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The Final Dissertation Proposal

Research Methods (ACHA7027)

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1. Introduction

1.1 Background of the project

The idea of this project came up with the objective of demonstrate the aerodynamic background obtained and work on a real-life development for a racing car, combining two of my main interests. To be able to achieve it, we will work with the contact on a racing team, Chris Bull, who is part of the team developing a Mygale Formula 4 car.

The vehicle has been competing in the HAS sprint championship for a few years, and their main objective is keep developing the car to achieve the first places. The regulations for the championship are presented on the Motorsport UK National Competition Rules 2026 Edition 3 (Motorsport UK, 2026, Ch.14.4.17), the restrictions for open wheel single seat racing cars can be found in chapter 14, Appendix 4, article 17. In the following figure the information is presented.

17. Regulations for Open Wheel Single Seat Racing Cars

17.1. Dimensions

17.1.1.

Maximum width ahead of front wheels	1500mm
Maximum width behind front wheels	1400mm
Maximum height of any part wider than 1100mm ahead of the front wheels	Not to exceed the top of the front wheel rim
Maximum height	900mm from the ground
Maximum rear overhang	1500mm behind rear wheel axis.

17.1.2. Maximum height is measured with the car in any condition and Driver aboard. Safety roll-over bars and air boxes are not included in this measurement.

17.2. Wheels

17.2.2. Twin rear wheels are permitted.

Figure 1.1. Design regulations. (Motorsport UK, 2026, Ch.14.4.17)

The last developments on the car were focused on the rear part of it, mainly on the rear wing and the diffuser. This condition led to a state where the balance of the car is between 55-60% rearwards, where the ideally state will be between 45-50%. Therefore, the idea is upgrade the front area of the car with the aims focus on move forward the centre of pressure and upgrade the overall performance.

1.2 Baseline Analysis

Before starting with any development, it was decided to run some initial simulations to understand the current baseline of the car and search for possible areas of improvement.

On the Figures 1.2 and 1.3, it can be seen the pressure and velocity distribution around the vehicle respectably. From these images it is possible to obtain different conclusions and understandings of the car.

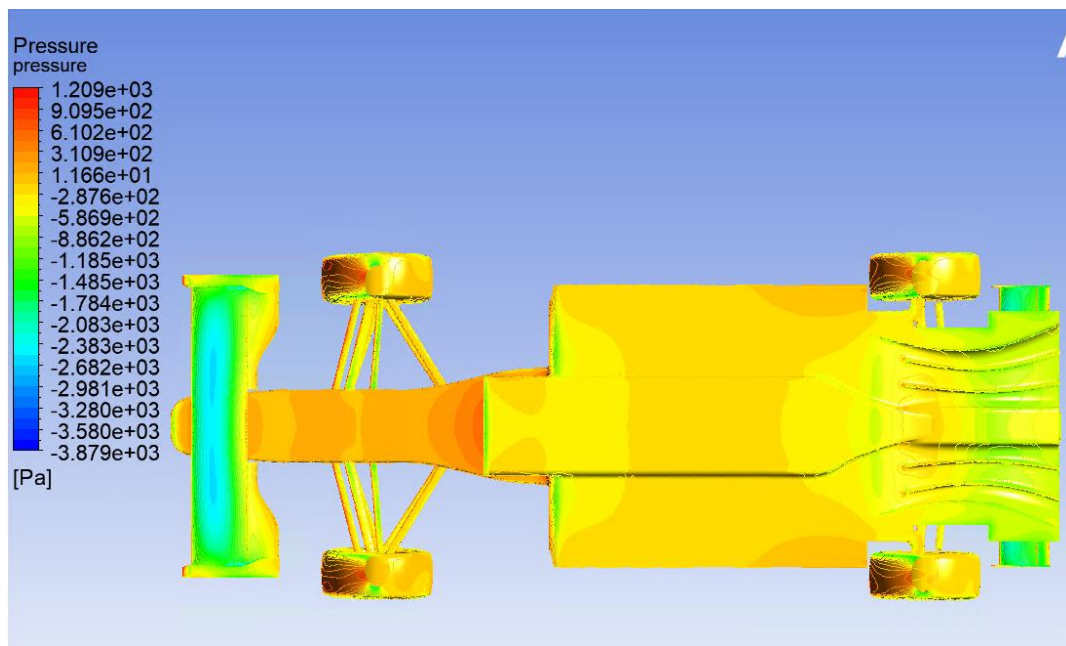


Figure 1.2. Pressure distribution under the vehicle

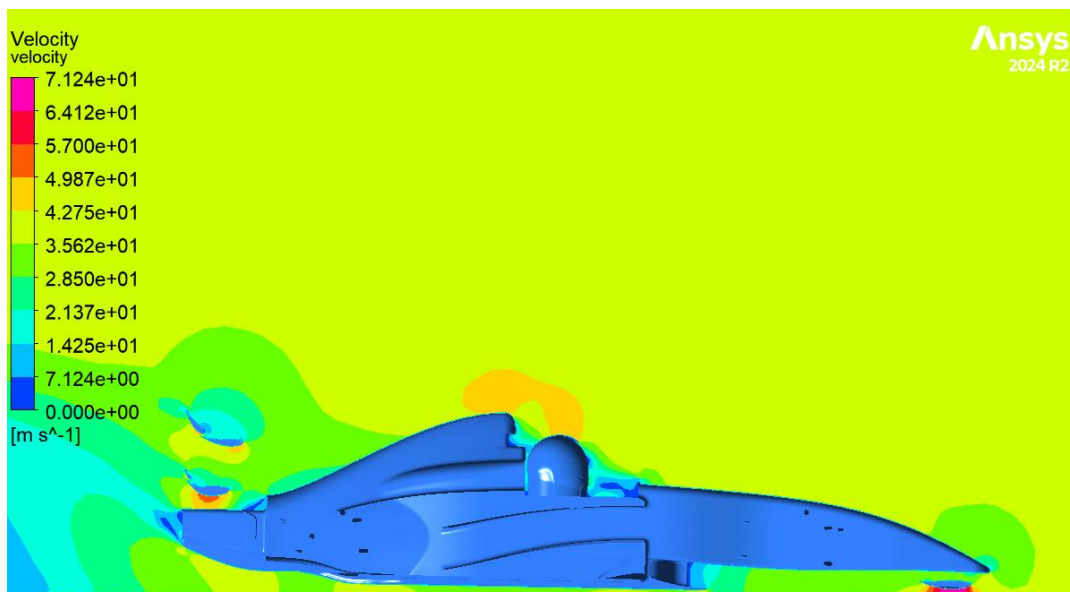


Figure 1.3. Velocity distribution around the vehicle

Regarding the values of pressure around the car, it is possible to see that the data we have of the underbody of the car are quite higher than what could be expected. This behaviour is related with what it can be seen on the velocity diagram as the velocity at the entrance of the floor is slower compare with other areas where it is interesting to have higher values of velocity like the lower surface of the front and rear wings.

This is one of the clearest potential areas of development on the car and would be the focus for this project. Comparing to different research and analysis (Thom et al., 2019; Shaalan et al., 2024), it should be possible to obtain a higher velocity (and lower pressure) at the leading edge of the floor and in the overall surface of the undertray that will lead the airflow in better condition to the diffuser increasing its performance (Nebot et al., 2025).

1.3 Possible Developments

After the initial analysis of the baseline of the car and found the potential areas of improvement, it was possible to came up with ideas of developments to upgrade the underbody of the car.

The first idea, as it was mentioned before, would be focus on a new leading-edge design with the addition of venturi tunnels structures (Hady, 2018) that would accelerate the air creating areas of lower pressure, a greater difference with the upper surface, therefore increasing the downforce generated.

The second idea for the project would be focus on design vortex generator structures. The objective of this aerodynamic design is to seal the underbody of the car; the creation of these vortices will prevent the external airflow to disturb the flow under the car and affect the performance of it (Thom et al., 2019). In addition, these structures could help to reenergize the upper flow to keep it attach to the surface to get in good condition to the rear end (Thom et al., 2019).

It was discussed with the team which idea the project should be focused on or the possibility of combine both in an overall package development.

After taking into account the timetables for this task, the leading-edge design became the main objective of the dissertation. However, if the development goes correctly, could be interesting to implement the vortex generators.

2. Methodology

2.1 Structure

The phases in which the project is divided are presented in the following Figure 2.1.

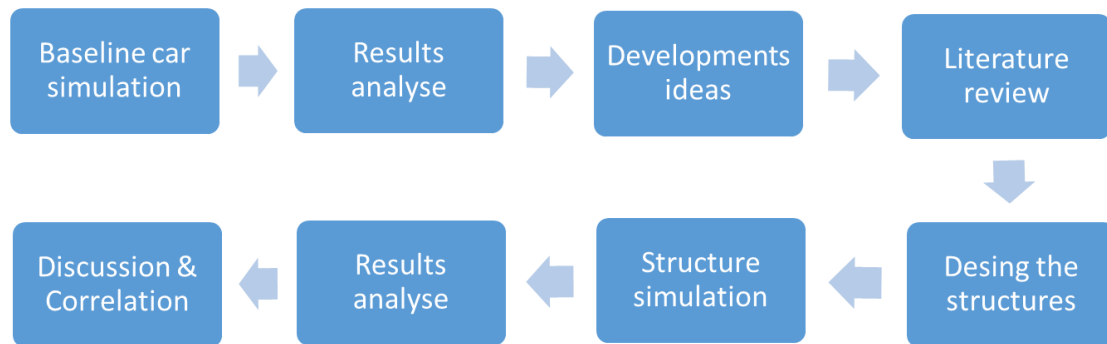


Figure 2.1. Methodology structure

The idea behind this simple, but clear structure, is to develop an efficient and proffesional plan to ahieve the aims of the project. The idea of this structure came from other projects (Lu et al., 2021; Sun, 2026, 160, pp.628-636) and how they work their analysis.

In the following sections, we will go further in details about the simulations set up and data analysis for the desing that will be implement on the car based on the research gap it can be detect in the literature review.

Furthermore, the current state of the project and the timetable of it will be present with a Gantt diagram in the upcoming chapter.

2.2 Data and Simulation

Regarding the simulation set ups and data collections, there are different strategies that will be used. Before talking about them, it is important to make clear that the designs for the leading edge of the undertray will be implement in the overall CAD of the car, as our objective is to obtain an upgrade on the overall performance of the vehicle not only the underbody.

The designs will be created with SolidWorks 2025 software, as it is the file type for the CAD model of the car it will prevent from incompatibilities. In addition, this software tool gives us the ability to convert to STEP files that are easier to read for the CFD software we will use.

In relation with the CFD software that will be used, it is going to be ANSYS Fluent, as it is one of the most powerful and all-around tools for aerodynamic simulation.

The strategy for the simulations that is going to be followed can be split in the next phases:

- **Domain design:** First, the dimension for the computational domain will be defined. In addition, an independency study will be developed with the aim to not have any disturb on the results from this aspect.
- **Mesh design:** Secondly, the grid design with different techniques found in the studies of Lu et al. (2021) and España et al. (2025) to achieve a quality mesh. Same as with the domain, an independency study will be performed to have an efficient use of the computational resources and reduce the time demanding on simulations.
- **Simulation set up:** For this stage, the simulation configuration will be defined based on the same studies as the mesh design (Lu et al., 2021; España et al., 2025) that had combined and tested the better environment for these aerodynamic simulations. Here the boundary conditions and turbulence model will be established.

- **Post-processing:** As the final phase of the simulations, here all the quantitative data obtained will be analysed and compare with the baseline results we had to validate the design and its better performance against the original configuration. Different trends and behaviours of the values of interest will be studied with software tools like Excel or MATLAB. In addition, a correlation exercise will be developed to ensure that the model and results are correct, this exercise could be performed with real data obtain from the team, depending on the availability and access to the racing weekends, or with research methodologies and studies of similar aerodynamic developments.

The values of interest of the project are focus on aerodynamic variables, pressure, velocity, downforce and drag force combining with the aero efficiency. These are the main values, furthermore, there will be other secondary variables of interest like boundary layer and energy of the airflow.

2.3 Gantt Diagram

Whit the objective of present the timetables and structure of the project, a simple Gantt Diagram is present on Figure 2.2.

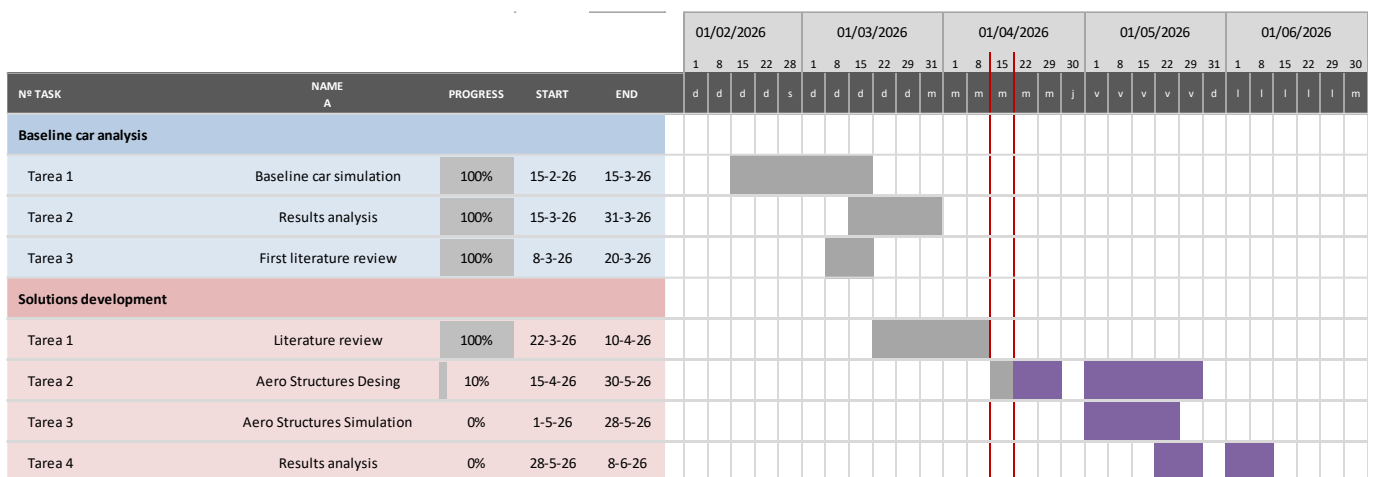


Figure 2.2. Gantt Diagram.

As it can be seen, at the moment of the presentation of the proposal, an important amount of work has been done in advance. Right now, the project has ended the literature review regarding the underbody development, with the objective of finding the gap or a novelty idea on the sector. Right now, the design of the new leading edge is starting, and the plan is to complete it by the end of April. The next step would be the start of the simulations of the design propose for the new undertray, every step perform on the project will be discuss and present it to the team.

3. Literature review

With the idea of searching for an opportunity or a novelty development, a literature review was performed. This research was focus on the latest studies and developments of the underbody of open-wheel racing cars, like Formula Student or Formula 1 vehicles. With this investigation it is planned to understand the current technologies around undertray design and to find an advantage for the team against its competitors, as well as to contribute on new investigation for the field.

The literature review strategy consisted of the three following databases, SAE Mobilus, ProQuest and ResearchGate respectively. The key words for each search are “aerodynamic”, “flow” and “undertray OR floor” and were maintained during the investigation in each database. As one of the objectives is focus on the newest developments in recent years, a filter was applied to each database search, from 1/4/2015 to 1/4/2026 to narrow down the research to the studies on the last decade.

3.1 SAE Mobilus

In SAE Mobilus it was possible to find 18 possible articles, 8 of them were discarded based on title and abstract because there were different approaches on them regarding underbody developments. Most of them were focused on characteristics and variables apart from aerodynamic upgrades.

After reading the 10 remaining articles, only 4 of them are going to take into account as references for the project, as the articles discard were focused on underbody developments in automotive vehicles.

3.2 ProQuest & ResearchGate

For these databases, they are going to be presented together, as the result from their review only shows 2 articles from each resource that were not discarded based on title and abstract. Therefore, the four articles were read to determine if they were useful for the project. One of the articles was discarded after they were read in each database as they were focused on automotive development on the underbody. The other two are going to be used as they were useful and align with the ideas of this project, presenting different aerodynamic developments in the underbody that are usually implemented.

3.3 Conclusions

After the literature review was completed, it was possible to come up with different conclusions for the project. Despite having only 6 articles that work for the development we want to achieve, it does not mean they are going to be the only references for the project. As they are going to be the base to support this initial phase of the project and justify the aerodynamic design we are planning to create and contribute to the field. Moreover, one of the first conclusions to highlight is that most of the studies and developments on the underbodies of vehicles are focused on the diffuser (Hady, 2018; Nebot et al., 2025) and not in the entrance part of the floor. This statement contributes to the value of this project for the underbody development field, as it could give another point of view and more information regarding the importance of the leading-edge of the floor of Formula racing cars. Because, although the diffuser is a critical part of an undertray and the aerodynamic forces generated on a racing vehicle, the entire underbody is the biggest downforce generator on a racing vehicle (Shaaan et al., 2024), therefore the front area plays a critical role too.

Another conclusion obtained from the literature review is the performance from straight strakes versus curved strakes. While the studies on Formula student suggest a better performance from straight design (Hady, 2018), at Formula 1 level the implementation of curved strakes seems to be the preference (Shaaan et al., 2024), although the more complexity in this development.

Taking everything into account from the references, it is possible to come up with different ideas to implement on the leading edge of the Mygale. All these ideas will converge in a redesign of the leading edge of the car.

The first modification will be the implementation of vertical strakes in the entrance of the floor that will create the initial tunnels which are going to conduct the airflow and accelerate. As this is usually the initial development on the floor, for this project the design will be combined with turning vanes to create those curved channels and squish the initial area. This comes up with the objective of provide more information and study around the benefits and use of curve channel and its implementation on the leading edge. In addition, another study will be the number of vertical strakes, therefore the tunnels, and how it affects the performance.

In relation with the turning vanes, the idea is to analyse how its implementation affects the airflow and which angle and direction should be the better option, as in the references there is only one study of it that suggest some beneficial performance (Nebot et al., 2025).

Finally, the last implementation to complete the redesign of the leading-edge will be a deflection structure. The objective of this implementation will prevent the turbulence airflow of the front wheels coming through the entry of the underbody tunnels, as this development is said to have benefits on the performance of the car (Thom et al., 2019).

4. Expected results

The results expected during this project can be summed up in three main points. First, we are looking forward to increasing the downforce generated by the underbody with the implementation of vertical strakes that will accelerate the airflow, creating lower values of pressure in the entrance of the floor. In addition, we have the expectation of a possible reduction in the drag coefficient with the deflection structure to prevent the turbulence from the front wheels affects the airflow on the tunnels. These results should give the opportunity to achieve one of the main objectives that is upgrading the performance of the vehicle.

The second result we should obtain, that is related with the first one, will be moving forward the centre of pressure of the car, as the downforce generated in the front area should increase with the new implementations on the leading edge of the floor. This should let the team have a better balance on the car, which is the other major objective of this project related with the performance of the vehicle.

Finally, the last expectation we have from this project, that is related with the third main objective would be the contribution of new data and research to the aerodynamic developments field. This contribution could be summed up with the results from the performance of curve strakes and the implementation of turning vanes, providing more information on these aero devices; and ending with the possibility of a novel design on the leading edge of the underbody that could give an advantage against competitors and present the importance of this structure.

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