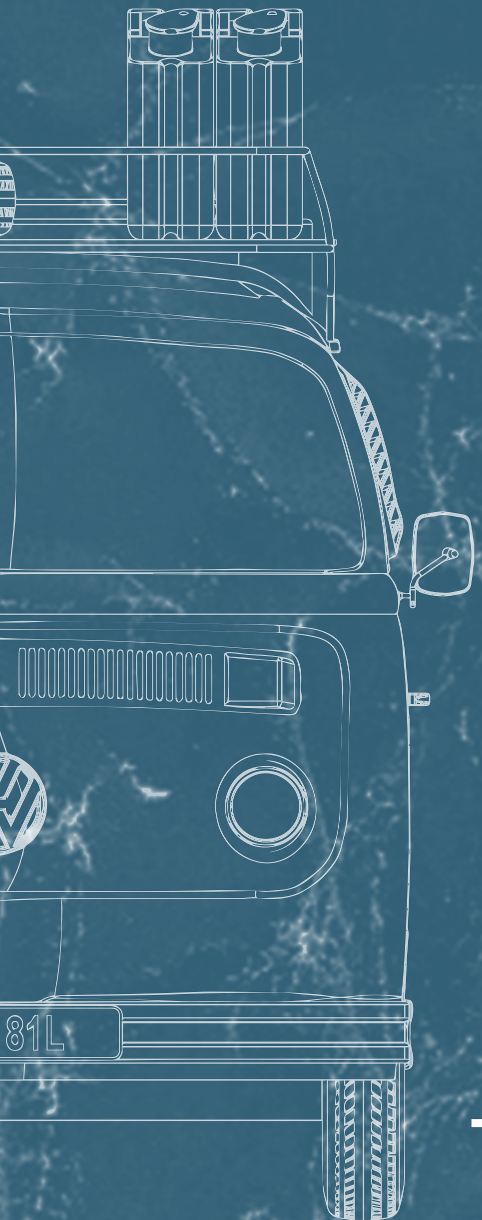
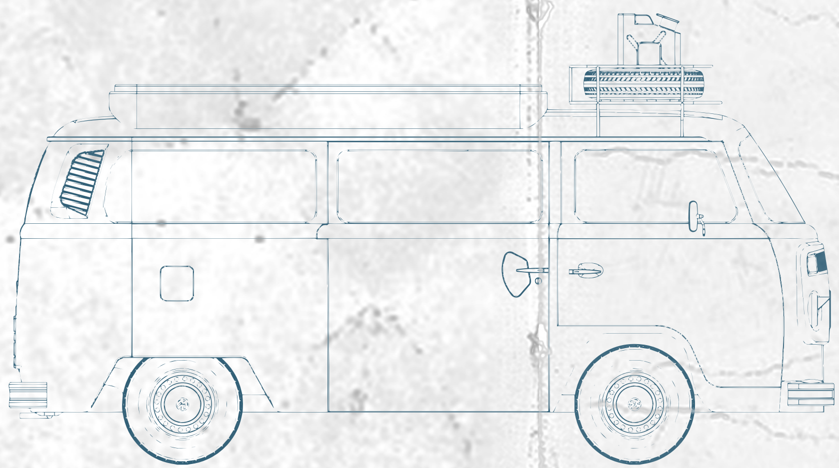




OWNERS MANUAL

VW CAMPERVAN

T2 1973

ABSTRACT

The report which follows is a look into the benefits and utilisation of surface modelling within a design engineering workflow. It will be focussing on the construction of a 1973 VW T2, structurally the same as the devon conversion which is most commonly associated with the “Campervan”.

The following sections will look into the techniques used to surface model an automobile, understanding the limitations of the Solidworks software for surface modelling as s Hybrid modeller. It will also then use Siemens Jack to analyse the ergonomics of the models through a series of controlled experiments.

Then there will be an analysis of the SolidWorks FEA and design analysis tools. As well as an overview of the motion studies and animation tools.

The real world application of FEA successfully integrated into the design process can save large amounts of money but also improve a product greatly. Whilst it may look great and perform great it may be over-engineered, there may be stress concentrations when loaded in certain orientations. It may just be that there is undetected collision when all the parts are assembled and put into motion.

CONTENTS

INTRODUCTION

Fig 1. VW Camper Side On (2015)

1. The design of this document is based on the original owners manual to the Westfalia Campmobile (Operating Instructions Campmobile 70, 1970). Hence the minimalist functional design style.

2. During the 40-year production life of the van, it underwent countless variants, even amongst the ones being released under the same model numbers they would be improving and changing things behind the scenes, the biggest change came in 1972/73 when they had a massive overhaul giving rise to the late bay or early bay monikers.

SURFACE MODELLING

1. Dimension Set-up
2. Modelling Methods
3. Model Evaluation

DIMENSION SET-UP

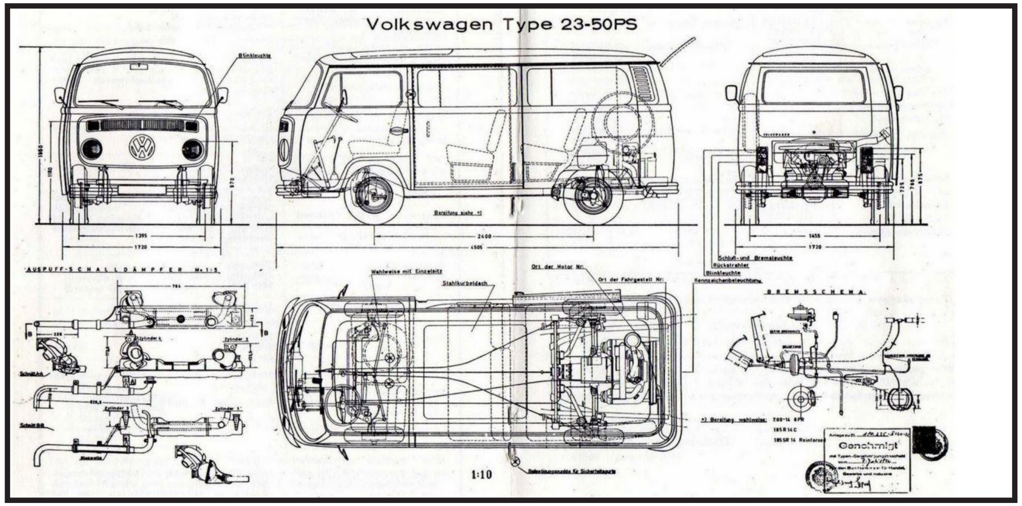


Fig 2. Volkswagen Type 23-50PS(1976)

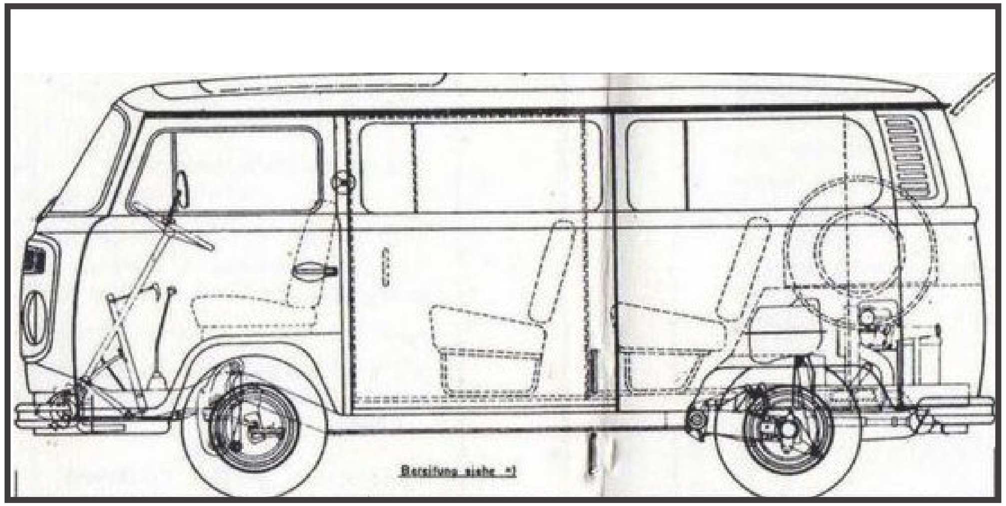
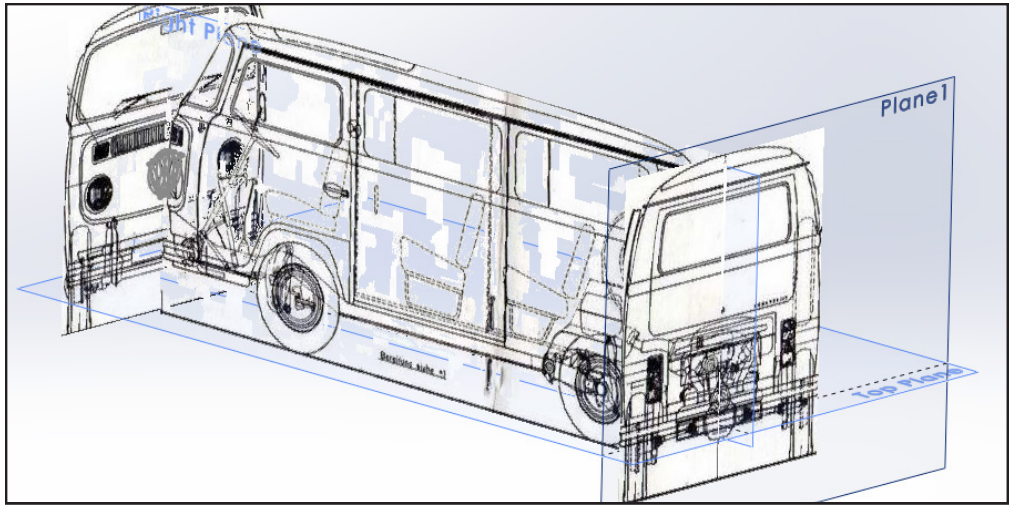
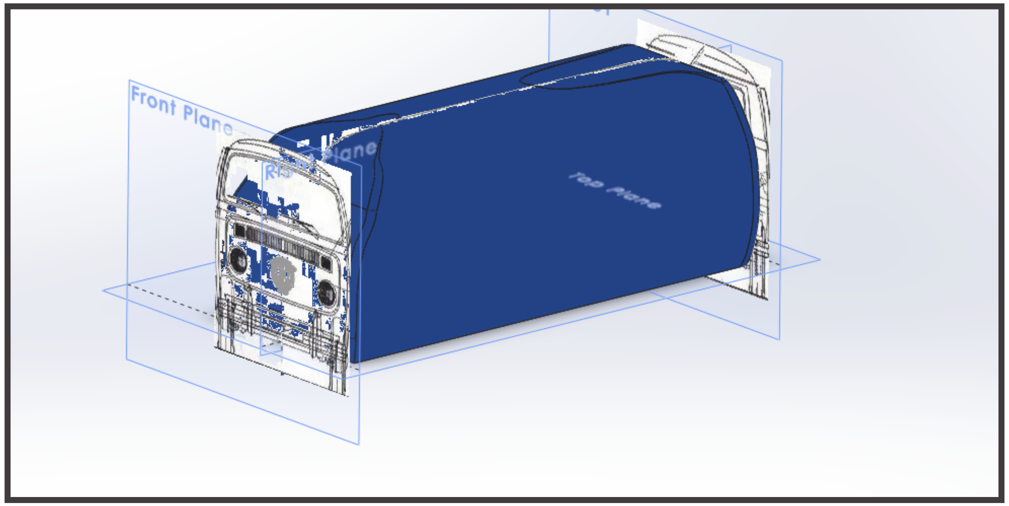


Fig 3. Volkswagen Type 23-50PS(1976)

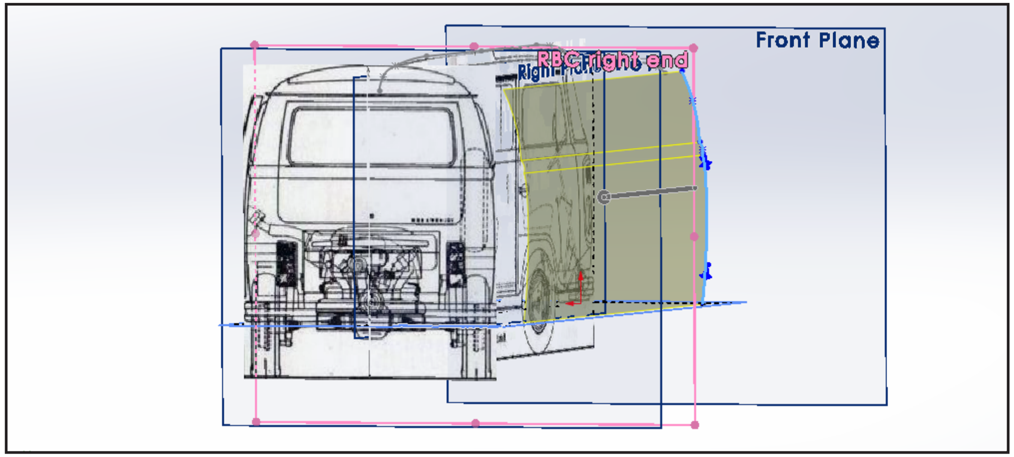




For the car choice I went with a 1973 VW campervan with a Devon pop-top conversion. However being a classic car from the 1970's the orthognal drawings are not what would be traditionally classed as accurate. Fortunately the dimensions are accurate and the dimensions were used to drive the drawing data rather than the otherway around.

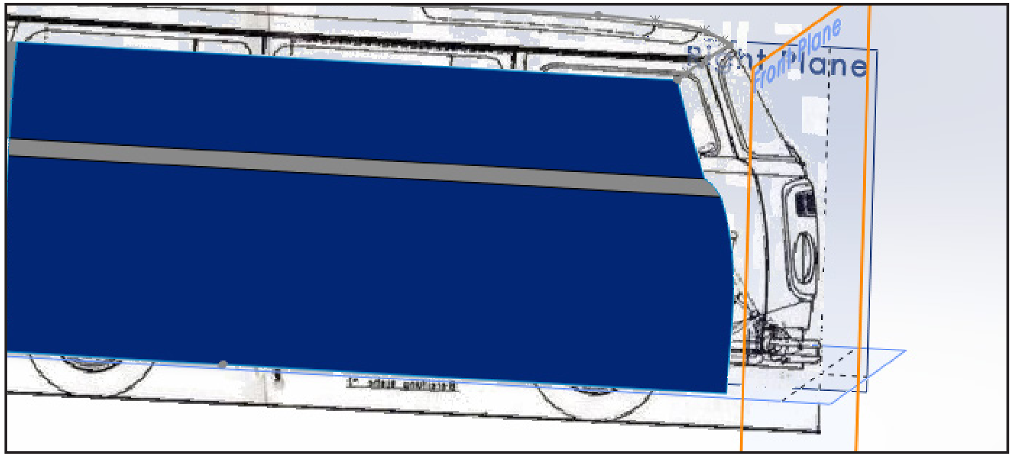
After setting the planes with their respective images I created a simple block model to give me a sense of scale, by my own admition this wasn't overly utilised during the construciton stage and acted more as a governer to see where sections needed reigning in and where they were falling short of the silloutete dimensions.

Side Panel A



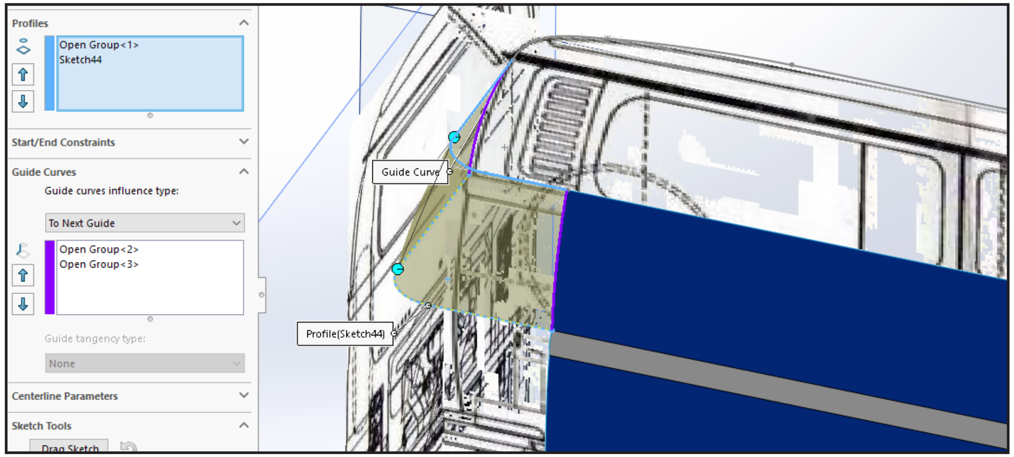
The side section is usually welded from several different panels but for the purposes of the modelling that was simplified to one large sweeping section before the curvature point. Panel A was built using a simple surface extrude of the side profile, the windows are cut out later.

Side Panel A Trim



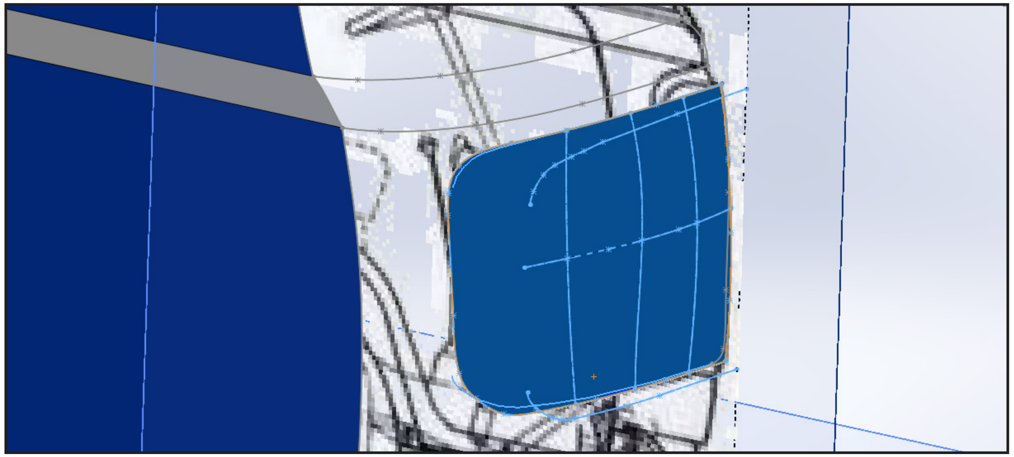
Side panel A runs the entire length of the body before curving into rear panel C, and rear panel B. In order to match up with its tangential panels It needed trimming down to shape, this was achieved with a simple sketch and trim tool.

Rear Panel C



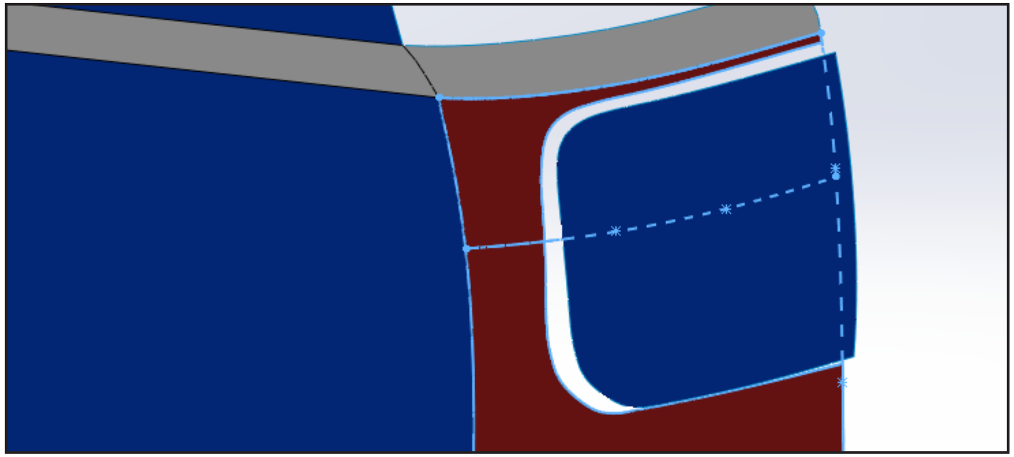
Rear panel C is the first of the curved surfaces, it has curves in two directions so the surface loft was created using the top and bottom profile then refined using guide curves to achieve the right shape. A direct copy entities sketch was used to match the tangential face.

Front Indent



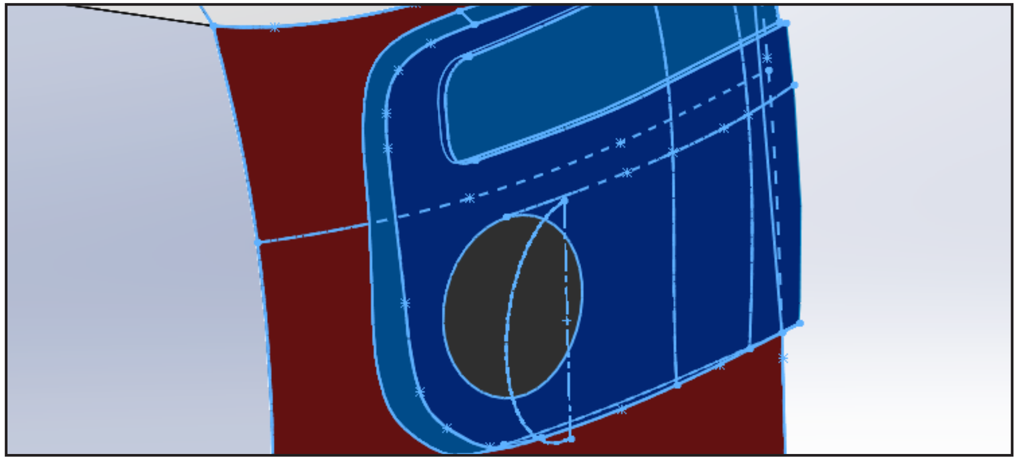
The front indent went through several iterations using the boundary surface tool to create the closest approximation to the final object. The zebra analysis showed issues here which were heavily improved upon however as you will be able to tell still require further refinement.

Front panel



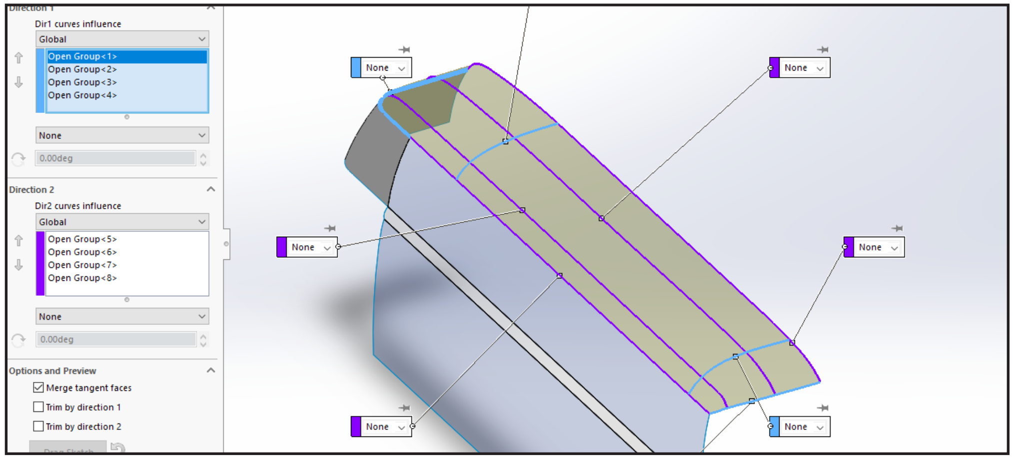
The front panel is comprised of a few sections and to reduce continuity issues was split into as few sections as possible, the large curved face was constructed of a boundary surface. A trim was used to cut out the offset hole that will then attach to the indent above it.

Front Panel Details



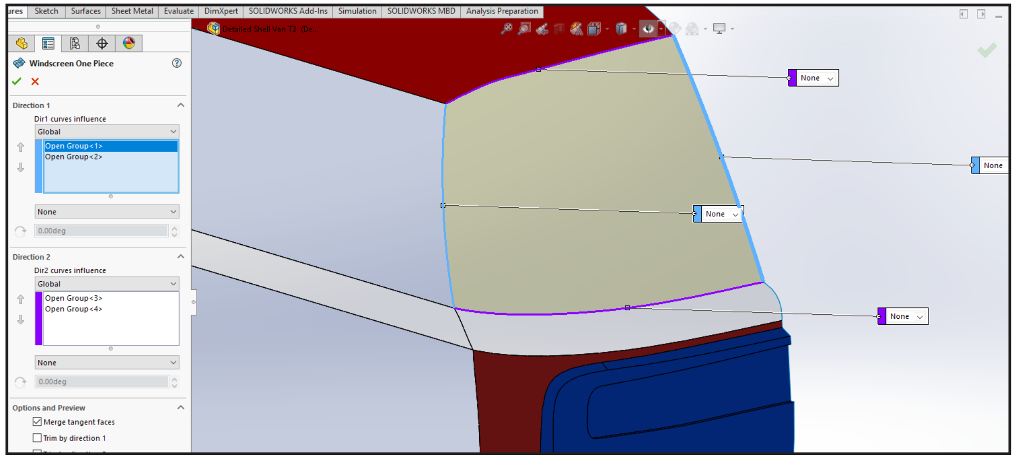
The front panel needed the gap between it and the raised section lofted and then the indentations which are present on the real sheet metal are there to provide the inserts for the front grill, indicators and headlights.

Roof



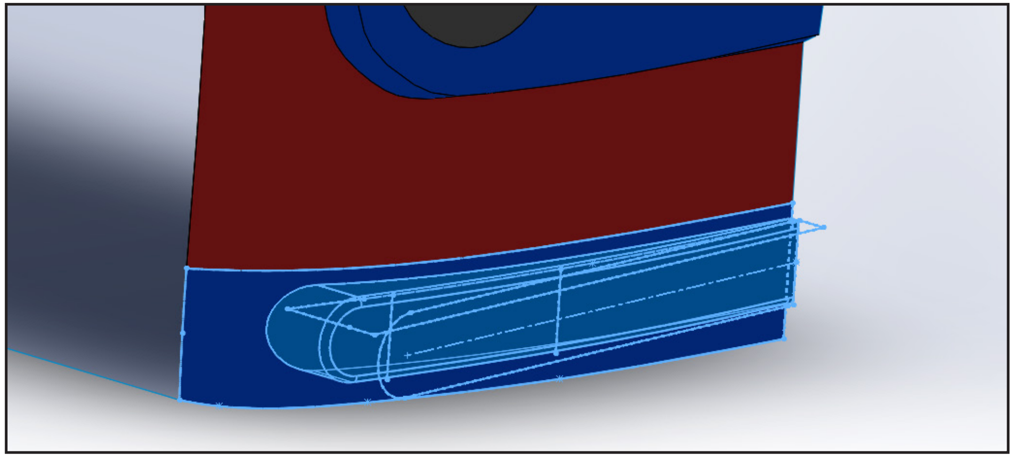
The roof has varying curvature along its length and width and as such some more guide lines were added, this was aligned to reference planes to ensure it met the extremities of the blueprints, The slight dip in the central section was evaluated using the curvature analysis and then cut and replaced with a fill cut.

Windscreen



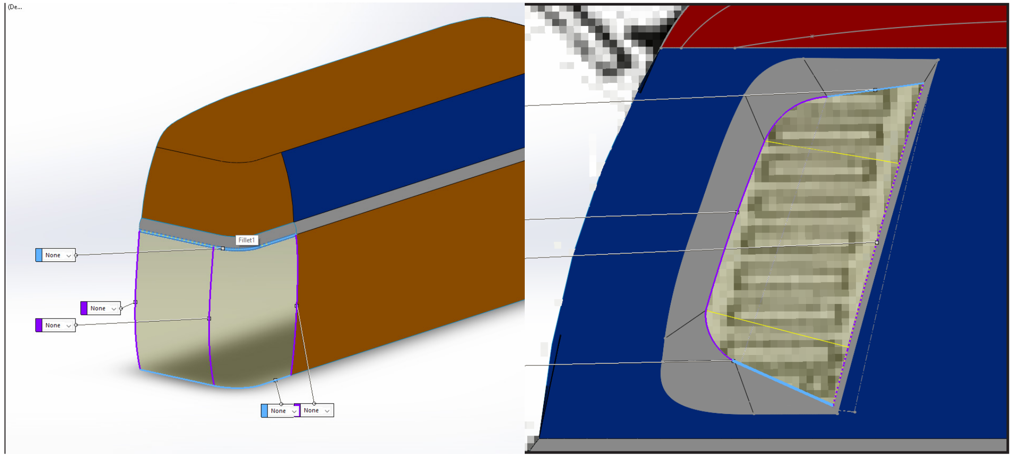
The windscreen and surrounding sheet metal were kept as a single boundary surface this ensured there was perfect continuity between it and the other surface. Originally the windscreen was modelled separately but didn't have good enough continuity so it was remodelled. The original sketches have been left in the design tree for reference.

Front Deformation panel



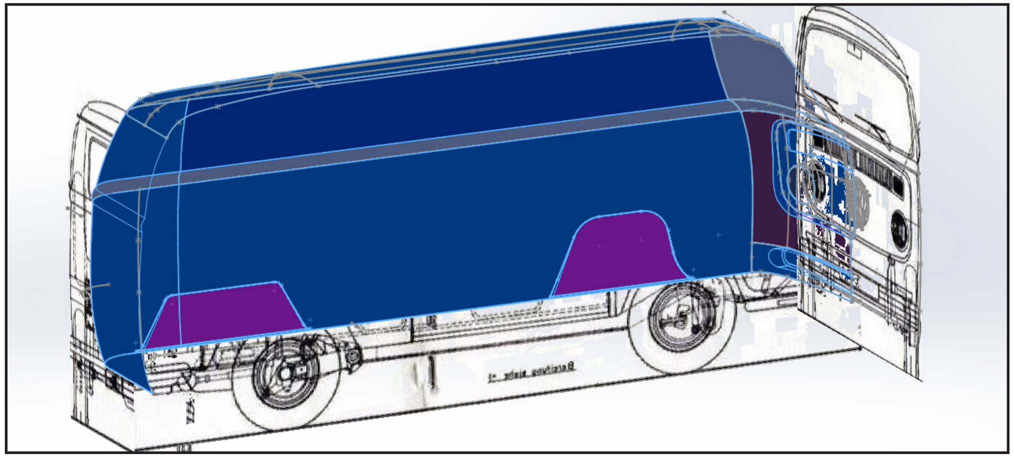
The front deformation panel is another one that isn't seen on the final assembly because it is what the front bumper sits on. The curvature to the panel was built using an extrude, a split line to get the secondary curve then delete and fill face to create the new hollow part.

Rear Panel B + Vents



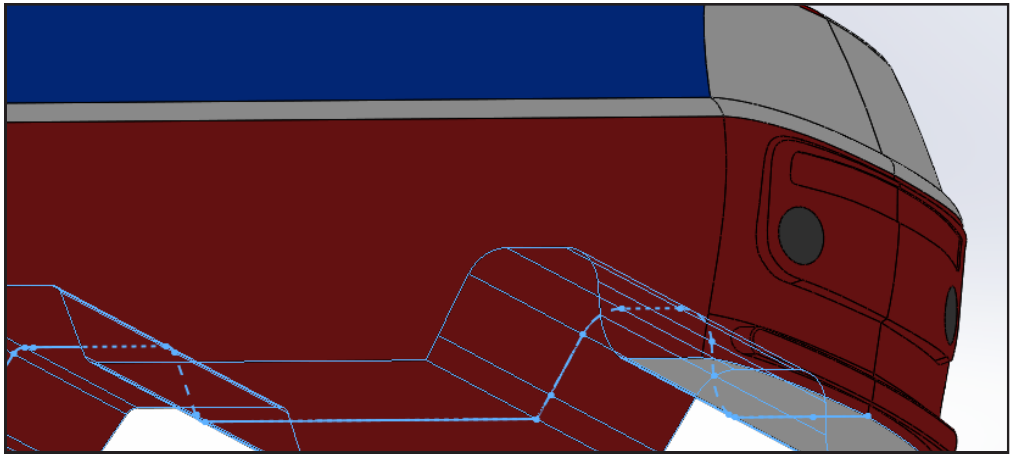
Rear panel B was matched to the side panel A curve and built in much the same respect as rear panel C, This tangential to the side panel A curve to aid continuity. The vent protrusion had to be left blank for print optimisation later. This was a simple loft, delete and fill face.

Wheel Arch Cut



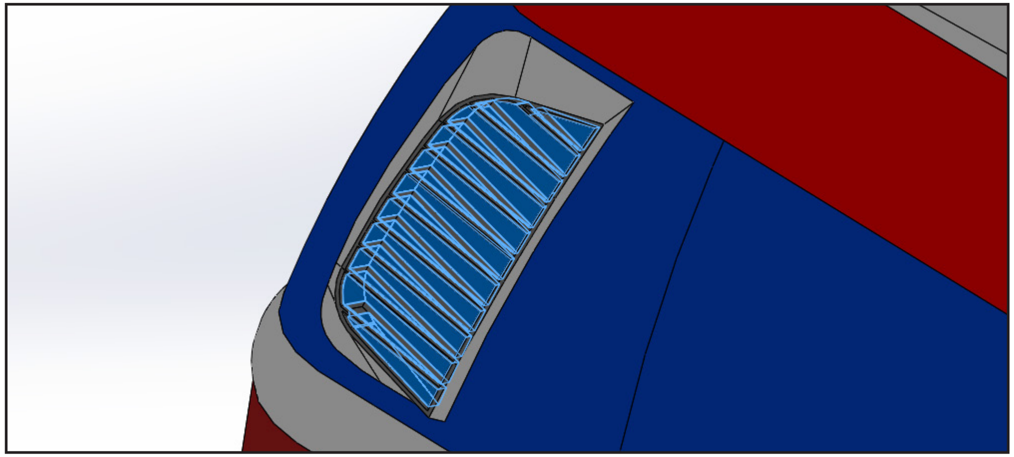
Wheel arches were cut out here to the same specification as the blueprints, this was then extruded out to the right plane for the solidification process. As you can see from the sketch they are non-symmetrical because the rear wheel sits inside the arch.

Solidfication



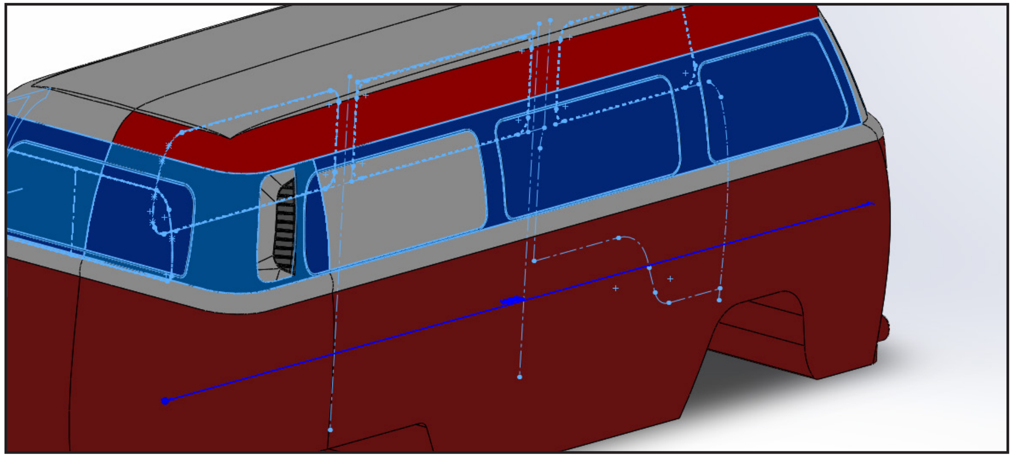
The solidification made use of the mirror tool and the knitting tools that have been used throughout to knit and bridge the gaps between tangential surfaces. There were some alignment and continuity errors that were rectified at this stage predominantly with the roof feature.

Rear Vent Cut



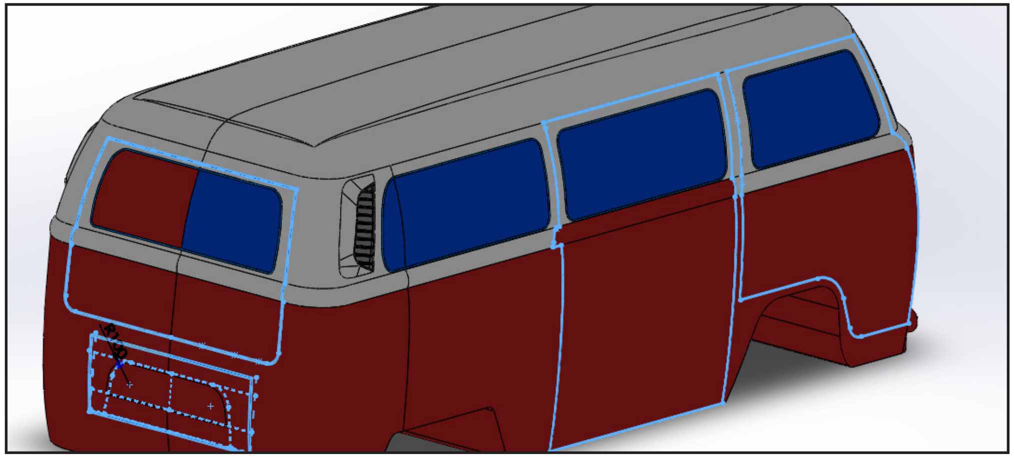
After solidification, the details were added in. In the case of the rear vents, these sit over a complex internal duct system that would have been unnecessary to model however with the extrude cut tool I was able to create an appropriate visual facsimile.

Windows & Seals



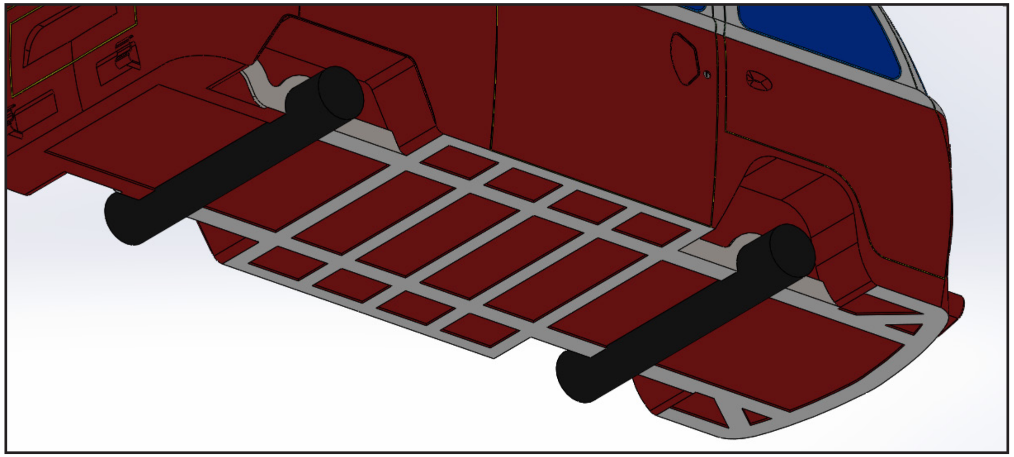
The windows and seals were added in here through the use of wraps scribing onto the surface and using the 3D sketch to sweep a rubber trim into the solid body. This, in turn, created a separate face for the windows whilst maintaining continuity.

Doors



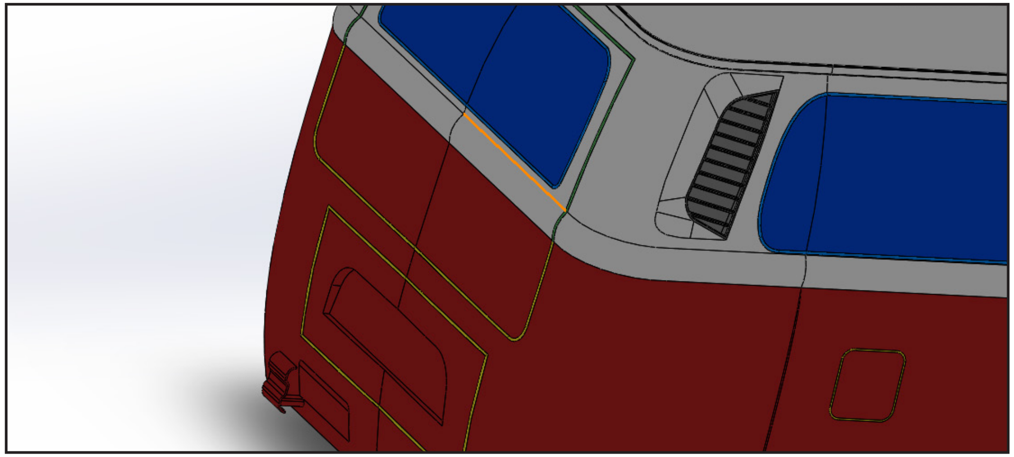
Doors were created with much the same effect as the windows, wraps were made from the orthogonal views to create the basis for swept cuts to create the effect of a door seam in the sheets. The number plate and door handle dents were created using wraps and cuts in a similar method.

Beams & Axles



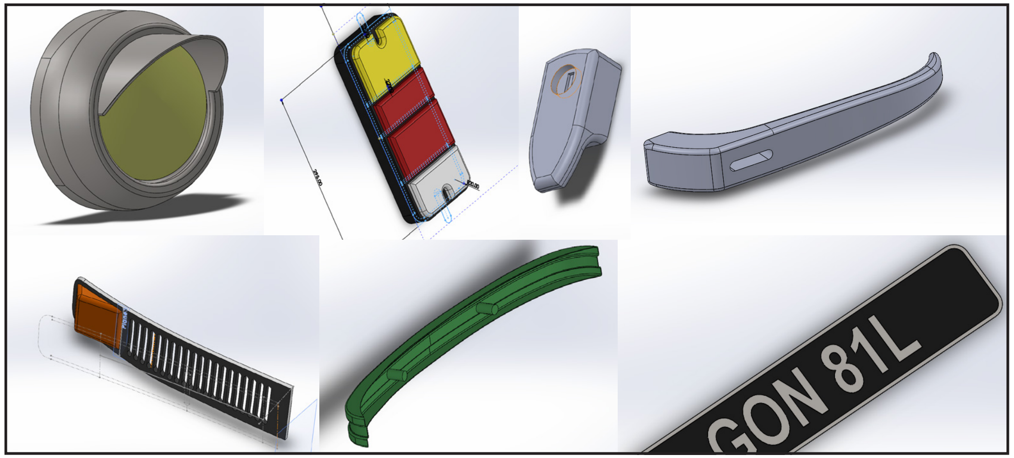
The chassis beams were copied from the Haynes owners manual and the authors own experience rebuilding the somewhat less structural chassis of his 1963 VW T2. They were cut out to indicate what the structure is like underneath the vehicle and provide a mounting point for the wheels.

Supports, Exhaust & Guttering



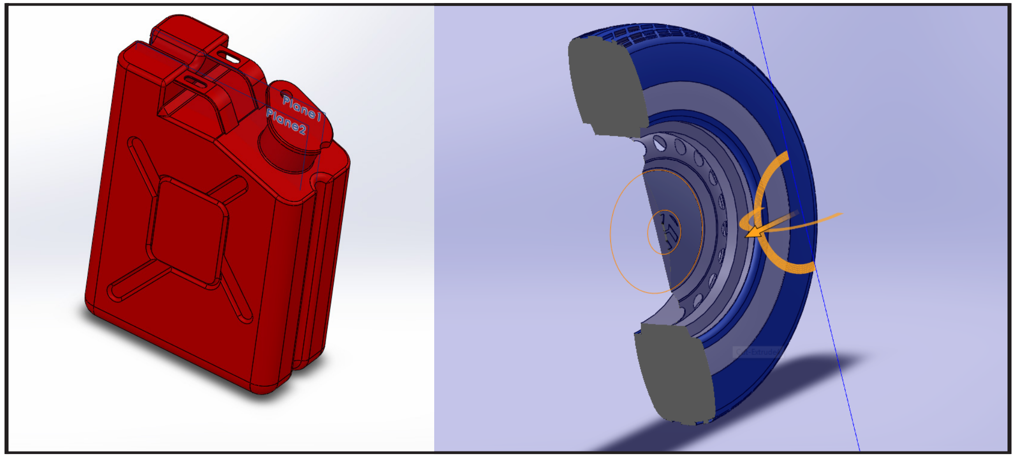
The rear bumper supports, exhaust and guttering were made with standard solid modelling methods and as close to the actual specification of the parts as possible, the exhaust system is a more of an approximation as the entire engine bay is open from the bottom.

Lights, Bumpers, Handles & Number Plates



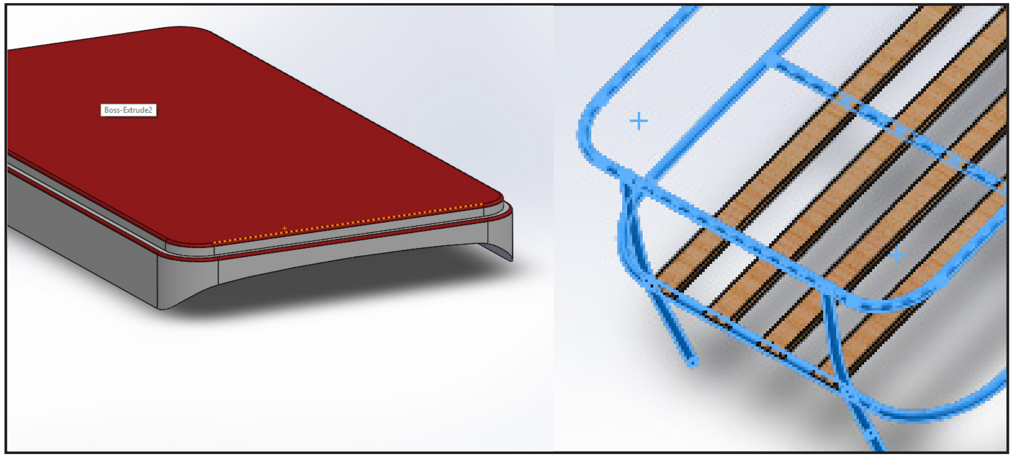
All the extra components were modelled separately in SolidWorks and then boolean into position for the print version. They were modelled separately so the van could be assembled as close to how it would be in real life as possible.

Wheels & Jerry Can



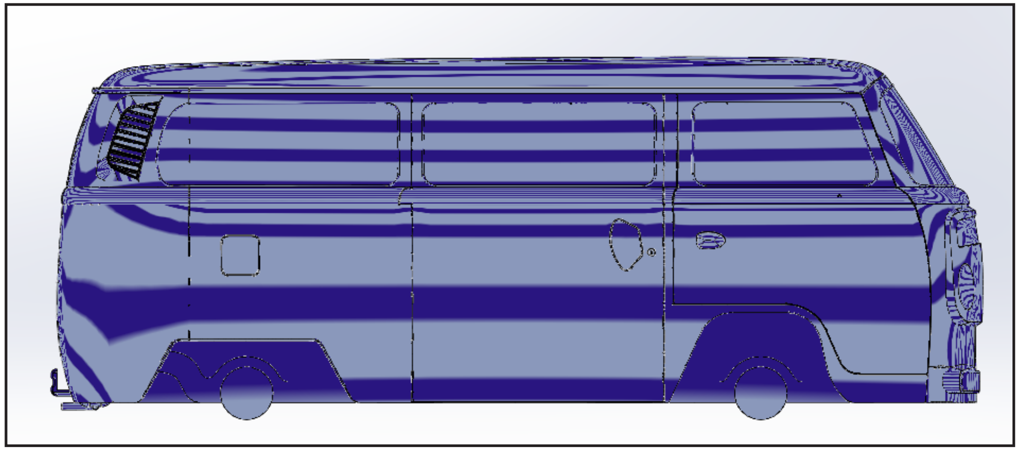
The wheels were built using the engineering drawings for the wheels found online, Justkampers.com. (2019). and the jerry cans were based on the generic commercial ones. Whilst not technically part of the van it was modelled as part of the accessories like the poptop and roof rack.

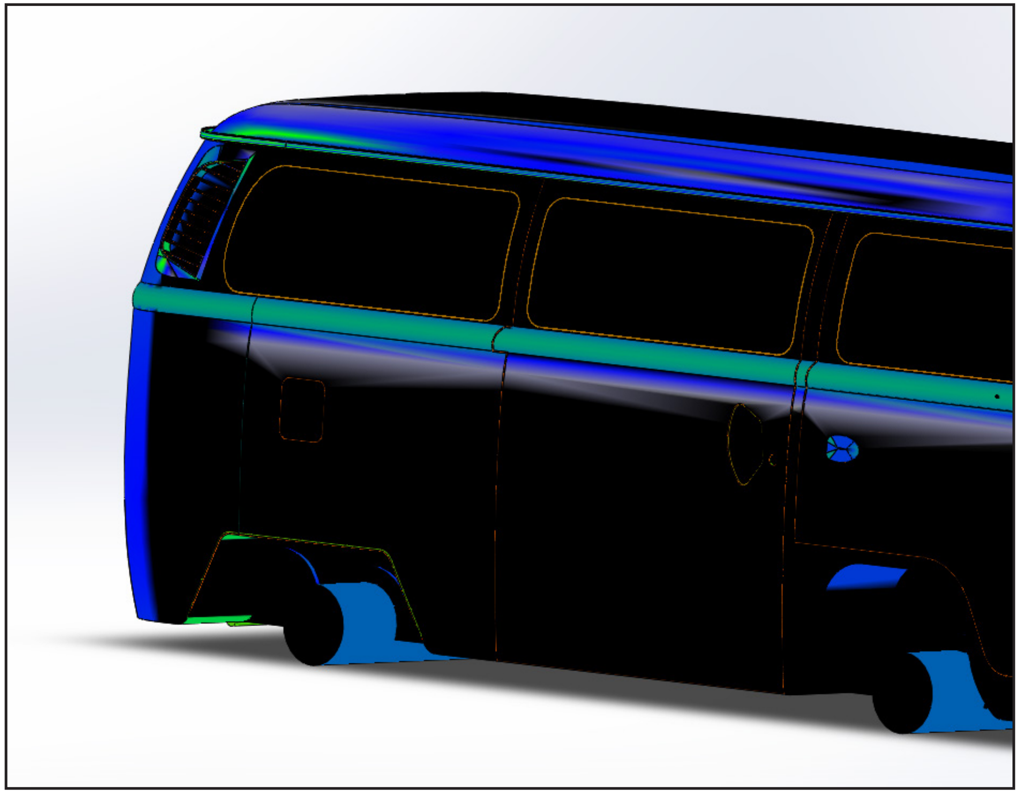
Roof Rack & Pop Top



The poptop and roof rack were standard components on the devon conversion of the original microbus, the pop top is a simple series of extrudes and the roof rack is a series of tubular sweeps.

MODEL EVALUATION





Continuity

The model went through standard zebra analysis to try and reduce continuity issues, the biggest problem area was the front indent panel. It has an issue from the way the panel was built in the factory. Due to the method of spot welding the front sheet to the deformation panel in order to essentially pull it taut and stiffen it up, it varies a lot from van to van. It also proved just as difficult to regain continuity on that point in both the digital world and the real world but due to time constraints, it was draining too much time to get it perfect so it was left at a, whilst improving, less than perfect state.

The continuity between the side panel A and the rear panels was adjusted and filleted to match the real world continuity of those panels.

Unlike a lot of the more sweeping designs being modelled the T2 has some very straight cut off points, whilst not as elegant as the supercar these rigid lines and unique panel terminations give the van a very noticeable character and one that is very noticeably wrong when modelled incorrectly.

The curvature analysis was used to check the dips in the roof and make sure the highest point was the right plane, this would have been a feature of the van to prevent water sitting on the roof and causing rust so it was crucial to make sure the surface matched the drawings here.

In Future

In evaluation of the modelling as a whole I would rebuild the front section completely and model it from the base panel first, then creating an offset surface for the raised profile to ensure a more accurate model.

3D PRINT OPTIMISATION

1. FDM Testing
2. Stratsys Objet24 Testing
3. Major Alterations
4. Model Print Optimisation
5. Painting and post processing

MODEL EVALUATION

Fig 4. 3D Print Testing Images (2018)

FDM Test

In order to test the detail quality and see where improvements needed to be made I printed off a series of parts no an FDM printer first. The main body came out fine and the logo definition was a bit small to be able to be seen so was bumped up for the final model.

Stratsys Objet24 Testing

The wheel dimensions and wall thickness testing was done using a small test plate on the final printer, A few test wheels and window trims were deemed too small and beefed up further for final printing, as was the front grill.

Major Alterations

The biggest alteration from the detailed model and the print models was the inclusion of a magnetic piston for the potop to be able to be pushed up and down. Given more time in future, a more precise way of adding the fabric would be found.

Model Print Optimisations

For the print variant of the model the bumpers where solidly modelled and boolean on, the guttering was removed and the rear vent grill and front grills were enlarged to not be lost in detail. The front panel logo was raised higher as was the wheel logos, however, both were lost somewhat through the use of enamel paint whilst wouldn’t be recommended for future models. The window seals were also increased from 7.5mm radius to 12.5mm (Size Before Scaling) to make them more visible. The number plate was also removed and the lights were boolean into the main body.

The model was then split into 4 for printing to better utilise the printers fine detail in the layering. locator pins were used to align the model however there was still minor movement in the pins.

PAINTING & POST PROCESS

PAINTING

For painting, I used enamel paints to give the gloss effect you would get on a full-scale car. It did, however, have the side effect of obscuring some of the finer detail such as the wheel treads. This would be improved on in future iterations. The pop-top utilises a magnetic plunger to act as a sprung roof that can be pushed up and down. The fabric acts as a retainer to stop the magnet from unseating. The wheels are seated on bearing so the car rolls. The base red is standard plastic spray paint. The while model was coated in primer, then base coated in red after which the white enamel was added in over the top.

Whilst critically the paint finish is not the finest it does highlight the print optimisation features well that even after a thick enamel coating they still are perfectly visible.

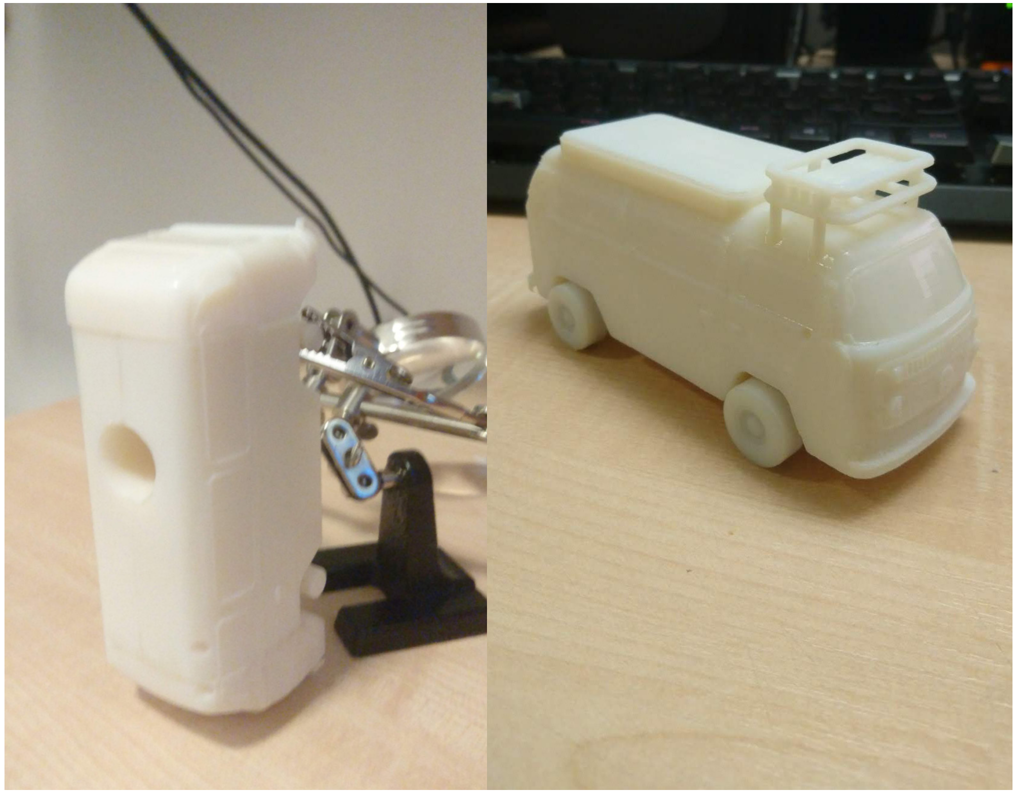


Fig 5. 3D Print Assembly Images (2018)

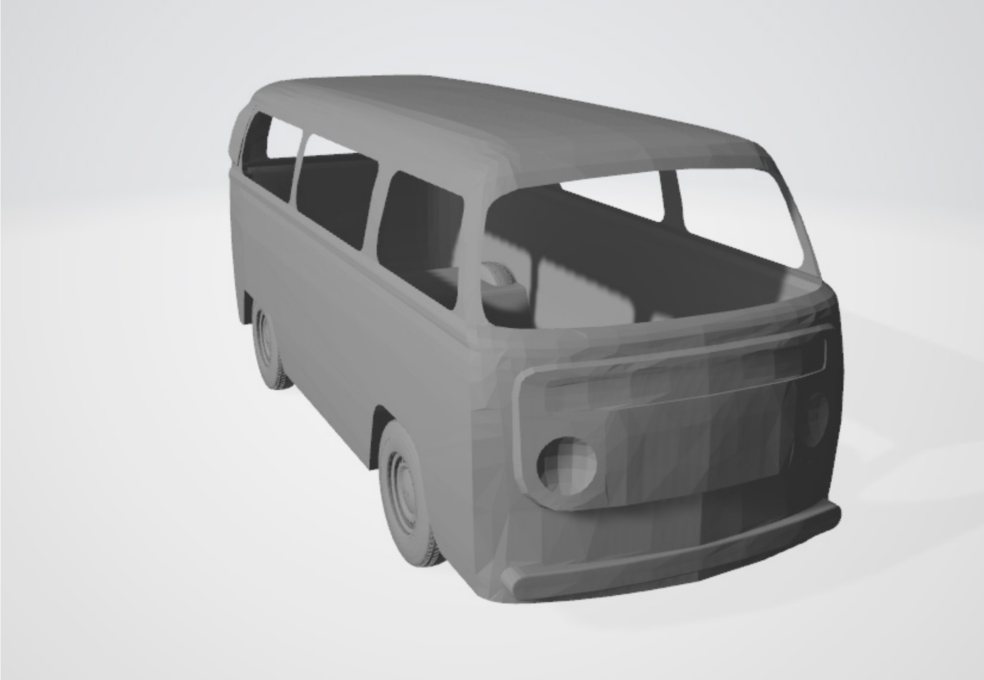
Fig 6. Final Painted Model Images (2019)

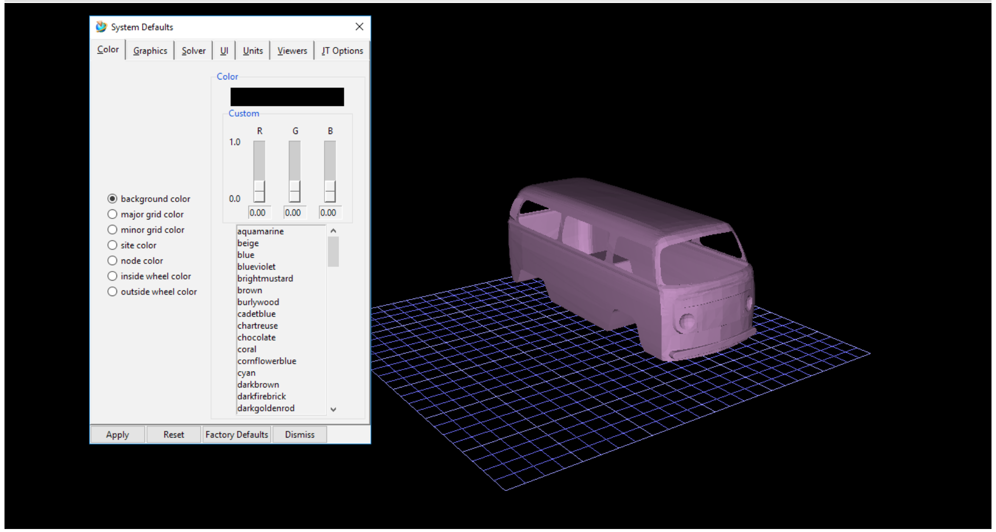
ERGONOMIC ANALYSIS

1. Software Overview
2. General Set-up
3. Vision Experiment
4. Strength Experiment
5. Reach Experiment

HUMAN JACK

Fig 7. Jack Model Previewed in Windows 3D Visualiser (2018)





Software Overview

After the 3D modelling stages of the assignment are complete we then wanted to test how well these cars are actually suited to human operation. As most people including myself had focused on more interesting cars, e,g supercars, classic cars, fictional cars. The ergonomic analysis provided some interesting results compared to your standard everyday car.

For this task of ergonomic analysis, we used a software called Siemens Human Jack, A tool that allowed for extensive analysis of various aspects. As software, it has its flaws mostly in the user interface department and a general lacking of common software usability features but it makes up for that by being an incredibly powerful analysis tool where other programs lose the depth that jack provides.

General Set-up

For using jack has to simplify the full 3D model down to ensure the smooth running of the software, taking the original surface mesh just after solidification and before extra details were added. Then taking out the windows and any unnecessary panels/features. This is then imported as an stl with the wheels. Any extra props such as the custom seats and steering wheels are then loaded in and attached to the vehicle

In terms of human set up Jack has a large range of fully editable anthropometric data sets and as such, we were able to provide testing for a wide array of occupants. For most of my experiments, we stuck with the standard array of users to allow for quick swapping them in and out. However, jack provides the ability to completely change almost every aspect about the user.

The experiments we carried out were as follows: A vision analysis, a strength analysis and a reach analysis. In order to test a wide range of jack's features and aspects of evaluating a car.

VISION ANALAYSIS EXPERIMENT

SET-UP

Experiment Focus

Vision Experiment testing to see the viewing distances for varying occupants of a 1973 VW Campervan. Utilising the Occupant Packaging Toolkit within the Jack Siemens Software.

Hypothesis

This experiment is designed to evaluate the viewing benefits of having a rear-engine van and measure the viewing distances for a range of occupants. It is my hypothesis that the taller the occupant the more visibility they will have of the ground and subsequently the measured obstacle in front of them.

Control Variable

Position of Car, Position of Occupant, Occupant Gender, Distance Between Car and Obstacle

Independant Variable

The Occupant dimensions: 8yr Old (1457.8mm), 1st Percentile Male (1600mm), 50th Percentile Male (1750mm) 99th Percentile Male (1910mm)

Dependant Variable

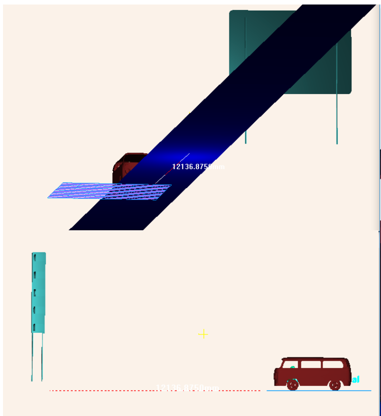
The height of the driver in relation to the percentage of the sign that becomes visible.

Method

For the vision analysis, we created a roadsign of 7m tall and with 1m raised incremental markers to enable us to calculate the total percentage of the roadsign visible from the users eyeline. By using the vision tools we were able to take a snapshot of what the user would be able to see.

We then set the road sign to be a distance of approx. 12m from the car and locked it in position relative to the car. The car was then locked into position relative to a road that was also added in to help provide a frame of reference for the user. It also provided a target marker to show the lower limits of the vision experiment, e.g there's no point being so small you can see 100% of the sign but then not see the road.

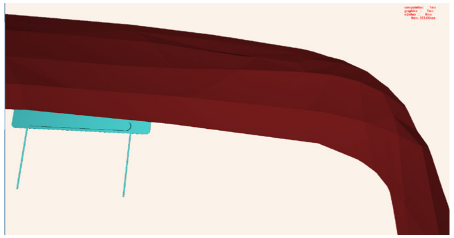
Each user was then placed inside the car. Great care was taken to set them up in as similar way as possible. To ensure this the initial human was set up with the standard seating posture than with pelvis and back locked the other humans were added in by altering that existing human's data in the configuration menu rather than by moving them out and in each time.



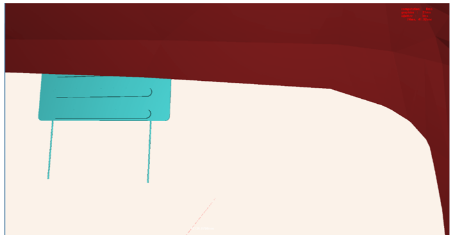
VISION ANALAYSIS EXPERIMENT

THE FINDINGS

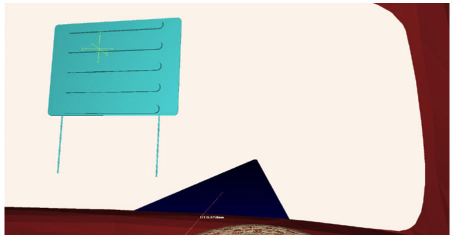
99th Percentile Male



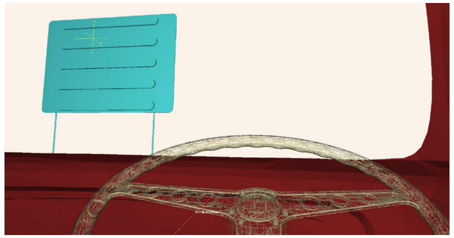
50th Percentile Male



1st Percentile Male



8 Yr Old Male



Occupant	Height(mm)	Percentage Visible
99th	1910	20%
50th	1750	45%
01st	1600	100%
8yr old	1457	100%*

Discussion of Results

A clear relationship is shown between the height of the occupant and their visibility. The issue stems from the lack of adjustability in the car's design. Whilst traditionally the car seats would be on runners they offer a total adjustment of around 5cm. They offer no vertical adjustment at all meaning that for anyone outside of the ideal percentile you were left with poor vertical visibility. In the case of this experiment, you can see a direct correlation between the height and the percentage of the sign that is visible.

The taller the user the more the roof of the car obscures the top of the sign. However, a side effect of reducing the height to be able to see more of the sign is that after a while you stop being able to see the road and horizon line.

If you happen to be an 8yr old or just of a height of 1.46m then whilst you will have a lovely unobscured view of any lofty signage you do somewhat loose the ability to accurately keep an eye on the road or see above the steering wheel.

Conclusion

If you are an 8 year old child you should not be driving this car, and if you are a tall male around the 99th percentile you shouldn't drive for too long for risk of back injury whilst constantly leaning forward to read the top of signs.

Modern cars have greatly improved in this area of adjustability in order to suit a wider range of users, the predominant factor here being not placing the wheel arches underneath the seat and placing the user into a more relaxed and reclined driving position than the bolt upright heightened seating position adopted in the VW T2 series. All the variants suffer in this regard.

STRENGTH ANALAYSIS EXPERIMENT
SET-UP

Experiment Focus

Strength Experiment testing perform analysis on the stress on the lower back specifically when pushing the car up differing inclines.

Hypothesis

This experiment aims to prove the benefits of fitting a reliable engine to a car of this weight range by showing how strenuous it can be to push it up the hill it had previously attempted to drive up. My hypothesis is that the larger the incline the harder and more dangerous the activity becomes for the occupants to perform.

Control Variable

Position of Car on ramp, Stance of Occupant, Occupant Gender and Anthropometric data. (Male, 1754.90mm, 77690kg)

Independant Variable

The incline of the ramp (deg): 1°, 5°, 20°

Dependant Variable

The moments and forces acting on the L4/L5 Vertibrae.

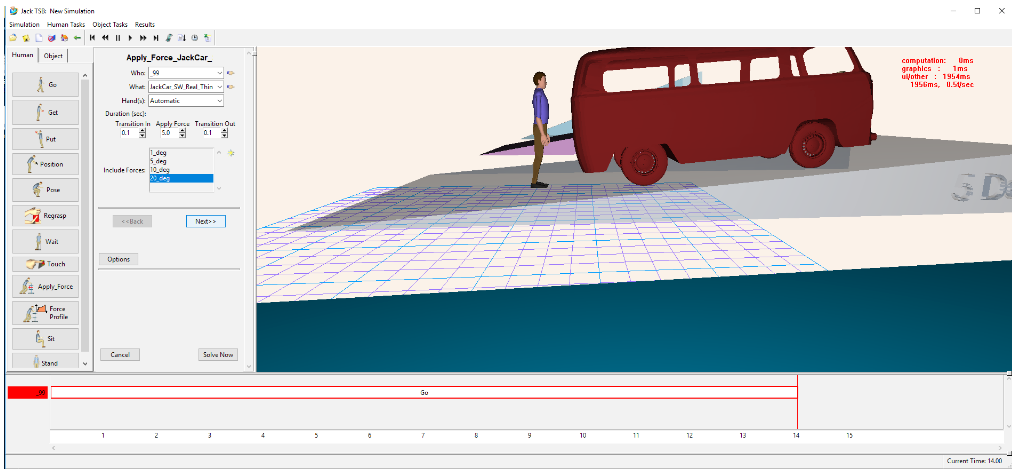
Method

For this experiment the set up is shown below, we'll be using the task simulation tool to move the occupant around and move him into the correct stance. The calculations for the forces are a simple resolution of forces equation with the total weight of the car to be 1320kg (Volkszone.co.uk, 2019) so the weight acting on the user can be given as:

$$F_{push} = (1320 \times 9.81 \times \sin(\theta°)) + F_{friction}$$

In this case to simplify the equation we'll assume friction to be close to zero so the forces for 1° = 225N, 5° =1128N, 20° =4428.88N.

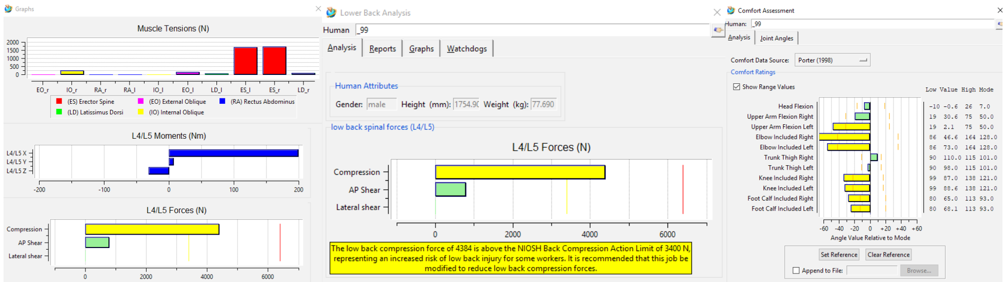
The van was then rotated to the respective angle to make sure the position of the user was as close to real life as possible. Using the Go task we moved the user from standing by the van to moving into a pushing posture. This was then saved as a separate posture for use with other angles. The hands were manipulated to grasp the van. The force was then applied to both hands using the apply force menu. Opening the LBA tab and activating the appropriate graph results enable us to track the user.



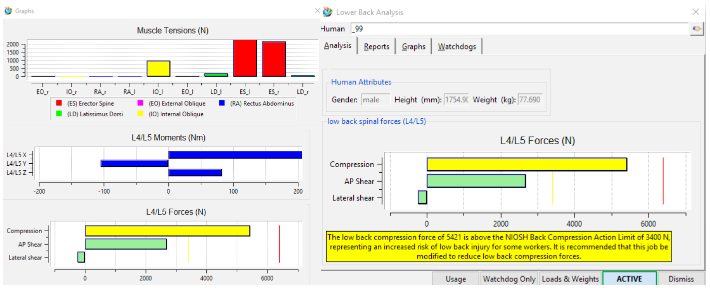
STRENGTH ANALAYSIS EXPERIMENT

THE FINDINGS

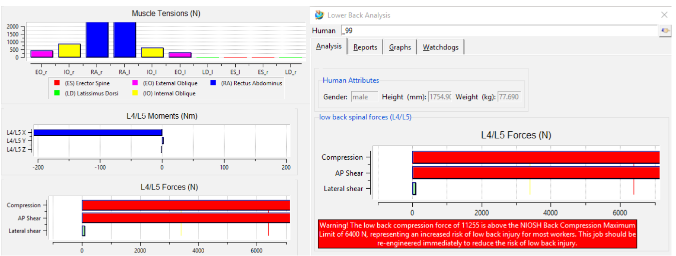
1 Degree Incline



5 Degree Incline



20 Degree Incline



Discussion of Results

The results show quite clearly that there is no scenario where a load of pushing a VW T2 up an incline is a suitable and repeatable strain to place an occupant under. For the 1° incline the user can push the vehicle up the slope but is still under a lot of stress.

The lower back is 4384N above the NIOSH back compression action limit and as such is a warning sign that this sort of activity is not suitable for a workload or for constant use. If this was, for example, a task of pushing a van around the warehouse to different stage of the assembly then either a whole team of people would have to help in the movement or an automated assistive vehicle of some sort would have to be employed to help reduce the strain otherwise serious damage could be done over time.

A comfort analysis was also conducted to see where the main strain was other than the lower back and it showed significant strain on the knees and elbow joints.

The case only gets worse with increasing workloads, 5° is 5421N above the NIOSH and 20° is 11255N above the limit indicating severe and lasting damage to the lower back when attempted.

Conclusion

Unsurprisingly in conclusion attempting to move a 1320kg van up a slope with no assistance leads to some serious strain on the back and can cause some lasting damage when not done in the correct way and with either support in the form of people or machinery.

REACH ANALAYSIS EXPERIMENT

SET-UP

Experiment Focus

Reach Experiment testing to see how the height of a user and by extension their reach affects their comfort when reaching for an item in the glovebox. There will be a lower back analysis of the L4/L5 Vertebrae.

Hypothesis

This experiment measures how user comfort is affected by the height of the occupant and how overextension to reach an item in the glovebox can cause discomfort. My Hypothesis is that the lower back analysis will show that the taller the user is the less discomfort due to overextension they will experience wit more twist in the back coming for the smaller occupants and subsequently more discomfort.

Control Variable

Position of Car, Occupant Gender, Distance Between Occupant and Glovebox

Independant Variable

The Occupant dimensions: 15yr Old (1683.6mm), 1st Percentile Male (1600mm), 50th Percentile Male (1750mm) 99th Percentile Male (1910mm)

Dependant Variable

Comfort of user/ is there over extension to reach glovebox.

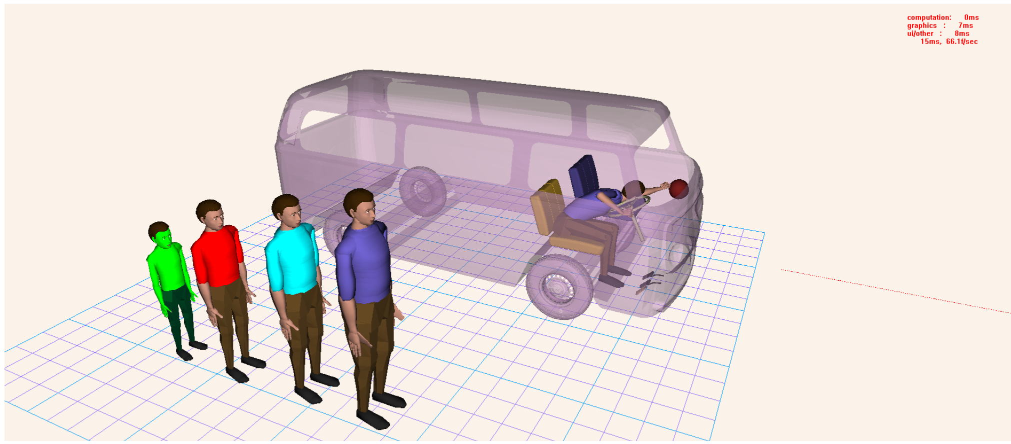
Method

The set up for this experiment is to load in the seat, steering wheels and props made as approximations of the actual items inside the van. These are then locked to the car and an occupant is installed into the driver's seat.

They are then repositioned to match a more natural upright position rather than the refined one associated with the jack defaults. Their feet are tied to the appropriate pedals and the glovebox location is set as the imported sphere. This is also then attached to the car to prevent any movement between experiments.

The occupant's hand is then attached to the glovebox location and their back adjusted to the most comfortable position as an occupant would naturally do themselves.

This is then repeated with the selection of occupants and the results are recorded and discussed on the facing page.



REACH ANALAYSIS EXPERIMENT

THE FINDINGS

99th Percentile Male

50th Percentile Male

Before Adjustment

After Adjustment

1st Percentile Male

15 Yr Old Male

Discussion of Results

The results to the left show that whilst there are improvements and benefits to be had by being taller there is major discomfort for all involved by reaching for the glovebox. By adjusting the rotation of the occupant's spine you can significantly increase their comfort. As that is what a person would automatically do the results show the lowest comfort values achievable through simple position manipulation whilst still maintaining some key markers like the position of the legs and the feet.

This was true with the exception of the child whose feet couldn't reach the pedals and as such have a massively lower strain on them but the higher strain in other respects due to the height disadvantage at reaching for the glovebox.

The key areas of strain were the Upper Arm Flexion Right with this showing best the fact that the taller people suffered less discomfort. The 99%ile showing the least discomfort with the 1st Percentile showing the most. Here again, the child showed less discomfort than it should simply because it couldn't reach. This aligns well with my hypothesis of it being a benefit to be taller when reaching across the cab.

Conclusion

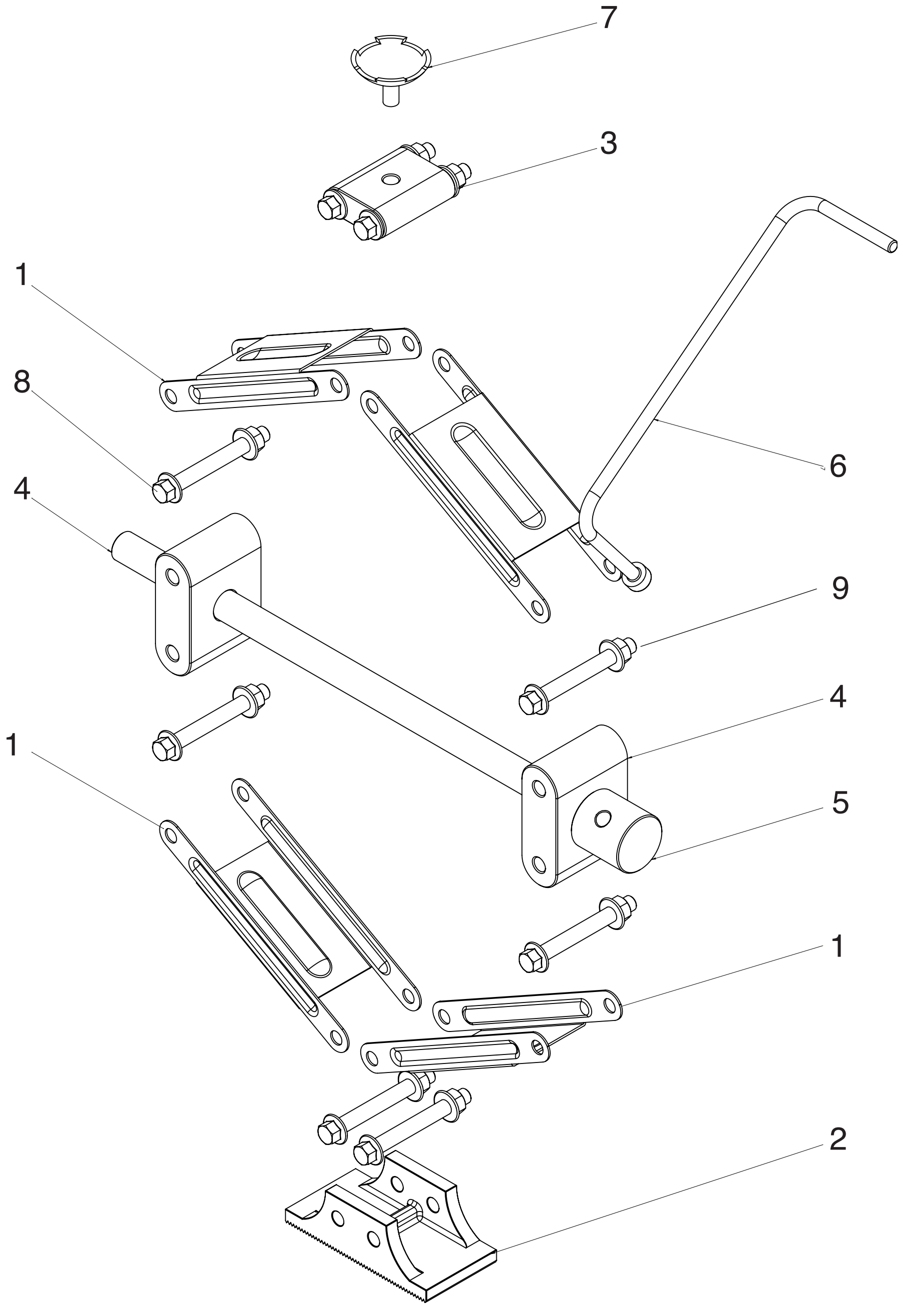
However, in all cases, the position of the glove box showed that is always at an uncomforatble overstretch and would cause damage when repeatedly reached for. The positioning would be much better suited to the operation from the passenger seat as it was designed for.

The 15 yr old male being unable to reach the controls and various other sections properly is a valid argument against the lower driving age in some countries as older cars with less adjustability are simply not designed for operation by people who sit at the extremities of the adult male dimensions.

MOTION STUDY FORCE ANALYSIS

1. Component Set-up
2. Motion Study 1
3. Motion Study 2
4. FEA Static Study 1
5. Design Study 1

COMPONENT SET UP



P#	Part Name	Material	QTY
1	Sheet Metal Strut	AISI 1020	4
2	Base Plate	Plain Carbon Steel	1
3	Top Plate	Plain Carbon Steel	1
4	Side Bracket	Plain Carbon Steel	2
5	Lead Screw	Plain Carbon Steel	1
6	Hand Crank	Plain Carbon Steel	1
7	Jack Cup	Plain Carbon Steel	1
8	Hex Flange Bolt ISO 4612	Plain Carbon Steel	8
9	Hex Flange Nut Grade A ISO 4161	Plain Carbon Steel	8

The following is a description of the motion study analysis of a car jack. The jack was modelled in SolidWorks using the engineering drawings provided in the car jack workbook. The system is then analysed using a series of motion studies and FEA tools.

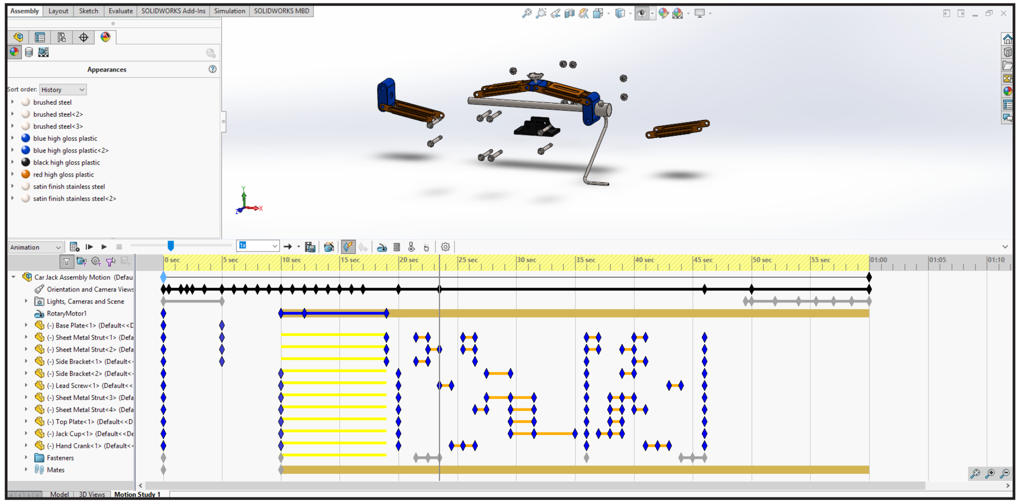
For the analysis section, a few assumptions were made to ensure consistency in the data. The weight of the car being lifted by the jack is the 1973 VW T2 and as such is 1320kg (Volkszone.co.uk, 2019). The weight acting on one of the four wheels is taken as 330kg.

MOTION STUDY 1&2

Set up

The initial motion study was built by mating the components only using mates to the temporary axis or to selected planes. this ensured that when it came to the FEA and design study the part was reconfigurable without altering the set-up already applied.

Using the SW Motion add in we were able to set some real-world forces onto the jack. For example, adding a motor on to the crank handle to simulate a person turning the jack. The initial motion study produced a video of just under 1 minute demonstrating a simple example of what the motion tool could be used for. The files can be located on the supplied USB under the SW Jack Files. This could easily be utilised for product demonstration purposes with such a simplified method.



The more practical use case for the motion study tools is to get results for different loads and testing different use cases within the modelling software moving onto a design study later for further analysis. In this case, we're monitoring the motor torque to see the peak torque used when operating this jack over 10s.

For calculation purposes, we simplified the force system as shown in fig.X to give us the equation used below. For the campervan, we have a force acting on the jack (simulated by a dummy weight sphere) of 330kg.

As you can see from the screenshot we get a max amplitude of 5012N/mm. We also get quite a large degradation in force required as the jack lifts from the horizontal and it's angle changes. The force to turn the jack can be calculated like so:

Torque = r x Fp

*5012Nmm = 309.477mm * Fp*

Fp=16.2N

*Force = Fp*cos(θ)*

*F=16.2*cos(14.26)*

F=15.7N

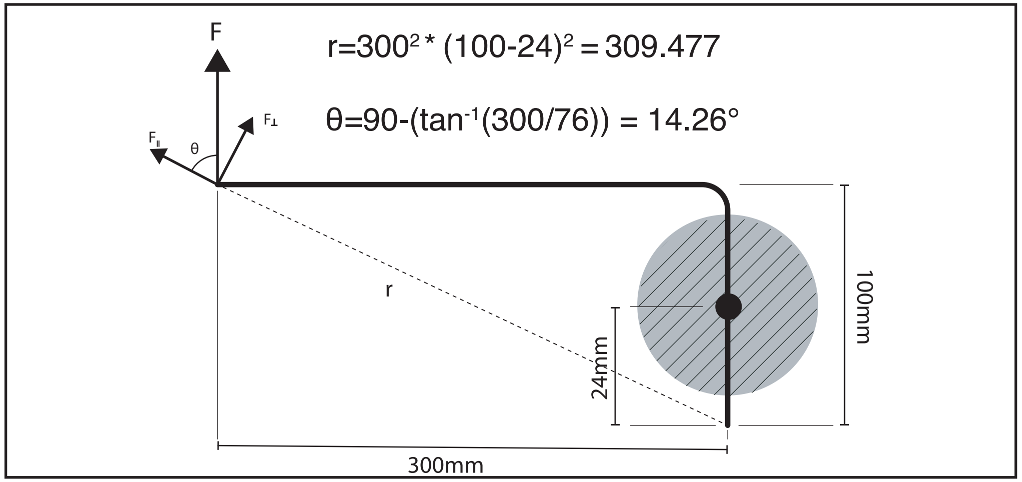
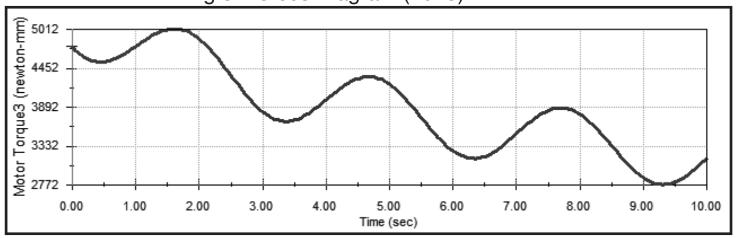


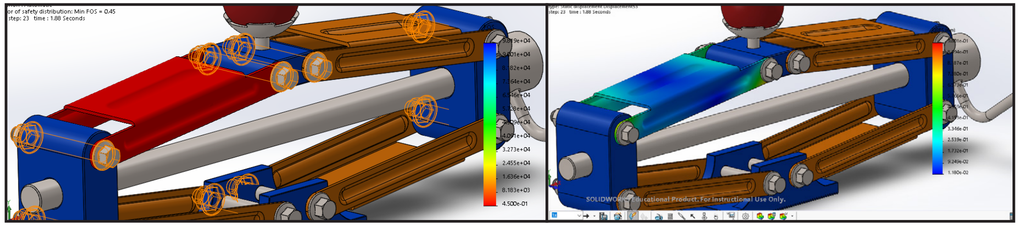
Fig 8. Forces Diagram (2018)



FEA MOTION & STATIC STUDY

Motion

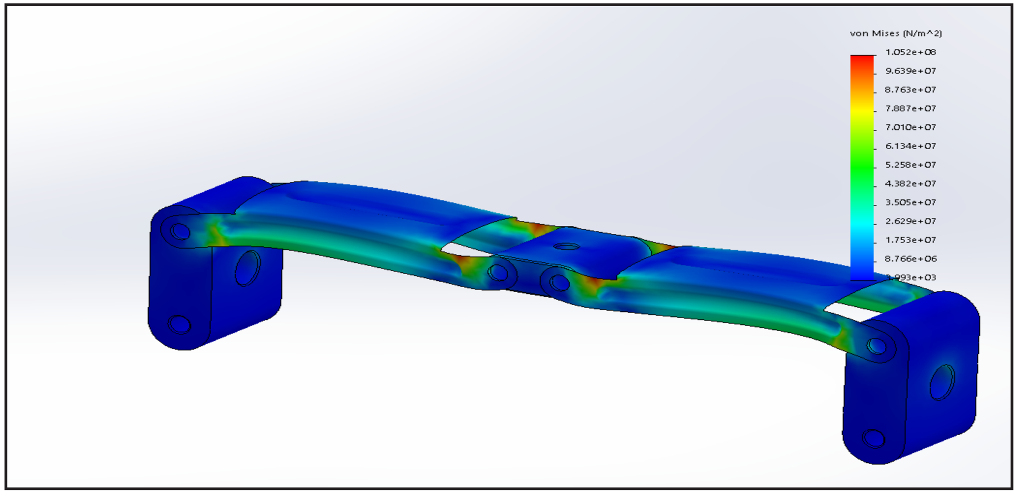
Continuing on from the motion study we performed a motion FEA to quickly analyse the Von Mises stress on the moving struts and also a FoS test to see how the jack's factor of safety is affected by the load.



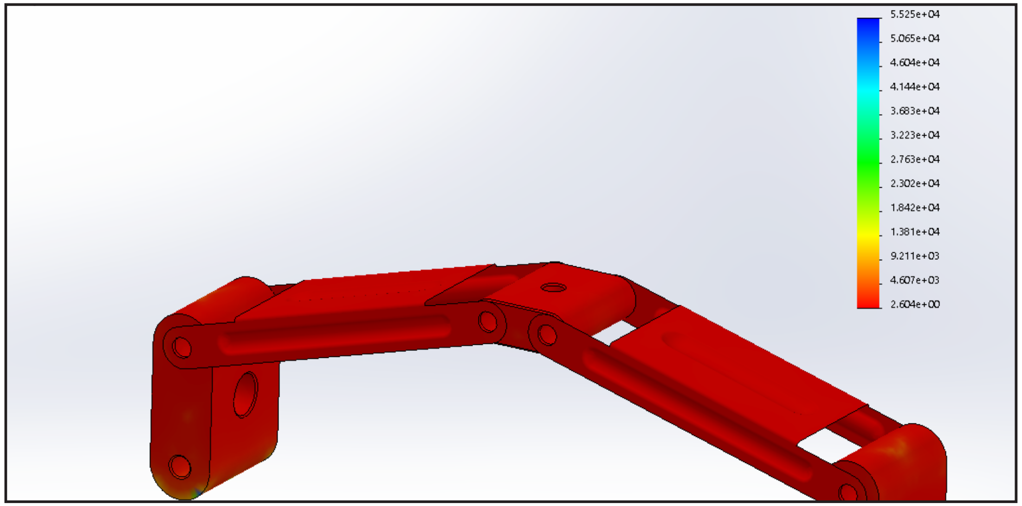
The FoS fell well over the minimum of 1 meaning the jack can easily withstand the required loads. The Von Mises stress can be used to highlight problem areas of stress concentration such as around the bolds and sharp edges, these could be minimised with smooth edges and some filleting.

FEA Static Study 1

The more in depth way of analysing the elements of an assembly is to use the SolidWorks FEA simulation toolkit and that is precisely what we did next. The general running order for simulations on SolidWorks is Materials>Connections>Fixtures>Loads>Mesh>Run. We simplified the system down to the active components and to help reduce compute time on the simulations. Followed by replacing the physical bolt connections with Pin connectors in order for interaction with the simulation software. Then the side plates were fixed in position to prevent any slippage and to emulate how they would be acting as a result of the lead screw in an actual active scenario. Then a load of (330kg*9.81=3237.3N was added to the top plate evenly spread on the top surface. This was meshed and the initial simulations were run. A report detailing these findings can be found on the included USB stick under Simulation Files. The finer the mesh the more accurate the results however they significantly increase load times, for the purposes of these experiments the mesh density was finer than default but not set to maximum.



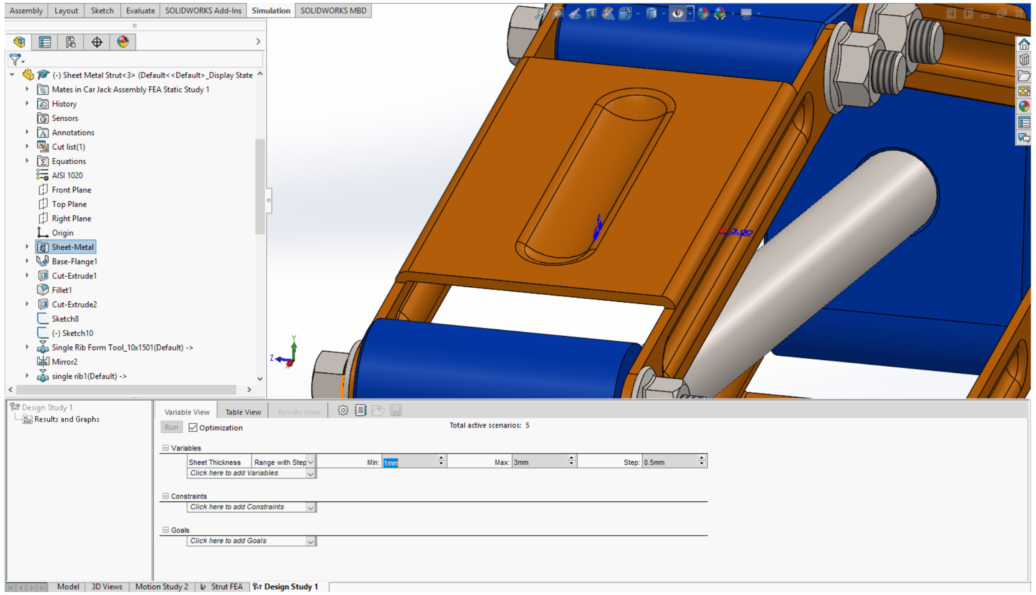
Here as you can see from the figures above and below the Von Mises stress is again concentrated around joints and sharp edges with a clearer focus than the previous around a buckling point from the main struts, what the FoS tells us however is this buckling occurred well outside of the normal use case. If we assume a factor of safety of 1.5 we could create ourselves a jack with a much wider use case without being over-engineered.



DESIGN STUDY

The purpose of any design study is to maximise the functionality of your design whilst ensuring you're utilising the material properties and geometry to their fullest extent. In our case, we'll be focussing on making the jack as thin and as light as possible whilst not compromising on the operating conditions. By setting ourselves a FoS of 1.5 we should ensure loading for a variety of use cases.

The materials we used for the jack will be kept the same as AISI 1020 Steel is a common and average choice for such a device and as such is readily available in terms of manufacturing keeping the cost of production low.



The set up involves assigning 3 main aspects. The variable, The constraints and the goals. Our variable is our sheet thickness, we started with a sheet thickness of 3mm and we initially want to test the range of 1mm-3mm at 0.5mm intervals. If we found the FoS well over 1.5 even at 1mm we would go back and lower this number further.

The constraint is our factor of safety, this is the variable we are hunting around, we've set this as greater than 1.5 to rule out any that are lower than that. The goal is set to the mass properties, so we are trying to reduce the weight of the jack as much as possible by reducing the sheet thickness without compromising the FoS.

		Current	Initial	Optimal (3)	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Sheet Thickness		3mm	3mm	2mm	1mm	1.5mm	2mm	2.5mm	3mm
Minimum Factor of Safety1	> 1.500000	2.604074	2.604074	2.051753	0.863564	1.435782	2.051753	2.691231	2.604074
Mass1	Minimize	505.0578124 g	505.0578124 g	333.5240573 g	165.1714531 g	248.9501113 g	333.5240573 g	418.893291 g	505.0578124 g

The initial run shows the optimum sheet thickness to be 2mm however the FoS is much higher than 1.5 at a value of 2.05, this is because of our 0.5 step resolution, by performing a secondary targeted pass we can find the values at 0.1mm intervals. This time around we found a much lower sheet thickness of 1.6mm to be above our 1.5 FoS.

		Current	Initial	Optimal (2)	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Sheet Thickness		3mm	3mm	1.6mm	1.5mm	1.6mm	1.7mm	1.8mm	1.9mm	2mm
Minimum Factor of Safety1	> 1.500000	2.604074	2.604074	1.556436	1.435782	1.556436	1.678654	1.801565	1.926160	2.051753
Mass1	Minimize	505.0578124 g	505.0578124 g	265.8012775 g	248.9501113 g	265.8012775 g	282.6842552 g	299.5990444 g	316.5456451 g	333.5240573 g

This, fortunately, is the correct side of a standard sheet thickness, or at least somewhat greater than 16 gauge at 1.63mm (Metal Supermarkets UK, 2018) which means that it is useable for manufacturing purposes. This offers us a mass saving of 239.7g per strut almost halving our weight per strut.

In conclusion, the benefit of a design study is shown well here. The ability to compare one type of product constraint against another is a time consuming and difficult task to complete by hand calculations and using the data from the visual representations you can easily alter the design shape to better reduce stress concentration zones whilst minimising any deflectionary damage to the structure.

RENDER GALLERY

All the numbered renders where built using SolidWorks then exported into Keyshot for final rendering. Then touched up using Adobe Photoshop where needed.

1. Van rendered in an underground garage with skylights.

2. Van in Blue under a beachside sunset. Orthogonal Side View of the van in blue, in the style of the original VW advertising from the 1970s.

3. Van on the open road, Sunset HDRI with seats and steering wheels built as rough approximations for the purposes of the render.

4. Overlay of a rendered image on VW's "Unintroducing" advertising campaign to mark the end of production after 4/5 decades.

5. Van on a grassy field at sunset, Grass blades modelled as individual objects to get the reflections of the light on the blades accurately.

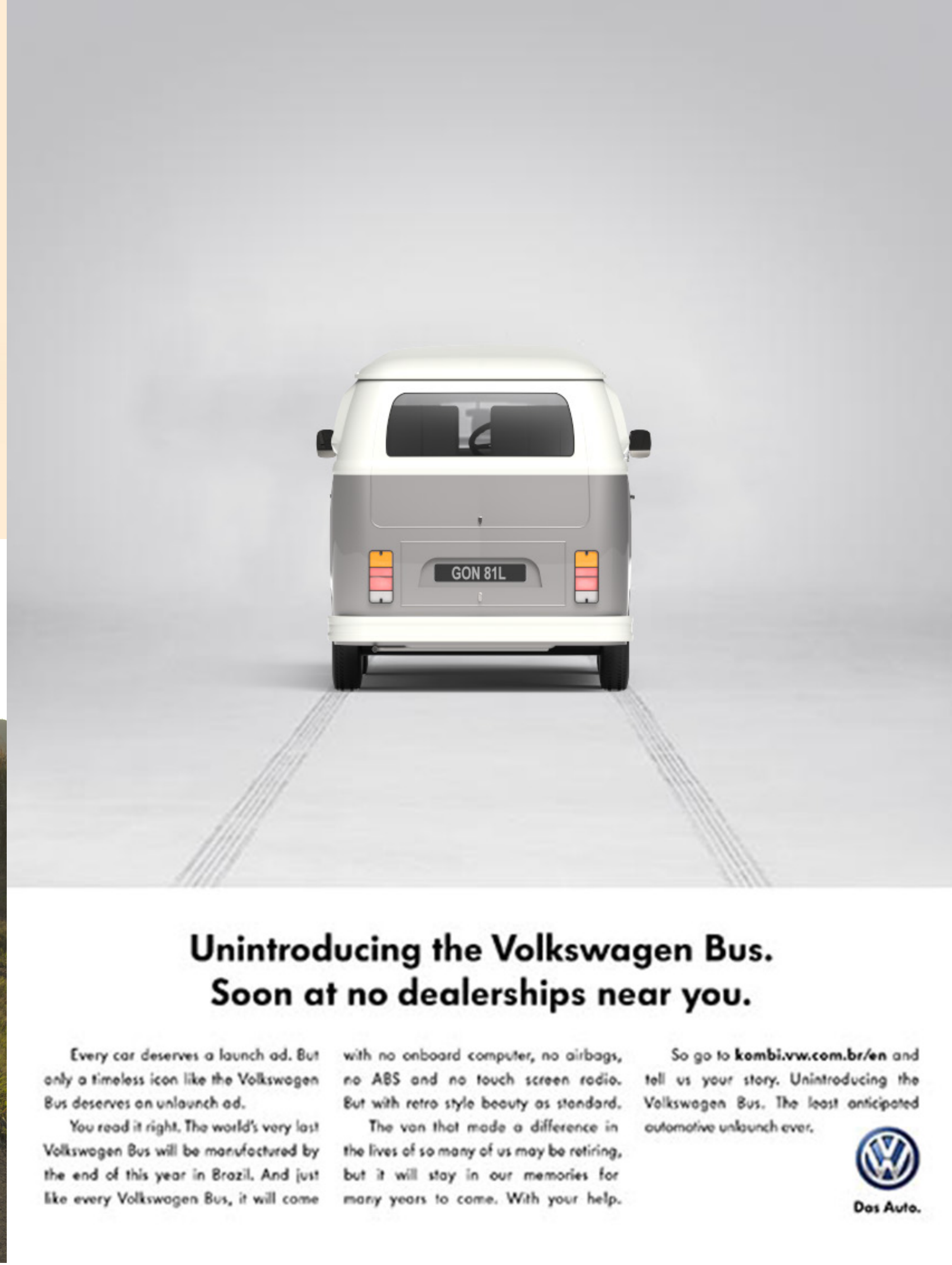
6. Van in Blue, In an underground garage with overhead natural light. A larger version of (1) with more detail.

3.

4.


GON 81L

5.


GON 81L
Unintroducing the Volkswagen Bus.
Soon at no dealerships near you.
Every car deserves a launch ad. But only a timeless icon like the Volkswagen Bus deserves an unlaunch ad.
You read it right. The world's very last Volkswagen Bus will be manufactured by the end of this year in Brazil. And just like every Volkswagen Bus, it will come with no onboard computer, no airbags, no ABS and no touch screen radio. But with retro style beauty as standard.
The van that made a difference in the lives of so many of us may be retiring, but it will stay in our memories for many years to come. With your help.
So go to **kombi.vw.com.br/en** and tell us your story. Unintroducing the Volkswagen Bus. The least anticipated automotive unlaunch ever.
Das Auto.


GON 81L

7.

REFERENCES

Render:

Maruzza, H. (2019). Hellebore Classic Steering Wheel Cad File. [STEP/IGES] N/A: GrabCad.

Zaal, G. (2019). HDRI: Skylit Garage I HDRI Haven. [online] HDRI Haven. Available at: https://hdrihaven.com/hdri/?c=indoor&h=skylit_garage [Accessed 21 Jan. 2019].

Turbosquid.com. (2019). Free 3D model 5 grass clumps - TurboSquid 1323560. [online] Available at: https://www.turbosquid.com/3d-models/3d-model-5-grass-clumps-1323560 [Accessed 13 Jan. 2019].

Zaal, G. (2019). HDRI: Mealie Road I HDRI Haven. [online] HDRI Haven. Available at: https://hdrihaven.com/hdri/?c=skies&h=mealie_road [Accessed 13 Jan. 2019].

Zaal, G. (2019). HDRI: The Sky Is On Fire I HDRI Haven. [online] HDRI Haven. Available at: https://hdrihaven.com/hdri/?c=skies&h=the_sky_is_on_fire [Accessed 13 Jan. 2019].

Volkswagen (2013). VW UNIntroducing Advert. [image] Available at: http://theinspirationroom.com/daily/2013/unintroducing-the-volkswagen-bus/ [Accessed 13 Jan. 2019].

Report:

Operating Instructions Campmobile 70. (1970). 1st ed. Westfalia - West Germany: Westfalia Motor Company, p.1+. [Accessed 10 Jan. 2019].

Volkszone.co.uk. (2019). What's the kerb weight of a T2?. [online] Available at: https://www.volkszone.co.uk/VZi/showthread.php?t=390884 [Accessed 13 Jan. 2019].

Metal Supermarkets UK (2018). Sheet Metal Gauge Chart I Metal Supermarkets UK. [online] Available at: https://www.metalsupermarkets.co.uk/sheet-metal-gauge-chart/ [Accessed 13 Jan. 2019].

Justkampers.com. (2019). Standard 14in. Steel Roadwheel (Silver) VW T2 Bay 1970–1979 - J40819. [online] Available at: https://www.justkampers.com/vw-t2-bay-window-parts/t2-bay-wheels-alloy-wheels-tyres-hubcaps/alloy-steel-wheels/211-601-027-h-standard-14in-steel-roadwheel-silver-vw-t2-bay-1970-1979.html [Accessed 10 Oct. 2018].

Figures:

Fig 1. VW Camper Side On (2015)
Moraitis, K. (2015). VW Camper Side on. [image] Available at: https://www.123rf.com/photo_53641547_vw-vans-and-camper.html [Accessed 13 Jan. 2019].

Fig 2,3. Volkswagen Type 23-50PS(1976)
Volkswagen (1976). Volkswagen Type 23-50PS. [image] Available at: http://www.smcars.net/attachments/vw-t2-bus-type-23-1974-jpg.151788/ [Accessed 28 Oct. 2018].

Fig 4. 3D Print Testing Images (2018)
Brister,B (2018) 3D Print Testing Images [Image] From the library of the author

Fig 5. 3D Print Assembly Images (2018)
Brister,B (2018) 3D Print Assembly Images [Image] From the library of the author

Fig 6. Final Painted Model Images (2019)
Brister,B (2018) Final Painted Model Images [Image] From the library of the author

Fig 7. Jack Model Previewed in Windows 3D Visualiser (2018) Brister,B (2018)[Image] From the library of the author

Fig 8. Forces Diagram (2018)
Minton,Tim (2018) Forces Diagram, Based off Car Jack Workbook Diagrams. [Image]

1504460
BRADLEY BRISTER
DM3601

21/01/2019
1973 VW T2
CAMPERVAN