Jacob Lockett - Final Year Project:

The Design, Development, and Manufacture of a Performance-Oriented Front Suspension System for a Porsche 356.

The following document provides an insight into the methodology of this project and the tasks completed. For each topic, there is a brief explanation of the work carried out, backed up by a series of images.

Please note: Some images have been taken directly from my project report. Any Figure numbers referred to do not apply to this document.

Please use the table of contents below to navigate this document:

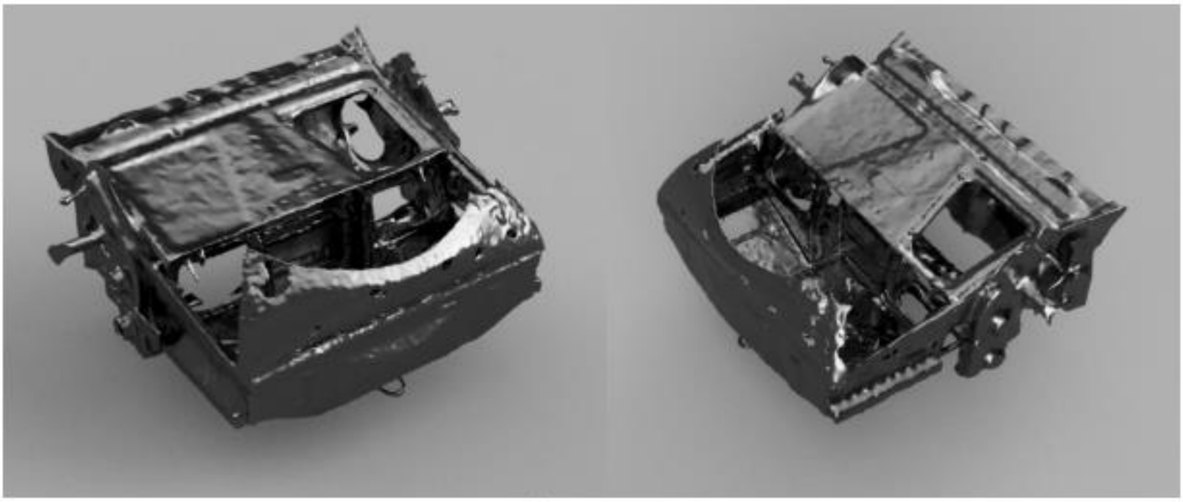
Document Contents

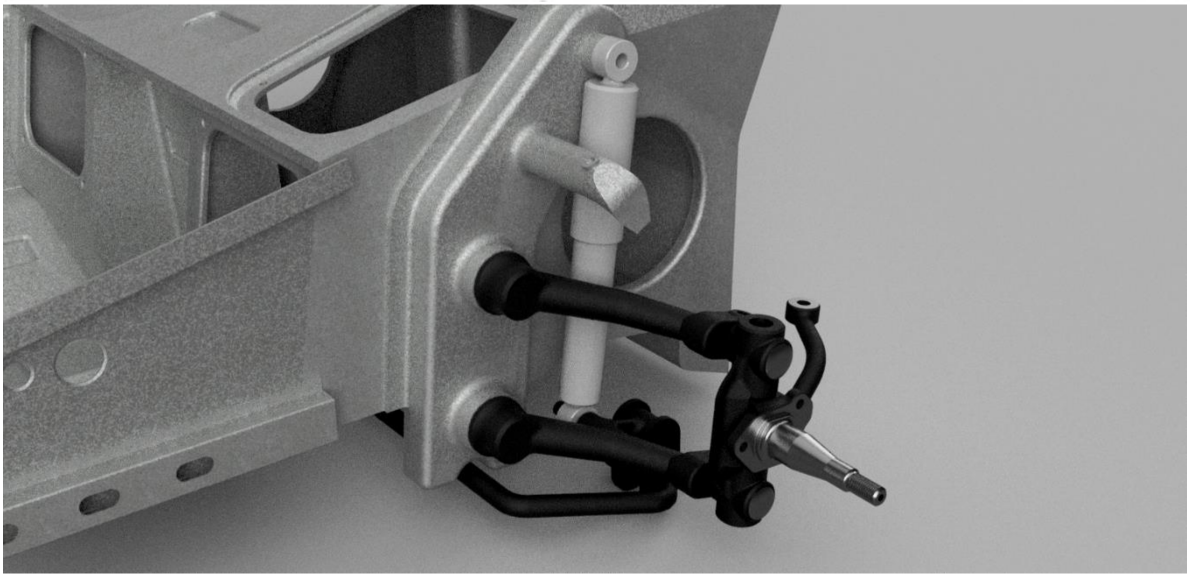
1). Literature Review.

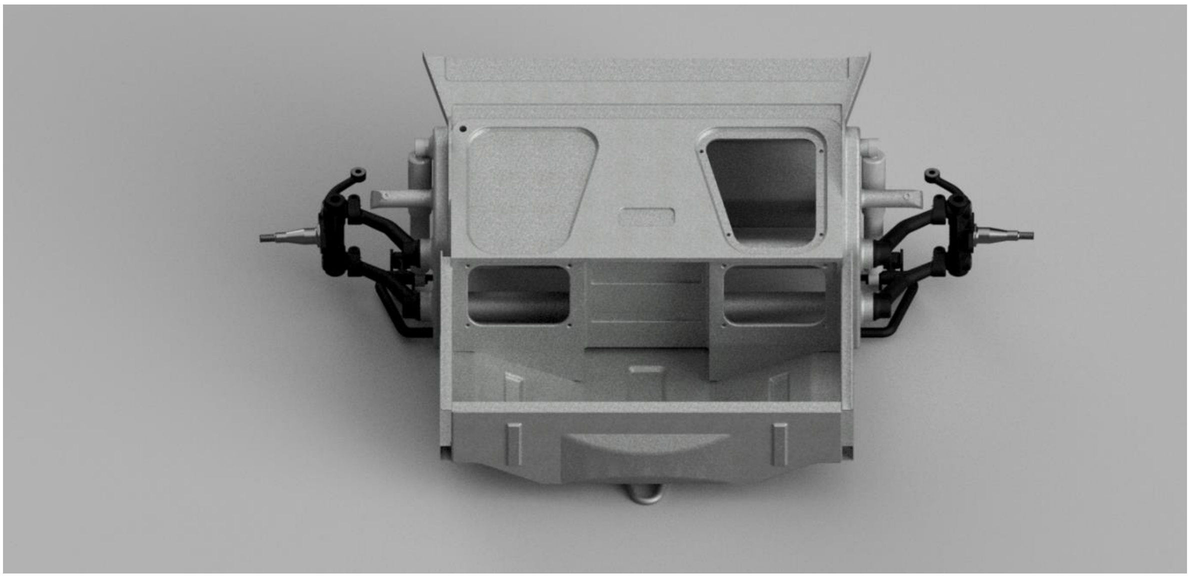
Used to gain knowledge on performance vehicle suspension types, requirements, and working principles, additionally, suspension geometry and mathematical calculations were explored, alongside common manufacturing methods and material selection.

2). Data Acquisition.

A Porsche 356 was 3D scanned, and an accurate CAD model of the original suspension was created within Fusion360. The model was used to acquire suspension geometry data for the original vehicle, in order to set a benchmark for the redesign.

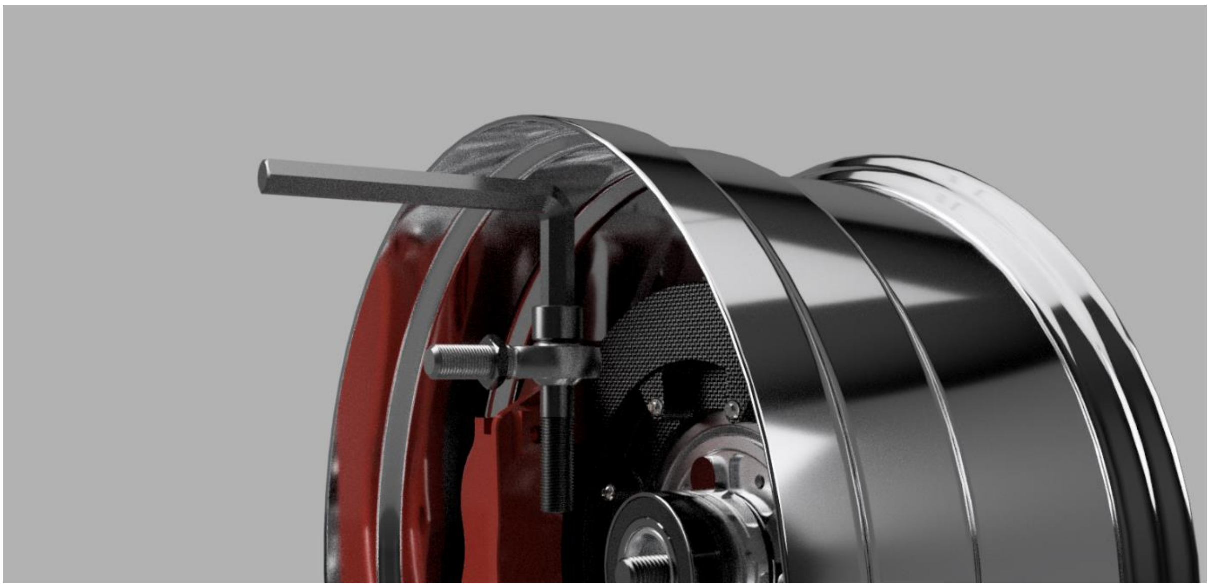


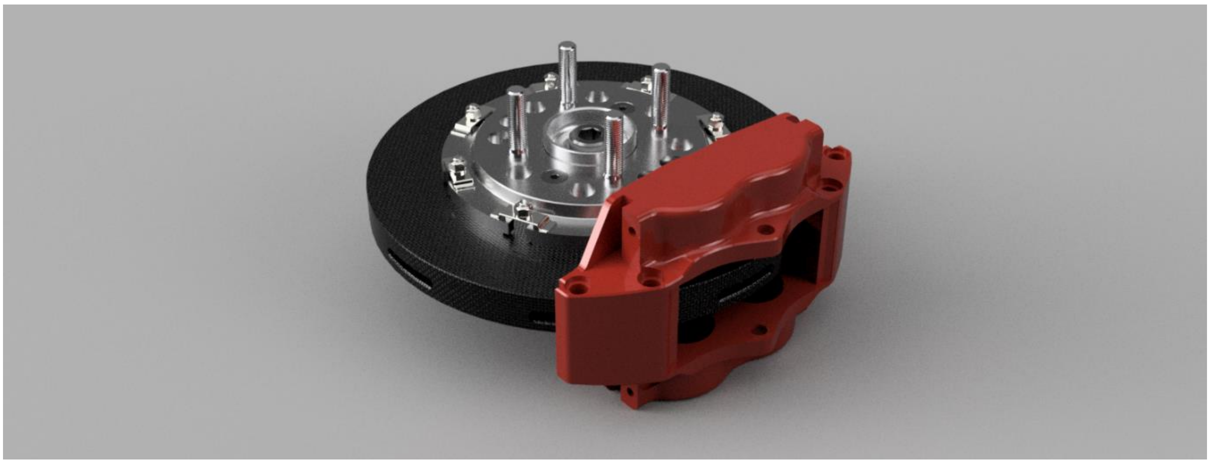


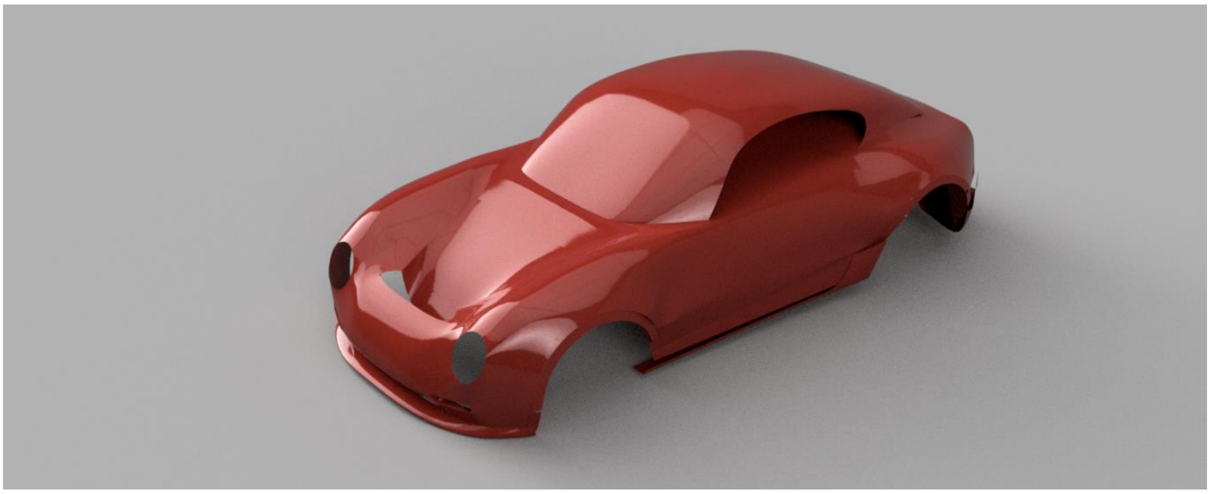


3). Suspension Design Constraints and Limitations.

Any limiting factors affecting the suspension design and manufacture were explored here, before concept development began. This included designing and 3D modelling bodywork, wheels, brakes, and other components that the suspension was required to incorporate and work around.

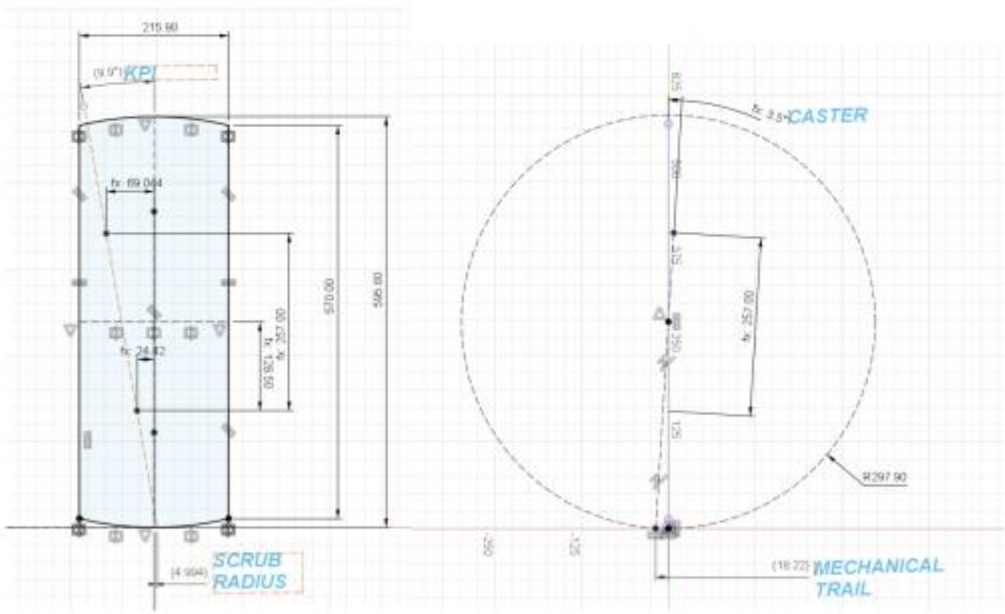


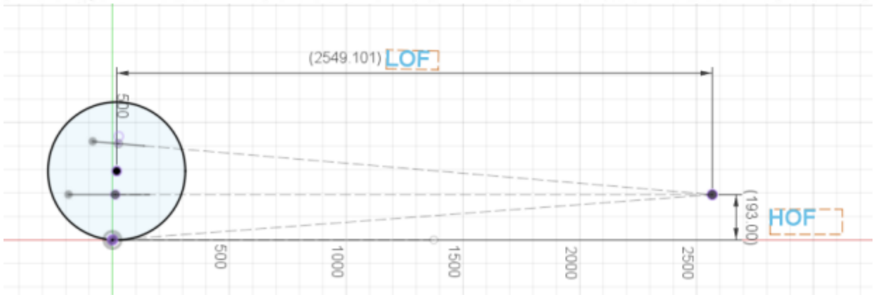


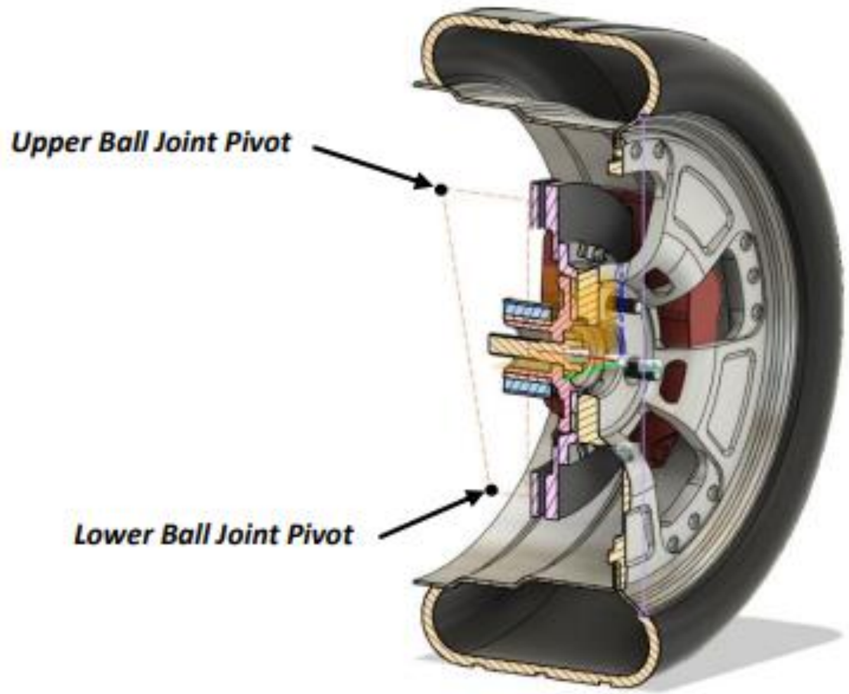


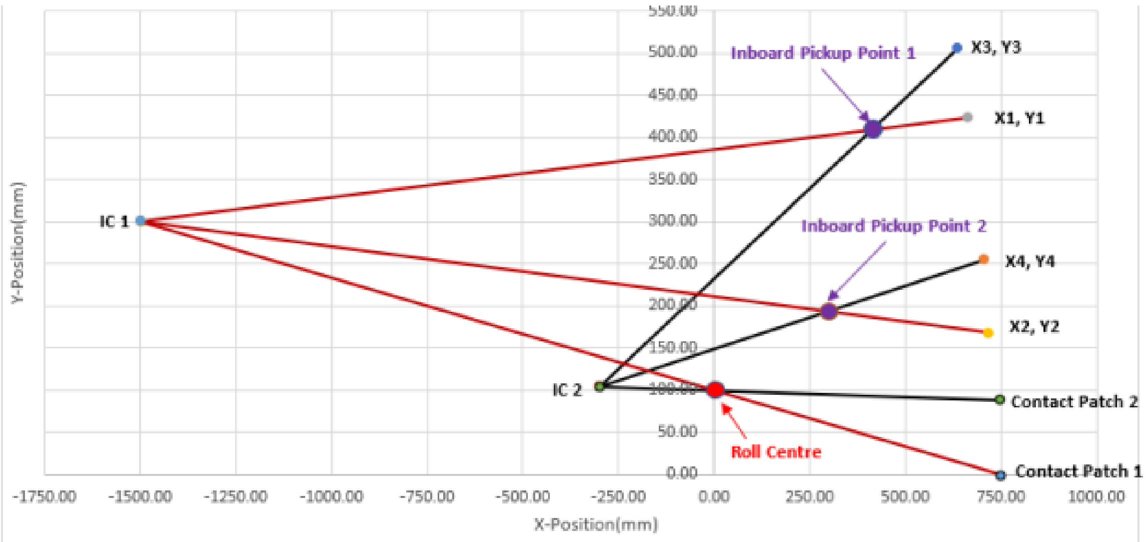
4). Suspension Design Calculations.

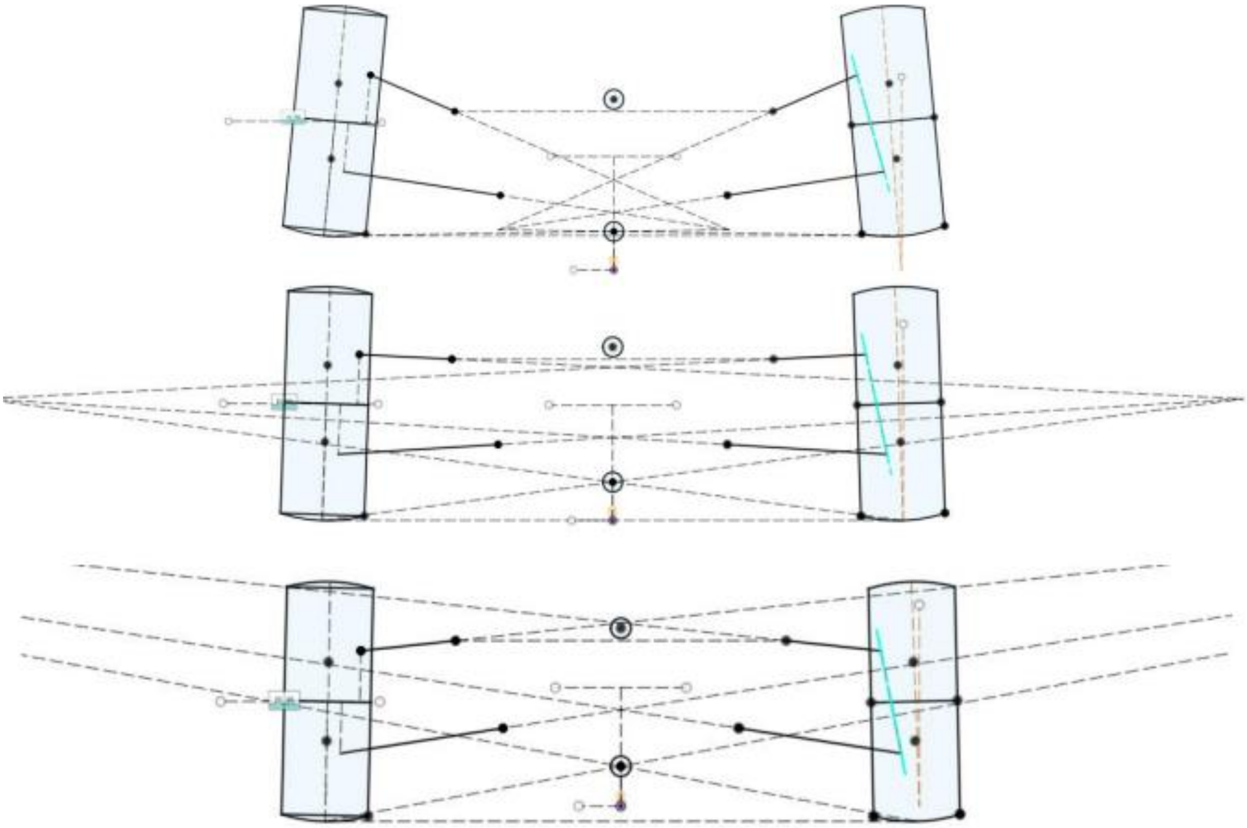
The Mathematical concepts explored in the literature review were applied to create a wire frame suspension geometry model, and a spring and damper simulation (within Simulink). These were later used as a framework for the CAD suspension model.



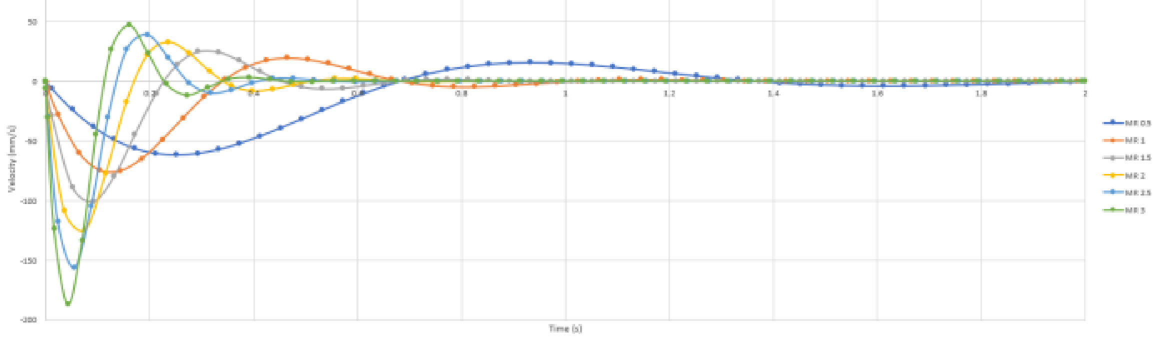






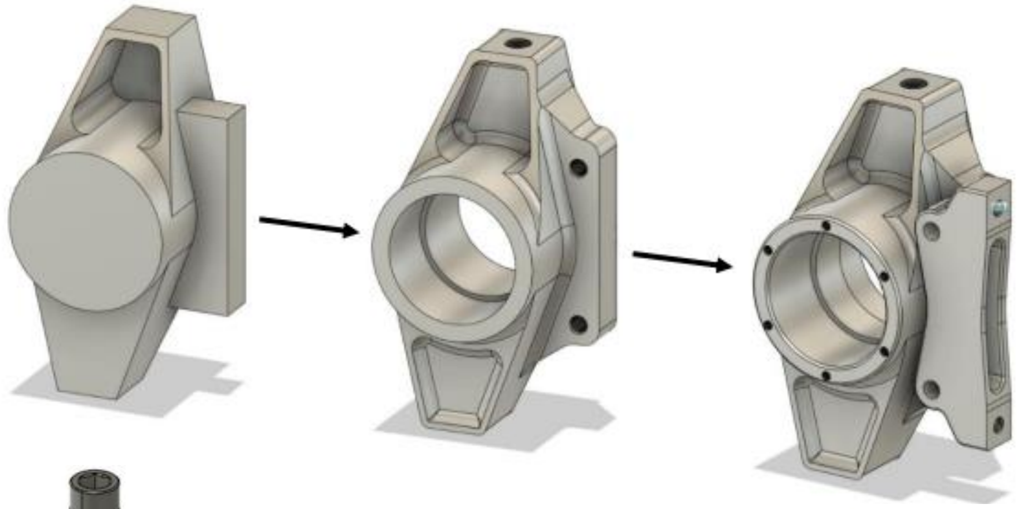


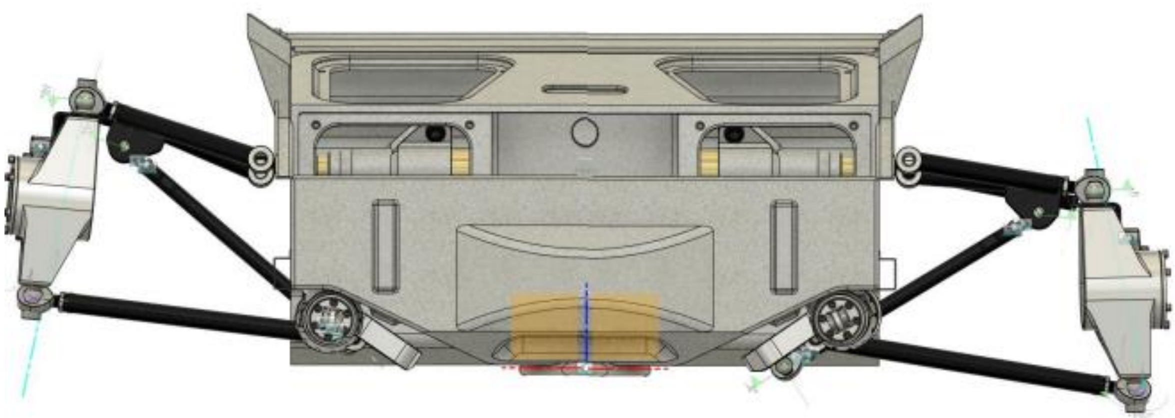
Graph 3 – Suspension Velocity Versus Time for Different Motion Ratios.



5). Suspension Prototype Engineering Design.

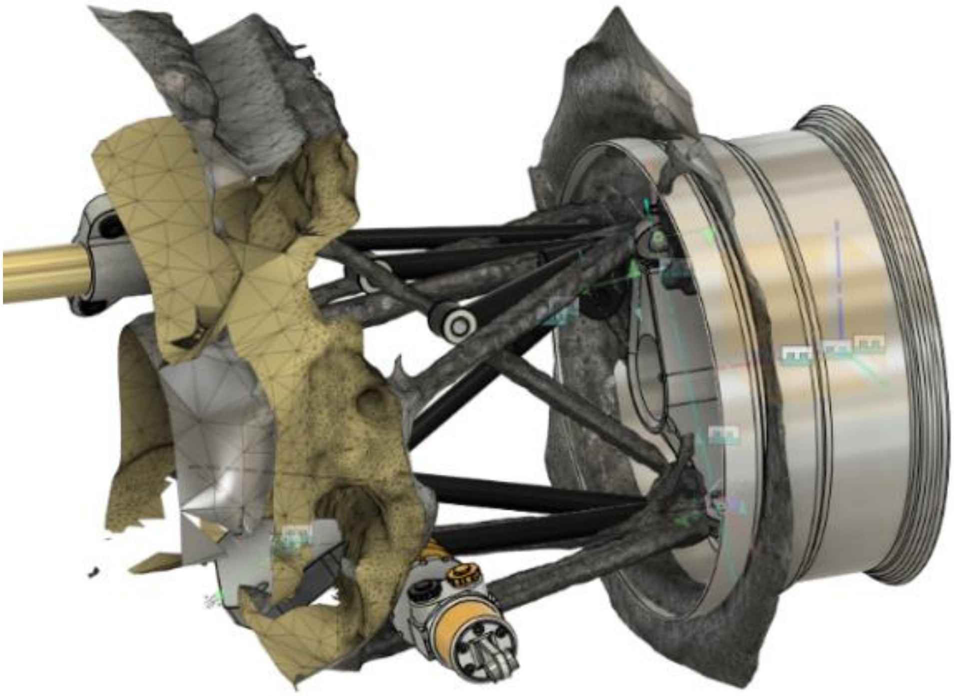
A CAD model of the new suspension system was produced within Fusion 360. Manufacturing jigs and fixtures were also designed.

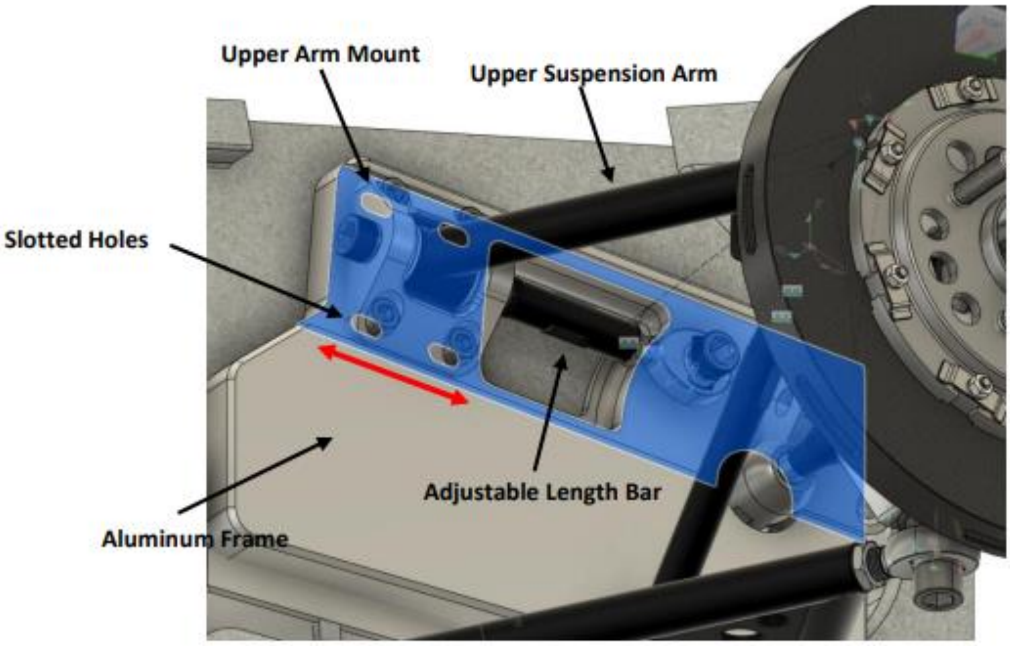




6). Performance Vehicle Design Validation.

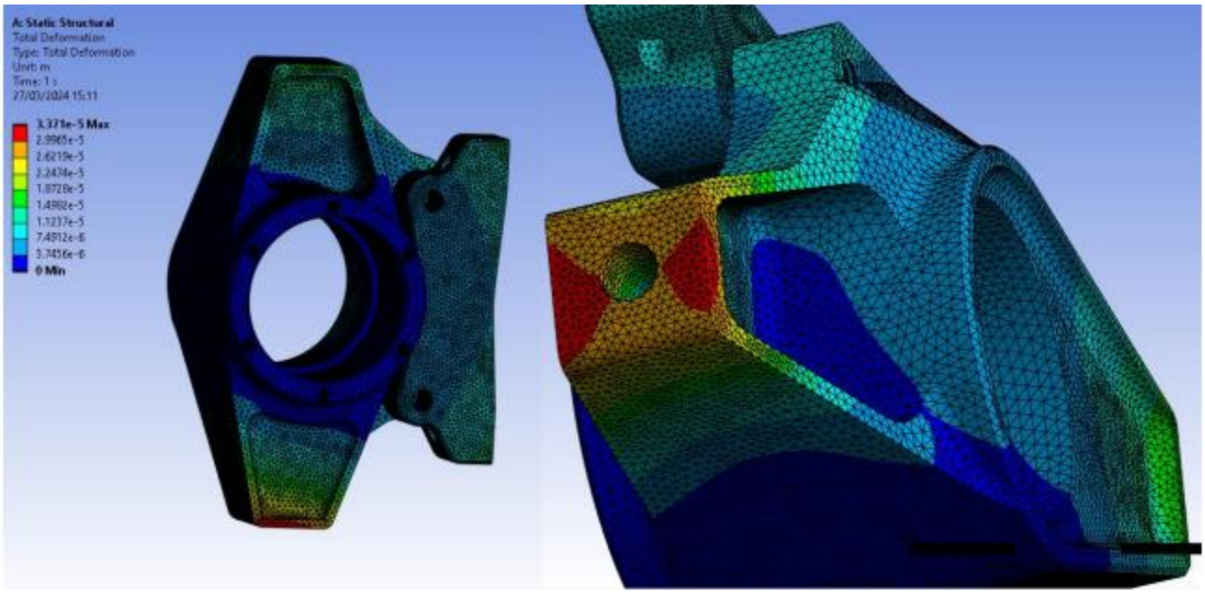
The suspension design and its geometry adjustability were validated through a comparison with a similar size and weight performance vehicle, the Ariel Atom. 3D scans of the Ariel Atom were taken for this comparison.

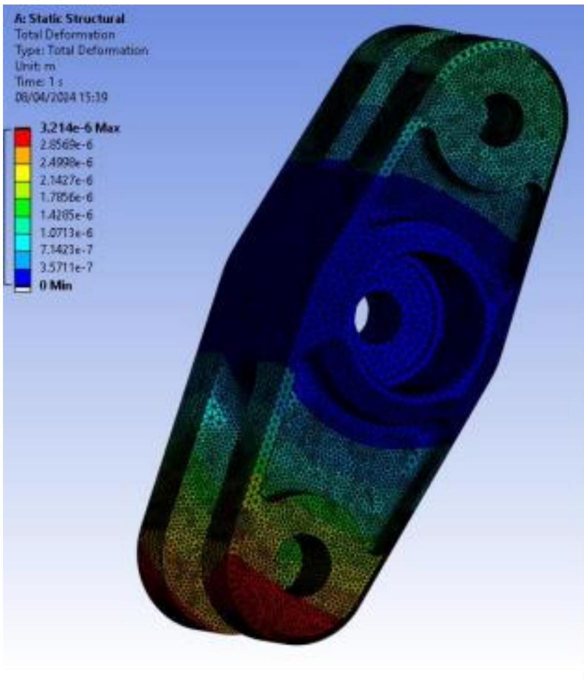


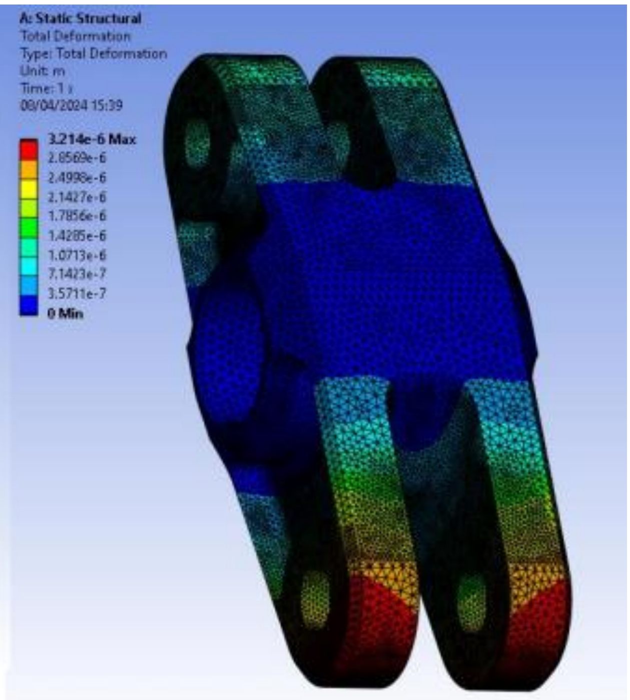


7). Finite Element Analysis and Design Optimisation.

The suspension forces during braking and cornering were calculated, and finite element analysis simulations were performed within ANSYS to ensure that suspension components achieved a safety factor of at least 2.5.

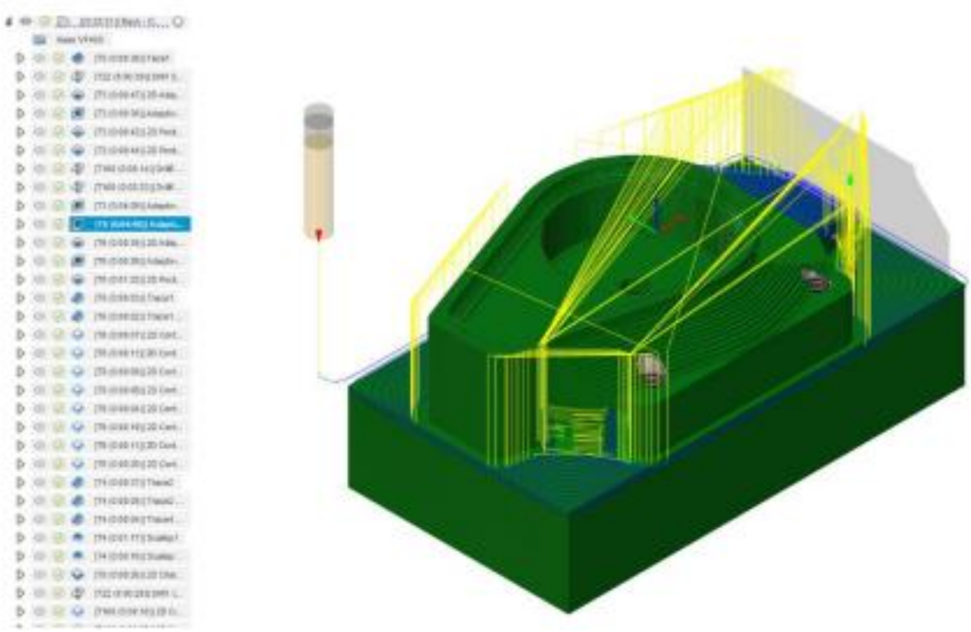






8). Component Manufacture.

Prototype components were 3D printed, and final components were CNC milled and turned, press-braked, tube-notched, welded and painted. A manufactured model was produced.



Cutting the suspension arm steel bar to a rough length.

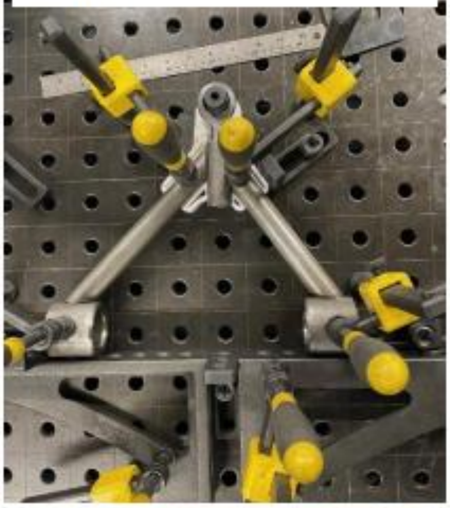
Facing and drilling the end of the bar ready for thread tapping.

Tapping the bar to M16x1.5 to accept the rose joints.

Tube-notching the suspension arm bars.

The lower suspension arm fixture (see Figure 39).

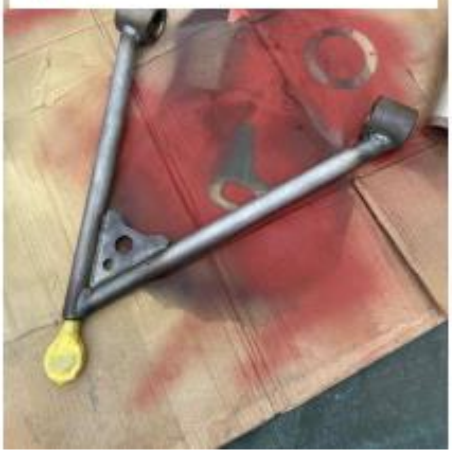
The upper suspension arm fixture.



Tack welding the suspension arms.

Fully welded suspension arms.

Sanding and degreasing before paint.




The laser-cut flat 4mm sheet metal steering arm components.


Bending (press-braking) the sheet metal brackets.


Welding the two brackets together to make the steering arm.

9). Result Discussion.

Compared the original suspension with the redesign, and discussed the project outcome.

		Suspension Geometry Targets			Result Analysis
Geometry Parameter	Original Geometry Values	Minimum	Maximum	New Geometry Values	See Note:
KPI (°)	4	0	8	10	1
Scrub Radius (mm)	0, but could be adjusted marginally.	0	+-10 (negative preferable)	-5	
Caster Angle (°)	5	3	7	3.5 (adjustable from 2 to 4.5)	
Static Camber Angle (°)	0, but could be adjusted marginally.	0	-4	-2 (adjustable from 0.55 to -4.65)	2
Bump Camber Gain (deg/m)	0	-25	-25	-25	
Anti-Dive (%)	0	0	20	18.5	
Roll Centre Mitigation (mm)	0	0	0	1	3
Roll Centre Height at rest(mm)	0	15% of the COG height.	30% of the COG height.	97.75	
Bump Track Width Change (mm)	0	0	0	8.77	
Bump Suspension Travel (mm)	82	50.8	88.9	76.2	
Rebound Suspension Travel (mm)	54	25.4	50.8	38.1	
Ackermann (%)	31.3	60	100	77.95	4
Ride Frequency (Hz)	Unknown	1.5	2	1.6	5
Damping Ratio	Unknown	0.25	0.65	0.4	
Mechanical Trail (mm)	27.13	Dependent on caster angle and suspension design.		18.2	1
Toe Angle (°)	Adjustable	Adjustable Toe in.		Adjustable from 4.2 (toe in) to -2.8 (toe out)	4
Bump Steer (°/mm)	0.012	Dependent on Ackerman geometry, but as close to zero as possible.		0.012	
Spring Rate (N/m)	Unknown	Dependent on Suspension Design.		70	5
Motion Ratio	1.6	Dependent on Suspension Design.		2.5