

UWTSD

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Introduction

For our group project, we were tasked with creating a new aerodynamic package and suspension setup for the MCR Sports 2000 race car. This entailed a complete redesign of the current body, starting with a clean slate. This redesign had to not only be an improvement from the current design but also be designed in a way that makes it feasible to make and practical to work on. The current bodywork was designed by previous students in 2020. In the year it was introduced, it won 10/13 races. Since then, it has had modifications added to it; however, these can be unpredictable at times. With this redesign, we aim to reduce unpredictability and improve efficiency. One key parameter with our new design is to increase downforce with little to no drag increase.

Roles and Responsibilities

Looking at the Belbin's model, I can see that for this task, I will need to take on the role of multiple different team roles as my specific zone intertwines with at least 4 of Belbin's roles. A Plant would be the main one due to my responsibility in creating and proving multiple different designs. With my area, I will have to create multiple separate designs for the roll hoop fairing, wing mount, and wing positioning separately. The role of a specialist is also relevant due to my extensive research into aerofoil shapes, as well as into the way the air reacts around an aerofoil in the free flow area for the fairing, as well as in some turbulence for the rear wing. Being an implementer will help me plan a strategy to carry out all my tasks efficiently. Within the team, I would also say that I am a bit of a shaper, helping the team gather and assisting with the coordinator to guide all team members in certain directions (Belbin, 1981).



Figure 1 shows the Belbin's team model (Sabre, 2014)

Group Tasks and Timings

Group Tasks

The main objective of this project is to create an all new cohesive design of the Sports 2000 race car that abides by all rules and regulations whilst still drastically improving the performance of an already dramatically improved design, with the combination of a new suspension upgrade alongside the new bodywork design.

Individual's Tasks

Jason:

Responsible for investigating droop stops and implementing them on the car. His role requires analysis of the car's current performance and position on the track using MoTeC Software. He will investigate how droop stops will affect the car and whether they are plausible with the current aero package through data analysis and testing. He is also responsible for the manufacture and installation of droop stops on the car.

Kiera:

Responsible for all data and simulation analysis tasks within the project. Her role involves the use of VI-Grade to simulate droop stop modifications and CFD developments using a virtual model that will be created using MoTeC software to compare real-world data to a previous baseline model.

Evan:

Responsible for the rear deck and engine cover aerodynamics, ensuring smooth airflow from the cockpit/sidepods to the rear wing region. The design will aim to reduce current drag, manage airflow over the engine cover while maintaining aerodynamic balance across the whole car.

Ethan:

Project Management: Establishing objectives and setting performance targets for each area of the group. Coordinating CFD analysis and design development. Ensuring tasks are delegated evenly, and deadlines are met accordingly. Aerodynamics: In charge of the design and development of the splitter, floors & nosecone for the MCR. Using CAD & CFD analysis to optimize airflow to the rear of the car to activate the deck as well as

reducing the overall pitch sensitivity. Collaborating closely with Noah & Cara to ensure integration and manufacturability.

Cara:

Her role focuses on the design and development of the midriff, sidepods, and cockpit regions of the car. These areas are key to managing airflow from the front to the rear, ensuring efficient aerodynamic performance across the vehicle. She will be responsible for refining these surfaces using CAD and CFD analyses. Her aim is to reduce drag and optimise airflow continuity, ensuring smooth integration with surrounding components while enhancing overall car efficiency and on-track performance.

Louis:

Responsible for designing and analysing the effects of introducing a downforce generating device over the roll hoop and its effects on the aerodynamic efficiency of the rear wing in different locations and mounting styles. This will be proved with the use of a CAD file in CFD. Using CFD, he will assess the different styles to find a model that works best with other members' designs to keep the overall balance and COP within tolerance.

Will:

Responsible for the investigation into front droop stops. Understanding how droop stops work and understanding how car characteristics change with and without droop stops during cornering. Investigating where they'll be mounted and what type of design will be beneficial for performance. There is a link between suspension kinematics and aerodynamic stability, which he will be looking at closely.

Noah:

Noah's role focuses solely on the aerodynamic refinement on the front section of the car, which consists of front pontoons, pushrod covers, and wishbone shrouds. The front of the car are crucial to the aero-mechanical interaction, where suspension and aerodynamic efficiency are directly in contact.

His responsibility is to the airflow around the front of the car using CFD simulations. His aim is to reduce drag and turbulence through improving designs, ensuring that the

sidepods and rear deck receive smoother airflow while enhancing front-end stability and aerodynamic efficiency

Group Timings

It is important to identify the overall group tasks within the project to see which tasks require multiple team members to achieve them. The table below shows a list of the tasks where it is a necessity for multiple team members to work together, and their associated hours required and timings.

Table 0-1 - shows a list of group tasks and associated timing and deadlines.

Tasks	Hours Required	Task Duration
Create aerodynamic maps using S2n bodywork runs	28 hours	2 weeks
Create aerodynamic maps using S2nb bodywork runs	28 hours	2 weeks
S2-UW CFD bodywork runs where sections of the car overlap	30 hours	3 weeks
Initial droop stops investigations	20 hours	3 weeks
Measurements of forces on droop stops	5 hours	1 weeks
Simulate droop stops in VI-Grade	8 hours	2 weeks
Analyse actuations due to droop stops in VI-Grade	8 hours	2 weeks
Simulate CFD alterations in VI-Grade	50 hours	4 weeks
Analyse and evaluate final model simulation	10 hours	2 weeks

Personal Tasks

When analysing the mcr current setup in CFD, it is apparent that there are a few areas that generate a lot of lift at speed. These main areas are the front pontoons and the roll hoop fairing. Thus, I took it upon myself to create a new design that not only generated negative lift but also reduced the coefficient of drag over the roll hoop. Implementing a high-angle-of-attack aerofoil over the roll hoop will cause the air that flows over it to be sent skywards (McBeath, 2015). This will influence how the rear wing acts, and this could have a negative effect on the balance of the car. In this project, I will look at different types of wing mounts as well as try various positionings of the wing to find the space with the best airflow.

Looking at the regulations, the wing can be moved 110cm upwards from the ground with the driver in the vehicle. And 110cm from the centre point of the rear axle. There are no regulations on how low the wing can be mounted, only that it is attached to a metallic support structure.

To do this, I first need to get an idea of how the current car acts. The first thing we did as a team was an attitude study on the original S2N bodywork, as well as the new J1 splitter and floors, as well as deck extensions on s2nb. For this attitude study, we set rear ride heights for individual people. I had 70mm, and then we all did a baseline and front ride heights of 20mm, 30mm, and 40mm. After doing this, we compared the results of the last 100 of the thousand iterations for each run against different front ride heights as well as the further runs done with other rear ride heights. It was 30, 40, 50, 60, 70mm rear heights. Using our baselines, we can determine the accuracy of our runs, as the results for these baselines should all be very similar. We can then compare the 15 runs with different ride heights to get the figures of CL, CD, Cop, and balance across different ride heights and rake. We can also see how the current car has been adapted from the original's new bodywork.

After creating an aero map, a mesh study was done; my task in this was to assess different element sizes in the mesh. The smaller the element, the more data points there were on the car. An increase in data points will increase the accuracy of the results; however, it will get to a point where it will plateau, and it is at this point that we want our runs to be done. This is due to the runs increasing in computational time as the mesh gets finer.

After completing a full validation on our CFD methods, the design process can be started. Initially, the roll hoop fairing was designed; due to there not being many rules restricting this area, the aerodynamic options were varied.

To prove the different designs, runs are made in Ansys with the validated settings determined by the mesh study. These runs consist of a variety of options, including changing individual components as well as combining them together to find a 'happy

median'. These different designs have to be made with the new rear deck in mind; with changes to the rear deck, the wing designs may not be able to be mounted in certain ways or positions. To avoid any issues arriving, communication with Evan, who is designing the rear deck, is a must. We will work closely together to ensure that both areas work simultaneously.

After shortlisting some designs, it is essential that FEA is carried out to ensure that all the different options are plausible to make as well as capable of withstanding the loads under high speed, as well as small collisions. To do this, a variety of different materials will be taken into the tensile testing lab to find a composite compound that is not only light and strong, but easy to work with and manageable to mould into any and all shapes needed for our design.

Personal Tasks and Timings

Table 0-1 shows a list of personal tasks and the timescales around them.

Task	Hours taken	Deadline
CFD Validation, mesh study	30	Week 2
Aero map of S2n Sabe	28	Week 4
Aero map of S2nb	28	Week 6
Mesh study	30	Week 8
Prepare for Viva	30	Week 10
Design roll hoop fairing	50	Week 15
Study wing mounting	50	Week 17
Run CFD with other members upgrades	15	Week 18
FEA analysis of material choices	30	Week 20
Small scale wind tunnel test	15	Week 21
Start production of upgrades	50	Throughout season
Final Viva and report	100	Week 24
Introduce on track	N/A	

Specialist Equipment Needed

Ansys and SolidWorks licence- this is used to do all the designing, CFD and FEA runs, looking at different models, wind tunnels, velocities, as well as all the post processing of the data.

High Computational power computer- essential to run Ansys and SolidWorks to design and test.

Composite lab- to produce the finalised product as well as test pieces, to test for the strength and cohesiveness of the design in a full or smaller scale model.

3d Printer- to create small scaled down components to test in the wind tunnel

Wind Tunnel- to validate CFD runs with smaller components.

Flow-Vis- to test real world conditions to analyse the flow over the car on track.

3d scanner- to get a full scale model of the current car to use as a base to build off.

Tensile strength tester- to aid with the choice of material for the final production copy.

Bill Of Materials

Table 0-2 - shows a list of essential items and their costs.

Equipment	Quantity	Cost	Lead Times	Source
Ansys Licence Fee	N/A	£17,000-£243,000	Instant	UWTSD
High Power Computer	1	£1,500 +	1-2 weeks	UWTSD
3d Printer	1	£250	1-2 weeks	CBM
SolidWorks licence	N/A	£2,500	Instant	UWTSD
Carbon Fiber	10m ²	£1250	1 week	Easy Composites
Epoxy and hardener	5kg	£80	1 week	Easy Composites
Composite equipment	N/A	£150	1 week	Easy Composites
Small scale wind tunnel	1		N/A	UWTSD

Milestones

The first real world test of our designs will be the November Pembrey test on Friday 14th, on this date the first initial design of the droop stops will be used, this is a perfect real world test to take a multitude of data points off to help adapt and improve the droop stop designs as well as creating a few baseline droop settings to use in the coming season.

The next milestone that takes place is the December Viva, which takes place week commencing the 8th of December. For this, we must have a presentation made as well as have completed our list of tasks, including creating a full aero map of S2n and S2nb, finalising a full mesh study, an aero study of our personal areas, relevant research into our areas, as well as a full understanding of the rules and regulations.

In the new year, there will also be another test day at Pembrey circuit this however has not been booked in yet. For this test day, we aim to have some prototype designs for different sections to test alongside each other as well as individually to validate the data taken from CFD. Tests will also be run to gather a deeper understanding of the current car to help find areas that need improvement.

Another key milestone will be the initial race of the 2026 season. Our aim is to have some aero upgrades available for this event. Although it's not feasible to have an all new body ready for then, it is possible to have some individual components ready to go, namely new splitter and floors or a new roll hoop fairing. On this race weekend, we will undergo testing using a baseline in the first test session and then add on our upgrades as the test day goes on.

As the season goes on we will slowly implement our designs until the whole aero package is put into production, and it all ties together as it is unveiled.

The final key milestone is our report and final Viva in March. By this point, we will have finalised our design as a group and have completed our full 20,000 word report, backing up our designs proving that it has met all targets made at the start of the project. We will all have an exceptional understanding of our relevant areas and be prepared to answer any questions given in the Viva.

Gateway Objective

The key gateway objective in this project will be to create a complete and validated aerodynamic map of the current vehicle. This aerodynamic map can be compared to data taken from external sources such as the wind tunnel and Sabe and be validated with a large scale mesh study. This provides a complete in depth understanding of the current car to understand what areas need to be developed more. It also allows measurable improvement and defines the starting point.

Areas of Concern

One main area of concern is a fault in the CFD study, which could be due to using the incorrect settings for any area in Ansys, from Geometry up to Fluent. To help reduce the risks of this happening, a mesh study was completed. In this mesh study, every setting that is altered from the norm has been altered and run a multitude of times to gain a range of answers. This info is then compared to existing data from prior students, as well as from Sabe when they tested the car, as well as from when the car was taken into the wind tunnel and tested physically. Once everyone completed their designated area, it was confirmed that the settings that we were using were the ideal balance between accuracy as well as reducing computational time. A fault in the CFD settings could mean misleading results, causing designs to be chosen based on false results or inconsistencies between team members.

The second area of concern, in particular with the roll hoop fairing and the wing, would be that the wing cannot work efficiently with the roll hoop fairing generating negative lift. To help mitigate this risk, multiple different designs will be made for the fairing to compare with the location and mounting of the wing. It may be the case that the rear wing simply does not work being mounted lower due to the interference with the driver's helmet. If this is the case and it has to be in the turbulent air from the fairing, then a low downforce design might be needed for the fairing, one that prioritises keeping the air flow laminar over the rear wing. This can only be determined after running designs in CFD. Thus, creating a multitude of different designs to cover all bases will be the best way to minimise the need to go back to the design stage.

Gantt Chart

Group Gantt Chart

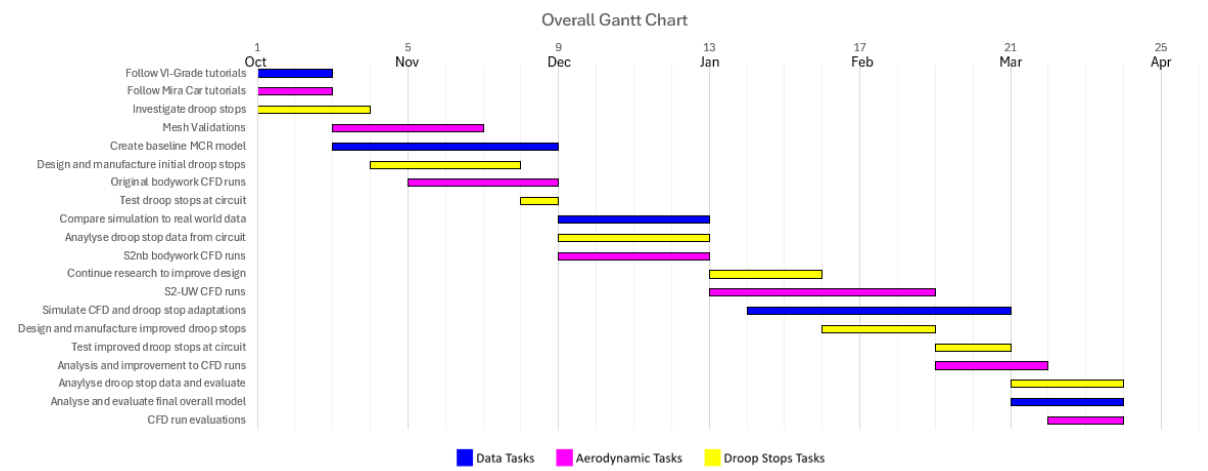


Figure 2- shows a communal Gantt Chart shared across the whole group.

Personal Gantt Chart

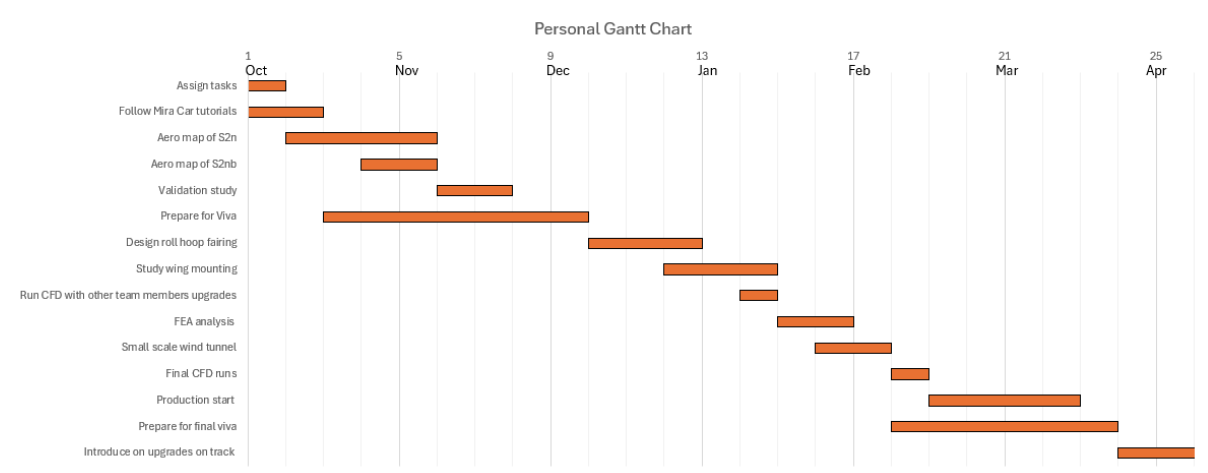


Figure 3- Shows a Gantt chart that is personalised with own tasks and targets.

Conclusion

The development of the MCR Aerodynamic package required a full team approach, combining CFD, physical testing, Structural analysis and collaborative design. By gaining a complete understanding of the current setup we could determine what areas needed the most work on, as well as improving our own knowledge.

References

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