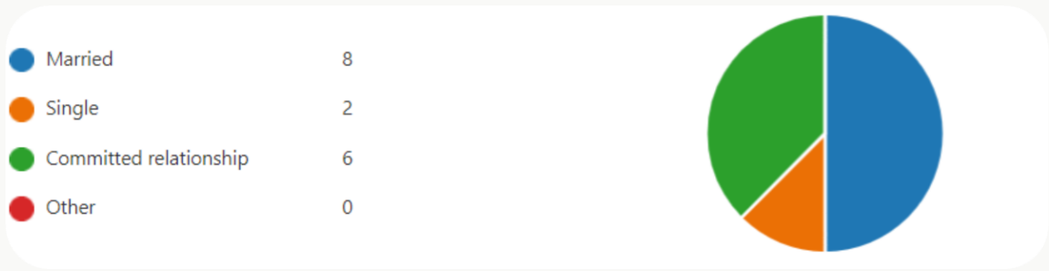
1. How old are you?



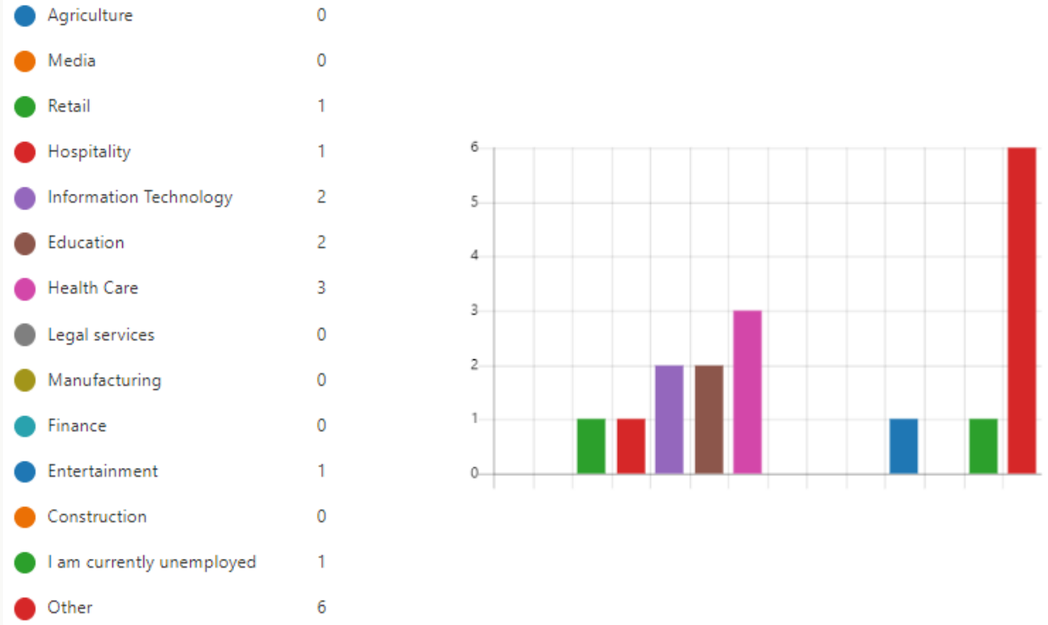
2. Gender?



3. What is your relationship status?



4. What is the primary industry do you work in?



Other industries:

Government: 2

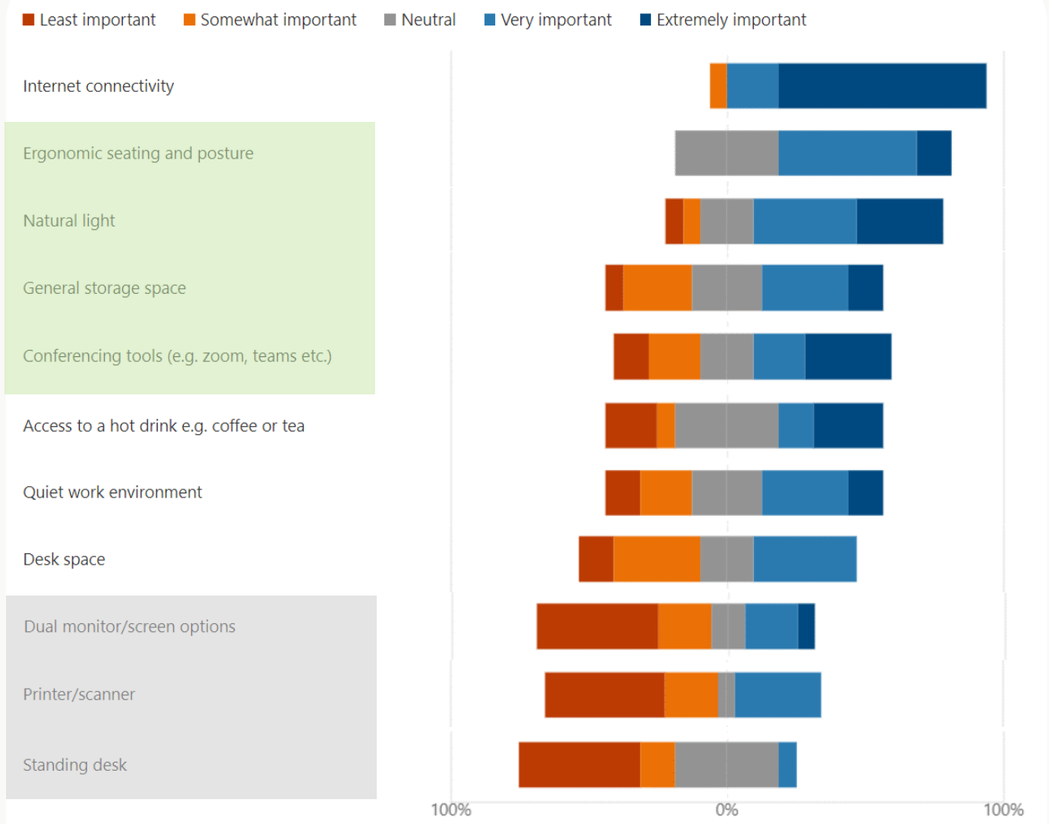
Environment: 1

Graphic Design: 1

Community services: 1

Property: 1

5. How much do you value the following when working remotely?



The results of this survey indicate the importance the following factors within a remote working environment

- Ergonomic seating and posture
- Natural light
- General storage space
- Use of conferencing tools

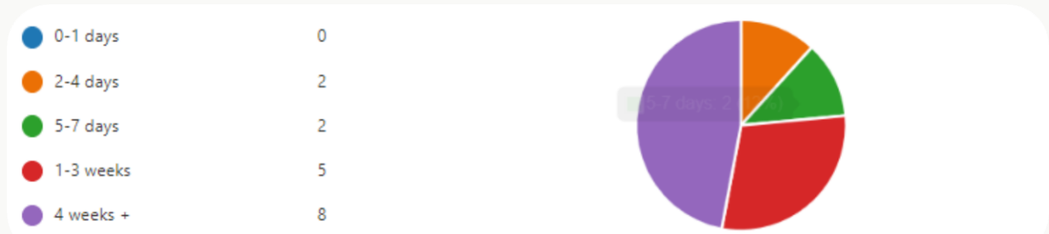
The following factors were found to be of low value and importance within a remote working environment:

- Dual monitor/screen options
- Printer/scanner

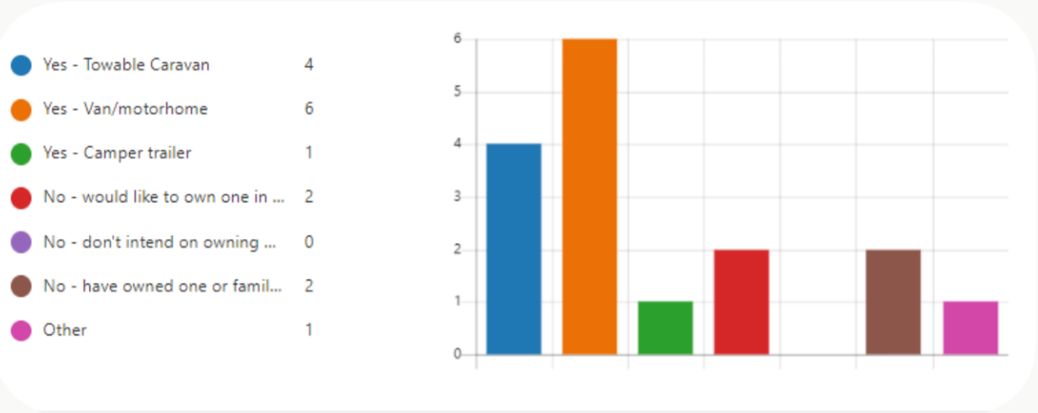
Standing desk

6. What percentage of work can be done with only computer/phone access?

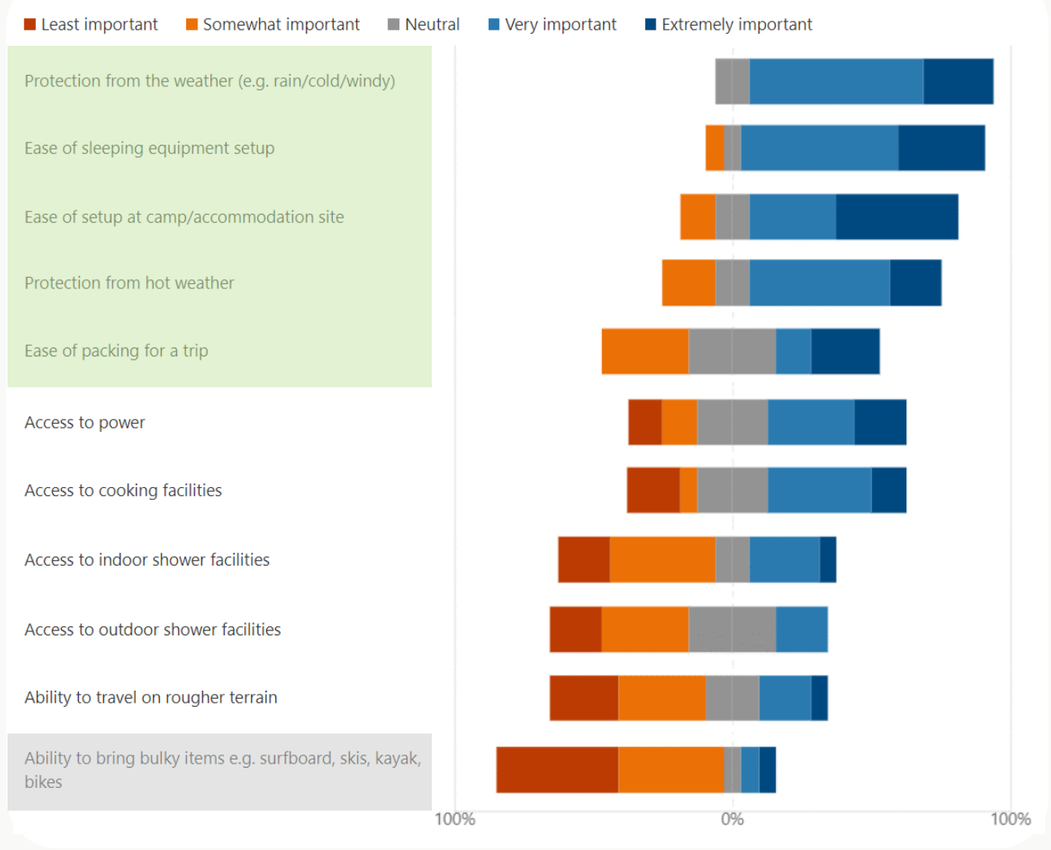
7. What is your ideal trip length when going on a nature based holiday (e.g.: camping, caravanning, adventure activities etc.)?



8. Do you currently own any kind of Recreational vehicle?



9. When on a nature based trip, how important are the following attributes



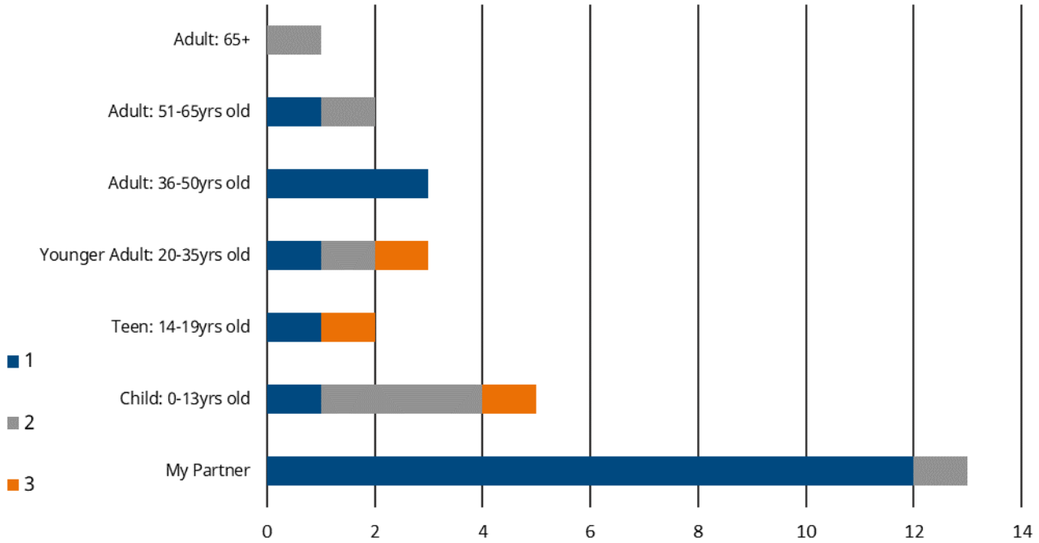
The results of this survey indicate the importance the following factors when on a nature-based trip:

- Protection from weather – rain/cold/wind/heat
- Ease of sleeping equipment setup
- Ease of camp/accommodation site setup
- Ease of packing for a trip

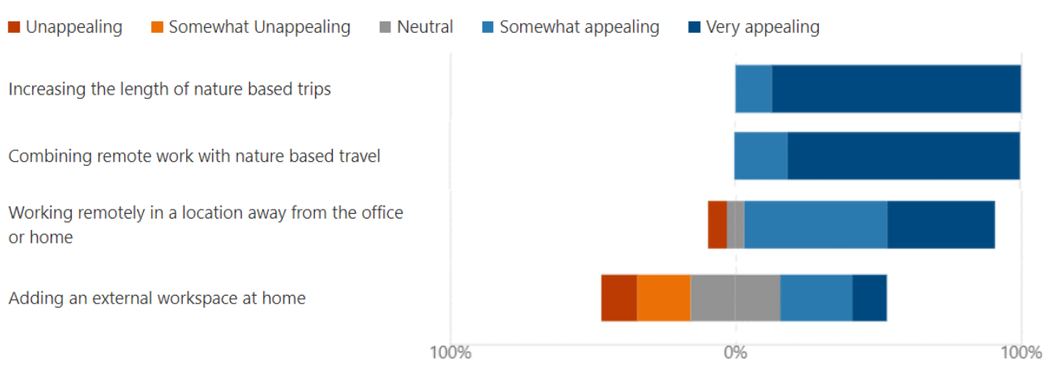
The following factors were found to be of low value and importance when on a nature-based trip:

Ability to bring bulky items e.g., surfboard, skis, kayak, bikes

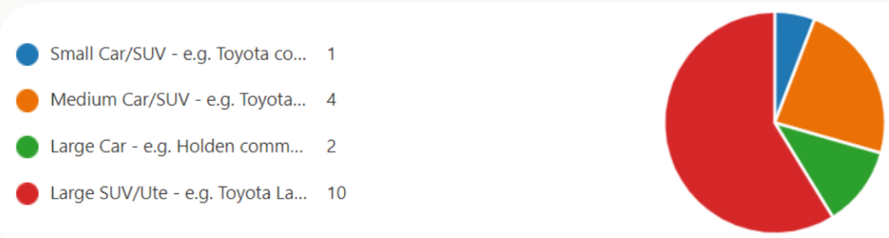
10. If you were going on a nature-based trip that included some remote work, other than yourself, how many friends and family would you like to be staying with you?



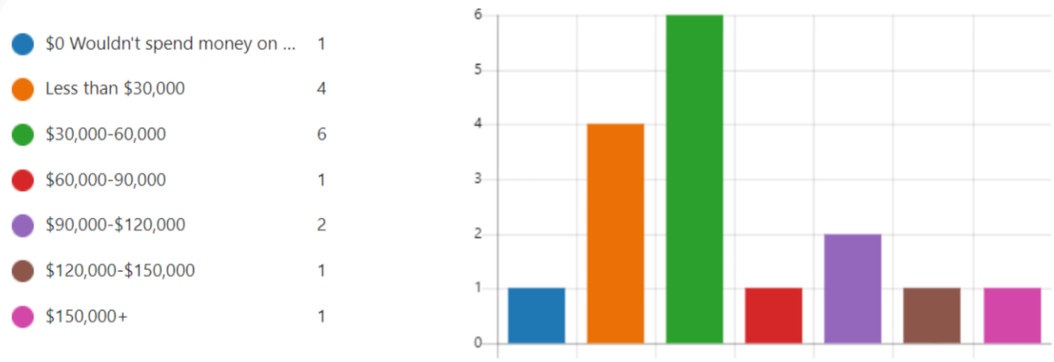
11. How appealing do you find the following scenarios?



12. What vehicle/s do you own or have access to?



13. How much would you be happy to spend on a vehicle/caravan that allows you to facilitate remote work alongside nature-based travel?



14. How would a caravan/vehicle that incorporates remote working facilities make it more likely for you to go on nature-based trips?

"To have internal shower and toilet and off grid power (solar)"

"Internet access in remote areas Storage for work stuff"

"I plan to do van life full time and continue my current office-based job but modify it to allow me to work remotely"

"In the emerging working from home climate I think if I was able to work remotely I myself would be extremely likely to go on a nature based trip."

"I plan to do van life full time and continue my current office-based job but modify it to allow me to work remotely"

“COVID travel restrictions means this isn't happening. Also need to install solar/second battery system up”

“It is a necessity if I’m going for longer trips without it, they are just no work short holidays”

“Would love to see more motorhomes and caravans with built-in office spaces for both inside and outside. We are living and working full-time on the road and really, we just need more shelter and better office spaces. Otherwise, it is an easy lifestyle and works well for us!”

B. CABINETRY MEASUREMENTS

Kitchen

	Aus std	Aus std range	Kokoda range
Kickboard height	150	100-200	0
Kickboard depth	50		0
Benchtop height	900	880-920	950-990
Benchtop depth	600	450-600	600-620
Overhead cupboard depth			350-390
Overhead cupboard height			1580/410
Bench overhang			30-35

Seating

	Aus std	Aus std range	Kokoda range
Seat height	420mm	380-510	530-pad (140)
Minimum seat width	450mm		
Seat slope	Max 5defg	0-5deg	
Seat depth		380-420	490,530,575-padding (300385@base)
Back height		N/A	910-930
Overhead height			1580/400
Overhead depth			370

Bathroom

	Aus std	Aus std range	Kokoda range
Basin height			1020 to top
Bench height			885
Bench depth			330 (cob)
Overhead depth			280-330
Overhead height			1660/330
Bench overhang			
Washing machine bench depth			530

Bedroom

	Aus std	Aus std range	Kokoda range
Bed length			
Bed width			
Bed height			480+mattress (700)
Mattress thickness			220
Height to overhead from bed			800
Cabinet depth			

General

	Aus std	Aus std range	Kokoda range
Doorway width			600
Doorway height			1900
Roof height			1990
Bench overhang	20		
Overhead cupboard height		1580-1700	

C. ELECTRICAL CONSUMPTION CALCULATIONS

12v from battery	**watt hours**	**Ah**
Mobile phones	30	6
Fridge	720	60
kettle (6 cups)	180	15
12V fan	108	9
Lighting	120	
Water pump	12	1
230V from inverter	**watt hours**	**Ah**
Laptops	960	
Electronic device charging	100	
	0	
	0	
Power generation	0	
Solar power	2400	
Power storage		
Battery power	3600	300

Approximate Energy Usage for some 12Volt Devices

Amp-hours per Day

	Typical use per day	Consumption	Ah per day
CPAP Machine (on 12V adaptor)	8hrs, humidifier off	varies by make	15-35 Ah
Electric Blankets (12Volt)	2 hours	3 Amps	6Ah
Fan 12V (brushless motor)	8 hours	< 0.5Amps	4 Ah
Fridges (see heading above)			
– Chest 30-50 litre	continuous use	24hr average	35 Ah
50-70 litre	continuous use	24hr average	45 Ah
80 litre	continuous use	24hr average	65 Ah
– Upright 110 litre	continuous use	24hr average	90Ah
140 litre	continuous use	24hr average	95 Ah
220 litre	continuous use	24hr average	125Ah
Inverter (12V to 240V)	depends on 240V equipment connected – see above		
Kettle (12Volt)	1 boil (½hr for 3 cups)	15 Amps	7.5 Ah
Laptop (via Inverter)	5 hours	50-80 Watts	25-40 Ah
Lighting – Halogen 20W	5 hours	20 Watts	8.3 Ah
– LED replacement	5 hours	3 Watts	1.3 Ah
– LED strip 1.2m	5 hours	1.5 Amps	7.5 Ah
Microwave 850W (via inverter)	5 minutes	110 Amps	9.2 Ah
Ovens (12Volt)	1 hour	6 Amps	6 Ah
Pumps – water pressure	5 mins	5 Amps	0.42 Ah
– transfer: diesel, water	1 to 3 minutes	4-6 Amps	minimal, variable
– bilge	who knows	2-20 Amps	see detail above
TV 12V LED 24-inch	5 hours	3 Amps	15 Ah

D. 3D PRINTING FILE TRACKING

The large majority of 3D printing files were tracked using this excel doc. (missing props and some smaller parts)

Item	Ready?	Printed?	Colour	Printer					
Bedframe			white	cr10	Rear window bottom			3d fillies grey	e3
Rear floor			white	cr10	Rear window top			Dark blue esun	e3
Shower			White	cr10	Interior E-tracks			Dark blue esun	e3
Toilet			White	cr10	Chair backs			Dark blue esun	cr10
Kitchen main			White	cr10					
Bed			White	cr10	Under lounge Crates			Dark blue esun	cr10
lounge frame - side			White	cr10					
lounge frame - rear			White	cr10	Bunk frame			White	cr10
Lounge cushions			White	cr10					
					Cooktop			PLASTEEL silver	cr10
Slide out kitchen			White	cr10	Wheel wells			black	cr10
Satelite dish			White	cr10	Chassis - front			PLASTEEL silver	e3
Bedframe flip up			White	cr10	Chassi - mid			PLASTEEL silver	e3
Kitchen top			marble	cr10	Chassis rear			PLASTEEL silver	e3
					Suspension			PLASTEEL silver	cr10
Front cnr support			3df White	cr10	Solar panels			PLASTEEL silver	cr10
Outer etrack			3df White	cr10	Sink			PLASTEEL silver	e3
reverse taillight					Gas bottles			PLASTEEL silver	e3
					Fridge			PLASTEEL silver	e3
Window frames			3d fillies grey	e3	Rims			PLASTEEL silver	e3
Front boxes			3d fillies grey	e3					
Wheel covers			3d fillies grey	e3	Water filler cap			Black	e3
Rear footrest			3d fillies grey	e3	dO35 hitch			Black	e3
Rangehood hatch			3df White	e3	Outdoor shower			Black	e3
Side Awnings			3d fillies grey	e3					
Roof fan			3d fillies grey	e3	Hot water service			Esun blue	
Satelite base & arm			3d fillies grey	e3	Water pump			Esun blue	
Kitchen drawer fronts			3d fillies grey		Water tanks			Esun blue	cr10
Exterior E tracks			3d fillies grey	e3	Grey water tank			brownish	cr10
Deck			3d fillies grey	cr10					

E. INITIAL STORYBOARD