THE DEVELOPMENT OF AN AERODYNAMIC BODY SYSTEM FOR THE EXISTING SINGLE SEAT ELECTRIC VEHICLE

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MG7101A Engineering Development Project

The Development of an Aerodynamic Body System for the Existing Single Seat Electric Vehicle

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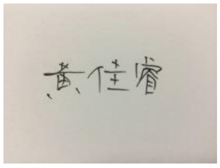
STUDENT`S DECLARATION

I have not copied any part of this report from any other person’s work, except as correctly referenced. Collaboration: No other person has written any part of this report for me.

Student Name:	Jiarui Huang
Student declaration of the above:	
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1. Abstract

The Report goes through the works done by the student before November 2018 for developing of an aerodynamic vehicle body shell, which includes the project background, design features, design outcomes and drawings, conclusion and recommendations.

2. Introduction

Nowadays, vehicles can be seen in everywhere. However, it is addressed that the vehicle exhaust has become the main reason of climate change. It is getting more and more serious and as the data from NASA shown, the global temperature has already increased 0.4°C from 2000 to 2017. On the other hand, with the impact of such as the increasing of crude oil prices, the energy crisis is getting more and more attention. Most people can feel that they are paying more and more for the fuel and according to the data from AA Motoring, the national fuel price of 91 Octane has increased to $2.11 per liter in 2017 from $2.02 per liter in 2016. Those factors are keep forcing and questioning engineers to discover a new technique developing the existing vehicles.

One answer from engineers like the Tesla`s CEO, Elon Musk, is to create and develop Electric vehicle. It is clean, environmentally friendly, without the reliability of fuel and has become an unstoppable trend to upgrade the current vehicles.

As an engineering student from Wintec, for getting a better understanding of mechanical engineering, testing my previous studies and having more practices and working experiences, I and my academic supervisor, Paul Ewart, both agree to make this project as the assessment of my Development Project course.

In this project, an existing single seat vehicle frame with wheels is given to the student. The student needs to design, simulate, prototype test the body system and complete a full report.

However, the final design prototype may not be done in the end of the project because of the schedule clash from the industry support. It creates a reasonable but big tolerance in both the design mould and the simulations.

3. Project background

3.1. BEV project

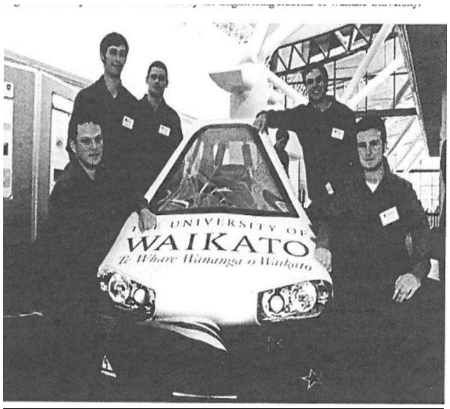

Figure 1:BEV project

This project is leaded by the BEV project from the University of Waikato. The students from the BEV team aim to increase the efficiency of the use of vehicles and reduce the automobile exhaust by promoting the single seat electric vehicle. (SSEV) They have successfully built the vehicle, however, with lots of issues on the car. One of the biggest issue is the high rolling resistance on its body system, caused using part designed for common vehicle. The vehicle then is disassembled and its frame with wheels were transported to Waikato Institute of Technology (Wintec), with the target of developing the whole vehicle. While the goal of this project is to develop an aerodynamic body system for the SSEV.

3.2. Client`s requirements

I was asked by my client, to work out three different hand sketches of vehicle body system designs based on the existing vehicle frame and wheels. After that, discuss the designs detailed with the client to select the final design.

After the designs was shown, the client ordered that each design need to include an aerodynamic cooling system, lighting equipment, rearview mirror and shells, which are for the head, the motor and the battery of the vehicle.

3.3. Design assumptions

The single seat electric vehicle (SSEV) is assumed to be safe to run with a maximum speed of 110km/h, successfully passed Warrant of Fitness (WoF) testing and follow all Low Volume Vehicle (LVV) standards and all related certifications will be obtained.

3.4. Equipment usages

Equipment that may be used includes:

- Laser, guillotine, plasma and gas for cutting
- Press break, rollers, bar benders and general hand tools for forming
- MIG and TIG welding machines
- Grinders, drill press, hand drills and various hand –held equipment

3.5. A-line Sheet Metals

A-Line Sheet Metals is a company located in 18 sunshine Ave, Te Rapa, Hamilton, NZ. The company is mainly focus on the manufacturing of stainless steel fabrication, food prep benches, balustrading & handrails, landscape features and commercial. Lots of staffs there love vehicles and have experiences to repair and replace vehicle doors and shells. There is a cooperation between the company and Wintec and this Wintec project is supported by the company.

Figure 2:A-Line Sheetmetals

3.6. Relative electric equipment applied

The vehicle will be supplied by 16 blocks of CALB 108Ah lithium batteries, which are placed under the driving seat, and is generated by two ME115 permanent brushless motors behind the seat. Additionally, a Gen4 DC brushed motor controller is applied for the battery management system(BMS). The batteries are produced by China Aviation Lithium Battery co., Ltd(CALB), the motors are made by Motenergy Inc and the controller is manufactured by Sevcon electric vehicle company.

Figure 3:Relevant Companies

4. Design Feature

4.1. Methodology summary

According to the experiences from the industrial supervisor, the manufacturing processes includes designing, marking out the shape and related dimensions, cutting off the required materials, forming, fixing all components and welding. All the processes must follow the guides of the Low Volume Vehicle Standard in NZ, which can be found in the official website of the Low Volume Vehicle Technical Association Inc.

After the discussions with supervisors, the methodologies are summarized as below:

4.1.1. Project Preparation	Research all related standards.
4.1.2. Materials Reseaching	Research the properties of 5005 Grade Aluminum.
4.1.3. Vehicle Frame Measuring	Measure the vehicle frame and create a Solidworks mold.
4.1.4. Concept Designs Researching	Research any existing designs which are suitable to the project.
4.1.5. Preliminary Report Reflection	Read and conclude the comments of the preliminary report.
4.1.6. Simulating	Simulate the design using computational fluid dynamics (CFD) from the Solidworks.
4.1.7. Prototyping	Visit and record how the machines are used and how the vehicle shell is made by the industry.
4.1.8. Reporting	Record what happens in the project.

Table 1:Methodology

4.2. Concept design

4.2.1. Design one

The concept of a microcar is referred to design one. It looks cute, steady and flexible, with multiple applications and especially good for short-distance travels. The enclosed shell provides a very safe driving space which can reduce the impacts and prevent the driver from throwing away in a traffic accident the body system also separates the interior space and exterior one, so that conditions from the weather will not affect the operation of the vehicle. Air conditioning becomes possible to be applied with such a concept, not only for the better driving environment but also for cooling down the operated motors and batteries.

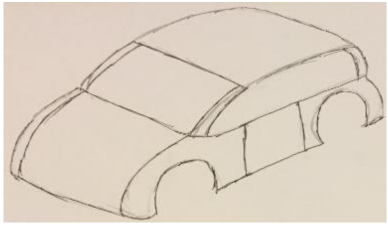

Figure 4:Design one

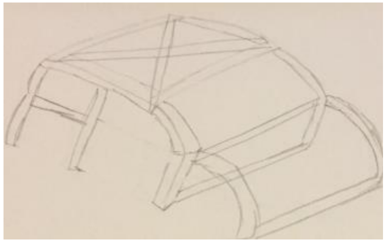

Figure 5:Extra Frame of design one

The design is mainly made by the 0.9mm aluminum plate and is about 1.3m high, 1.8m long and 1m wide, with a surface area of about 7m^2 costing about $93.38. Extra frame is needed which is long 15m with a 3 cm of outside diameter and 2 cm of inside diameter. The total budget of this design will be about $450 including the fee of labor (GST is excluded).

The manufacturing time is about 12-60 hours varied by the experience of the engineers.

Limitations of the design mainly include the experience of the student, long manufacturing time, high cost and each part is difficult to replace.

4.2.2. Design two

Design two basically refers to the idea of cobra car. Since its nice, smooth and aerodynamic outlook, it is mainly used for racing. There are two parts of the design and both are widened enough to cover the wheels, avoiding lifted dusts and gravels. Unwanted airflows and dusts are blocked by the windshield. Large internal spaces allow more equipment added to the car. Roof and doors are removed which makes the design more achievable.

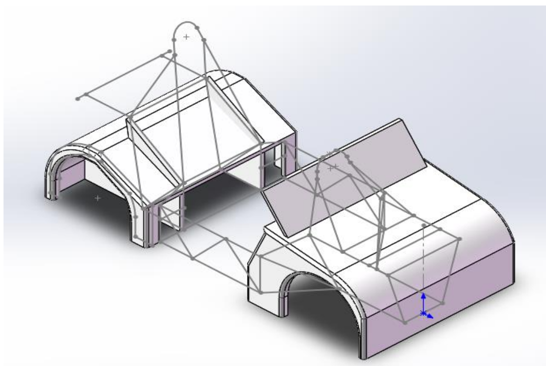

Figure 6:Design Two

The design is mainly made by the 0.9mm aluminum plate and is about 0.65m high, 1.2m long and 1m wide, with a surface area of about 5m^2 costing about $66.7. The total budget of this design will be about $270 including the fee of labor (GST is excluded).

The manufacturing time is about 8-45 hours varied by the experience of the engineers.

Limitations of the design mainly include the lack of technique for bending the materials, difficulties of avoiding effects from the weather and the undersigned ventilation duct because of the late order.

4.2.3. Design three

With the concept of an exocet kit car, the option three is designed as light as possible. Main application of it will be racing. Only the necessary eases are covered which saves a lot of materials. All parts are built in the existing frame simplifies the overall manufacturing processes and makes it more achievable for a no-experience-student. The duct in the front leads the air blows through the motors and batteries and cooling them down.

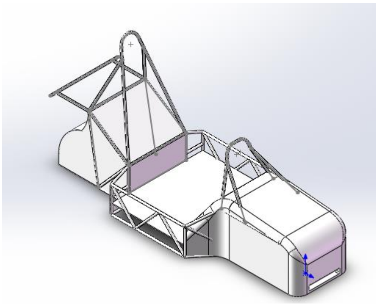

Figure 7:Design Three

The design is mainly made by the 0.9mm aluminum plate and its surface areas is about 6m^2 costing about $80.04. The total budget of this design will be $250 including the fee of labor (GST is excluded).

The manufacturing time is about 8-40 hours varied by the experience of the engineers.

Limitations of the design mainly include small internal space, difficulties of avoiding effects from the weather and safety issues since the volume are too light.

5. Design outcomes and Drawings

5.1. Outcomes descriptions

The main outcomes of the project include that a student design of a vehicle body shell and the simulation data of the design. The design then will be given to the industry support for manufacturing.

Another outcomes comprise the relevant standards, CAD mold of the vehicle frame, information of three different kinds of vehicle and the reflection of the preliminary report.

However, the prototype of the vehicle hasn`t been done yet as the reason mentioned above.

5.2. Project Preparation

5.2.1. WoF Test

According to the research, it is necessary to contact with the LVV certifier for checking our modifications. If the modifications meet all the standards, the plate will be posted or given by the certifier. The plater must be fitted in the vehicle within two months after the test. Then, the WoF test can be applied with the LVV certification. (Modifying your vehicle, 2018)

Neal Miller	Modified Vehicle Certification Centre	6c Sloper Ave		Hamilton	07 847 1934
Kane Marsden	Nostalgia Motors	4e Wickham Street		Hamilton	07 846 1623
Noel McMillin	Nostalgia Motors	4e Wickham Street		Hamilton	07 846 1623
Wayne Brocket	Matangi Motors Ltd	449 Tauwhare Road	Matangi	Hamiton	07 8295709

Figure 8: LVV Certifier List(Modifying your vehicle, 2018)

This is a part of the contact details of the LVV certifiers in New Zealand, which shows there are only four certifiers in Hamilton. The plan of doing the LVV certificate test will be discussed if I pass the stage one of this project. (Modifying your vehicle, 2018)

5.2.2. LVV standards

- Standard for Rear View Mirrors

For LVV, there must be an interior rear-view mirror in the suitable position which will not interfere the forward view, and an exterior one which need to be fitted on the side of vehicle nearest to the driver. Both must be adjustable and not obstruct the forward vision of the driver. Typically, on the edges of the interior and exterior rear-view mirror and their attachment structure, there must be a radius of no less than 3mm. Also, there must not be any sharp edges when the mirror is bent or broken by accident. (LVV standards, 2016)

- Standard for the connection part

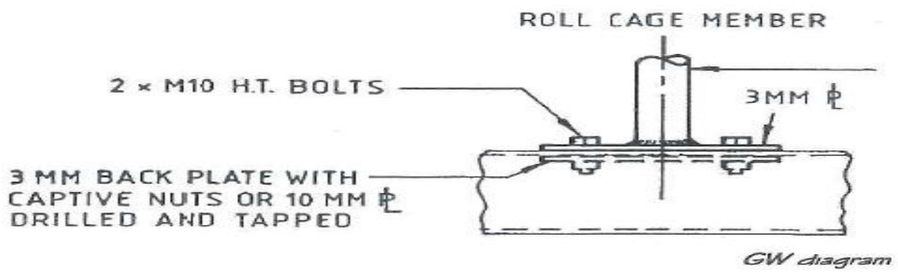

Diagram 13.1 Roll-bar attachment for body/chassis vehicles

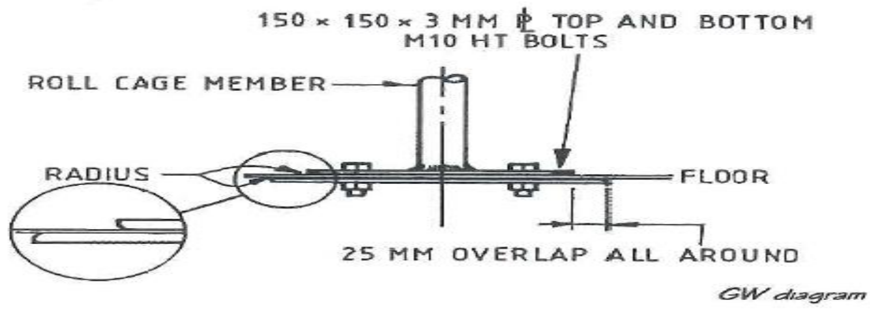

Diagram 13.2 Roll-bar attachment for unitary constructed vehicles

Figure 9:fitting method

-The roll-bar of the LVV must be fitted in the way as the figure shows and be welded to the chassis.

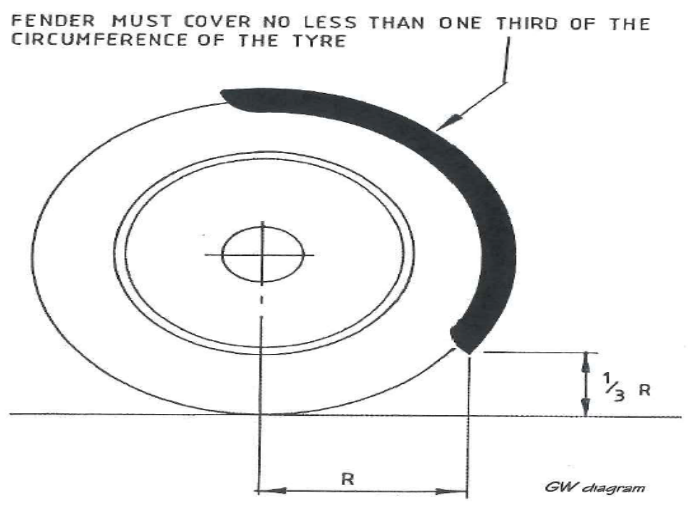

Diagram 13.3 Mudguard positioning

Figure 10: Mudgard

-The size of mudguards in a LVV must be the same width of the tread and 1/3 of the circumference of the tires.

-Two latching devices must be assembled in the engine hood.

- Standard for the Lighting

	A	B	C	D	E	F	G	H
1	Classification	Number	Colour	Electrical connection	Position	Visibility(output)	Visibility(angle)	Size
2	Dipped beam headlamp	a pair	white or amber	automatical activation with rearward-facing position lamps&registration-plate illumination-lamps	see table 17.1	-	-	-
3	Stop-lamp	a pair	red	-	see table 17.1	20watts flament bulb or equivalent brightness LED	diagram 17.1	22 sq cms
4	High-mounted stop-lamp	one	red	must illuminate when the vehicle`s ignition system is on and the servise brake is applied or the stop-lamps is on	in a central high-mounted position at the rear	15watts flament bulb or equivalent brightness LED and can be seen with the distance of 100m	-	22 sq cms
5	Direction-indicator lamp	two	white or amber(Front) red or amber(Rear)	60-120 flashes/mins	see table 17.1	15watts flament bulb or equivalent brightness LED	diagram 17.2	22 sq cms
6	Forward-facing position lamp(park)	a pair	white or amber	as a part of the headlamp assembly	see table 17.1	5watts flament bulb or equivalent brightness LED	diagram 17.3	22 sq cms
7	Rearward-facing position lamp(tail)	a pair	red	automatically operate when the headlamps are activated	see table 17.1	5watts flament bulb or equivalent brightness LEDcan be seen with the distance of 200m	diagram 17.4	22 sq cms
8	Rear registration-plate illumination-lamp	one	white	automatically operate when the headlamps are activated	the position where the figures and letters can be illuminated	Not be directly visible&the registration-plate can be seen with the distance of 20m	-	-
9	Retro-reflector lamp(reflector)	a pair	relecting any white as red light(Rear) relecting any white as white or amber light(Front)	-	see table 17.1	relecting without causing undue or discomfort to other users	-	22 sq cms

Figure 11:Lighting Standards

- Standard for the exterior projection

-As the LVV standard addresses, there must be a clear visibility to the front and both sides around the driver. In this case, as an open vehicle, there must not be any components or fittings forward of the firewall which protrude above a straight line measured from a point on the vehicle's longitudinal center-line 730 mm above and 270 mm forward of the junction of the uncompressed seat base and back, with the seat in its rear-most and lowest position, to:

(a) in the case of protrusions 250 mm or less in width, a point at ground level
15 meters forward of the front of the vehicle; or

(b) in the case of protrusions between 250 mm and 400 mm in width, a point
at ground level 12 meters forward of the front of the vehicle; or

(c) in the case of protrusions 400 mm or more in width, a point at ground level 8 meters forward of the front of the vehicle.

- Standard for Electric and Hybrid Vehicle

-There must be a label of the word "electric vehicle" and a warming label, which is shown in the right-hand side, fitting together in the vehicle shell. (LVV standards, 2016)

Figure 12:Warming

5.3. Material properties

5005 grad Aluminum is widely used in architectural applications, general sheet metal and high strength foil, because of its corrosion resistance in normal atmosphere. Usually, it reacts very quickly with the air and create an oxide film, which protects the surface. Its corrosion resistance may be destroyed by the failure of the reaction. Therefore, it is highly recommended to use it without any reducing media. It can be TIG

Chemical Element	% Present
	SPEC: BS EN 573-3:2009 ALLOY 5005
Manganese (Mn)	0.0 - 0.20
Iron (Fe)	0.0 - 0.70
Copper (Cu)	0.0 - 0.20
Magnesium (Mg)	0.50 - 1.10
Silicon (Si)	0.0 - 0.30
Zinc (Zn)	0.0 - 0.25
Chromium (Cr)	0.0 - 0.10
Other (Each)	0.0 - 0.05
Others (Total)	0.0 - 0.15
Aluminium (Al)	Balance

Figure 13:Properties 1

welded or MIG welded in a clean and dry condition avoiding unassay defects and during welding, the shielding gas needs to be free of hydrogen and moisture. Also, it is very light because of its low density. The heat dissipation will be very good as well since its high thermal conductivity.

Mechanical Property	Value
	SPEC: BS EN 485-2:2008
	ALUMINIUM SHEET - 0.2MM TO 12.5MM
Tensile Strength	145 - 185 MPa
Proof Stress	110 Min MPa
Hardness Brinell	47 HB

Figure 14:Properties 2

Physical Property	Value
Density	2.70 g/cm³
Melting Point	655 °C
Thermal Expansion	23.5 x10^-6 /K
Modulus of Elasticity	69.5 GPa
Thermal Conductivity	201 W/m.K
Electrical Resistivity	0.033 x10^-6 Ω .m
Electrical Resistivity	52 % IACS

Figure 15:Properties 3

5.4. Concepts design researching

- Design research one – Microcar

As the diagram shown above, microcar is a kind of small vehicle. Most of them are no more than 700cc and two doors. The roof on the top perfectly separates the interior and exterior so the motor and batteries get prevented from the rain. The window in the front avoid those unwanted winds and make it easier to control the steering wheel.

Figure 16: Microcar(Techon-Nikkeibp and Yomiuri, 2012)

- Design research two – Cobra car

The body system of the cobra car is nice, smooth and aerodynamic, reducing a lot of air resistance. The special shape of the body has attracted thousands of fans since it is first produced in 1962.

Figure 17: Cobra Car(Valdes-Dapena, 2016)

- Design research three -- Exocet Kit car

Exocet is first made in 2010 and it is still being driven currently in a UK race series regulated. The body of an exocet is easy to remove and replace, aerodynamic and light. Only the important parts of the vehicle are covered saves lots of materials and reduces the price.

Figure 18 Exocet Kit Car(List, Jenny, 2016)

5.5. Preliminary report reflection

According to the comments of the preliminary report, the number and arrangements in the contents are wrong. The mudguards need to be assembled to the final design. Rather than showing all the contact details of certifiers in NZ, only the ones in Hamilton need to be show. More information of electric vehicles and relevant technologies need to be researched. More Books about electric vehicles need to be read and referred.

5.6. Final design

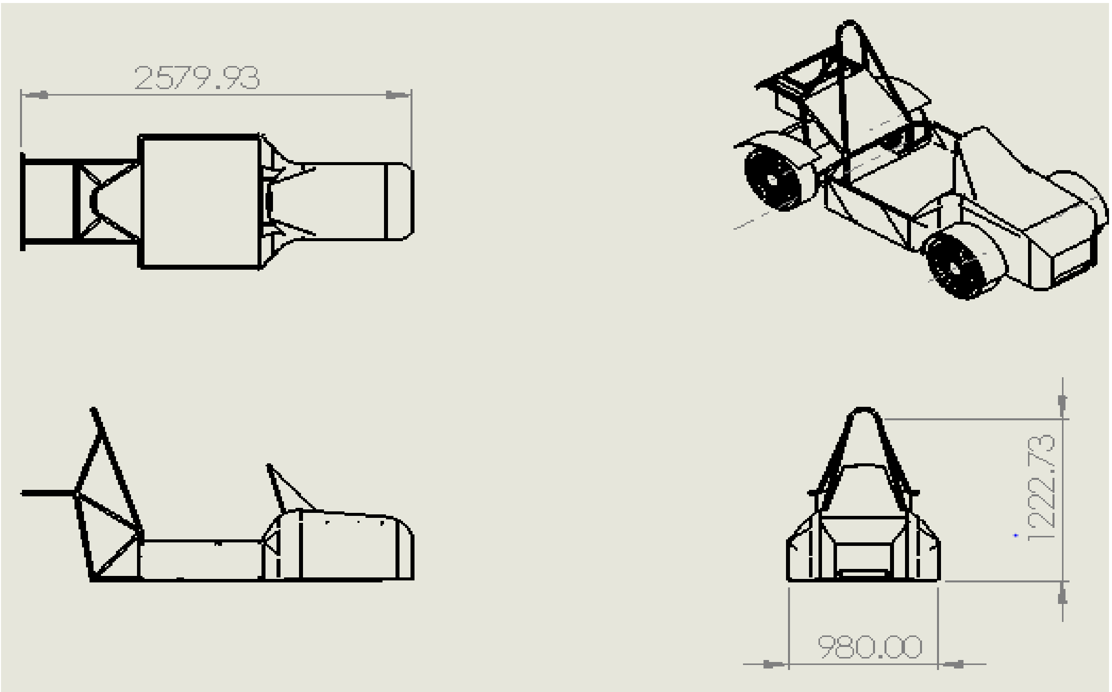

Figure 19:Final Design

As mentioned, when the vehicle shell was developing, the industry support did not always follow the student design. The diagram above is showing the works done up to a week before the report due. The design is about 980mm width, 1,222mm high and 2579mm long which fully made by 5005 Grade Aluminum. The back of the vehicle has not been fully developed yet since the project from the electrical team is still on process and the dimensions of their design is ungiven. The font of the vehicle shell is almost done which have a maximum space of about 90,000,000mm^2. In the future, a rectangular box will be added to the middle of the design, which is for covering and carrying all the batteries. The whole design is highly covered, avoiding unwanted dirt or liquid goes to the electric circuit. A ventilation duct goes through the bottom of the shell for cooling the batteries, motors and relevant circuit.

5.7. Budget

	Price	Amount	Total
Aluminum 5005 Grade 2mm	$31.38/m^2	15m^2 (Current)	$470.7
Labor	$13.2/hr.	12hr (Current)	$158.4
Total			$628

Table 2:Budget

5.8. Manufacturing processes

Measuring & Marking

During this step, it is required that measuring and marking out the size in the Aluminum plates following the concept. Usually, engineers will mark slightly bigger than the design which allows to modify if there is a mistake.

Cutting

After that, the measurements will be double checked and cut. Different sizes of cutting tools will be applied depending on the size, shape and feature of the design. It is highly recommended that there should be supervisors and this step should be done slowly since it may cause hazards and materials waste.

Folding

In this case, the Break Press and a hand folding machine are introduced by the industrial supervisor. In the company, the Break Press, which is a bigger folding machine, is mainly been used to fold any plates that is rectangular. The Break Press is more accurate since it is controlled by computer. While the smaller one can fold almost any shapes.

Assembling & Welding

After the sheets are made to specific shapes, they will be assembled with bolts and nuts or by welding. In this case, both MIG and TIG welding are suitable.

Rolling

In this specific case, the mudguards need to be produced by a rolling machine. Usually, this step need to be done by an experienced engineer because the machine is controlled by hands. More details about this will be described in relevant technique.

5.9. Relevant techniques

Folding

Rectangular sheets:

If we are folding a rectangular sheet, a more advanced and convenient folding machine, which is called Break Press, will be used.

Figure 20 :The Break Press

1. All measurements will be entered to the computer of the machine. Then the machine will start simulating and work out a diagram. With that diagram, we can easily see if the machine can fold following the design.
2. The reason of a fail in a simulation is usually because that the sheet will touch the machine in an unexpected way after folding, against the folding pressure, so that the sheet will not have the folding angle we want. In severe cases, the workpiece will be damaged. If the simulation is failure, we need to redesign the sketch based on given diagram and simulate it again.
3. Once the simulation is successful, we can fix the sheet in the Break Press. Before we start folding, we need to make sure our hands are holding the sheet on the side near the ground. Otherwise our hands may fly to the punch and get cut.
4. When the start button is pressed, the punch will fall, and its speed will become slower and slower. Such a low speed will make the folding process more accurate and avoid the unwanted hazards.
5. We always cannot get the expected folding angle during the first folding. Therefore, we need to measure the folding angle of the workpiece and enter the data to the computer.

6. After that, we need to second-fold the sheet. The machine is ready once the new data are entered. Pressing the pedal and start falling the punch down. When the punch and die are close enough, we need to try moving the sheet and see if it is in a suitable position. Usually, it will be tight and hard to be moved if it is in a good position. Then we can give it a fold by stepping on the pedal.

7. If we are folding part A and part B in one design and the design is symmetrical, we don`t need to change the setting once we finish second-folding on part A.

Irregular sheet:
Almost all irregular sheets are not allowed to be placed in the Break Press, because it is hard to be set in the machine and its sharp angle may damage the machine. Usually, irregular sheets are folded by a smaller hand fold machine.

Plates rolling:

In this case, a plates-rolling machine is used for making the mudguards.

Figure 21 :Rolling Machine

1. The aluminum sheet will be marked based on the design.
2. Then the sheet will be cut in the big cutting machine which is called guillotine.
3. There are three rollers in this machine, the black roller is fixed which can only rotate. The red roller can be moved vertically, controlling the space between the left rollers, so that the aluminum sheet can be put in. The green roller can be moved horizontally, which controls the rolling radius.
4. After the sheet is in, the red roller will be raised for locking up.

5. Then the green roller will start rotating and the workpiece will be rolled but one side of it will stay flat.

6. For rolling it thoroughly, the workpiece need to be rolled again starting in the flat side.

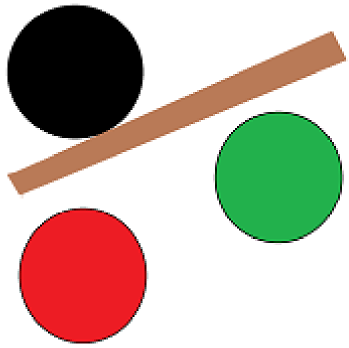

Figure 22:Rollers

7. A circular or sector plate will be made before plates-rolling. The radius of it is same to the mudguards. Once the plates-rolling is finished, we double check the radius of the mudguards, by comparing it with the circular plate.

8. If the plates-rolled workpiece`s radius is incorrected, we need to re-roll it by adjusting the green roller. Usually, we would like to over roll it because the rolled workpiece is easy to open but hard to be rolled by hand.

9. If we are rolling a cylinder, after rolling, a vice grips will be used for holding both ends of the workpiece, so we can weld them together.

Installing vehicle lights

- Measuring the length between the power supply and the lights to determine the length of the wires.
- Marking out the position of the switch.

  Drilling a hold in the firewall if necessary. It is recommended that adhesive tapes in the surface of the place being drilled to avoid the unwanted surface damages.
- Connecting the wires and test it.
- Fix the lights and switch with bolts and nuts applying the interior side of the shell.

5.10. Simulation

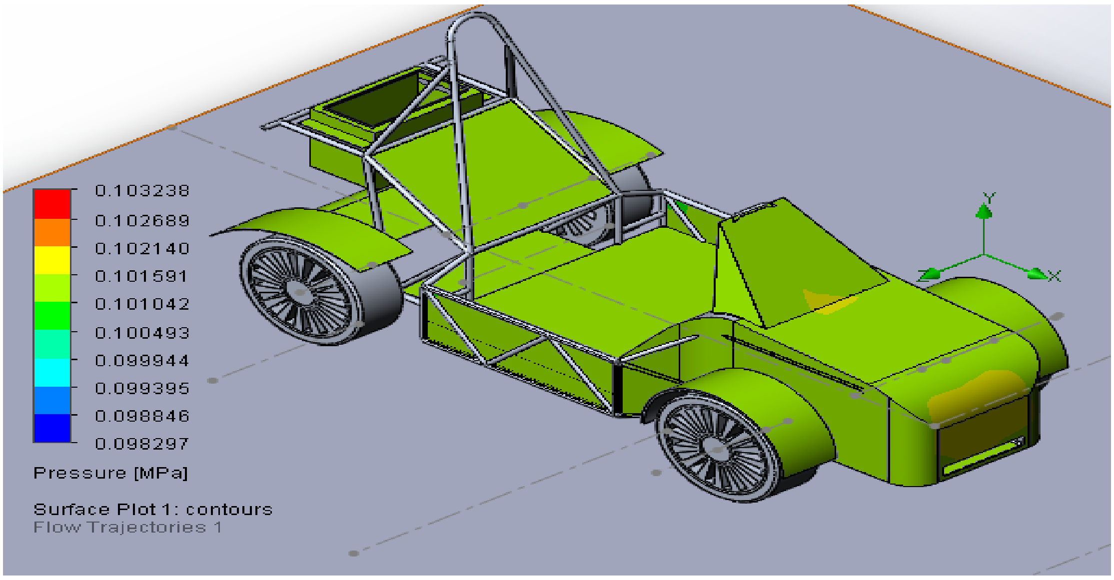

Figure 23Simulation 1

The figure shows the different pressures acting on the surfaces of the design when the air slow is -30m/s, which is for assuming the vehicle is running in the speed of 108km/hr. The highest pressure occurs in the yellow areas in front of the vehicle which is only about 0.10214MPa and safe for driving.

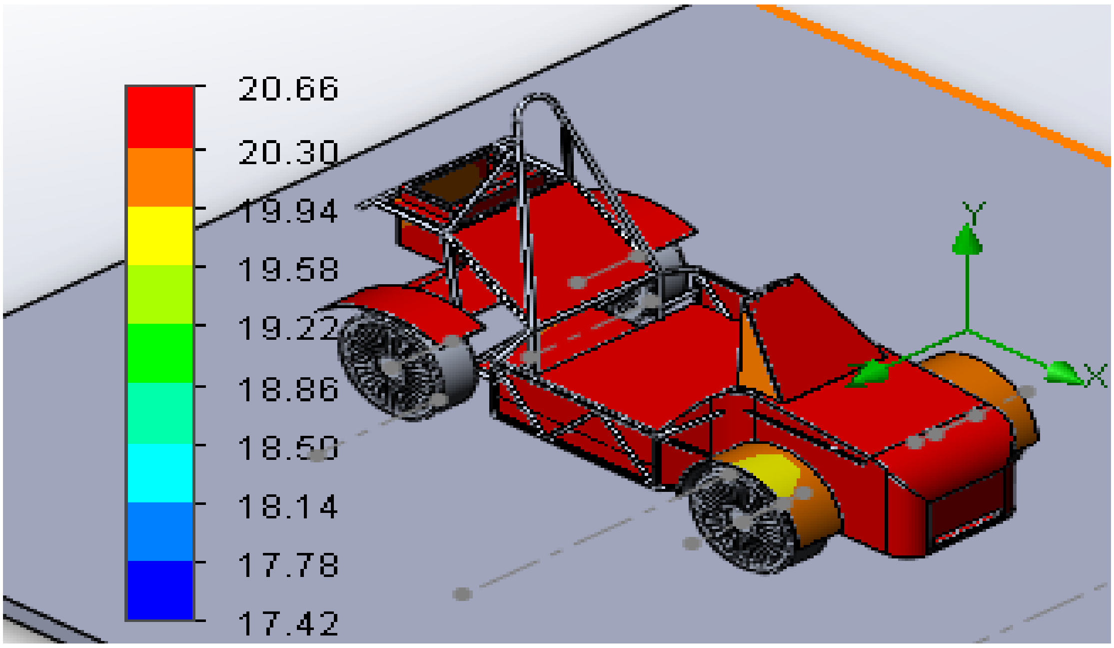

Figure 24Simulation 2

While in this figure, it shows the temperature differences around the surface in the same condition. The highest temperature is about 20° C which is good for reducing the internal heat of the vehicle.

5.11. Relevant calculation

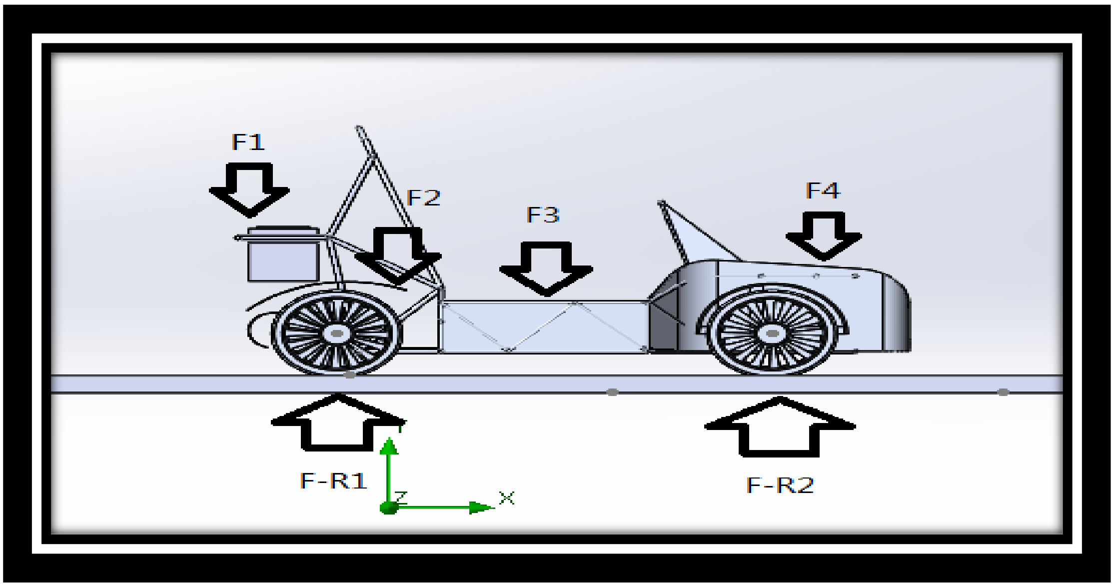

Figure 25Calculation 1

Where:

F1= The weight of baggage assumed as 30kg.

F2= The weight of all the electric circuit in the back assumed as 15kg.

F3= The weight of the driver, batteries and the design, where the weight of driver is assumed as 120kg, the weight of batteries is assumed as 30kg and the weight of the design given in the solidworks is 450kg.

F4= The weight of the electric circuit in the front assumed as 20kg.

F-R1= The reaction force on the back wheels.

F-R2= The reaction force on the front wheels.

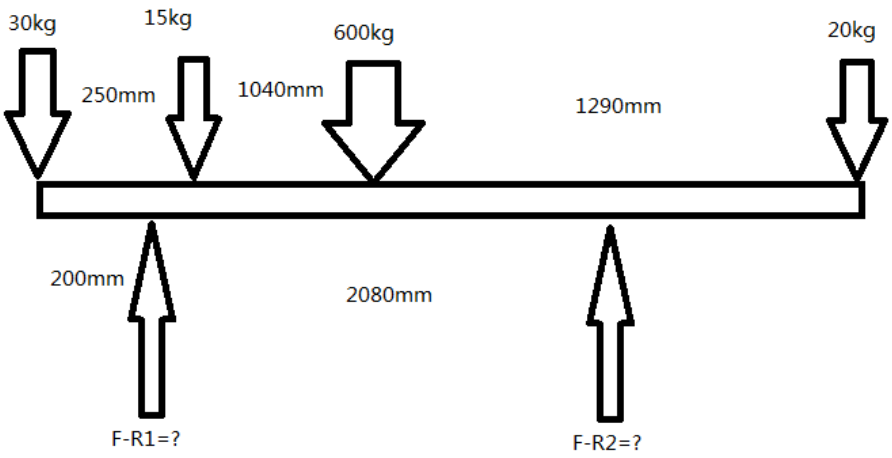

Figure 26Calculation 2

The problem is simplified as the figure shows above.

If F-R1 is the center of moment:

-(-30*200) = (-15) *50+(-600) *1090+F-R2*2080+(-20) *2380

Therefore,

F-R2 = 340.55kg

So,

30+15+600+20 = 340.55+F-R1

F-R1 = 324.45kg

If $g=9.81m/s^2$

F-R1 = 3182.85N

F-R2 = 3340.80N

6. Conclusion and Recommendation

6.1. Design issues

- Unachievable components of the design with the existing tools from the industry support.
- Unsuitable size of the batteries cover box which needs to be redesigned since the batteries are bigger than what we imaged.
- Uncompleted prototyping caused by the schedule clash from the industry support.
- Developing design mold which cannot be updated because of the uncompleted prototyping.

6.2. Design features

- Corrosion resistance because of the usage of 5005 Grade Aluminum.
- Good quality of heat dissipation of the material, highly reducing the internal temperature of the vehicle.
- Nice, flat and smooth surface providing a good aerodynamic quality.
- Good looking open design with fully covers preventing dirt and liquid from the internal vehicle.

6.3. Limitations

- Acceptable errors in the dimensions of the mold because the existing vehicle frame is not allowed to be disassembled during measuring.
- The weights shown in the calculation part is only for the current design.
- The design is still being developed.
- The budget is counted until the project has been submitted.

6.4. Recommendations

- The budget needs to be upgraded after the electrical team share their requirements of the vehicle shell`s size.
- The weights shown in the calculation part need to be renewed after the electrical team finishing their project.

6.5. Further works required

- Measure the internal temperature with an on-road-testing.
- Test of the waterproof.
- Tidy up all electric circuits.
- Wof test.

7. References

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8. Glossary & Abbreviation

SSEV…………………………………………….…………….……………….Single seat electric vehicle

WOF………………………………………………………..…………………….………Warrant of Fitness

ALS Company…………………………………………………….……..A-Line Sheet metals Company

BEV project……………………….The electric vehicle project from the University of Waikato

LVV……………………………………………………………………………………Low Volume Vehicle

Wintec……………………………………………………………………….Waikato institute of technology

F1………………………………………………………………..The weight of baggage assumed as 30kg.

F2…………………………….The weight of all the electric circuit in the back assumed as 15kg.

F3……………………………………………………………The weight of the driver, batteries and the design, where the weight of driver is assumed as 120kg, the weight of batteries is assumed as 30kg and the weight of the design given in the solidworks is 450kg.

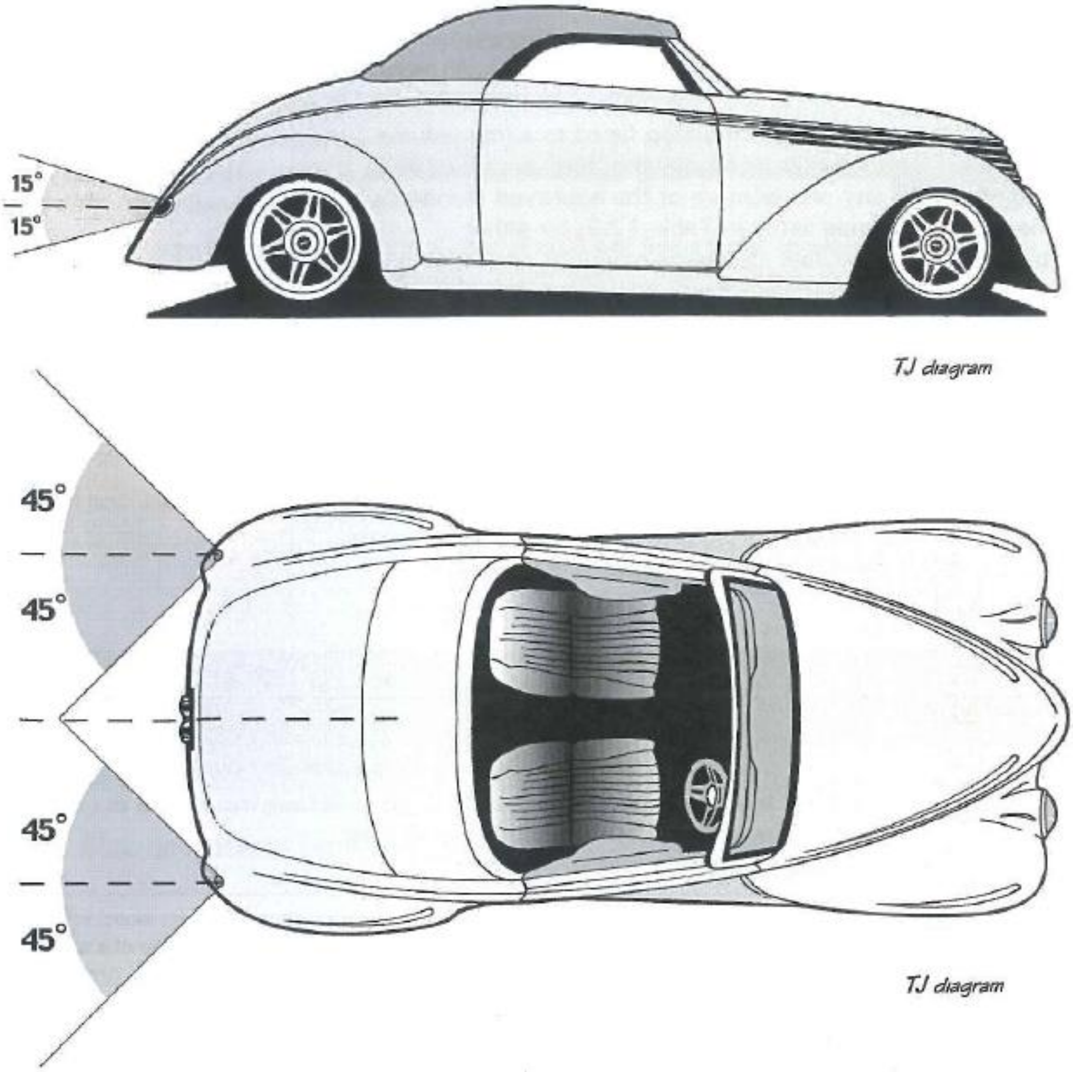
F4……………………………….The weight of the electric circuit in the front assumed as 20kg.

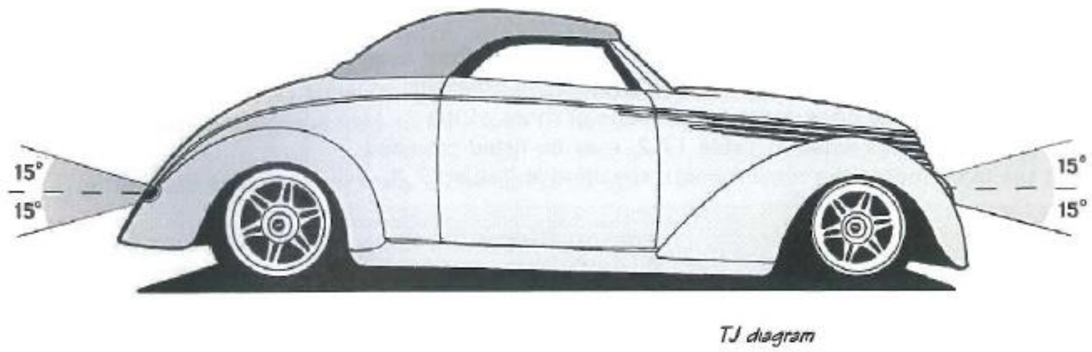
F-R1………………………………………………………………..The reaction force on the back wheels.

F-R2………………………………………………………………..The reaction force on the front wheels.

Appendices

Figure 27Diagram 17.1





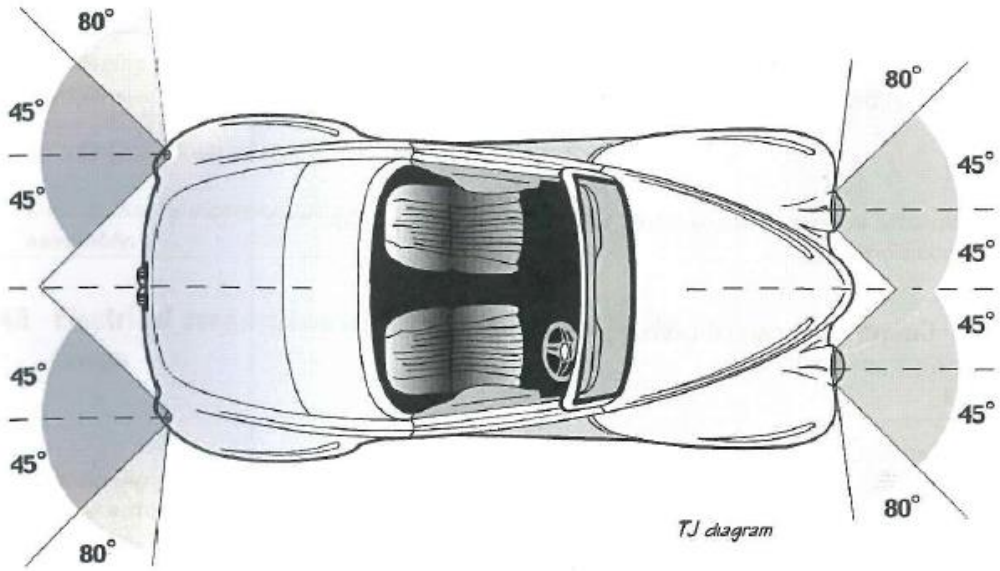


Figure 28Diagram 17.2

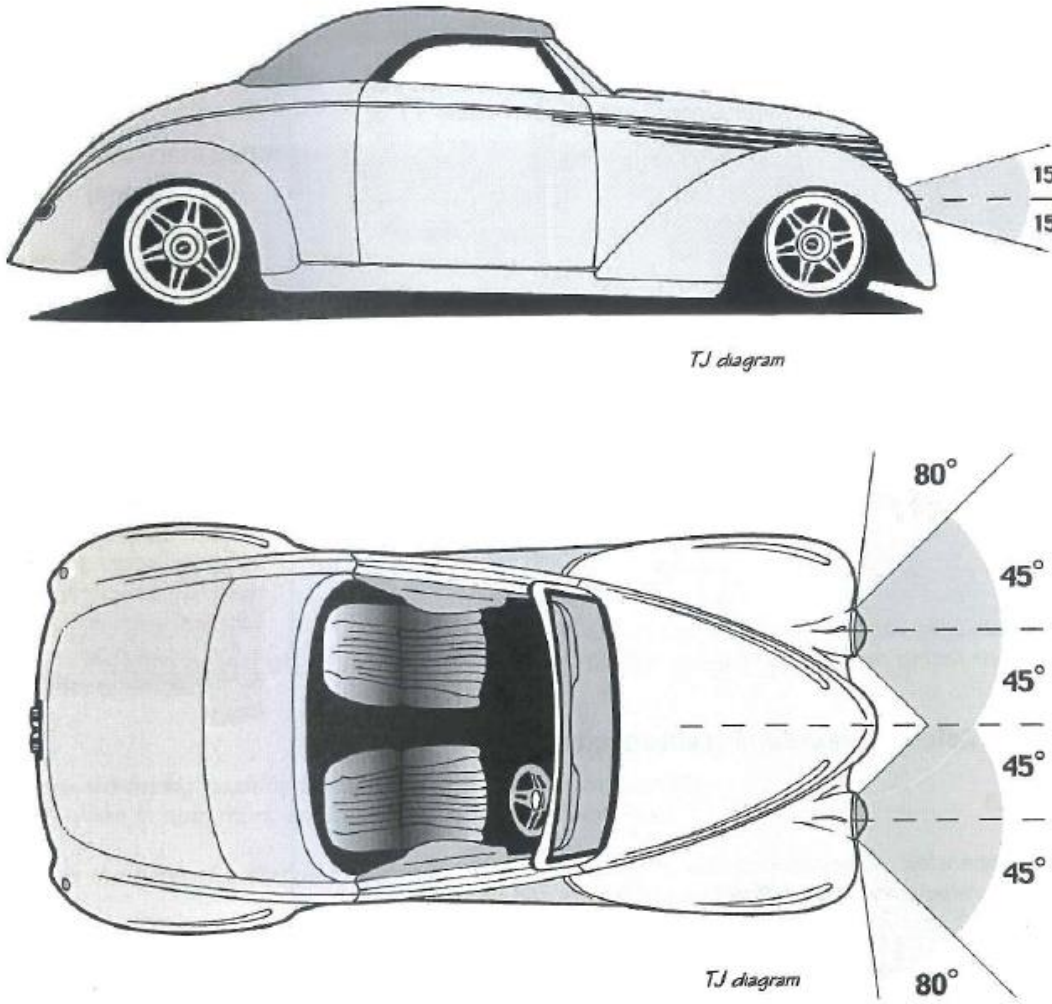


Figure 29Diagram 17.3

ORIENTATION	REQUIREMENTS
Width:	▪ no further inboard than 400 mm (16") from the outer-most part of the vehicle; or
	▪ in the case of a low volume vehicle that is less than 1300 mm (53") in width, no less than 400 mm (16") apart; or
	▪ in the case of a low volume vehicle whose body design makes achieving this impractical, no less than 600 mm (24") apart; or
	▪ in the case of a vehicle for which a valid LVV Authority Card issued by the New Zealand Hot Rod Association (Inc) has been issued that specifies 'mudguard exemption', closer to the vertical centreline of the adjacent tyre than to the longitudinal centreline of the vehicle.*
Height:	▪ no less than 250 mm (10") from the ground; and
	▪ no more than 1500 mm (61") from the ground.

Notes to accompany table 17.1

- All lamps fitted to a low volume vehicle must be positioned as far toward the outer edges of the vehicle as practicable, so as to reasonably indicate to other road users at night, the approximate width of the vehicle.
- *This means that the distance from the lamp to the centreline of the tyre is less than the distance from the lamp to the vehicle centreline.

Figure 30Table 17.1