

A CFD-Based Aerodynamic Development of The Morgan Plus 4 Car

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(Image from Official Morgan Website, 2026)

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1.0 Introduction (2400990 – Ryan)

This final written report presents the development, analysis, and implementation of an engineering project focused on aerodynamic enhancements to the Morgan Plus 4 platform. The project centres on investigating the vehicle's current aerodynamic performance and redeveloping the bodywork to improve aerodynamic efficiency, reduce drag, and enhance overall performance. Alongside the Morgan Plus 4 redevelopment team, a Concept Team was established to operate under a more open design framework. This team was given greater geometric freedom when creating revised bodywork solutions, with the primary constraint being the retention of the original Morgan Plus 4 chassis architecture.

An initial computational fluid dynamics (CFD) analysis was conducted to provide a baseline understanding of aerodynamic characteristics, including velocity contours, pressure distributions, and, more importantly, airflow patterns. Early simulations suggested substantial frontal pressure accumulation and major rearward flow separation, leading to a large turbulent wake region. These findings have grounded the team's decision-making in the design of aerodynamic devices and the overall bodywork.

This report will document the final progress of the project, from the initial baseline to the design and development of new aerodynamic devices, simulation analysis, and the critical evaluation of the outcomes. Each team member has made a technical contribution and is clearly identified throughout the report, which will be compiled at the end into a collective review of the overall performance and limitations of the aerodynamic refinement.

1.1 Project expectations

The two avenues explored in this report are to develop the existing Morgan Plus 4 bodywork improving its drag and lift coefficient to be more appropriate for a racing scenario. Preliminary numbers discussed in December 2025 where that the target reduction in drag would be 10% of the initial coefficient of drag which after initial runs was found to be 0.406 therefore targeting a full package coefficient of drag of 0.365. Preliminary reduction of coefficient of lift target was to reduce by 15% with a larger target of being in a state of negative lift when travelling at 20 metres per second, with an

initial value of 0.066 therefore targeting a coefficient of lift of 0.056 however success would be to have the full package to have a negative coefficient of lift. These targets intended to be met with a design that is not only cost effective but also realistic in terms of practical applications and all components to conform to the Welsh Sports & Saloon Car Championship (Welsh Racing Drivers Association Ltd, 2025).

The Conceptual Design team have a lot less restrictions and are allowed to fully redesign the entire bodywork including any additional aerodynamic devices to target improvements far beyond the scope of the Morgan Plus 4 team. Main targets are to severely increase downforce and develop a body which streamlines airflow which will in turn reduce drag whilst also keeping the bodywork somewhat classical and equivalent to the style of the original Morgan Plus 4. An additional target of the conceptual team is to accomplish the targets stated before whilst also maintaining and/or improving the mechanical efficiency of the existing Morgan Plus 4 Components.

1.2 Project Organisation and Team Structure

This project is sectioned into two teams: the Conceptual Design Team (Concept Team) and the Aerodynamic Package Team (Plus 4 Team). As shown in the table below, three members per team. Ryan Williams oversees the overall group project, ensuring everyone meets and has the opportunity to share findings.

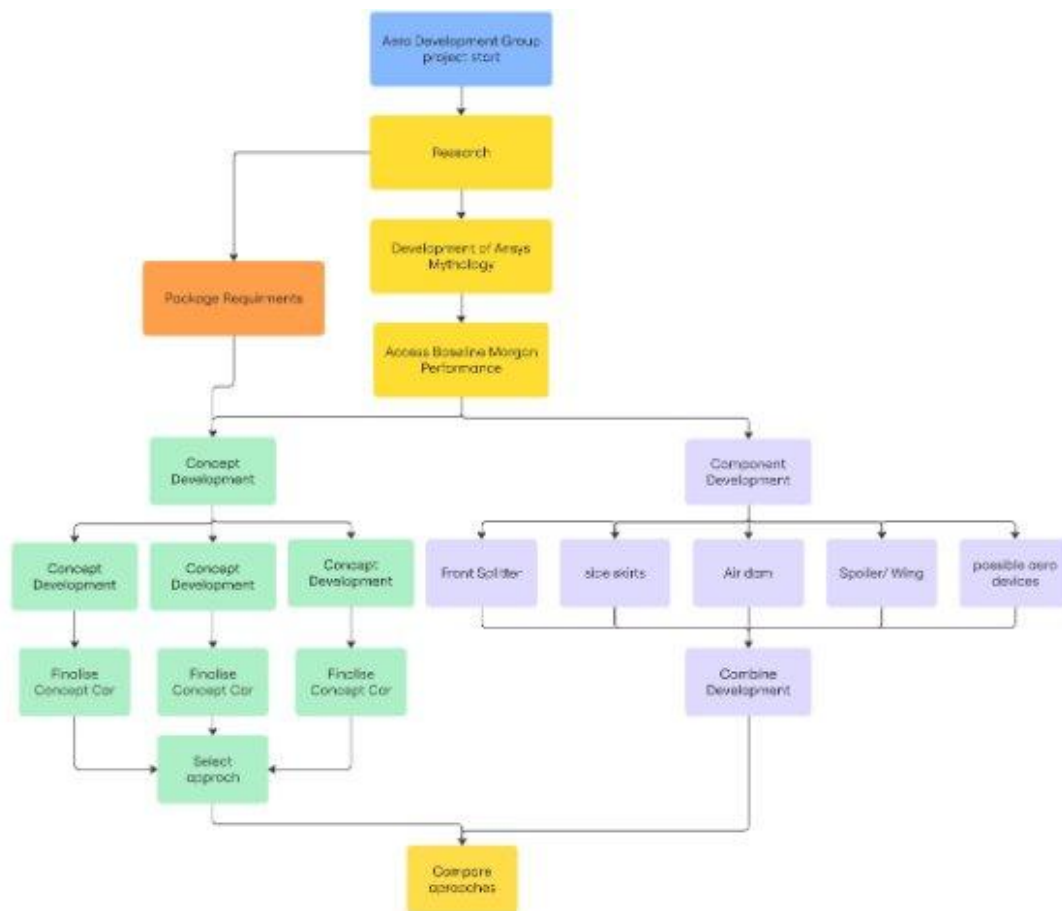
Group Project Leader: Ryan Williams

Name	Role		Name	Role
Concept Team			Plus 4 Team	
Ethan Davies	Team Leader		Thomas Holland	Team Leader
Dominic Walton	Technical Director		Luca Gray	Technical Director
Alexandros Griffiths	CFD Engineer		Ryan Williams	CFD Engineer

Table 1: Team Rolls

The whole group works in tandem at the beginning of the project, where research topics are distributed among the engineers. Furthermore, the development of an Ansys methodology for CFD is started and refined, allowing the engineers to access the baseline Morgan Plus 4’s performance. This leads into each team defining the requirements for their package. At this point the teams are split and each team starts developing Aero packages. At the end of the project each team will have a final design that they will compare to choose the best approach to improve the current Morgan. This can be seen in the flow chart below.

Figure 1: Flow chart Showing Project Organisation



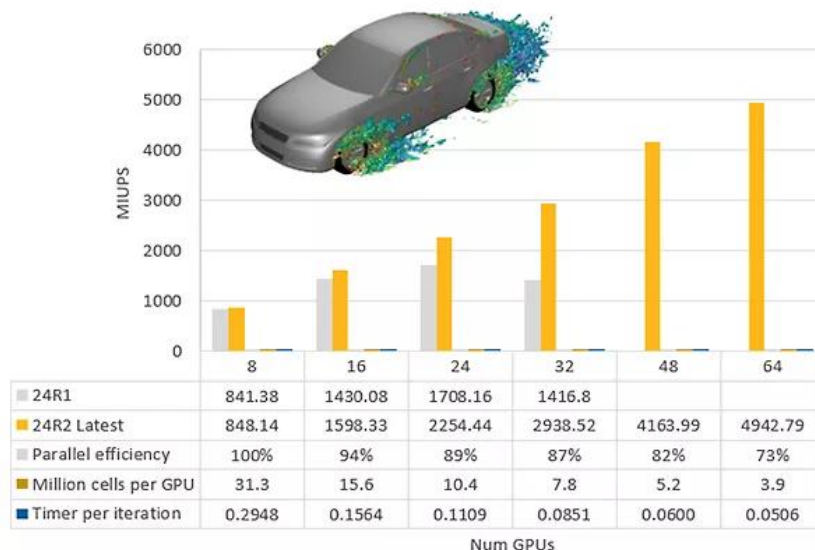
2.0 Ansys Software (2405602 - Ethan)

Ansys 2024 R2 is a consumer-oriented version of industry-leading physics simulations. Ansys R2 specifically focuses on accelerating run times, scaling capacity, and providing flexibility for computational hardware. Furthermore, within this version of Ansys is the Ansys Fluent fluid simulation software that can use a multi-GPU solver as well as enhancements to the previous versions' computational fluid dynamics (CFD) tools. Ansys R2 come equipped with a new pre-processing workflow that is supposed to increase meshing accuracy.

Ansys R2 also supports NVIDIA and AMD GPUs, which is beneficial to the engineers on this project, as hardware differences could have impeded project performance and productivity. Computers used by engineers on this project are provided by the University of Wales Trinity St David (UWTSD); therefore, Ansys R2 can operate on any computer utilised throughout this project.

Additionally, Ansys R2 can run much faster with better performance when compared to its previous version. See Figure 1. This is imperative to this project as the engineers are constrained to a short six-month time span.

Figure 2: Figure that shows Processing time compared with Ansys R1 & R2 (Ansys, 2025)



This project uses Ansys Workbench 2024 R2 for all aerodynamic simulation testing. It is efficient in time and processing power, allowing the project to effectively progress throughout the workflow. Furthermore, as Ansys 2024 R2 is a consumer-friendly version of industry physics simulation software, there are multiple forums and tutorials online

to assist the engineers in learning this software. UWTSD also has Ansys 2024 R2 available on most computers on the campus.

There are three main modules used to complete a CFD run: Geometry, Fluent (with Fluent meshing), and Results. The geometry module uses Space Claim to prepare the model for testing. This links to Fluent (with Fluent Meshing). This is the main body where tests will be conducted, as this structures the mesh of the geometry and the surrounding areas, as well as where the actual iterations of CFD take place. Continually, this then links to results where engineers can visualise and plot data that was collected from the previous module.

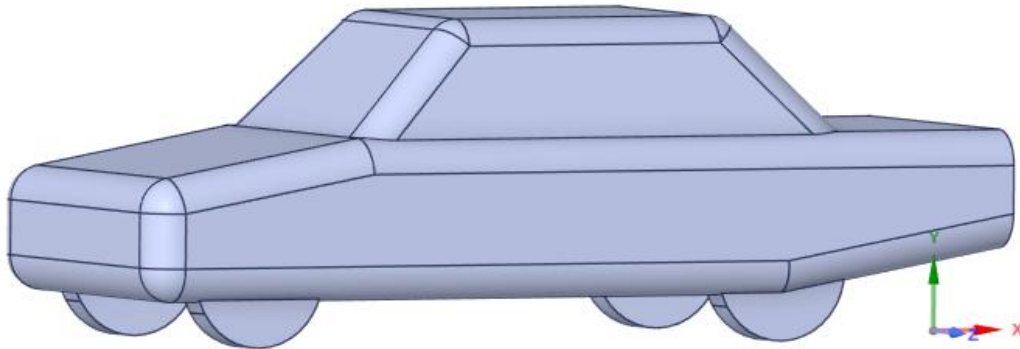
3.0 CFD Methodology (2405602 - Ethan)

3.1 Methodology Process

It is imperative to the success of this project that a methodology is created and easily replicated to ensure that each member is working to the same standard, as results will be compared later in the report. The methodology must be held to a high level of accuracy as it will inform most design choices throughout the project.

To create a methodology, engineers at UWTSD are provided with pressure tap data from the Mira Car. As seen in Figure 2. This real wind tunnel data will be compared to simulated data, and only when these results are within a threshold will the methodology be considered acceptable and accurate. UWTSD engineers will be looking for results that are within the threshold of 5% accuracy, allowing for numerical changes later in the project for different geometries. Ranging from simple to complex geometries.

Figure 3: Geometry of the Mira Car Used in Creating a CFD Methodology



As UWTSD engineers are learning this process for the first time, a lecture has provided experience and knowledge to assist the engineers in completing a CFD methodology. These settings are the foundation for further development of an accurate methodology.

3.1.1 Geometry Preparation

In the geometry module of Ansys, this is where the model is prepared for testing. When starting a CFD test, it is crucial to ensure a repeatable process to ensure accuracy later in testing, as well as ensuring the correct process in the solution stage.

Firstly, the model gets repaired, ensuring there are no split ends, voids, or duplicate faces, as well as removing small features that will complicate the geometry, causing a bad mesh quality that won't take away from the model's accuracy. Ensuring that the model is not oversimplified or loses model quality.

As the Mira car is symmetrical, the enclosure can be downsized, reducing the model to half its size to save computational time. BOIs (body of Influence) are added to control element size when creating the mesh in later stages. There are two BOIs created during this stage, one to control elements near the body of the geometry and the other to control elements further from the geometry. The first BOI is drawn to the size shown in Figure 3. This is then used to create the second BOI, extruding it 600mm larger and extending it to the outlet end of the enclosure as seen in Figure 4. This ensures that small and refined mesh values are strictly around the geometry's body and become larger as it moves further from the geometry. This also simplifies the process, saving computational time and maintaining accuracy.

Lastly, the Enclosure can be split into named selections that will be used to section the enclosure and define values for each selection to create the mesh and plot results.

Figure 4: Show how BOI Near is Drawn in the Geometry Module of Ansys R2

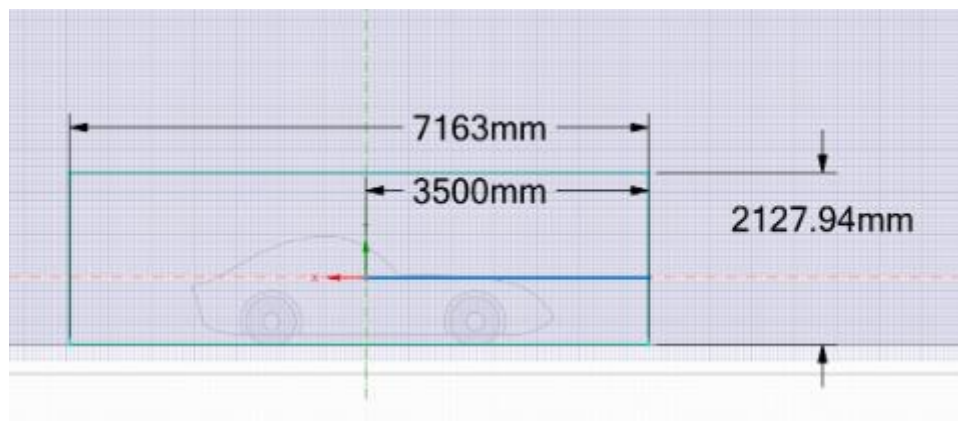
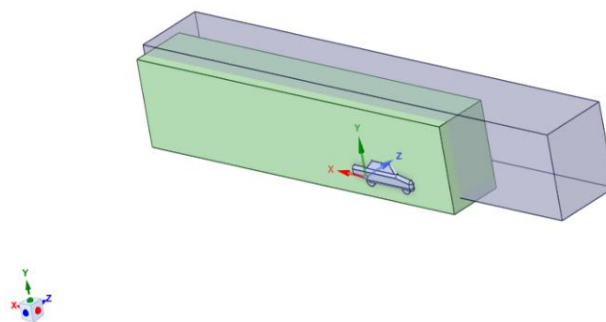


Figure 5: shows the finale stage of the Geometry Module

Click an object. Double-click to select an edge loop. Triple-click to select a solid.

Ansys
2024 R2



3.1.2 Meshing Strategy

During the meshing strategy, the engineers had to conduct research into the defining areas of the mesh section. Selecting a mesh type determines how the mesh fills the volume of the enclosure. This mesh can be structured, unstructured, or generated together to create a hybrid mesh. For this methodology, a hybrid mesh has been chosen as it offers improved mesh quality with fewer cells, leading to less computational time that retains a high accuracy.

Mesh Type	Characteristics	Advantages	Disadvantages	Applications
Structured	Arranges cells in a grid-like way (Show in figure ?)	High computational efficiency and	Has difficulties with complex geometries and is more	Best for simple geometries,

		higher accuracy	time-consuming	prioritising accuracy
Unstructured	Arranges irregularly shaped cells (shown in figure?)	Can adapt to complex geometries and automatically generate meshes for complex spaces	Higher computational costs. Can cause convergence delays	Best for complex geometries, prioritising flexibility
Hybrid	Combines Structured and unstructured meshes (shown in figure?)	Can have the advantages of both structured and unstructured mesh types	Can also cause convergence delays	Best for both simple and complex geometries

Table 2: Showing the Advantages and Disadvantages of Mesh Types

This project uses the Polyhedral mesh type, a hybrid mesh type that is, at its core, a Tetrahedral mesh that can convert its nodes into cells that form a mesh with multiple faces per cell that fills the enclosure. This mesh type is best suited for the project's needs, as the Morgan is a complex geometry with multiple small spaces and faces. A polyhedral mesh type ensures the accuracy of each test while saving computational time that will save the project from stagnation while testing multiple design choices.

Figure 6: An Example of a Polyhedral Mesh Type

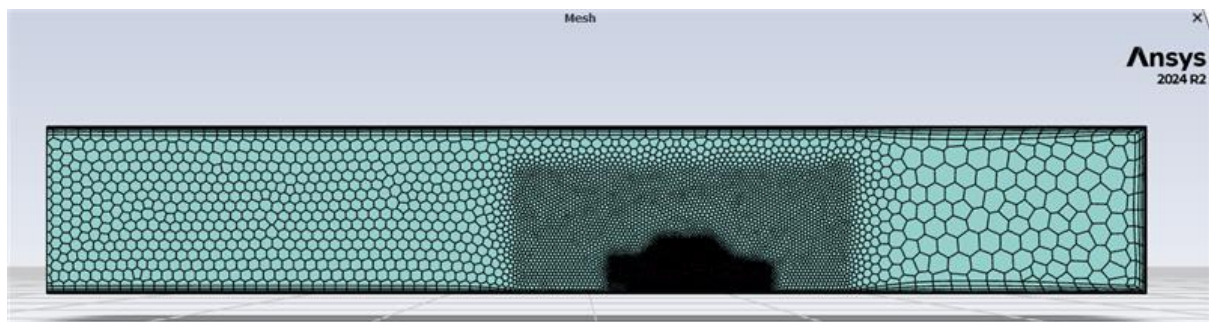


Figure 7: An Example of a Tetrahedral Mesh Type

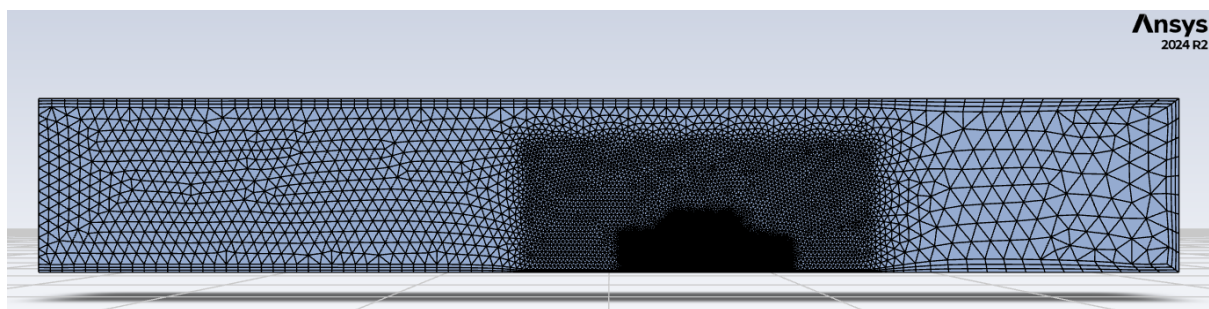
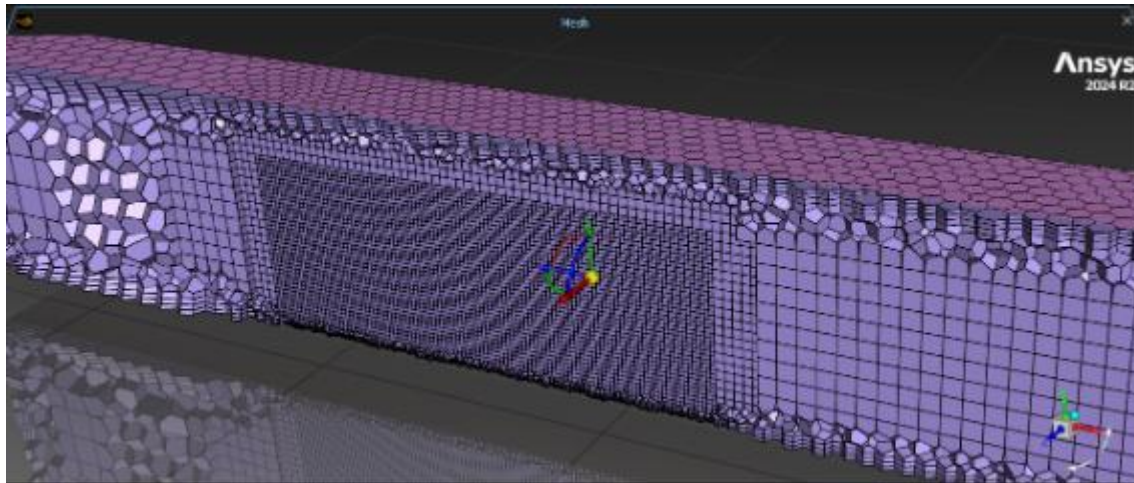


Figure 8: An Example of a Poly Hexcore Mesh Type



Meshing went through extensive testing to find the best values for results that reflected the real-world pressure tap data. These tests changed the number of boundary layers as well as values, creating surface meshes and volume meshes. These tests resulted in the setting listed below as the most accurate for the pressure tap data.

3.1.2.1 Mesh Settings

Settings that are not mentioned are left at their default settings

Section	Name	Setting	Value
Add Local Sizing	Mira Surface	Target mesh size	0.04 m
	BOI near	-	0.1 m
	BOI Far	-	0.3 m
Generate the Surface Mesh	N/A	Minimum Size	0.02 m
		Maximum Size	0.75 m
		Curvature Normal Angle	14 Deg
		Cells Per Gap	8
Describe Geometry	Geometry Type	The Geometry consists of only fluid regions with no voids	N/A
	Change all fluid-Fluid boundary types from 'wall' to 'internal'	No	-
	Do you want to apply share Topology?	No	-
	Enable Multizone Meshing?	no	-

Update Boundaries	Floor	Wall	N/A
	Inlet	Velocity-inlet	-
	Mira-Bottom	Wall	-
	Mira-Side	Wall	-
	Mira-Top	Wall	-
	Mira-Wheels	Wall	-
	Outlet	Velocity-Outlet	-
	Symmetry	Symmetry	-
	Tunnel-Walls	Wall	-
Update Regions	Enclosure-enclosure11	Fluid	-
Add boundary layers	-	Add boundary layers?	yes
	-	Number of Layers	5
	-	Transition Ratio	0.27
	-	Growth Rate	1.4
	-	Grow on	Selected-labels(Mira surfaces, Tunnel walls, and Floor)
Generate the Volume Mesh	-	Fill with	Polyhedra
	-	Max cell length	0.7875395 m

Table 3: Listing settings needed to complete the mesh section of Ansys

3.1.3 Boundary Conditions

Boundary conditions can be added to simulations so that it knows where the flow is coming from and where it's going, as well as what areas to interact with, which will create turbulent air.

Part of these boundary Conditions is the boundary layers. When an object is moving through the air, molecules stick to the surface of the object, creating a thin layer near the surface of the fluid, which reduces the number of molecules that further into the free stream a molecule is. These boundary conditions contribute to aerodynamic development, and factors like skin friction, heat transfer, and wing stall.

3.1.4.1 Turbulence models and methodology (2403677 - Alex)

Making a methodology in fluent was the first step, this outlines what parameters to set in the mesh and setup before running a simulation. This includes Body of Influence sizes, wind tunnel sizes, mesh type, turbulence model, surface mesh, boundary layers. This keeps the results consistent with each test run and keep results consistent between team members where we can collate and compare our results. Another boon in creating a methodology is to test to see if your settings are accurate to real wind

tunnel results, the reason we use simulations is that it is cheaper and faster to test designs but that collapses if our results don't mirror real world behaviours.

3.1.4.2 MIRA Baseline (2403677 - Alex)

Choosing the MIRA baseline car to build the methodology came down to making sure the simulation setup works before the team can trust it on the teams' own designs.

The main reason is validation. The MIRA car has been tested in real wind tunnels many times, so its drag and lift numbers are well known. Running this geometry first gives a target to hit. If the engineers can get our simulation results to match the real-world data, the team knows our mesh settings, turbulence model, and boundary layers are correct. If the team started with one of our own car designs and got strange results, the engineers would have no way of knowing if the issue was the geometry or the simulation setup. Using the MIRA car removes that guesswork.

Another reason is simplicity. The MIRA model is a clean, simple shape without all the complex details like engine bays, cooling paths, or small surface features that you get on a full production model. This is useful when building a methodology because it lets the engineers focus on the core settings things like Body of Influence sizes, wind tunnel dimensions, and mesh refinement without being distracted by geometry issues.

3.1.4.3 Problems With MIRA Baseline (2403677 - Alex)

The issue with relying solely on the MIRA baseline is that its simplified geometry does not reflect the complexity of our actual test articles, and settings like surface mesh and turbulence models are highly dependent on geometric complexity. A setup that converges cleanly and captures accurate flow separation on the MIRA's smooth, bluff body may prove entirely inadequate when applied to a model with detailed underbodies, sharp edges, or intricate cooling paths.

3.1.4.4 Turbulence model (2403677 - Alex)

The team used the drag and lift coefficients as the primary metrics for checking each turbulence model, comparing the simulated results against the established MIRA baseline values. The model that produced the closest correlation across both coefficients was selected as the best for the methodology.

The k-epsilon model was ultimately chosen. For lift, k-epsilon produced a value of -0.1084 compared to the MIRA baseline of -0.0845, giving a difference of -0.0239. This was the smallest deviation of all models tested. For drag, k-epsilon produced 0.3328 against the baseline of 0.2963, a difference of 0.0365. While the Reynolds Stress Model achieved a marginally closer drag result at 0.3327, k-epsilon offered the stronger overall balance across both coefficients and required significantly fewer iterations to converge.

CL		Kepsilon	Komega	Reynolds	Spalart
Base	-0.0845	-0.1084	-0.0408	-0.1574	-0.1151
Difference		0.0239	-0.0437	0.0729	0.0306
Count		239	437	729	306
CD		Kepsilon	Komega	Reynolds	Spalart
Base	0.2963	0.3328	0.3591	0.3327	0.3532
Difference		-0.0365	-0.0628	-0.0364	-0.0569
Count		365	628	364	569

The reasons for each model's performance remain theoretical, as no further testing was conducted to confirm the underlying causes. One possible explanation is that Spalart-Allmaras, being a simpler one-equation model, may have struggled to capture the wake structures behind the vehicle accurately. K-omega, which is designed to handle near-wall flows well, may have proved sensitive to mesh resolution and potentially required finer boundary layers than were applied. The Reynolds Stress Model, despite its detailed treatment of turbulent anisotropy, may have over-predicted lift separation. K-epsilon, with its balance of wall function treatment and robust convergence behaviour, may have produced the most consistent results across both metrics.

3.1.4.5 Boundary Sizes (2403677 - Alex)

The team also tested the effect of wind tunnel size on the simulation results. The size of the computational domain determines how much space surrounds the vehicle, and this directly influences how the airflow develops around the model before reaching the far-field boundaries.

If the wind tunnel is made too small, the walls or boundaries sit too close to the vehicle. This can artificially constrain the flow, causing pressure distributions to build up incorrectly around the body and leading to inaccurate drag and lift readings. The vehicle effectively becomes choked within the domain, and the results no longer represent true freestream conditions.

If the wind tunnel is made very large, the boundaries are pushed far enough away that they no longer interfere with the flow around the vehicle. This improves accuracy and brings the simulation closer to real-world conditions. However, increasing the domain size also increases the total cell count in the mesh, which drives up solve times and computational resources required. There is a point of diminishing returns where further expansion yields negligible gains in accuracy but continues to add runtime.

The team tested several domain sizes and ultimately chose to stay with the default dimensions. This size provided the best compromise between computational efficiency and result accuracy. It was large enough that the boundaries did not meaningfully influence the flow around the vehicle yet compact enough to keep mesh counts manageable and solve times practical for the team's workflow. This decision reflected the same principle applied to the turbulence model selection: balancing theoretical ideal against the practical demands of running multiple simulations consistently across team members.

3.1.5 Solver Setup (2405602 – Ethan)

When solving, CFD Engineers use two Solution Methods, one after another. These first standard pressures with first-order Upwind to initialise the first 100 iterations. Once these have been completed, the second wave of iterations will use second-order pressure and Second order Upwind for the last 500 iterations. This ensures that the Calculation has enough iterations to let the residuals converge.

3.2 Validation (2405602 - Ethan)

Results with this methodology can be seen in Table 3 and in Figures 9,10, and 11.

	Mira Experimental data	Mira Simulation data	Total Difference	Total Difference (%)
Coefficient of Lift (Cl)	-0.0845	-0.085656188	0.085656188	1.368269822
Coefficient of Drag (Cd)	0.2963	0.30547869	0.00917869	3.097769153

Table 4: Results of CFD Methodology Testing

Figure 9: Velocity Contour of the Mira Car

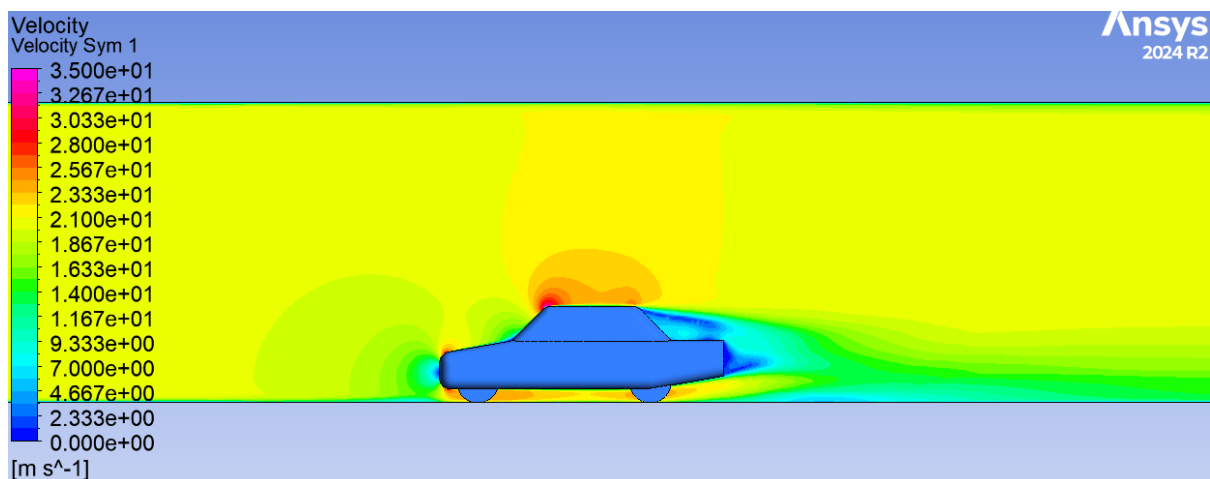


Figure 10: Pressure Contour of the Mira Car

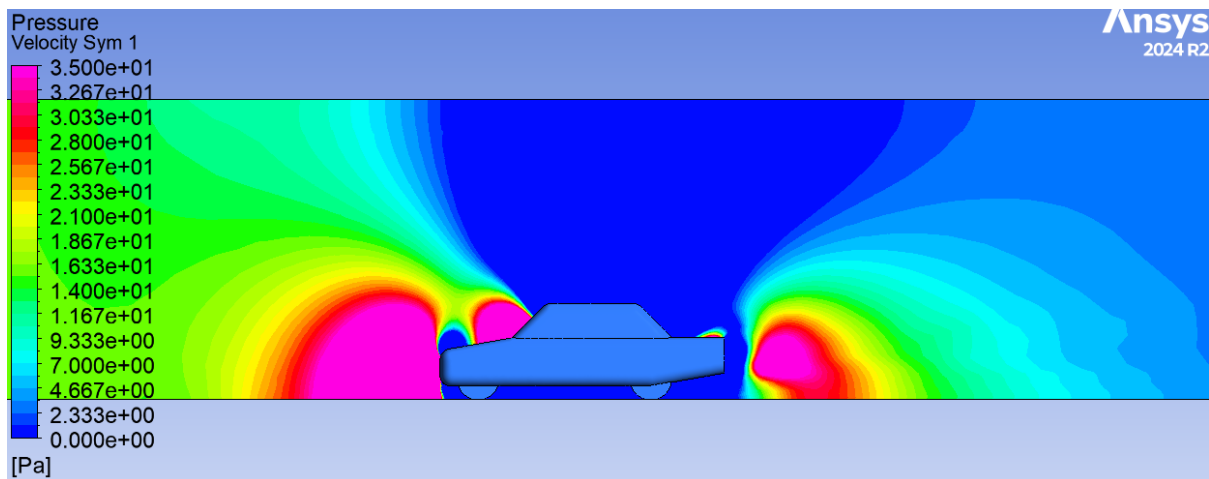
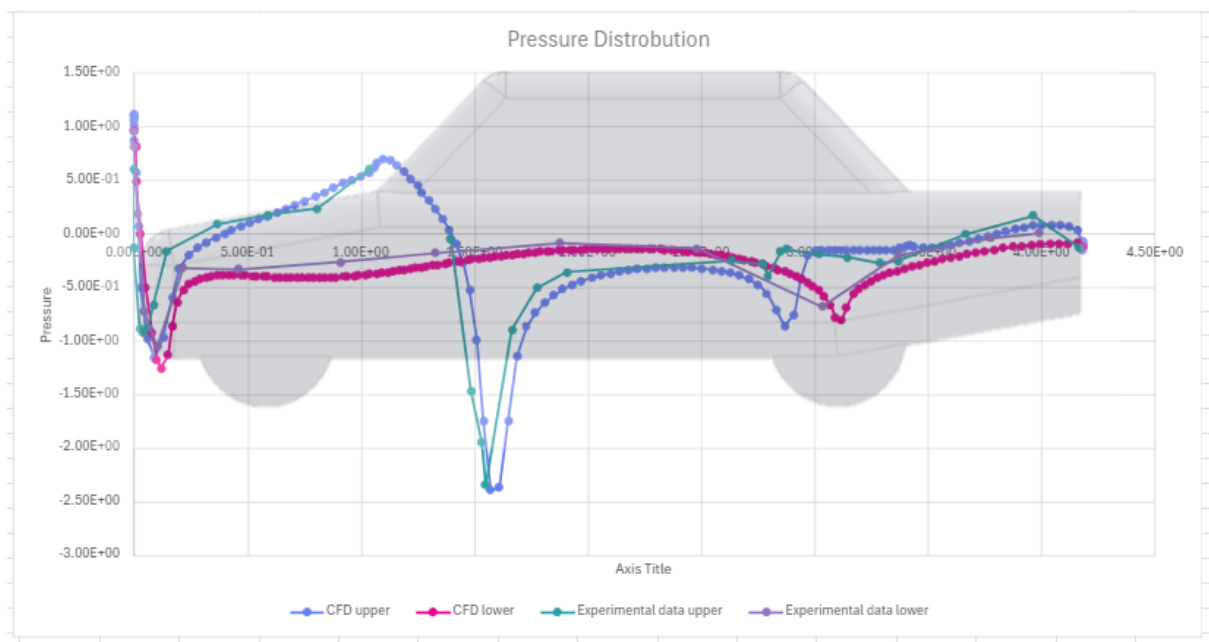


Figure 11: Pressure Distribution Around the Mira Car



3.3 Problems with Methodology

Problems that can occur with this methodology are that it is suited to simple geometries and may struggle with complex geometries. This methodology will require very minimal additions when used for the Concept design side of the project. However, the Aerodynamic design package side of the project may struggle with refined geometries and may require modifications to suit the needs of the Plus 4 Team.

Furthermore, this methodology is not as detailed as it could be, as the methodology does not consider exposed mechanical components or internal air flow. This would limit the use of this methodology to purely outer bodywork of vehicle models; there are no concessions for internal aerodynamics use in engine and system cooling. Engineers

can still use this methodology to plan where to locate cooling and intake systems, but it will not show them how those systems will interact with the airflow.

3.4 Recommended Additions

Applying realistic conditions, such as a moving ground plane and spinning wheels, can yield more realistic results, as it better simulates driving than a stationary vehicle with air moving around the geometry. Furthermore, research can be conducted into higher-fidelity turbulence models that suit the project's needs. Most turbulence models are made with a specific utilisation in mind. Engineers at UWTSO could design a custom turbulence model for the project, but this is not necessary, as the results are promising and would complicate the project.

Additionally, the use of multiple meshing strategies could benefit a more complex geometry, as the current setting may result in poor surface and volume meshes, as small areas on the geometry will have trouble generating to the current numerical specifications. Combining mesh types could solve these problems.

3.5 Further Work

Further Work would surround a thermal study to gather how much heat the friction of the air is generating, as well as an attitude study that changes the model's pitch, yaw, and roll angles to see how the geometry of the models affects the air from different angles. Additionally, simulating weather effects would be useful. Weather such as fog would create a thicker fluid for the model to travel through, showing different viscosities of fluids.

Moreover, a stress analysis study could be conducted to observe the stress and strain acting on the model because of the aerodynamic qualities.

4.0 Compiling Data (2405602 - Ethan)

During this project, multiple engineers are conducting simulations; therefore, compiling all data together is imperative as it ensures consistency, traceability and reliability throughout each study. This section outlines how simulation outcomes are stored, processes and visualised.

For each test conducted, there are four main areas the engineers are looking at, which are the Coefficients of Drag and Lift, the Centre of Pressure (COP), and lastly, efficiency. These values are plotted within Ansys R2 for each iteration as seen in Figures 12, 13, and 14.

Figure 12: Plotted Residuals of the Mira Car

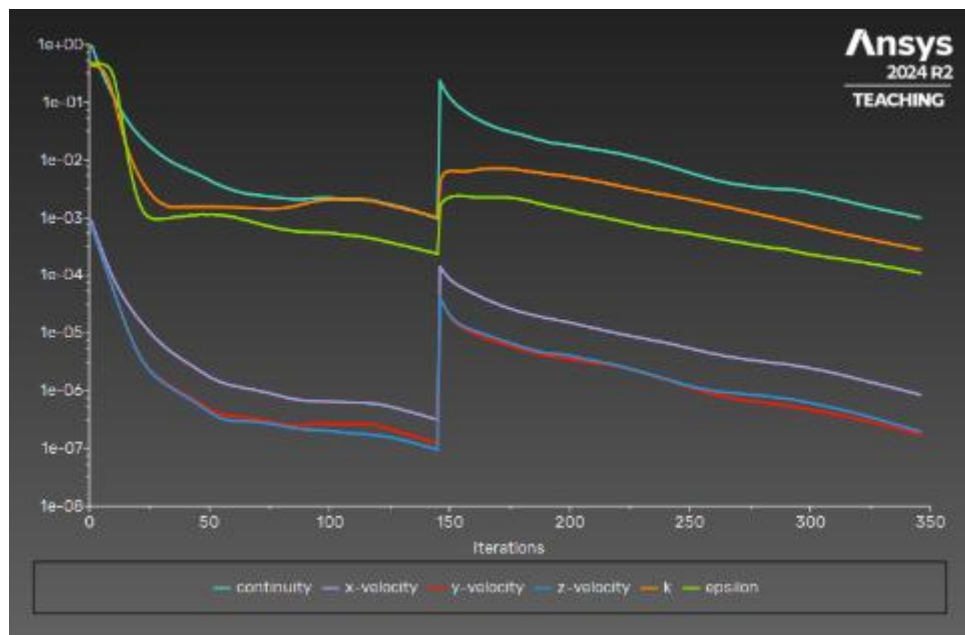


Figure 13: Plotted Drag Residuals of the Mira Car

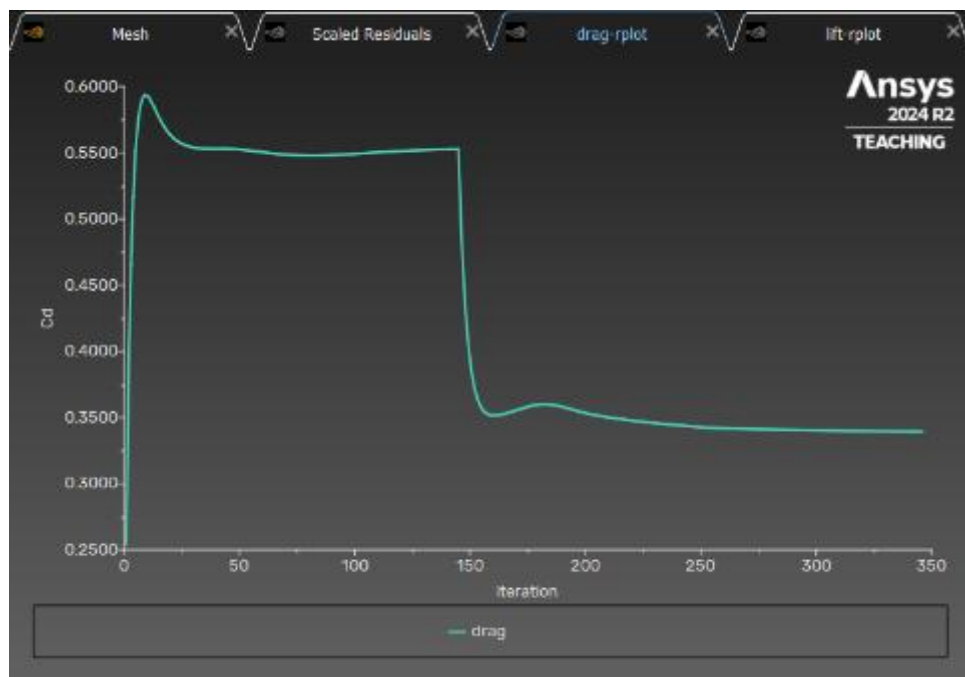
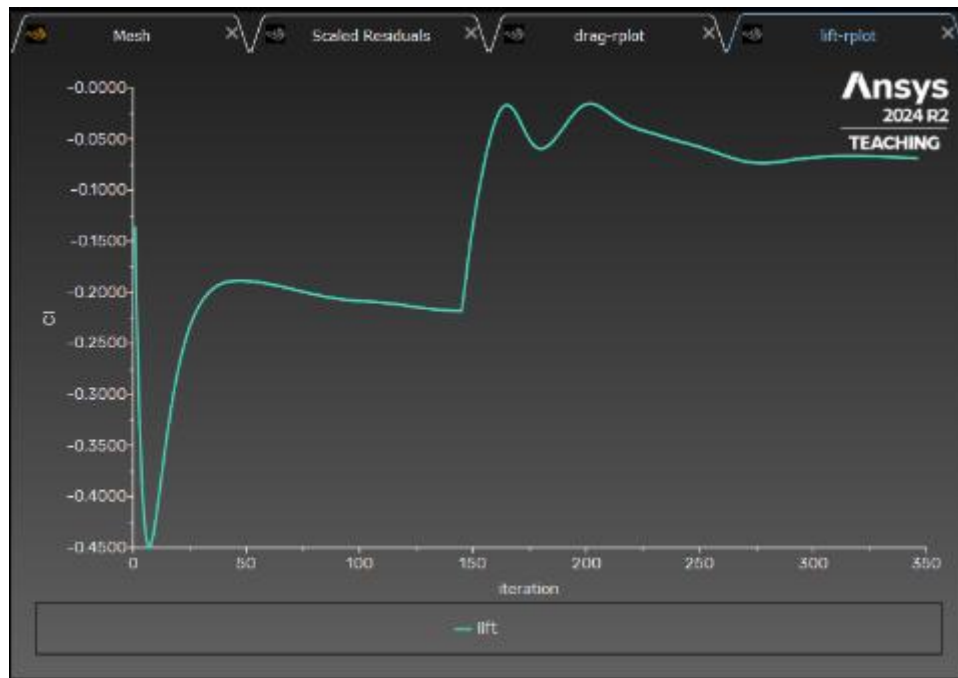


Figure 14: Plotted Lift Residuals of the Mira Car



This data is exported to data processing software like MATLAB and Microsoft Excel to ease of comparison and data management. Furthermore, Cl, Cd, centre of pressure (COP) and aerodynamic efficiency are also taken from Ansys and noted in Microsoft Excel in tables like Table 4 seen below.

Comparison									Difference			
Test	Test Data				Original Data							
	Drag	Lift	COP	Efficiency	Drag	Lift	COP	Efficiency	Drag	Lift	COP	Efficiency
1												
2												
3												
4												
5												

Table 5: Example of How to Set Out Test Results

Furthermore, the results of the data can be displayed with multiple different types of Contours, vectors, and streamlines that assist in the understanding and conveying of the results. See figures 14, 15, 16 and 17 below.

Figure 15: Example of a Plotted Contour of the Mira Car

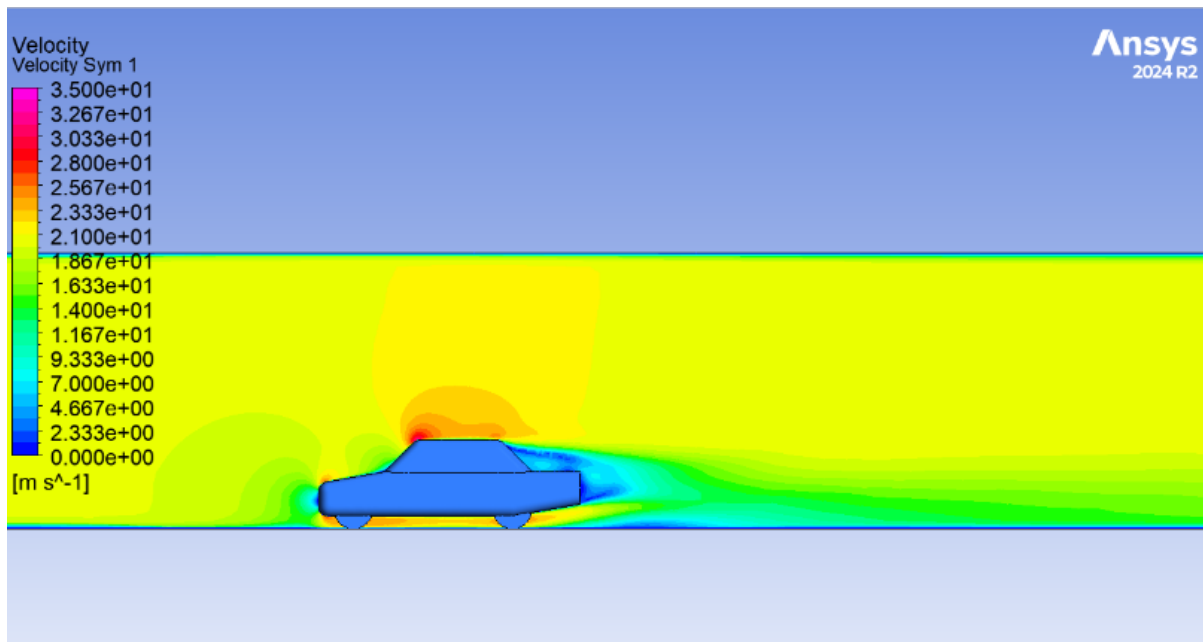


Figure 16: Example of Plotted Vectors of the Mira Car

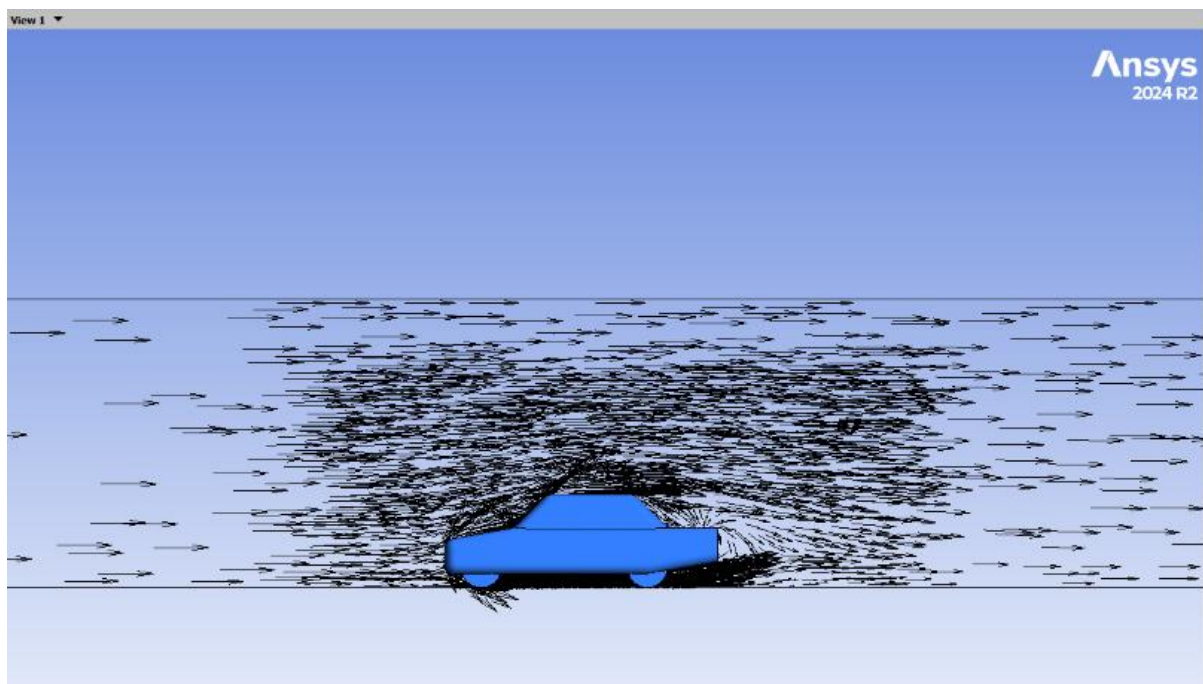


Figure 17: Example of Streamlines Plotted of the Mira Car

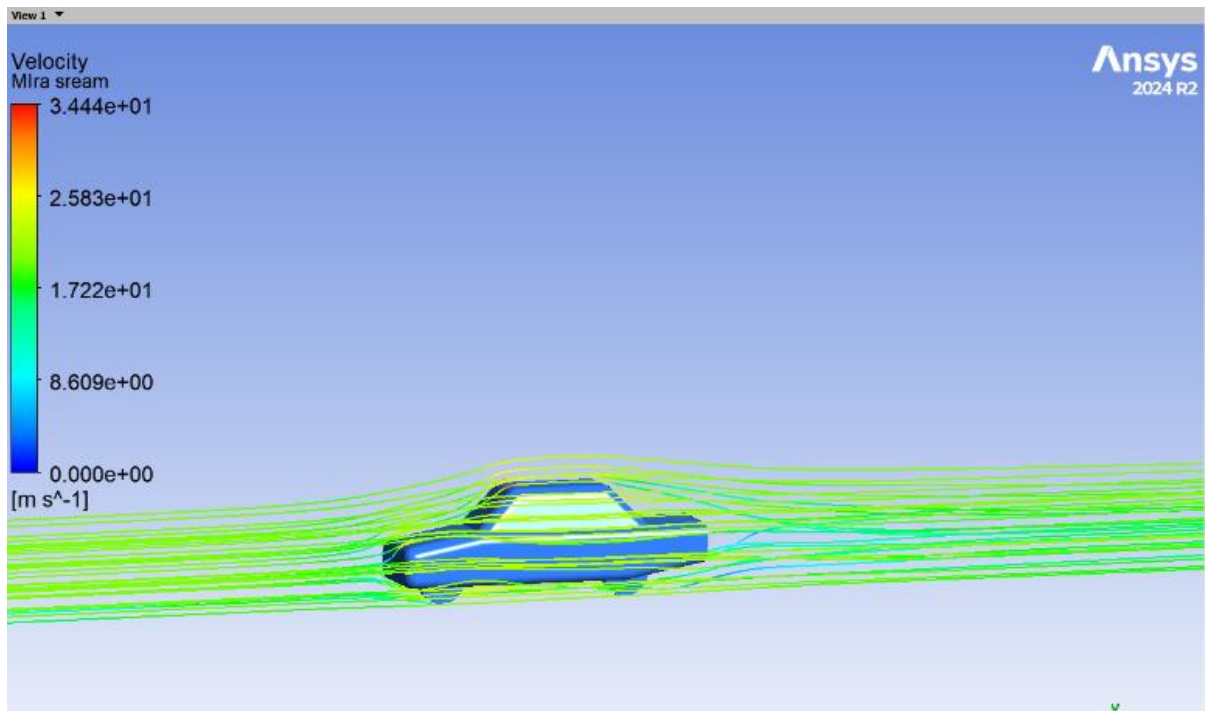
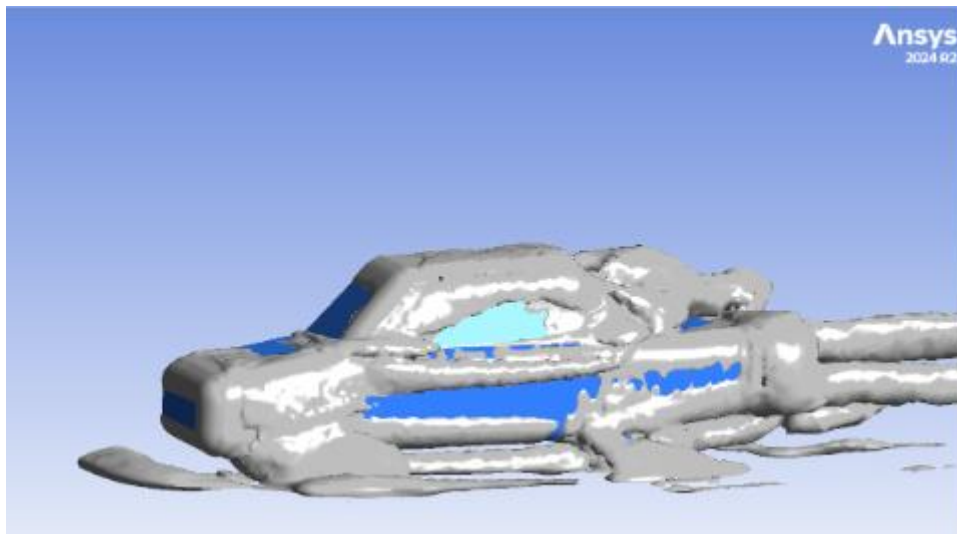
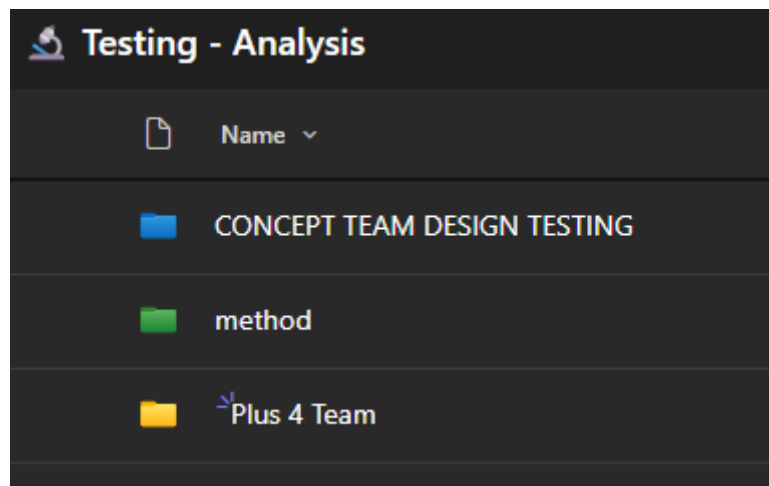


Figure 18: Example of Turbulence Plotted of the Mira Car



Given that the Project has two teams working in the same storage space, it is important to make sure that each team's files are organised and labelled accordingly, the Plus 4 Team and the Concept Team. Each team must adhere to this structure so that files and designs are not lost between the two teams. Examples of this can be seen below in Figure 19.

Figure 19: Example of Filing method



5.0 Plus 4 Aero Package Design

5.1 CFD Method (2400990 – Ryan):

During the initial CFD runs of the Morgan baseline configuration, the team's method was only suitable for simple geometries. This includes the MIRA baseline and the Morgan without any aerodynamic devices.

5.1.2 Why the Change in CFD Method (2400990 – Ryan):

As the engineering team starts introducing additional devices to improve the overall handling characteristics of the vehicle, the original method became unsuitable for more complex geometries, such as the Morgan with an airdam and rear wing. Therefore, a new

CFD method was developed to better handle more complex geometries while ensuring accuracy.

5.1.3 CFD issues & Resolutions(2400990 – Ryan):

During development of the new CFD method, several issues were encountered transitioning from simple to more complex geometries. The addition of aerodynamic devices, such as an air dam and a rear wing, resulted in poor mesh quality and instability during mesh generation. As shown in Figure 20, on the left-hand side is the original method showing how it doesn't mesh suitably with the rear wing, while the necessary adjustments were made to allow more suitable meshing as seen on the right.

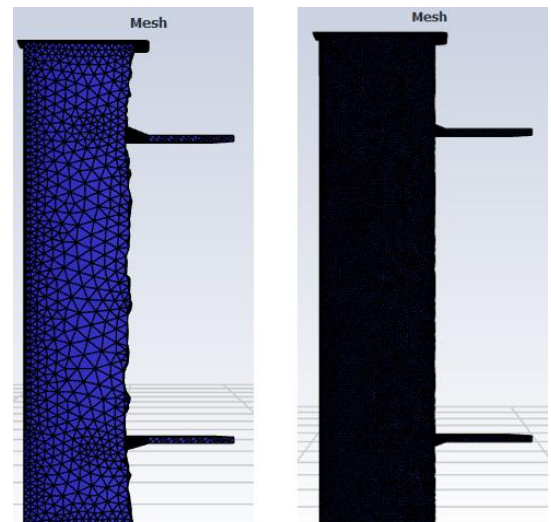


Figure 20 Comparison of mesh quality, Poor mesh (left) and improved mesh refinement (right)

Additional refinements were conducted to ensure that meshing was to a suitable standard, local sizing were changed for different devices to ensure that no detail was lost during CFD runs.

5.1.4 Morgan Roof Down & Roof Up(2400990 – Ryan):

5.1.5 Morgan Roof Up(2400990 – Ryan):

During the initial CFD runs of the Morgan 'Roof up', it was discovered that running with the roof up caused significant rear flow separation as seen in Figure 21.

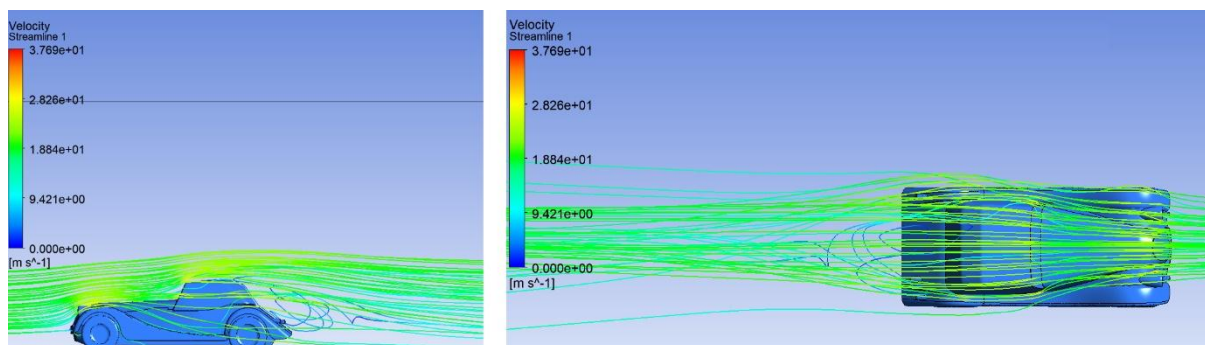


Figure 21 Morgan Roof Up - Airflow

The presence of both the windshield and roof increased the frontal area of the vehicle. Creating a greater stagnation region at the front and mid-point of the vehicle. Therefore, increasing aerodynamic drag as can be seen in Figure 22.

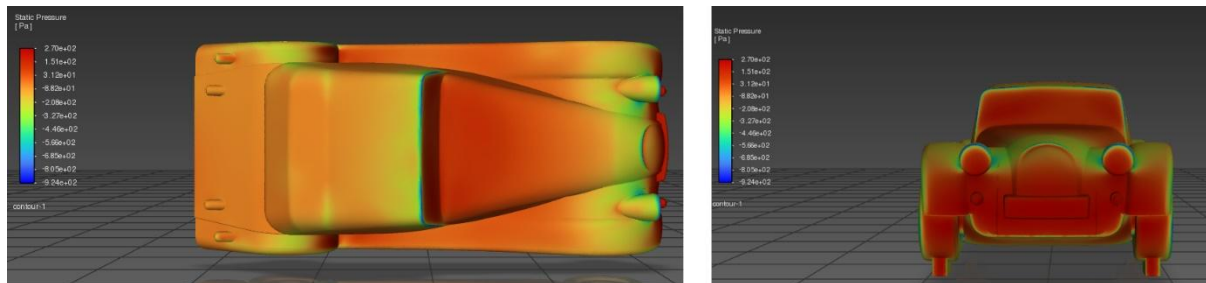


Figure 22 Morgan Roof Up - Static Pressure

In respect of the baseline performance numbers, the roof-up configuration produced a total of (0.406 **Cd**) drag and a total of (0.066 **Cl**) lift. Now that the baseline had been established, the Morgan Plus 4 team could begin work to improve the vehicle's overall performance, particularly downforce generation and drag reduction.

5.1.6 Morgan Roof Down(2400990 – Ryan):

During the initial CFD runs of the Morgan 'Roof down', it was discovered that running the roof down reduced some of the rear separation and allowed improved airflow towards the rear, which made use of a rear wing more practical (Bayındırlı and Çelik, 2020). Moreover, a decision was made to remove the windshield and windows, as the windshield angle can directly affect a vehicle's drag. Due to chassis restraints, the angle could not be changed; therefore, removal was the most viable solution (Cakir, 2012).

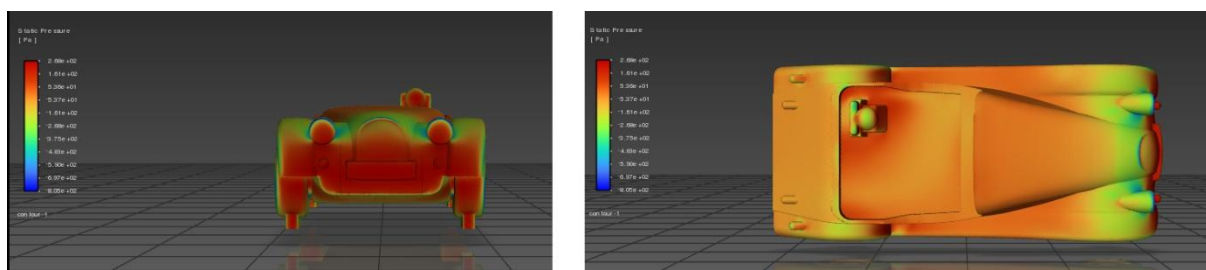


Figure 23 Morgan Roof Down - Static Pressure

In respect of the baseline performance numbers, the roof down was producing a total of (0.454 **Cd**) drag and a total of (-0.020 **Cl**) lift. Airflow was improved immediately, therefore a rear wing is now more practical as well as other aerodynamic devices such as an air deflector, an airdam and a splitter.

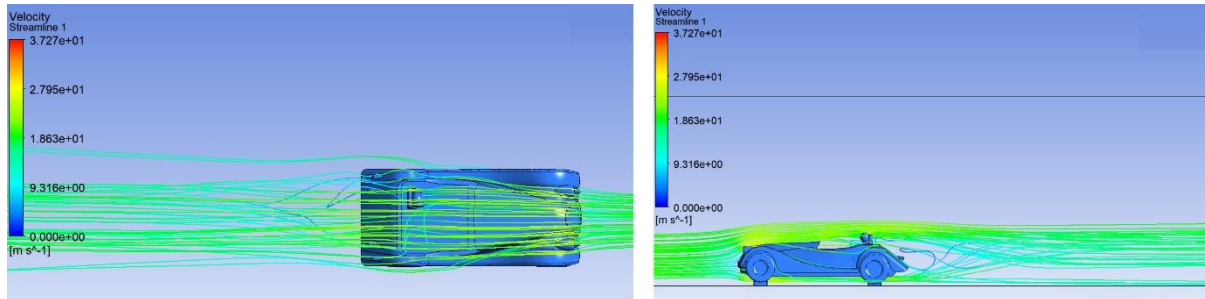


Figure 24 Morgan Roof Down – Airflow

5.1.6 Morgan Configuration Justification(2400990 – Ryan):

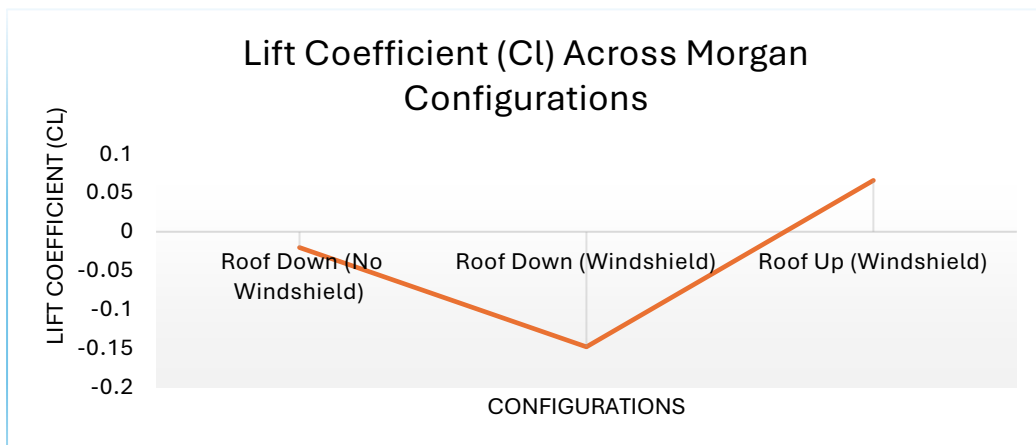


Figure 25 Lift Coefficient (Cl) Across Morgan Configurations

When reviewing the data in Figure 25, the Roof Down (Windshield) configuration produces the greatest downforce, indicating better aerodynamic loading than the configuration without the windshield. However, the presence of the windshield will introduce negative effects, such as flow separation at the rear of the vehicle. The team plans to implement a rear wing and maintain clean airflow to the rear of the vehicle; the trade-off is between maximising downforce or ensuring an effective rear wing.

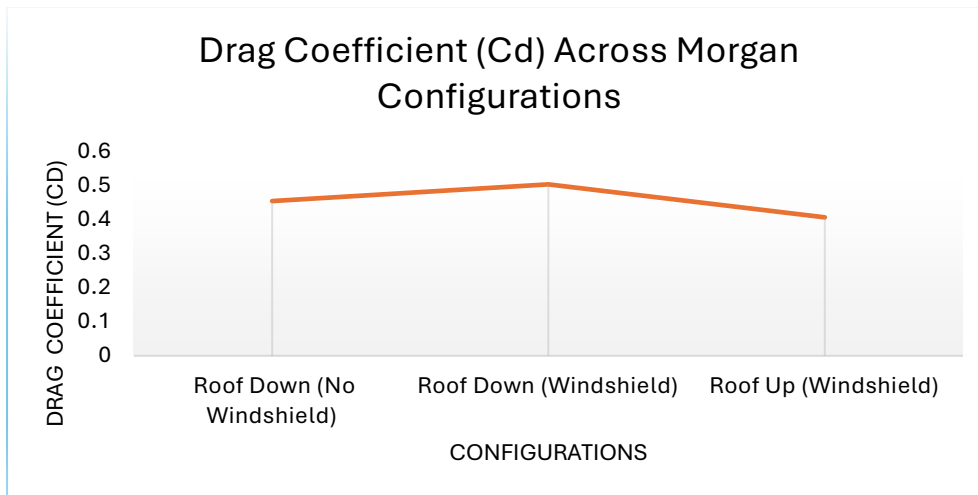


Figure 26 Drag Coefficient (Cd) Across Morgan Configurations

In Figure 26, the roof-down configuration with no windshield produces the second-highest drag. This would be due to the reduction in the frontal area due to the windshield being removed. However, the roof-up has a lower Cd value because it controls the flow at the front of the car a little better.

5.1.7 Airflow Management(2400990 – Ryan):

5.1.8 Cockpit Cover(2400990 – Ryan):

During the development of the Morgan, the engineering team realised they could reduce the vehicle's overall drag by installing a passenger-side cockpit cover. This should allow airflow to pass smoothly over the cockpit region, which, in turn, should improve airflow quality towards the rear wing.

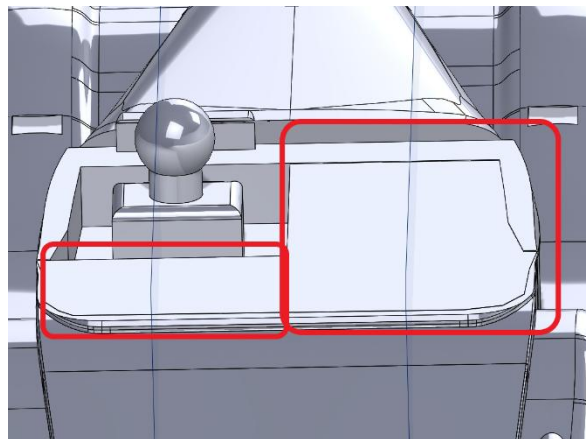


Figure 27 Morgan Plus 4 Cockpit Cover

Having an exposed cockpit without any type of cover will only increase the vehicle's drag levels the faster it goes, even a simple flat cover would help reduce the drag of the vehicle. (Abed Alrzaq Alshqirate, Dastan Zrar Ghafoor, and Sachin L. Borse, 2021)

As shown in Figure 28, the implementation of the cockpit cover was successful, reducing the Morgan drag coefficient from 0.454 (Cd) to 0.3514 (Cd), which represents a 0.1032 in drag.

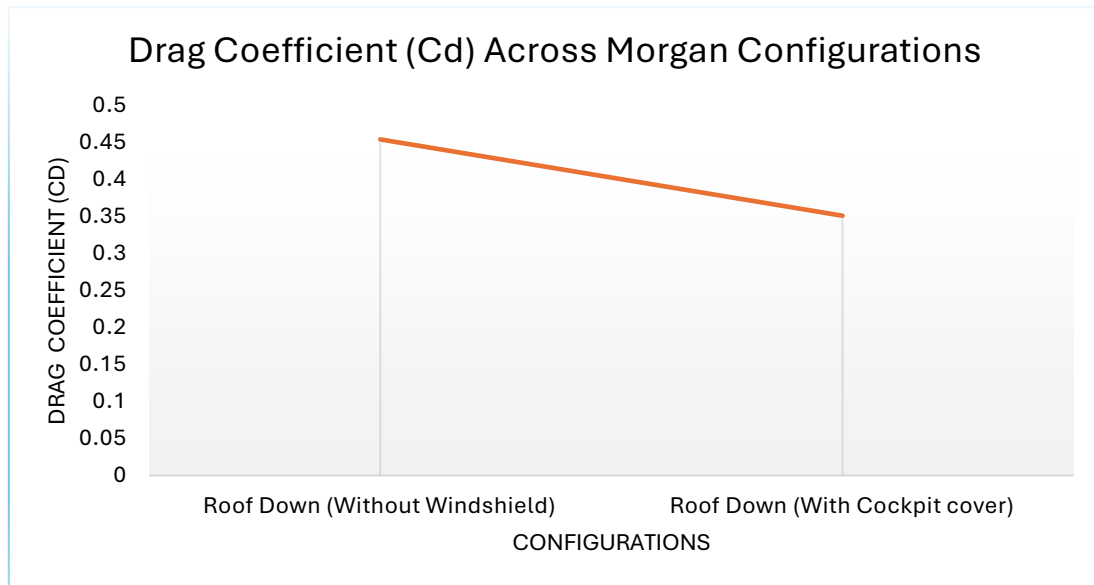


Figure 28 Comparison of Drag Coefficient (Cd) showing effects of Cockpit cover implementation

5.1.9 Air Deflector(2400990 – Ryan):

An air deflector was installed to improve airflow over the vehicle's cockpit. The primary purpose was to redirect incoming airflow upwards, reduce direct airflow interaction with the driver and improve comfort levels. At higher speeds, the driver's helmet will be subjected to forces that could lead to discomfort over time. Moreover, the secondary purpose of this device is to improve the quality of airflow reaching the rear wing and increase its overall aerodynamic efficiency. This should also promote a more stable airflow for downstream aerodynamic devices.

The 5° angle of attack was created to provide a subtle deflection of the airflow. The purpose was to introduce a small, controlled upward redirection of the oncoming airflow while minimising disruption to the natural airflow around the area. In addition this should assist in driver comfort as it will deflect air above the drivers helmet and stop from so many aerodynamic forces from acting upon the helmet.



Figure 29 (5) Deg Air Deflector

The 10° angle of attack was created to provide a more aggressive deflection of the airflow. The purpose was to introduce a larger upward redirection of the oncoming airflow while maintaining control over the natural airflow in the cockpit area. This should also deflect airflow more for the driver, therefore improving the driver's comfort levels by reducing the aerodynamic forces on the helmet.

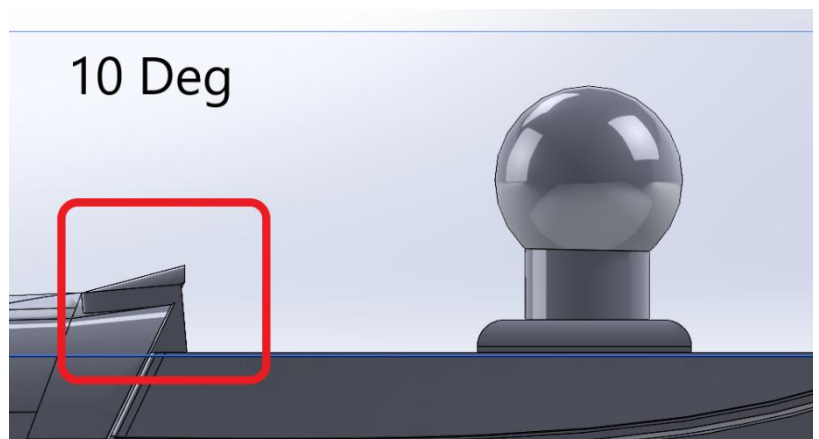


Figure 30 (10) Deg Air Deflector

5.1.10 Side Skirts(2400990 – Ryan):

Side skirts were implemented to control the airflow along the lower side of the vehicle, which should reduce the amount of high-pressure air entering the underfloor region. The skirts should seal the underbody floor off. The side skirts are there to act as a barrier between the external flow and the underbody(Hwang *et al.*, 2016).

The implementation of the side skirts has reduced overall aerodynamic drag by limiting the high-pressure air from entering the underfloor. A stepped lower profile was incorporated to deflect airflow away from the underfloor, preventing it from becoming unstable beneath the vehicle. The profile also helps guide airflow along the side of the car while maintaining a consistent, attached flow structure.

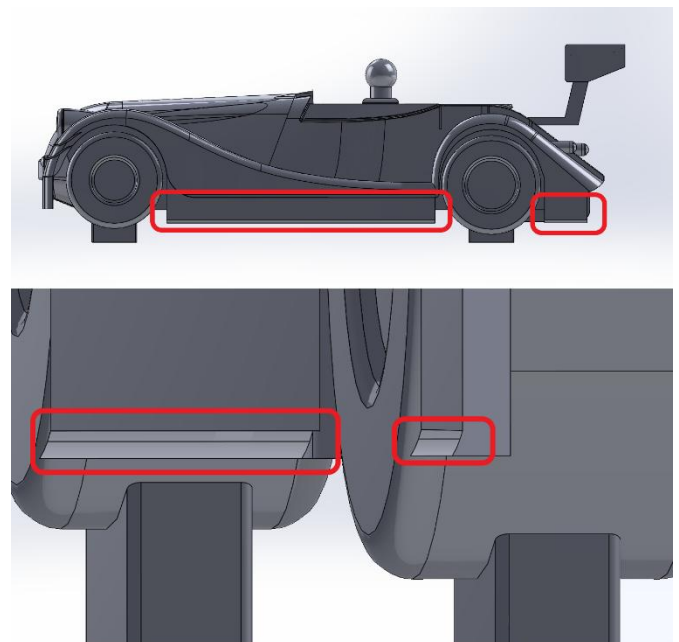


Figure 31 Side Skirts design

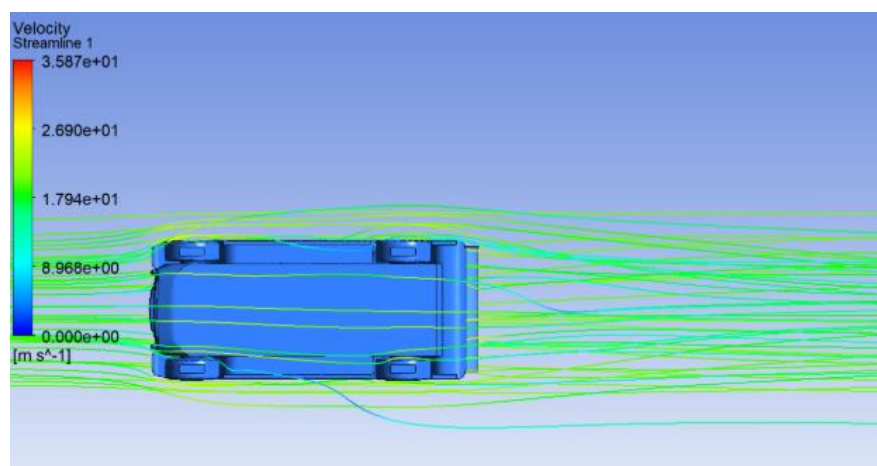


Figure 32 Side Skirts Airflow Morgan Plus 4

As shown in Figure 32, the side skirts to contain some of the airflow, it would seem that the side skirt design is allowing some airflow and creating unstable flow below the underfloor.

5.1.11 Wheel Arch Vents(2400990 – Ryan):

During analysis of the CFD, a high-pressure region was identified at the rear wheel arch as can be shown in figure 33. When Wheels are rotating, they generate a non-uniform pressure distribution around the wheel and within the wheel housing (Vdovin, 2013; Berg and Brandt, 2018). This region can account for up to 25% of the total

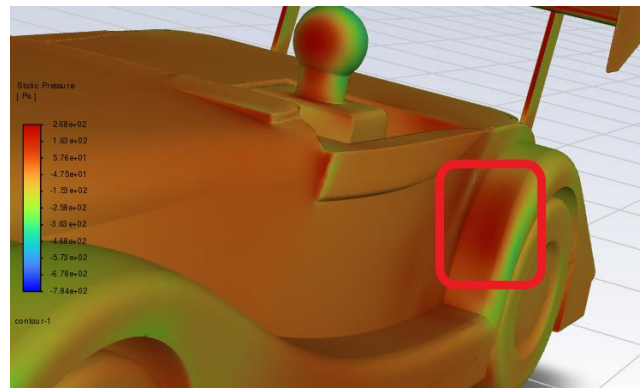


Figure 33 High Pressure Region On Rear Wheels Arch

aerodynamic drag of the vehicle, therefore reducing the pressure round and within the wheel arch is essential for improving the aerodynamic performance of the morgan plus 4.

To achieve a reduction in aerodynamic drag on the morgan plus 4 the engineers came up with a solution which has a reduction in the frontal area of the rear wheel arch which therefore in turn should reduce the overall drag of the vehicle. Having the vents on the rear allows the high pressure generated from the wheels to also escape which should further decrease the drag of the morgan plus 4. As shown in figure 34, the location of the vents are highlighted in red.

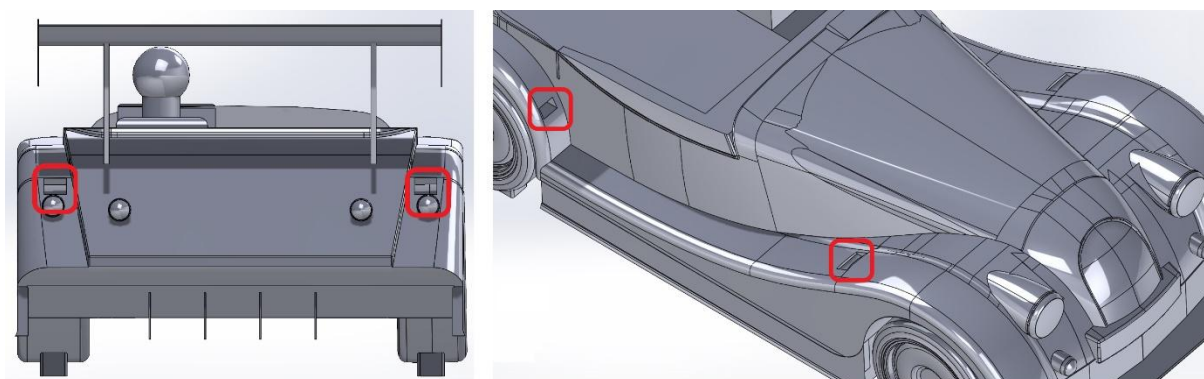


Figure 34 Concept For Vents to reduce high pressure within wheel well

After running this design in CFD it was found that they did assist in the reduction of drag although a small amount of drag was removed overall helps in respect of total aerodynamic drag.

5.1.12 Combined Aerodynamic Device(2400990 – Ryan):

5.1.13 Air Deflector & Rear Wing(2400990 – Ryan):

The engineering team evaluated two angles of attack for the air deflector in combination with the rear wing at 8 degrees (V1.2 8 degrees) to assess their influence on airflow behaviour and rear-wing performance. The air deflector is supposed to redirect airflow upwards and over the driver's helmet to improve airflow quality, assist in energising the rear wing, and increase the overall efficiency of downforce generation.

5.1.13.2 No Air Deflector – Baseline Roof Down (2518952 – Ran CFD for No air deflector):

The baseline model without the roof was used to establish an initial reference for the rear wing performance. The configuration produced a negative lift coefficient of -0.2818 (Cl) and an increase in drag coefficient of 0.03252 (Cd).

5.1.13.3 Air Deflector – 5 & 10 Degree(2400990 – Ryan):

Now the engineering team had the baseline to work off, the goal would be to improve the airflow behaviour and to try to further energise the rear wing to produce more downforce. After running the rear wing with a 5 degree and 10 degree Air deflector, it was found that the air deflector made the rear wing less efficient and reduced the overall downforce generation capacity, and increased the drag coefficient, it must be noted that the position of the wing was changed late on therefore, the numbers might be slightly off with respect to Cd and Cl.

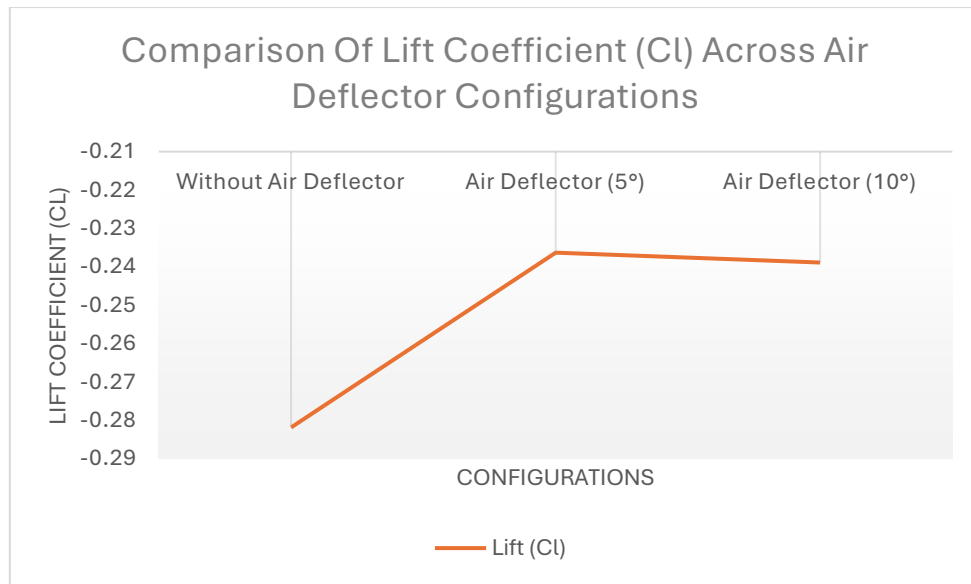


Figure 35 Comparison Of Lift Coefficient (Cl) Across Air Deflector Configurations

As shown in Figure 11, the baseline configuration without the air deflector produces the greatest level of downforce. The introduction of the air deflector at either of the two configurations results in a reduction of downforce. The 5° air deflector has the largest reduction, which indicates that the air flow is being redirected, reducing the efficiency of the wing; the 5° produces -0.2363 (Cl).

The 10° air deflector results in a slight recovery when compared to the 5° configuration. The 10° air deflector suggests an improved airflow behaviour for the rear wing; however, it remains below the baseline numbers. The 10° produces -0.2389 (Cl).

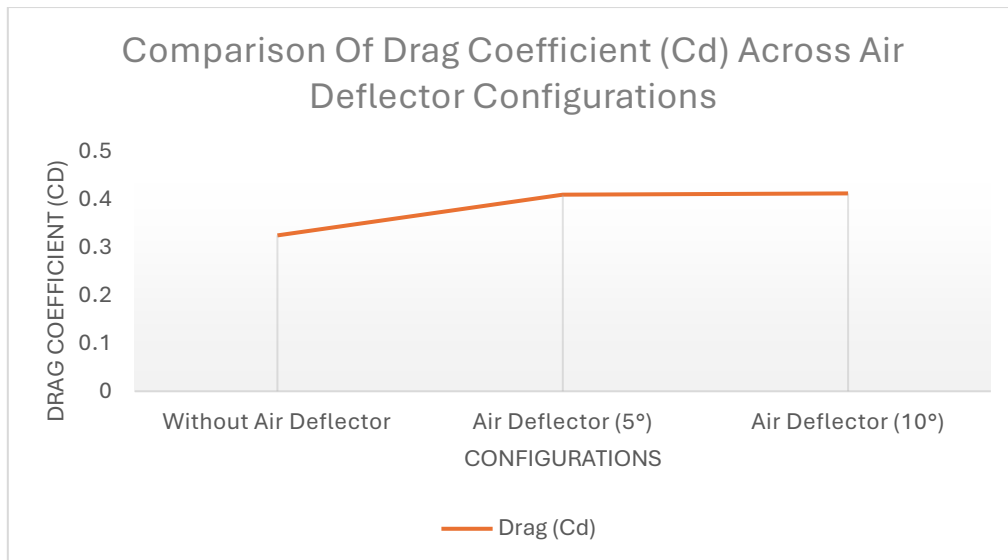


Figure 36 Comparison Of Drag Coefficient (Cd) Across Air Deflector Configurations

As shown in figure 36, the baseline configuration without the air deflector produces the lowest drag coefficient. The introduction of the air deflector within both configurations results in an increase in drag. The 5° air deflector shows a noticeable increase in drag, which indicates that the redirection of the airflow is creating further areas of pressure stagnation.

The 10° air deflector results in a slight increase in drag when compared to the 5° configuration. This suggests that the airflow continues to create additional areas of higher pressure, which in turn leads to more drag.

5.1.14 Further Work(2400990 – Ryan):

Further development work could be undertaken to refine and optimise the individual components which make up the Morgan Plus 4 current packages. While the rear wing and wheel arch vents have demonstrated major improvements upon the previous baseline configuration, there remain additional areas where, if investigated further, a greater level of performance of the vehicle could be extracted.

Future work could focus on refining the current package which has been developed and tested by the engineering team. This would then ensure that all components would be interacting efficiently with each other while remaining within the constraints of the vehicle's regulations (Reed, 2025).

5.1.14.2 Air Deflector(2400990 – Ryan):

As found during the investigation into the introduction of an air deflector, it made the rear wing less efficient by kicking up airflow and creating unfavourable conditions for the rear wing. A new design could be created to help prevent this unfavourable airflow and allow the rear wing to become more efficient like originally planned.

Therefore, further work could be on refining the geometry, angle and position of the air deflector to help better control the airflow over the cockpit. Changing the geometry and profile of the air deflector could then allow the wing to become more energised.

5.1.14.3 Side Skirts(2400990 – Ryan):

As found during the investigation into the side skirts, some airflow was spilling into the underfloor, creating an unstable region that wouldn't assist in reducing drag. Therefore, a new profile of side skirt could be developed to further ensure the sealing of the underfloor and prevent any high-pressure air from entering the underfloor.

5.2 Rear Wing Development (2518952 – Thomas)

A simple and effective way to increase a vehicle's downforce is to attach a rear wing. An aerofoil placed in an area of unobstructed flow can generate an area of low pressure under its surface by accelerating the speed of the air travelling underneath the aerofoil relative to the upper side of the aerofoil (Qiu, Z., Zhang, H. 2023). This comes with both positives and negatives with the ability to generate downforce at the rear of the Morgan Plus 4 being very potent using this method generating a respectable amount of downforce however this can heavily rearwardly bias the centre of pressure potentially causing severe understeer when at speed. This problem means that the Morgan Plus 4 team will either have to produce a significant amount of downforce acting on the front of the Morgan Plus 4 or have to reduce the potency of the rear wing through either adjustments in angle of attack or by reducing its potency with other aerodynamic devices that target an alternate purpose such as driver comfort.

5.2.1 Rear Wing Viability (2518952 – Thomas)

A requirement for a rear wing is to have clean airflow so first the Morgan Plus 4 team had to analyse the Morgan Plus 4's existing aerodynamic characteristics observing how airflow reached the rear of the car.

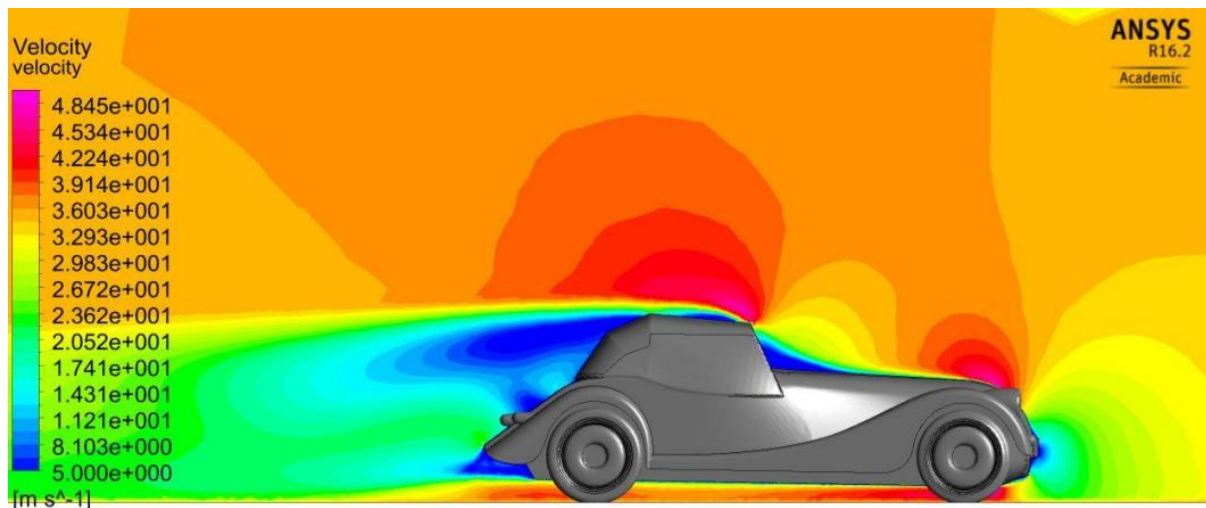


Figure 37 - Velocity Contour on Morgan Plus 4 with the Roof up and Windshield attached

Figure 37 above shows the large area of stagnated air created in the wake of the Morgan Plus 4 with the roof up and a windshield attached. This condition causes the implementation of a rear wing as allowed by the WSSCC (Welsh Racing Drivers Association Ltd, 2025) to be ineffective as the regulations state that the aerodynamic

device must not extend past the existing bodywork of the car which restricts its placement to within the area of stagnating velocity. A solution to this issue would be to remove both the roof and the windshield to allow clean airflow to the rear of the car.

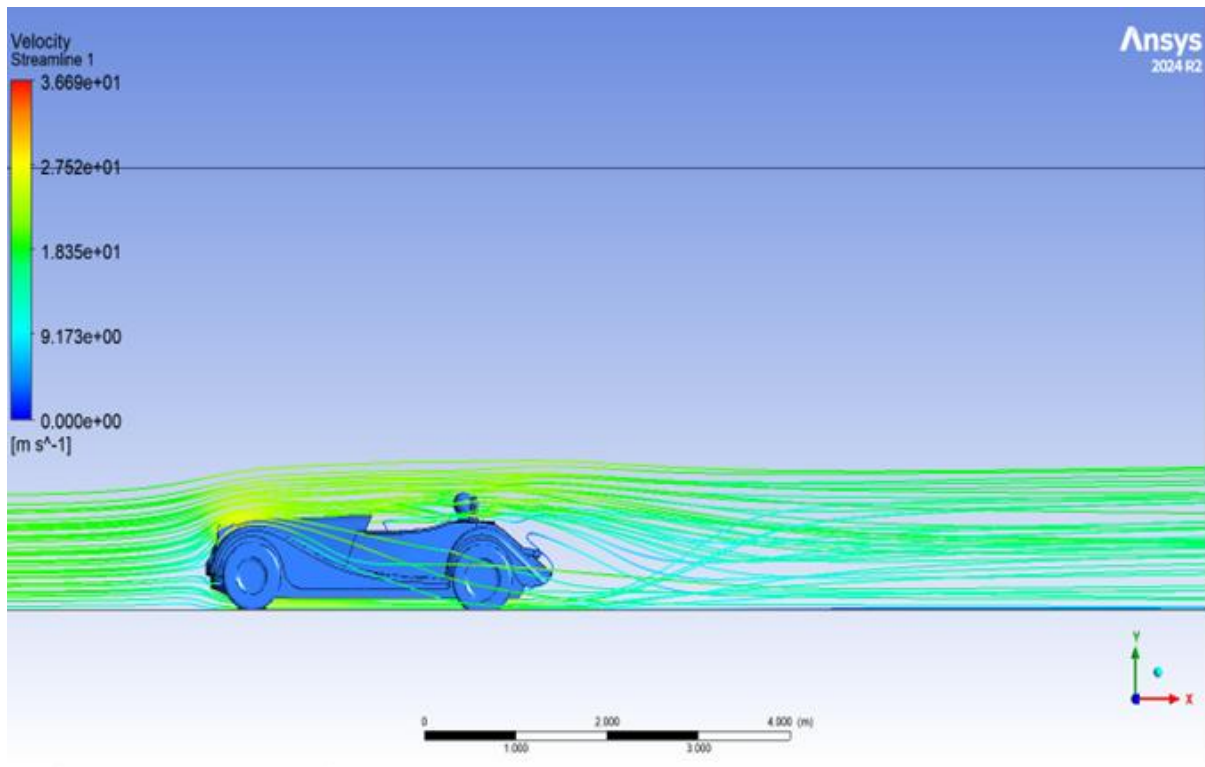


Figure 38-Streamline airflow of Morgan Plus 4 roof down no windshield

As seen in Figure 38 above, the removal of the roof and windscreen allows clean airflow to reach the rear of the car. For motor racing a roll cage is mandatory for safety purposes (Welsh Racing Driver's Association Ltd, 2025) and does serve as the maximum height of the rear wing when the windscreen and roof have been removed, due to meshing errors when implementing a roll cage in any Ansys simulations the Morgan Plus 4 team as of this report being submitted have been unable to perform any CFD runs with a roll cage fitted so henceforth the impact from the roll cage has attempted to be minimised by adjusting the positioning of the rear wing to move it into what would be the least impacted area.

5.2.2 Rear Wing Design (2518952 – Thomas)

The starting point for the rear wing was to select a profile to start with. Unfortunately, due to unsolved errors as of the submission of this report, the engineer behind the design of the rear wing was unable to import any other wing profiles than NACA 6412 which was the initially targeted as a starting point for rear wing profile as Chiplunkar et al. (2023) had found it suited for their application for use in a similar scenario although far more of a complex application. Endplates were incorporated and developed from the initial V1.1 design to the updated V1.2 design. Please see Figure 39 for V1.1 and Figure 40 for V1.2.

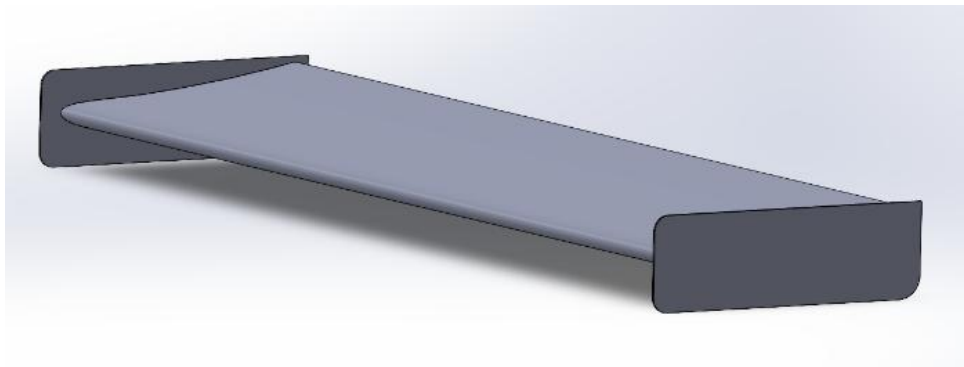


Figure 39-Rear wing version V1.1 at 8 degrees

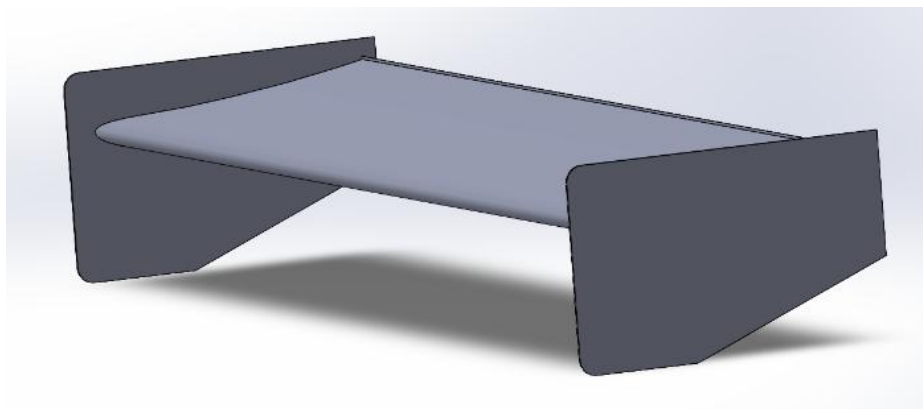


Figure 40- Rear wing version V1.2 at 8 degrees

Initial testing for V1.1, Figure 39, started with an AOA of 8 degrees to test a more aggressive AOA to find out if there was airflow separation happening on the underside of the rear wing. These tests proved that the airflow remained attached through the chord of the aerofoil as shown in the figure below.

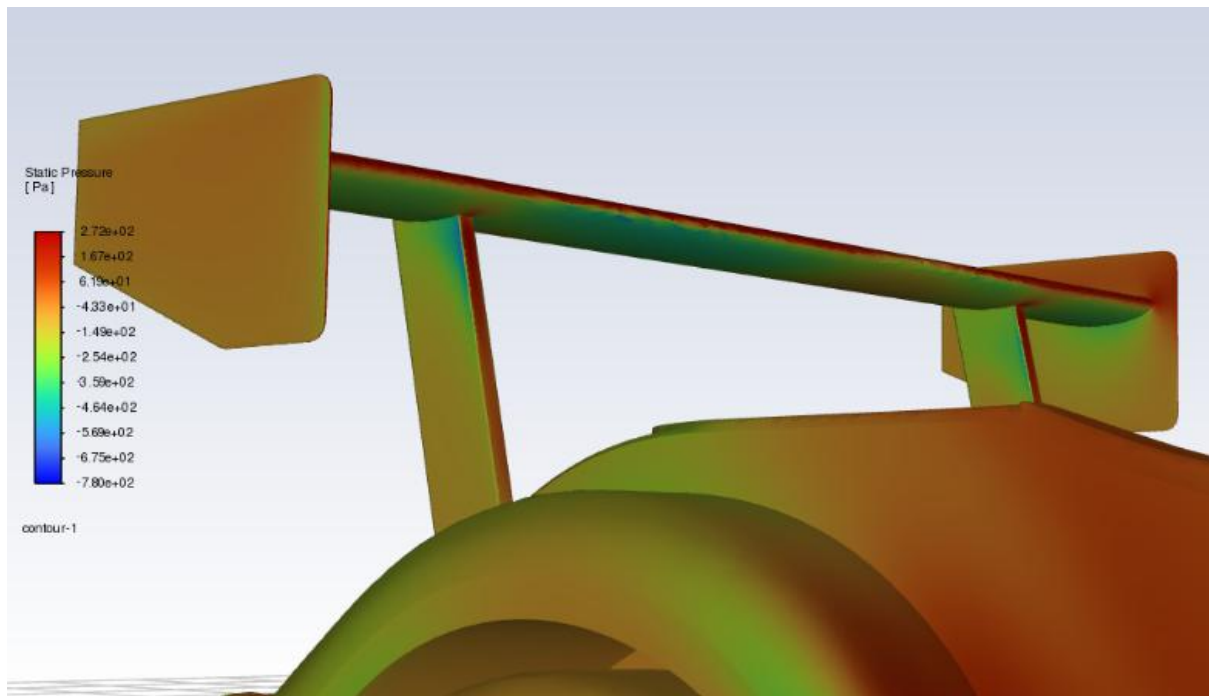


Figure 41-Static pressure of rear wing V1.2

However, the endplates were not large enough to prevent airflow from spilling into the underside of the wing reducing its efficiency. To solve this issue the endplates were increased in vertical size significantly and slightly increased in horizontal size as well as a slant introduced on the latter part of the wing in attempt to reduce the naturally occurring wingtip vortex that occurs at the edge of the wing. A gurney flap was also introduced which will help further ensure avoidance of flow separation (Kurniawan et al. 2025).

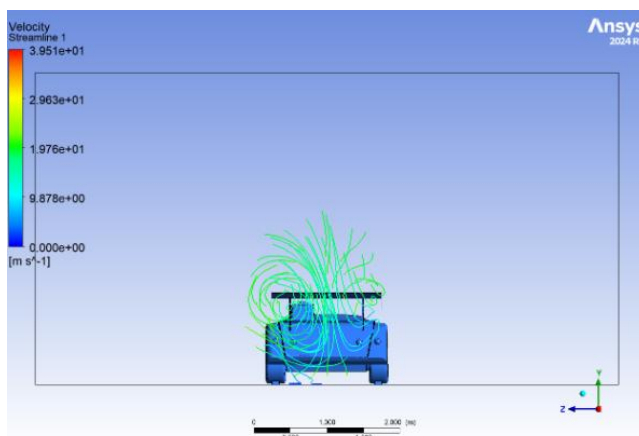


Figure 43-Velocity Streamline behind with rear wing V1.2 at 8 degrees

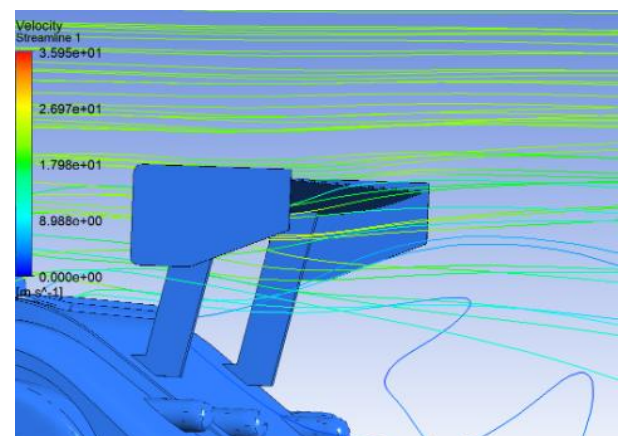


Figure 42-Velocity streamline focusing on rear wing V1.2 at 8 degrees

5.2.3 Rear Wing AOA Investigation (2518952 – Thomas)

Investigation took place into the effect of changing the angle of attack (AOA) of the rear wing to either reduce the amount of downforce should the frontal part of the car not be producing enough downforce to allow the centre of pressure to shift forwards as well as to investigate how the adjustment of angle could change downforce values should further developments incorporate an adjustable rear wing.

Preliminary values of adjustment were decided to be the default 8 degrees as initially designed, 5 degrees and 3 degrees. These 3 angles should give a good range of values which can be compared to one another.

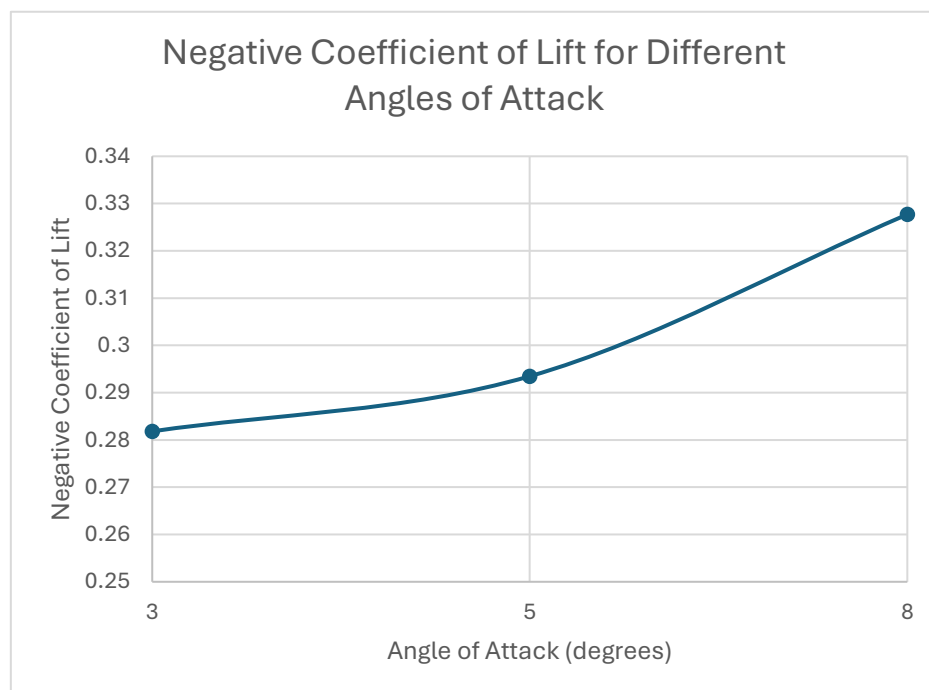


Figure 44-Graph of Negative Coefficient of Lift against rear wing V1.2 angle of attack

Figure above shows the increase in negative coefficient of lift for the 3 stated angles of attack. A reduction of roughly 0.05 negative coefficient of lift is the result of the difference between an AOA of 8 degrees to an AOA of 3 degrees.

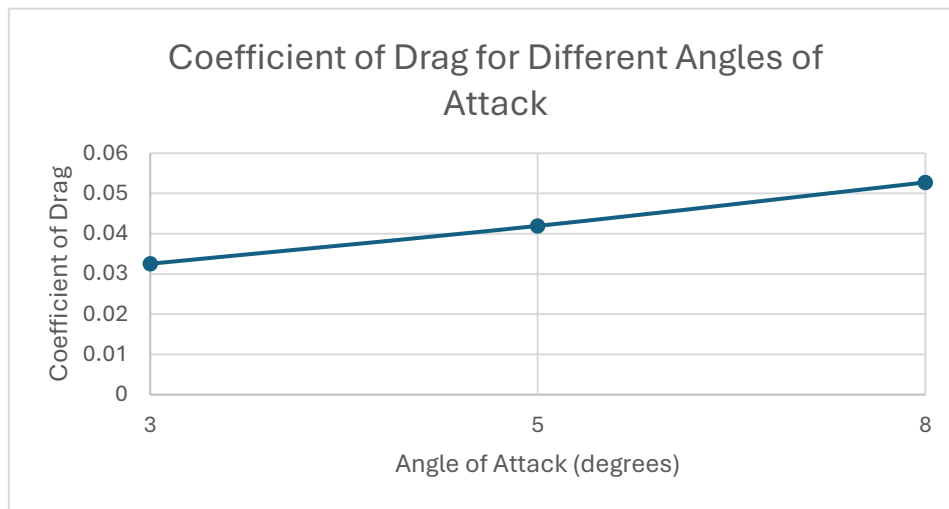


Figure 45-Graph of Coefficient of Drag against rear wing V1.2 angle of attack

Figure above shows the coefficient of drag for the stated angles of attack. As would be expected the coefficient of drag increases as the AOA increases. Figure [NUMBER] also appears to show that the increase is near linear with an increase in drag of 0.0094 from 3 degrees to 5 degrees and an increase of 0.0108 from 5 degrees to 8 degrees.

In conclusion for the rear wing, it would be best to use V1.2 rear wing at 3 degrees. A key motivator behind this choice is the difficulty the Morgan Plus 4 team have had in trying to generate front downforce with too potent of a rear wing potentially causing some severe handling characteristics. A steeper angle of attack could be exchanged in lieu of the 3-degree wing angle due to the stall created by a driver air deflector as mentioned previously.

5.2.4 Rear Wing Further Improvements (2518952 – Thomas)

Keeping along the lines of improving the aerofoil profile itself there could be a development in which the NACA profile and AOA with a steeper AOA outside of the area behind the cockpit of the car allowing the rear wing to further utilise the clean air mostly unaffected by the wake of the car whilst also optimising the efficiency of the section in the airflow effected by other aero components and the car itself. Creating a geometry that suits this description is beyond the current capability of the member of the team responsible for the CAD of the rear wing. Whilst this implementation could be a potential improvement it would also potentially require a rework of the CFD methodology due to the more complex profile and design of the rear wing adding more requirement for stronger computational power and computing time. Alternatively, the rear wing could go into a double plane design on the outer sections as mentioned before which could potentially provide greatly increased underside wing area and therefore increase downforce, however this development could be costly and mechanically difficult as the endplate they would be mounted to could be difficult to reinforce enough if the shear stress provided by the downforce is too great.

The endplates of the rear wing could also see more improvements by utilising the clean air at the sides of the car as mentioned above but by adding winglets/dive planes to create cheap and easy downforce in the clean air of the car. The rear wing sits at a span of 1500mm with more room for expansion at either end however increasing the span itself of the rear wing beyond this measure will increase in cost of manufacture more than if winglets were to be added onto the end of the endplates.

The uprights of the rear wing are also incredibly simple having no mass reduction and strengthening. Further development on the uprights would target a mass reduction and strengthening by removing unnecessary material creating an almost frame like look as typically seen on high level performance rear wings. This design could also incorporate the addition of adjustable mounts for the rear wing allowing the aerofoil to have its angle of attack changed without the need of installing a new rear wing.

Finally, an improvement which concerns the aerofoil and the uprights would be to swap from a conventional rear wing design to a swan-neck rear wing. As stated by Desai et al. (2008) the difference in mounting point frees up the underside of the rear wing allowing for more efficient underwing flow improving the downforce produced by the rear wing. This mounting method also allows for reduced drag and more stable cornering airflow.

5.3 Front end – Air dam and Splitter (2304962 – Luca)

5.3.1 Background (2304962 – Luca)

Whilst the Morgan Plus 4 is admired by many for its classic styling and dedication to heritage, it is this styling that hinders it significantly. As the Morgan company's philosophy is to stick to its roots, which is classically styled, the actual design of the Plus 4 has not changed significantly since it was first produced in 1950, as shown in Figures 46 and 47. As such, from an aerodynamic perspective the Morgan Plus 4 is fundamentally inefficient. Its semi-exposed front wheels, near-vertical windscreen and encourage turbulent airflow, particularly around the front wheel arches and around the sides of the car. The Plus 4's flat floor also exacerbates this issue on the underside of



Figure 47 - A 1959 Morgan Plus 4 (Longstone Tyres, 2026)



Figure 46 - A Modern-day Morgan Plus 4 (Morgan Motor Company, 2026)

the car, as there are no devices to guide airflow in order to make it less turbulent. All of these influences in combination increase drag and reduce the efficiency of the car, and in turn cause the car to feel less planted and more unpredictable when at speed, especially in comparison to modern vehicles that do not have the constraints of attempting to stay within a classical design.

In an attempt to combat these issues, a number of measures can be taken, in the form of adding aerodynamic devices. Two of these include an air dam and splitter, which are devices that are fitted to the front end of a vehicle and often combined to increase effectiveness, as shown in Figure 50. These will be discussed in further detail later on.



Figure 48 - An effective air dam-splitter combination on a NASCAR Generation 5 car (NASCAR Hall of Fame, 2026)

5.3.2 Understanding the Morgan's Aerodynamics (2304962 – Luca)

Before any possible improvements to the Plus 4 could be made, it was essential that the engineer working on this section of the project understood where the baseline Morgan was and get an idea of the car's values for Drag Coefficient (C_d) and Lift Coefficient (C_l), in order to establish how effective the future additions of the air dam and splitter are. As at the time there had been no running of the baseline Morgan with no roof, windscreen and roll cage, the engineer involved in this section of the project used a previously created CAD model of the Morgan Plus 4 with all of these features removed (Figure 51).

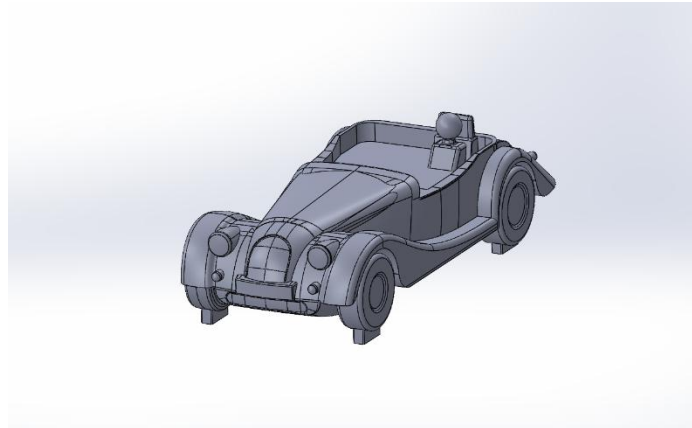


Figure 49 - The baseline version of the Morgan used in this section of the project

5.3.2.1 Baseline Morgan Results (2304962 – Luca)

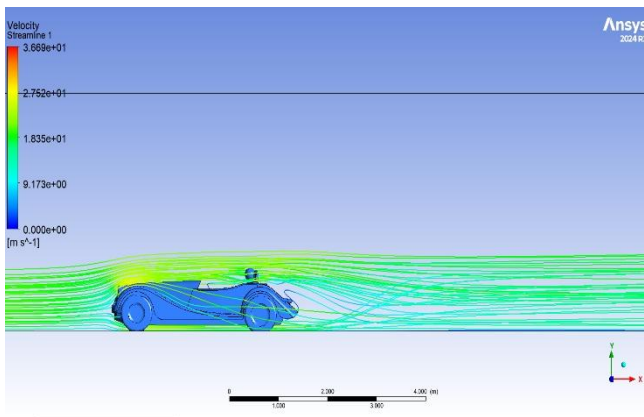


Figure 51 - The airflow around the baseline Morgan (side view)

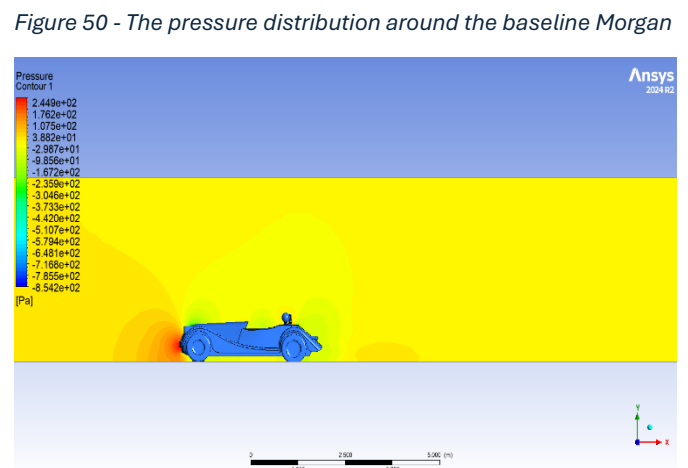


Figure 50 - The pressure distribution around the baseline Morgan

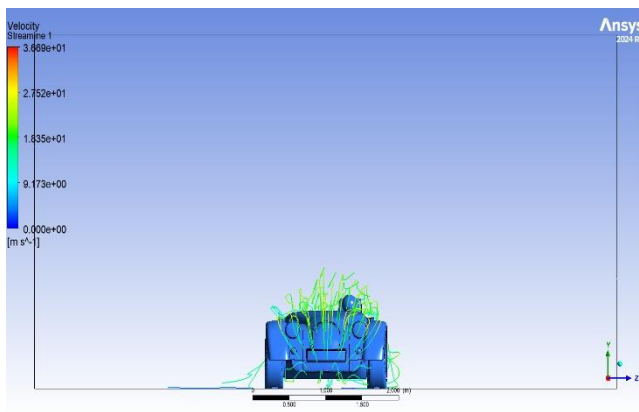


Figure 52 - The airflow around the baseline Morgan (front view)

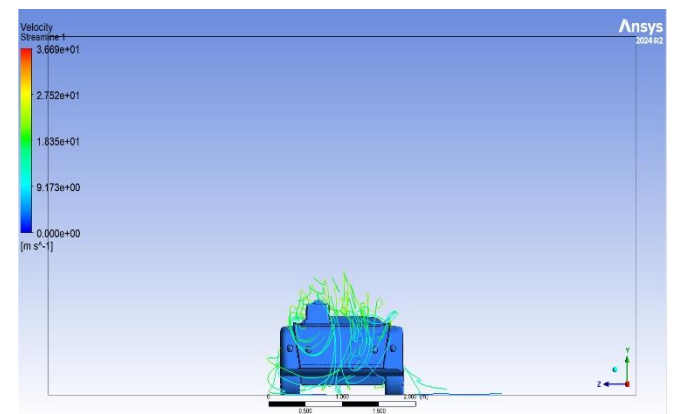


Figure 53 - The airflow around the baseline Morgan (rear view)

Using the previously developed CFD methodology, the engineer ran the model shown in Figure 51 in Ansys 2024, and from this methodology attained a C_d and C_l of 0.482 and 0.227 respectively, to two significant figures. As shown in Figure 53, the uniform airflow

accelerates over the front wheel arches and grille area and then separates as it flows over the driver and rear end of the car, forming a turbulent wake. This indicates that there is a large low-pressure recirculation zone. This is a major contributor to drag, as the smoother and more streamlined and attached the airflow is the car, the less drag is produced.

The front and rear velocity plots (Figures 50 and 51) reinforce this. Around the front of the car, the flow is highly disturbed by the front wheels and the frontal area. Instead of smoothly guiding the air around the car, these features cause many localized vortices and contribute to a chaotic flow structure. The rear view confirms that there is a large turbulent wake, as the airflow is moving in multiple directions and is far from uniform. This kind of behaviour shown in the airflow of the car massively increases drag and decreases the overall aerodynamic efficiency. Additionally, much of the turbulent air created at the front of the car is forced underneath. This creates instability at high speeds, as the flow should be as uniform as possible to create a stable car.

The pressure plot (Figure 52) shows much of the problems that are created with the Morgan Plus 4. At the front of the car, there is a very clear high-pressure zone, which is caused by stagnation as the flow of air impacts the frontal area of the car. On the other hand, the pressure drops significantly along the top and especially the rear of the car. This difference in pressure between the front and rear sections of the car is a primary source of drag. Furthermore, there is also relatively high pressure underneath the car, which is created from the turbulent airflow previously discussed. This is a major reason for the car being unstable at high speed, as higher pressure under the vehicle than above produces lift. This decreases the available grip from the tyres, and worsens at high speeds, which is a major factor in the Morgan's instability.

To mitigate these issues, two simple additions can be fitted to the frontal area of car, a splitter and air dam. An air dam simply blocks a large amount of air from entering the underneath of the car, instead forcing the flow around and over car. This reduces the underbody turbulence, helping to limit lift created at high speed and limiting instability. A splitter would help manage the high-pressure zone at the front of the car and generate some downforce. These will be discussed in the following sections.

5.3.3 Air dam (2304962 – Luca)

5.3.3.1 Initial Research (2304962 – Luca)

When looking at existing air dams that have featured on successful motorsport vehicles, it can be seen that they are largely just an extension of the front end of a vehicle (Figure 56). An air dam works by forcing more of the high-pressure air created at the front of the car over, instead of underneath (Figure 57). This creates a low-pressure zone directly behind the air dam on the underside of the car. With this difference in pressure, downforce is created.



Figure 54 - An extreme air dam on a Mazda Miata (Occam's Racer, 2019)

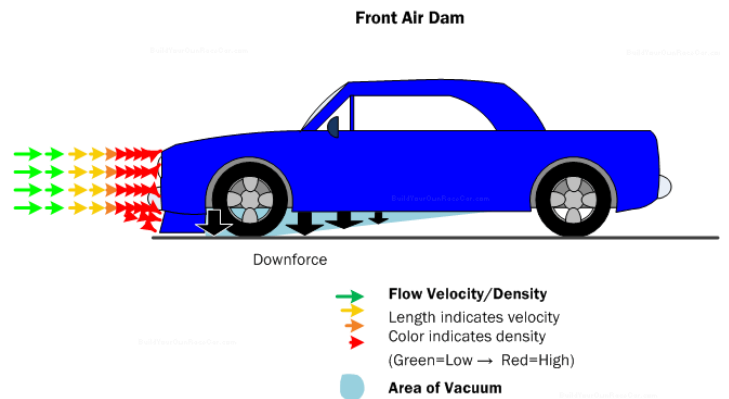


Figure 55 - A diagram of how an air dam works (Build Your Own Race Car, 2026)

5.3.3.2 Air Dam Study (2304962 – Luca)

Before deciding on how to proceed with the design of an air dam, the engineer first studied the regulations which the modifications are being made to fit within. As stated in regulation 4.4.14 of the 2025 Welsh Sports and Saloon Car Championship (WSSCC) regulations, air dams and splitters must not extend more than 100mm beyond the existing bodywork of the car (WSSCC, 2025). From this, it was decided to extend the frontal area of the car in steps of 10mm, starting from the bottom of the mesh at the front end of the Morgan, as shown in Figure 58.

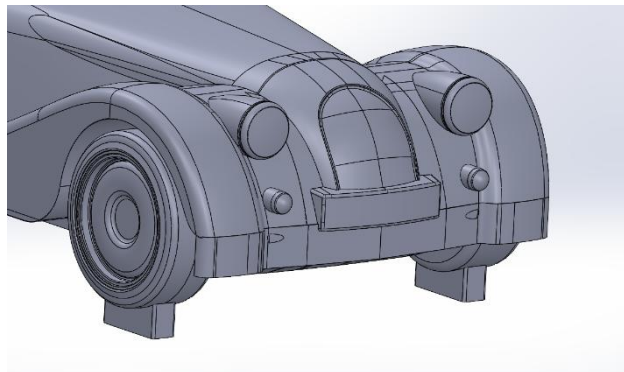


Figure 56 - The air dam at 0'mm

Using the previously developed CFD methodology, each step was analysed using Ansys simulation software to determine which air dam height would be most suitable to use for the Morgan Plus 4. Table 5 shows exact values and percentage differences for Cd and Cl for the base car (Roof Down) and each 10mm step in air dam length. Figures 59 and 60 visualise these changes on a graph, making it easier to understand what changes with each step and which air dam length to proceed with.

	Roof Down	0"mm	10mm	20mm	30mm	40mm	50mm	60mm	70mm	80mm	90mm	100mm
Cd	0.4815939	0.449453	0.447794	0.463404	0.442719	0.445198	0.451593	0.444073	0.439450	0.443082	0.443332	0.451207
diff.	-	0.032141	0.033800	0.018190	0.038875	0.036396	0.030001	0.037521	0.042144	0.038512	0.038262	0.030387
% diff.	-	6.90	7.27	3.85	8.41	7.85	6.43	8.11	9.15	8.33	8.27	6.52
Cl	0.2270267	0.182642	0.160832	0.127826	0.134333	0.118424	0.108777	0.097734	0.085785	0.085315	0.114136	0.129461
diff.	-	0.044384	0.066194	0.099201	0.092694	0.108602	0.118250	0.129293	0.141242	0.141711	0.112891	0.097566
% diff.	-	21.67	34.13	55.91	51.30	62.88	70.43	79.62	90.30	90.74	66.18	54.74

Table 6 - The values of Cd and Cl for each 10mm step on the air dam

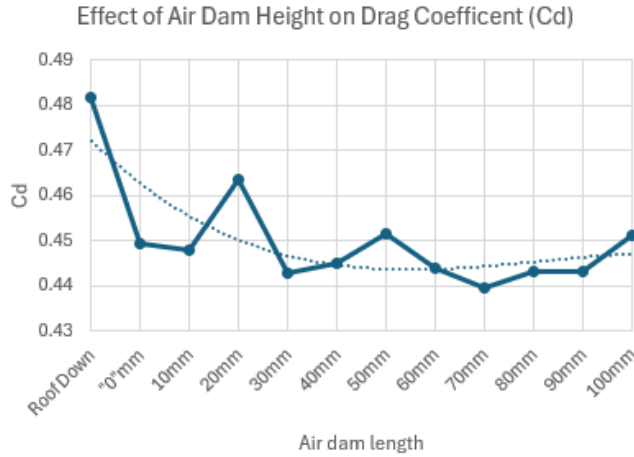


Figure 57 - A graph to show how Cd changes with air dam length

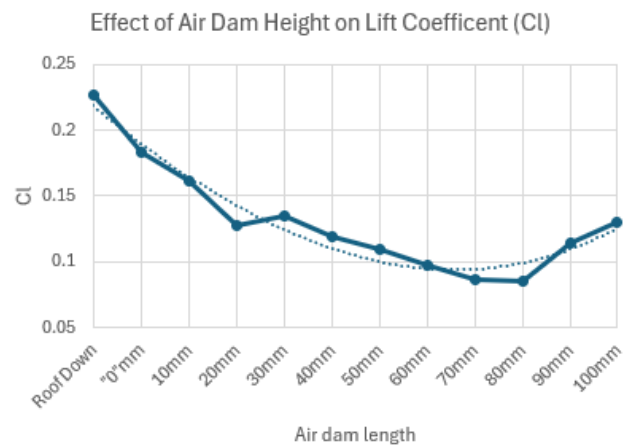


Figure 58 - A graph to show how Cl changes with air dam length

Based on the numbers shown in the previous figures, the engineer responsible for this part of the project decided that an air dam length of 70mm is the most viable option. This is because even though the Cl of this length is not the most effective, it has the lowest Cd, and when looking at the Cd of 80mm, it is much worse when compared to the Cl difference of the two lengths.

As show in Figure 64, the airflow around the Morgan isn't changed very much when the car is fitted with a 70mm air dam. However, with the extra air that is forced over the top of the car, the wake becomes slightly more turbulent. Even with this slight extra turbulence, the gains of the Cd and Cl on the car are significant enough to disregard this as a negative. On the pressure plot however (Figure 65), it is very clear that the air dam is working as intended. Behind the air dam, there is a large low-pressure zone. Above and immediately surrounding the car, there is a higher pressure, which suggests that the goal of forcing the high-pressure air around and above the car is being achieved.

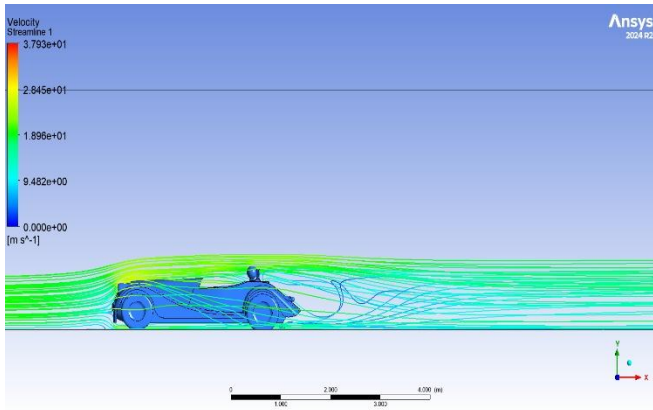


Figure 62 - The airflow around the Morgan with a 70mm air dam (front view)

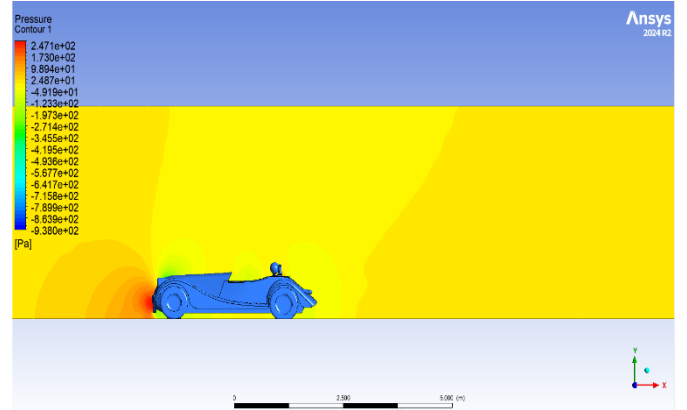


Figure 61 - The pressure distribution around the Morgan with a 70mm air dam

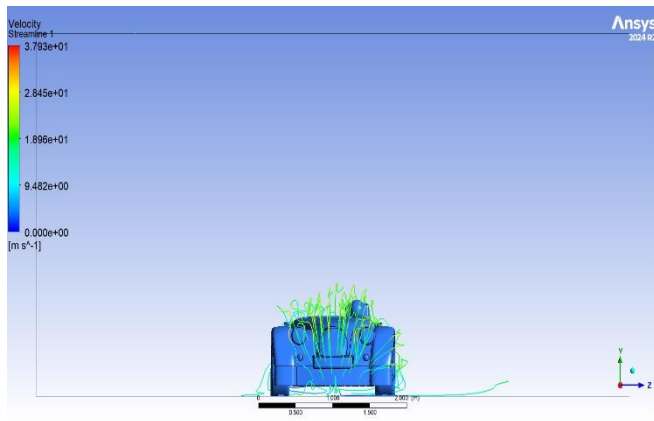


Figure 60 - The airflow around the Morgan with a 70mm air dam (front view)

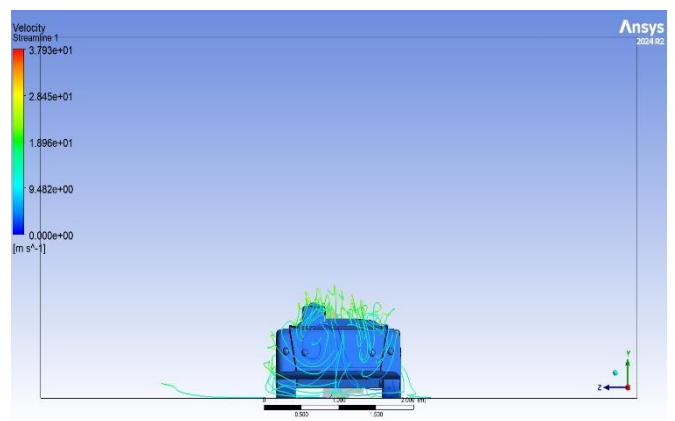


Figure 59 - The airflow around the Morgan with a 70mm air dam (rear view)

5.3.4 Splitter (2304962 – Luca)

5.3.4.1 Initial Research (2304962 – Luca)

A splitter is a small plane extended on the front of a car (Figure 66) and is usually combined with an air dam. It works by forcing more of the high-pressure air that stagnates at the front of the vehicle over the top and limiting the amount of air that can pass underneath. This creates a greater pressure difference than with just an air dam (Figure 65), generating more downforce. With less air entering the underbody of the vehicle, there is also less turbulence, which also decreases drag. This makes a vehicle more stable at high speeds and makes it more aerodynamically efficient.



Figure 64 - A splitter as used on a Mazda RX-729P (Katz, J., 2019)

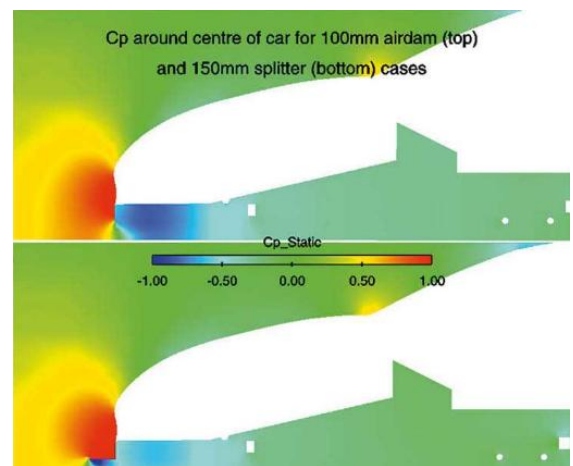


Figure 63 - Pressure plot with and without a splitter (McBeath, S., 2017)

5.3.4.2 Splitter Study (2304962 – Luca)

As with the air dam, the WSSCC regulations must be taken into account before any changes to the car can be made. Again, as stated in regulation 4.4.14 of the 2025 WSSCC regulations, air dams and splitters must not extend more than 100mm beyond the existing bodywork of the car (WSSCC, 2025). This plays into the engineer's hands, as the maximum total downforce that can be extracted from a splitter is when it is at 100mm (McBeath, S., 2017). This is shown in Figure 67.

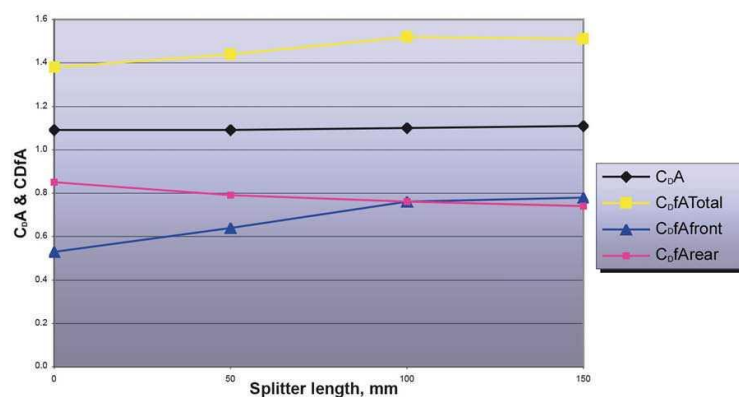


Figure 65 - How splitter length affects downforce (McBeath, S., 2017)

5.3.4.2.1 Splitter Designs (2304962 – Luca)

For this study, it was decided to have one base shape for the splitter, and to change the shape of the leading edge and depth of the splitter. Figure 68 shows the base shape, which is a 100mm extrusion from the front of the car, with rounded corners to smoothen the airflow. Splitter 1 (Figure 70) has 10mm depth with a 10mm bottom fillet, and no top fillet. Splitter 2 (Figure 69) has 10mm depth with a 5mm fillet on both edges. Splitter 3 (Figure 72) has 15mm depth with a 10mm bottom fillet and a 5mm top fillet. Splitter 4 (Figure 71) has 20mm depth with a 10mm bottom fillet and a 5mm top fillet.

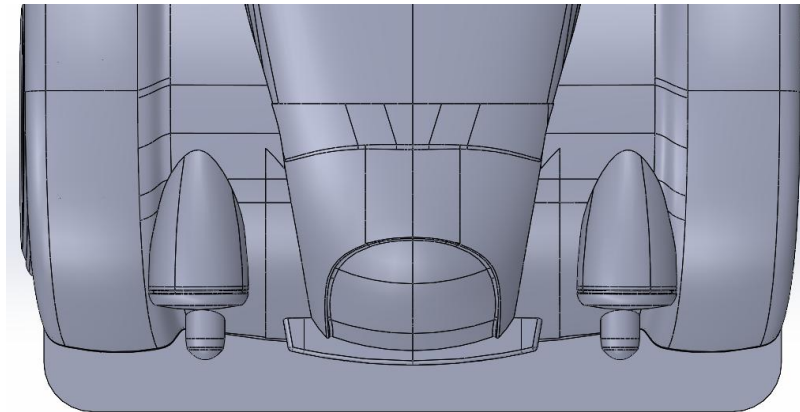


Figure 66 - The base shape of the splitter, viewed from above

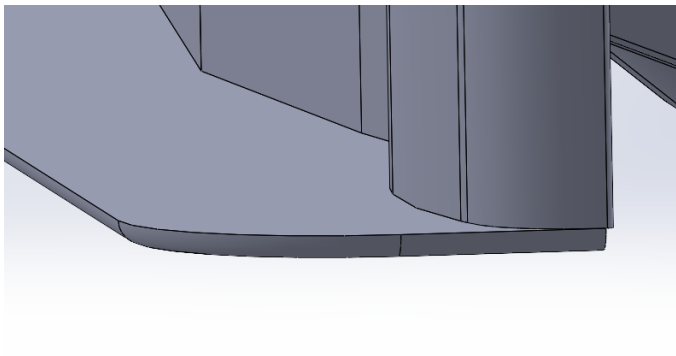


Figure 68 - Splitter 1 design

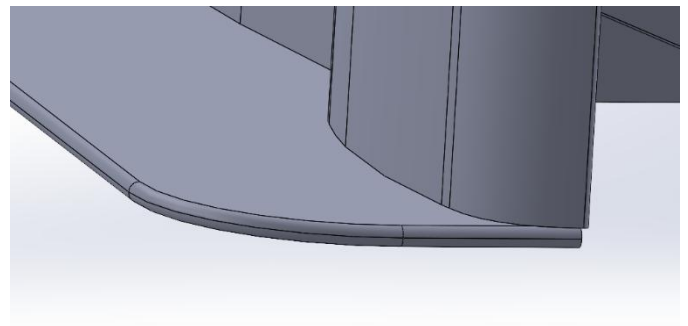


Figure 67 - Splitter 2 design

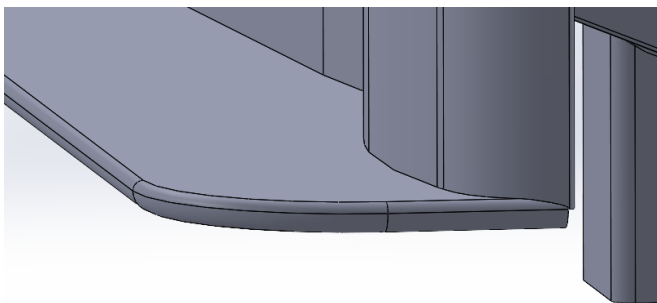


Figure 70 - Splitter 3 design

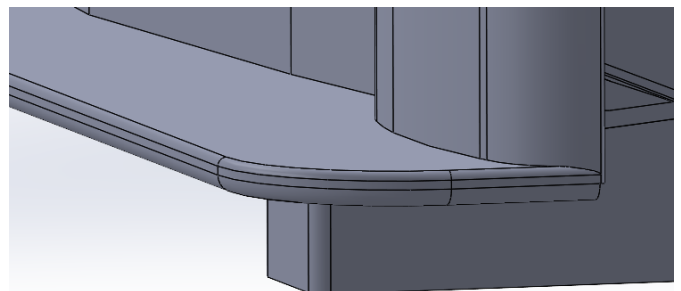


Figure 69 - Splitter 4 design

5.3.4.2.2 Results (2304962 – Luca)

Again, as with the air dam, the same CFD methodology using the Ansys software was used to analyse which splitter design would be the best to incorporate on to the Morgan Plus 4. However, with the addition of the splitter, the mesh was not working, so Ai (ChatGPT, 2026) was used to refine the methodology in order to be able to run the car. Table 6 shows exact values and absolute differences in the C_d and C_l for the “base” (70mm air dam) and each splitter design. Figures 73 and 74 visualise these improvements on graphs, making it easier for represent which design is best with which to proceed.

	Base	Splitter1	Splitter2	Splitter3	Splitter4
C_d	0.439450	0.470985	0.463779	0.467155	0.464084
diff.	-	0.031534	0.024328	0.027705	0.024634
C_l	0.085785	-0.045718	-0.022392	-0.057320	-0.023970
diff.	-	-0.131503	-0.108177	-0.143105	-0.109755

Table 7 - The values of C_d and C_l for each splitter design

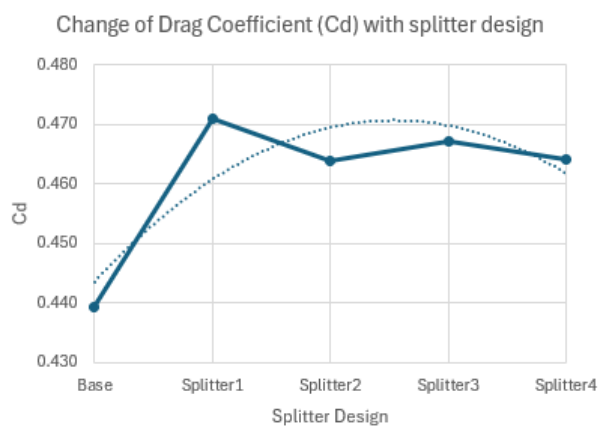


Figure 72 - A graph to show how C_d changes with each splitter design

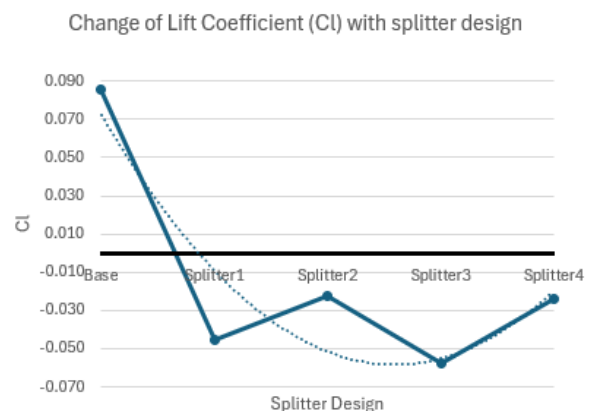


Figure 71 - A graph to show how C_l changes with each splitter design

Using the numbers shown in the figures above, the engineer working on this section decided that splitter 3 is the best option. Since it is expected that drag will increase slightly overall when adding a splitter, the small increase in C_d with splitter 3 can largely be disregarded. With the third design having the best increase in C_l , it is a relatively simple choice for the engineer to make. In addition, adding a splitter causes the car to produce downforce, even with relatively simple devices, which showcases the potential in the Morgan Plus 4.

As shown in Figures 74, 75 and 76, the airflow around the Morgan with the splitter attached is much closer to what is expected with an aerodynamically efficient vehicle. The flow that is forced around the side of the car stays attached, and the underbody

flow is much more uniform, therefore less turbulent. The turbulent wake at the rear of the car remains, however it is now much better than before. This suggests that the car is much more efficient, even though the overall drag has increased.

On the pressure plot (Figure 75), the low-pressure is much more defined underneath the splitter and behind the air dam, and the high-pressure is forced above the car. This will make the car much more stable at high speeds, as this is much closer to the ideal of a vacuum beneath the vehicle and high pressure above.

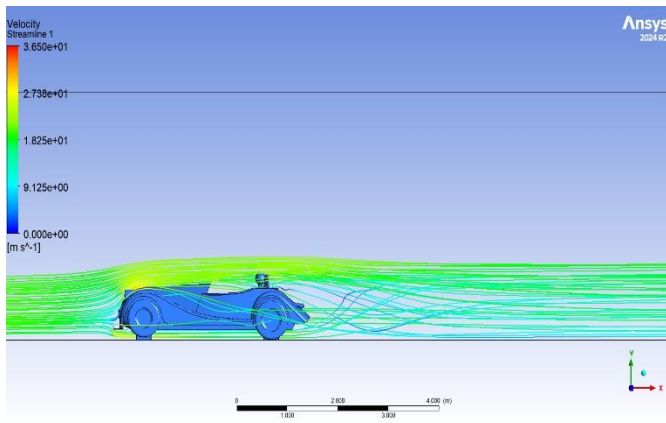


Figure 74 - The airflow around the Morgan with a splitter (side view)

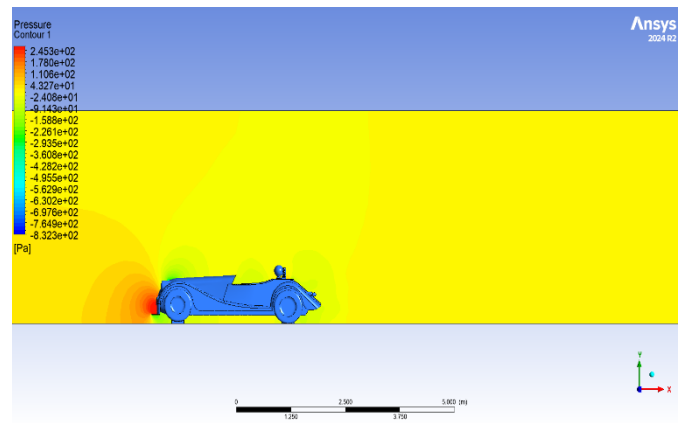


Figure 73 - The pressure distribution around the Morgan with a splitter

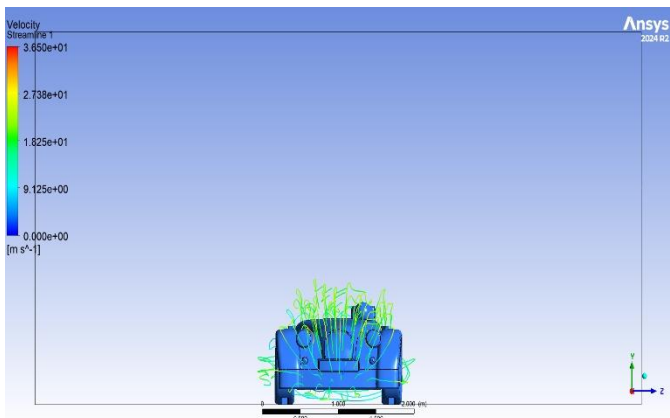


Figure 76 - The airflow around the Morgan with a splitter (front view)

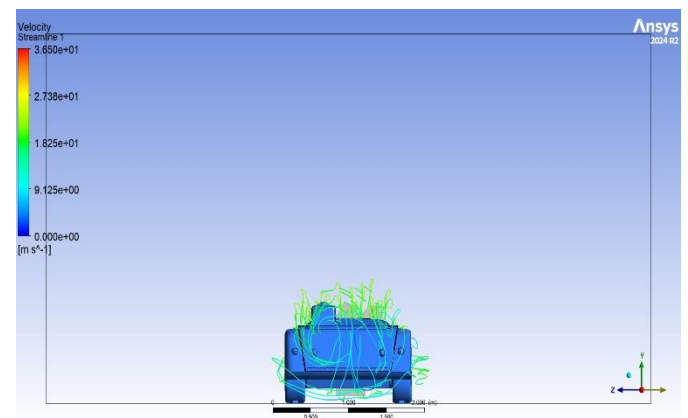


Figure 75 - The airflow around the Morgan with a splitter (front view)

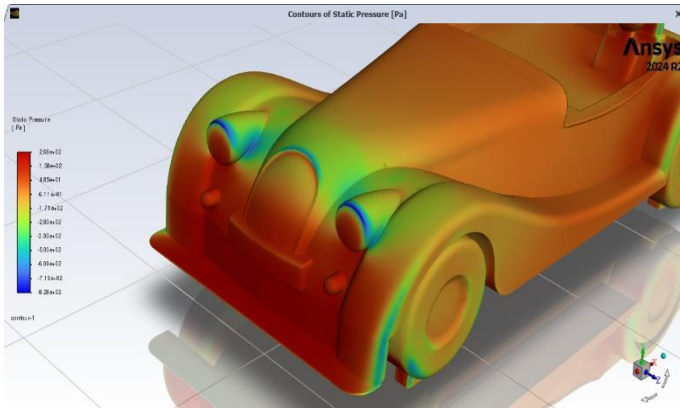


Figure 78 - Static pressure above the splitter

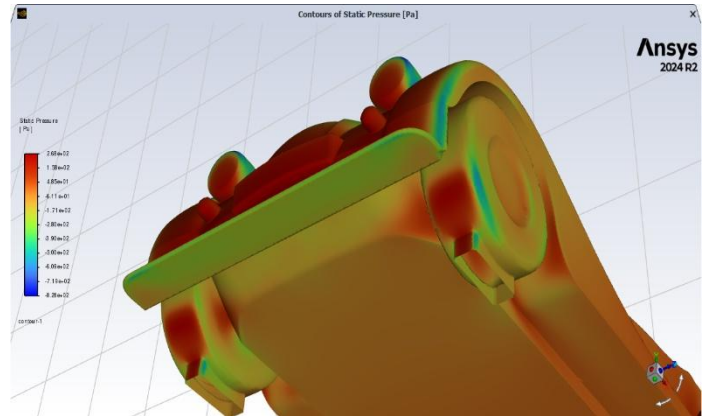


Figure 77 - Static pressure below the splitter

5.3.5 Further Work (2304962 – Luca)

Whilst the additions of the air dam and splitter have proved to be highly effective in improving the aerodynamic efficiency of the Morgan Plus 4, there is still improvements to be made, and not just for aerodynamic purposes. One of these improvements is the possibility of adding brake ducts into the air dam, as shown in Figure 81. These brake ducts would feed air into the wheel arches and cool the brakes. This would increase the car's performance, as the driver would be able to lean on the brakes more without the worry of them overheating. However, this could lead to turbulent air being created around the holes on the air dam, and this would have to be investigated as to whether that turbulence is large enough to negate the benefit of the extra cooling to the brakes.

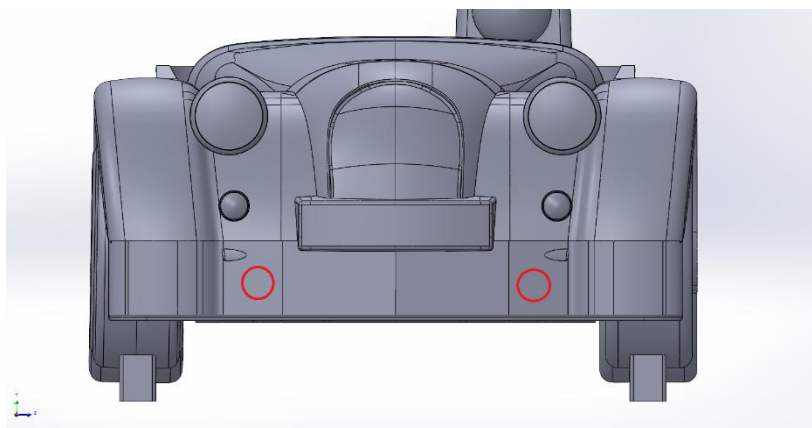


Figure 79 - The location of possible brake ducts

Another improvement which could be explored is the extension of the underside of the splitter. Whilst the underside has less turbulence than before, there is still much of it caused by the sudden break of the splitter as it reaches the end of the air dam. To

mitigate this, the splitter can be extended with streamlined geometry (Figure 82) to minimize the detachment of airflow beneath the car. By doing this, it reduces the potential of turbulence created from the engine/suspension parts and wheel arch, as the flow is not chaotic as it enters the underside of the car.

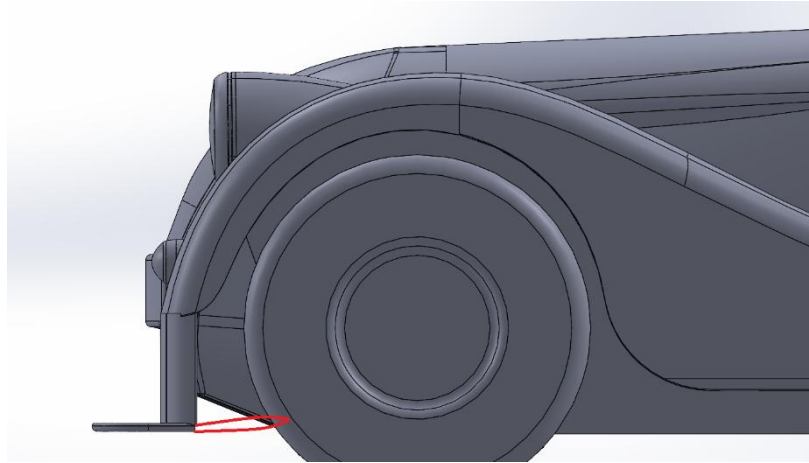


Figure 80 - An example shape of an extended splitter

6.0 Conceptual Package Design

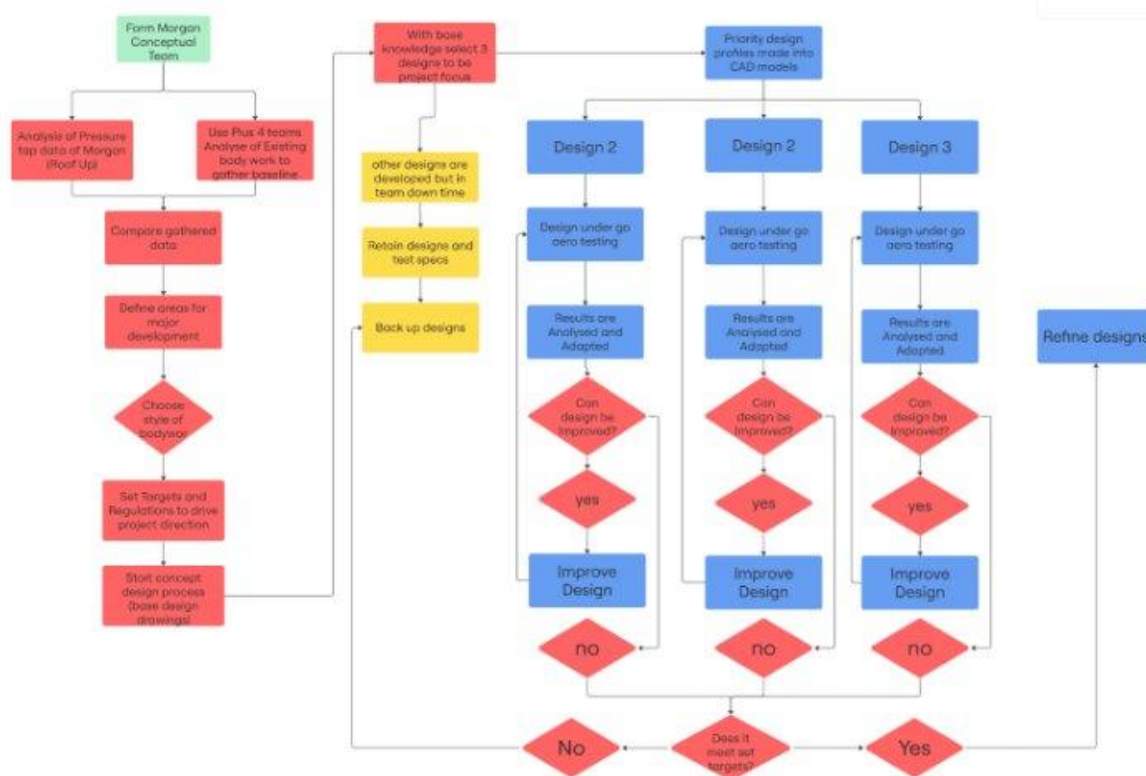
6.1 Conceptual Design Process (2405602 – Ethan)

The second half of the project explores a full redesign of the Morgan Plus 4 cars, where the only aspect of the car that the Concept Team work with is the base chassis.

Designing a completely new bodywork to attach to the Morgan chassis that aims to improve on the current aerodynamics. This is a more costly approach, but should result in a greater reduction of Drag and possibly generate downforce at the same time.

The Conceptual Team will focus on research at first to assist in their design choices, as they have a larger scope to work on, they will need to decide what direction to take their design process. Below is a flow chart depicting the conceptual Teams design process.

Figure 81: Flow Chart showing the Conceptual Teams Design Process



This Chart sets out the basic plan that the Conceptual Team will follow throughout the course of the project. The next steps after initial research are curating a selection of Designs that can be developed into fully defined designs. The basic structure focuses on 3 main designs to develop that will be tested and then analysed. This analysis will determine which features on the design are worth investing time in refining or bringing over to new designs. In doing so, the team will create the next batch of designs that will again follow the same process. This design process will continue until the team has found a design that fits the criteria set. Ending with a Refined and finished Concept car that will be compared to the Plus 4 Teams' final design.

6.2 Body research (2404454 – Dominic)

6.2.1 Streamlined Fastback – Research on Body Type

Figure 82: Ferrari 250 GTO



Ferrari 250 GTO (Top Gear, 2023)

I researched into the Streamlined Fastback, this design highlights bold styling with good aerodynamic function (Ferrari, 2022). The wide and rounded fenders give the car a more planted stance, while the long curves help keep airflow attached to the body. This lowers turbulent air and improves stability and predictable handling at speed. The longer bonnet lets the engine to be set further back in the chassis, which gives this design much better weight distribution and makes the car feel more balanced and responsive overall.

6.2.2 Fastback – Research on Body Type

Figure 83: 1968 Mustang Fastback restomod



1968 Mustang Fastback restomod (MotorBiscuit, 2022)

I researched closely at the pure Fastback shape and how its roofline affects aerodynamics. The researchers found that a roof sloping smoothly from the windshield all the way to the rear bumper helps air follow the surface rather than separating and creating drag (MustangSpecs.com, 2019). This uninterrupted slope reduces flow separation, which improves stability. The study also confirmed that making the rear screen angle shallower—laying it back more—helps airflow stay attached to the glass, further boosting efficiency (MustangSpecs.com, 2019).

6.2.3 Modern GT – Research on Body Type

Figure 84: Amg gt



Amg gt (Mercedes-Benz UK, 2023)

the Modern GT takes an advanced approach to aerodynamics. Smooth, flowing surfaces lower drag and improve fuel efficiency a lot, but the body is also very carefully sculpted to improve high speed stability and performance. A lower centre of gravity and optimised weight distribution make these style of cars a more responsive and supply a balanced feel behind the wheel. Mercedes-Benz also notes that many Modern GTs now feature active aero systems like moving spoilers or shutters that adjust to improve efficiency at lower speeds and stability when pushing harder (Mercedes-Benz UK, 2023).

6.2.4 Teardrop – Research on Body Type

Figure 85:jaguar e type



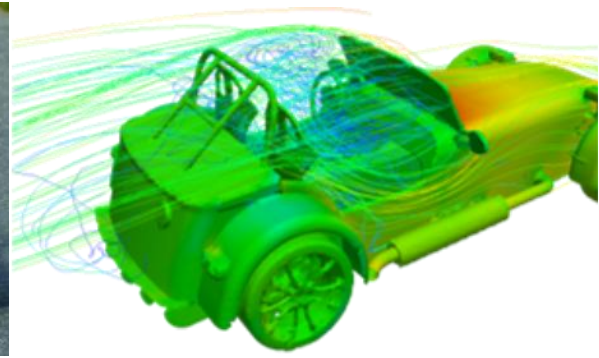
jaguar e type (Wikipedia, 2026)

Looking into the Teardrop shape, it strikes an effective balance between classic style and aerodynamic efficiency (E-Type UK, 2023). Its smooth and tapering rear reduces drag far better than more muscular or cut-off designs, yet it still retains a timeless presence. For a car producing around 250 bhp, this shape is well suited; the Morgan Plus 4 does not need extreme modern aero tricks to perform. The teardrop is naturally efficient enough to make the most of that power without the added weight or complexity of active aero systems found on modern GTs (E-Type UK, 2023).

6.3 Current problems and possible solutions (2404454 – Dominic)

6.3.1 Morgan Plus 4 – Current Design Problems

Research into the Morgan Plus 4 reveals a number of fundamental design challenges that stem from its heritage-focused construction. The Plus 4 was never designed with aerodynamic efficiency in mind, it is essentially a pre-war body shape still being produced today. This outdated form leads to significant wind buffeting and air recirculation, particularly when running aero-screens or with the soft-top folded down. The result is that fuel efficiency suffers noticeably at motorway speeds, purely due to the drag created by the bluff, unoptimized bodywork.



1957 morgan plus 4 (hemmings 2024) wind buffeting (MakerStuff, 2017)

6.3.2 Cooling System – Current Problems

Figure 86: Morgan Plus 4



Morgan plus 4 (top gear, 2024)

The cooling system on the Morgan Plus 4 presents its own set of issues rooted in the classic design. GoMoG (n.d.) notes that the radiator intake is simply too small. The combination of the classic grille and cowl design restricts airflow significantly, especially in slow-moving traffic or when pushing the car harder. This leads to another common problem: under-bonnet heat soak. The long, elegant bonnet that defines the car's look also traps heat effectively, causing the engine bay to overheat and reducing overall reliability (GoMoG, n.d.).

6.3.3 Cooling Improvements – Research on Solutions

looking into these cooling challenges requires targeted modifications instead of a complete redesign. a paper by Chai (2022) says placing extractor louvers in areas where internal pressure is higher than the outside airflow, specifically just after the radiator or right at the top of the engine bay just Infront of the windshield. When properly located, these louvers allow hot air to exit rather than recirculating under the bonnet, which

increases through-flow and reduces turbulence. Chai (2022) emphasizes that placement is critical, race louvers must match the duct path to be effective.

6.4 Aerodynamic Improvements – Research on Solutions (2404454 – Dominic)

Figure 87: Jaguar d type



Jaguar d type (GTspirit, 2014)

The intake should be placed exactly at the high-pressure point in the nose to maximise airflow. Second, a smooth, sealed duct should lead directly to the radiator, preventing any spillage into the engine bay (ResearchGate, 2018).

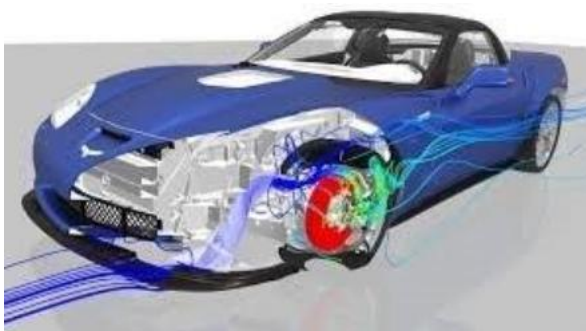
Figure 88: Triumph Experience 2020



Triumph Experience 2020

Third, large louvered extractors on top of the bonnet ensure air flows through the radiator rather than swirling around uselessly inside. Chai (2022)

Figure 89: Siemens Digital Industries Software



Siemens Digital Industries Software

Finally, True Geometry recommends providing separate brake cooling ducts so that turbulent air from the brakes does not pollute the cleaner air flowing to the radiator intake.

6.5 Possible aero devices (2404454 – Dominic)

6.5.1 Underbody Sealing – Research on Aerodynamic Function

Figure 90: Examples of Side skirts

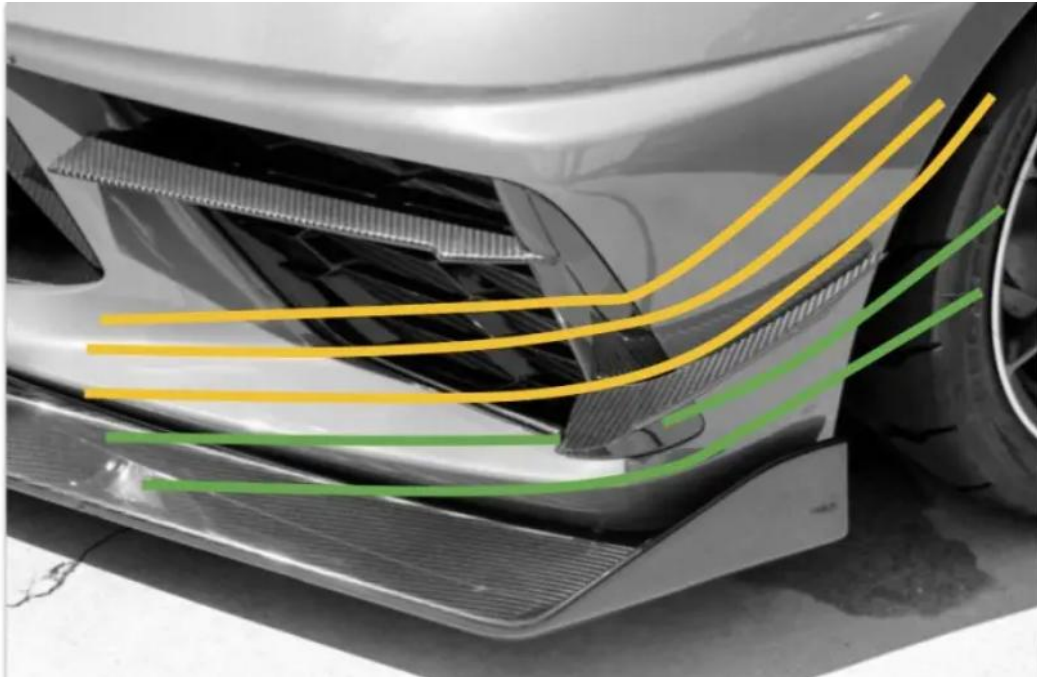


Side skirts (Formula 1 Dictionary)

Researching into underbody aerodynamics shows the importance of sealing off the floor to maximise downforce. According to Formula 1 Dictionary (n.d.), if you seal off the low-pressure area under the car it will stop outside air from leaking in underneath and distorting ground-effect downforce. By containing the low-pressure zone, the underbody can generate and maintain suction more effectively, pulling the car down toward the road for improved grip and stability.

6.5.2 Front Downforce Generation – Research on Splitters

Figure 91: Example of Splitters



Splitters Max Kuchen (2025)

Max Kuchen (2025) explains how the front end creates downforce through management of airflow. A splitter forces air up and over the car, creating a high pressure zone above the car and a low-pressure zone below. The addition of fences on the end of the splitter stops this high-pressure air from spilling off the edges, preserving the pressure that generates downforce at the front axle (Kuchen, 2025).

6.5.3 Underbody airflow – Research on Underbody Flow

Figure 92: Example of a Flat Floor Design



Scott Mansell (2024) goes over the role of smooth and fast airflow under the car, which aids in reducing turbulence and drag. When the underbody is properly shaped, it accelerates airflow under the car which lowers pressure and increases suction pulling it into the ground. This clean flow then allows the rear diffuser to work more effectively, expanding the air gradually to further reduce drag and generate additional downforce (Mansell, 2024).

6.5.4 Wheel Well Management – Research on venting air

Figure 93: Wheel Arch Vents



Wheel arch vents Rob Capaldi (2025)

Rob Capaldi (2025) paper points to the wheel wells being a major source of aerodynamic inefficiency. huge amounts of Turbulent, high-pressure air gets trapped in the wheel wells which create lift and drag, hurting both straight line speed and cornering grip. By venting this turbulent air, lift is reduced, front tyre grip improves, and brake cooling can also benefit from cleaner flow through the wheel assembly (Capaldi, 2025).

6.5.5 Rear Wing Cleanliness – Research on Downforce

Figure 94: Swan Neck Wings



Why porsche uses a swan neck Amreetam Basu (2024)

Amreetam Basu (2024) emphasizes the importance of keeping the underside of a rear wing clean and unobstructed. This lower surface is where downforce is primarily generated, and any disruption to the airflow here reduces effectiveness. By ensuring clean air reaches this area, the wing can produce more rear downforce with less associated drag, improving overall efficiency.

6.6 Reference points (2403677 - Alex)

Reference points are values that the team uses to compare between models and gauge how well each simulation performs. This provides an objective way to determine and compare models without relying on guesswork. The reference points used in this methodology included the coefficient of drag and lift, pressure and velocity at specific points on the car, the centre of pressure, and flow separation behaviour.

The Coefficient of Drag and Lift were the main points of reference as it was a quick and easy way to determine the overall characteristics of the bodywork, as a secondary point of reference, we looked at the pressure and velocity at multiple points over the bodywork, key areas such as on the front splitter, on the top of the car, the wake/rear of the car and the underside of the car. The team outlined these key areas at the start of the research as they carried importance secondary to the overall Drag and lift.

The Pressure and velocity around the front of the car is important as the Morgan Plus 4 has a problem of overheating. Airflow through the engine bay is not part of the team's design philosophy due to time constraints and complexity but the team made it a side note to keep the pressure high on the front of the car as future consideration for a overheating solution.

The top of the car was also a point to look for as it was the main area where low pressure built up, and as it was on top of the car it caused lots of lift, opposite to what the team was looking for. The engineers couldn't design the windshield and the top of the car to a high degree as it had to adhere to the original roll cage. Due to time and complexity constraints the team didn't do more research into air deflectors and vortex generators to remedy the issue, but the engineers kept it as a point to keep in mind during the design phase.

The rear of the car was important as the team did plan to add a wing onto the rear of the car, this required clean airflow to maximise its effects. This meant the engineers had to come up with designs that kept the airflow stuck to the back of the car, making sure it wouldn't interfere with the rear wing as if it separated too quickly from the rear of the car, the negative pressure would disrupt the airflow around the wing.

The main consideration of the bodywork the engineers had was the underside of the morgan. As a team we decided to focus on underbody downforce, utilising the long rear deck of the morgan as the roll cage and chassis limited the design freedom on the upperbody. Utilising ground effect, the engineers main design points were to maximise the amount of air going under the car, as to speed it up and create a negative pressure zone which in turn creates downforce.

6.6 Design Iteration (Alex)

The iterative design philosophy the team decided to use was a batch strategy, the engineers made 3 to 4 designs per batch with differing designs depending on which batch then took the best design on the batch and iterated on that design conforming to the needs and goals of the next batch.

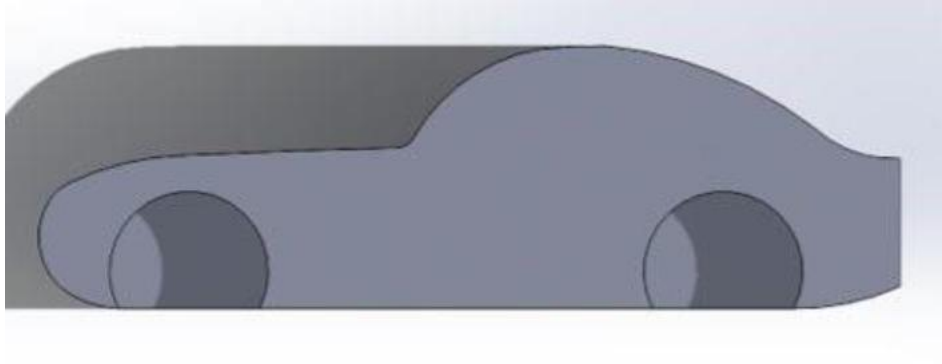
6.6 Batch 1 (Alex)

The first batch's philosophy was finding a general bodywork design, not just the best coefficient of drag and lift, but a design which would be easy to iterate and design with that still matches and conforms to the original Morgan Plus 4 chassis. The team took inspiration from motorsport vehicles in multiple classes and era's to find what would work best with the needs of the Morgan chassis and the teams' own goals.

6.6.1 Model designs (2404454 – Dominic)

6.6.1 design 1 – Curved Front End with Kamm Tail

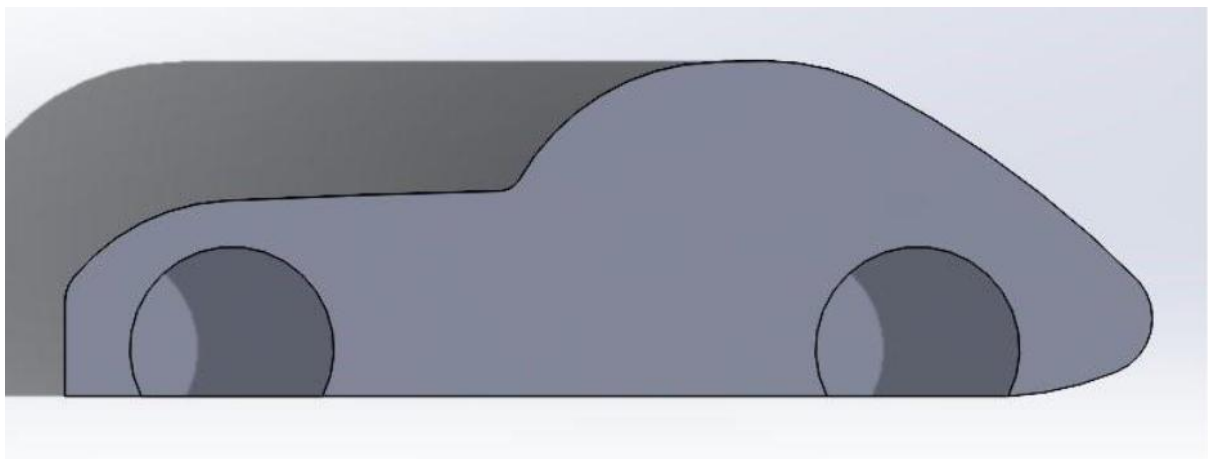
Figure 95: Concept Design 1



The first design concept takes a straightforward approach to drag reduction. It features a curved front end, which helps air flow smoothly around the nose of the car with minimal disturbance. This curvature reduces the initial impact of the air and encourages attached flow along the bodywork. The roofline is rounded, further helping to guide air toward the rear without early separation. At the back, a short Kamm tail provides a compromise between aerodynamic efficiency and styling—it cuts off the airflow cleanly to reduce drag while maintaining a compact appearance.

6.6.2 Design 2 – Porsche 911-Inspired Lines

Figure 96: Concept Design 2

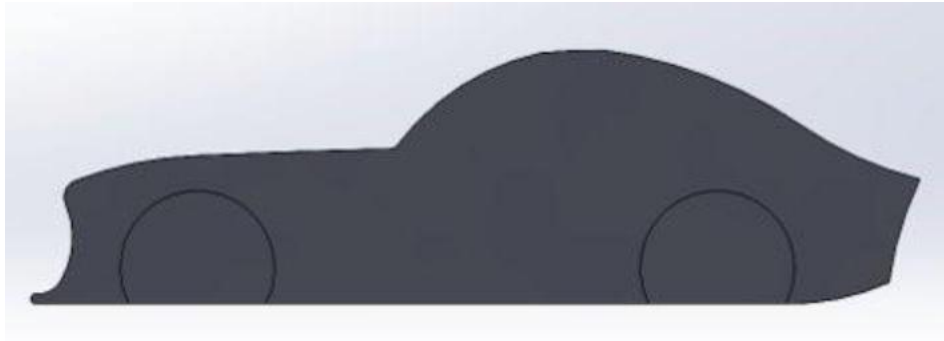


The second design draws clear inspiration from the classic Porsche 911 shape. It follows similar body lines, with a rounded profile and a long, sloping rear end. A notable feature is the flat spot on the front bumper, which houses a grille for cooling intake. This flat section creates a small stagnation zone where pressure builds, helping to push air

into the radiator while the surrounding curves manage the airflow around the rest of the body. The design prioritizes a timeless aesthetic while incorporating functional cooling elements.

6.6.3 Design 3 – Marcos Mantis Inspiration with Long Kamm Tail

Figure 97: Concept Design 3



The third design takes inspiration from the Marcos Mantis, incorporating more aggressive aerodynamic features. It includes a front splitter, which forces air to travel up and over the car while creating a low-pressure zone underneath to generate front downforce (Kuchen, 2025). The front bumper also features a curve designed to deflect air in two directions—some into the grille for cooling, and some up and over the bonnet to manage flow toward the windscreen. The roofline remains rounded, but at the rear, a long Kamm tail extends the body before cutting off abruptly, helping to reduce drag and improve stability by controlling airflow separation (Moto Gallery, 2025).

6.6.4 Design 4 – Streamlined Shape with Covered Rear Wheels

Figure 98: Concept Design 4



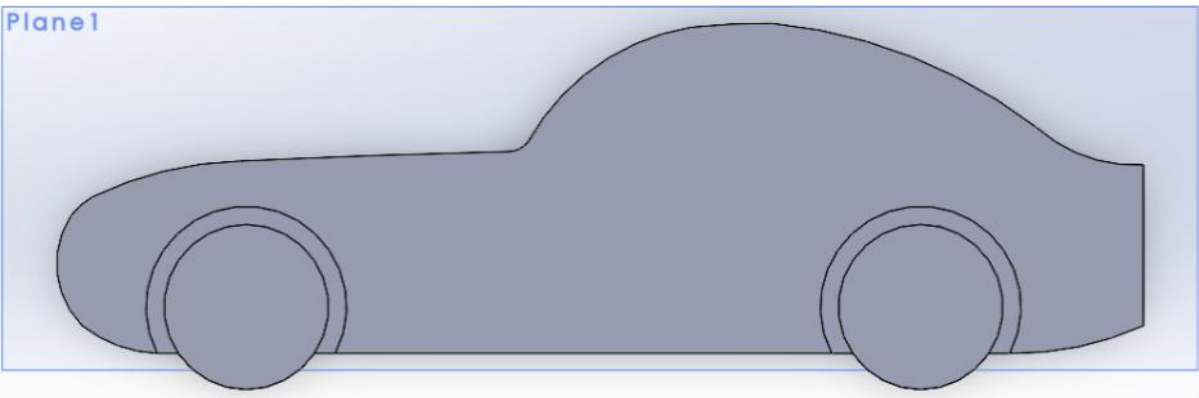
The fourth design is the most aerodynamically focused of the group. It features a streamlined shape with a flat spot on the front for a grille, similar to Design 2, but the surrounding surfaces are carefully rounded to manage airflow in a more sophisticated way. The front end is curved on both top and bottom surfaces, designed to throw air both under the car and over the top simultaneously. This approach aims to reduce the frontal area's impact while feeding clean air to both the underbody and the upper

surfaces. At the rear, the wheels are fully covered—a proven method for reducing drag and lift by preventing turbulent air from spinning inside the wheel wells. A long Kamm tail completes the package, extending the body to manage airflow before a clean cut-off reduces the wake and improves overall efficiency

6.7 Cfd results (2404454 – Dominic)

6.7.1 Design 1

Figure 99: Concept Design 1 (Results)



Drag- 0.41210423

Figure 100: Design 1 Result Forces Drag

Forces - Direction Vector (1 0 0)						
Forces [N]						
Zone	Pressure	Viscous	Total	Coefficients Pressure	Viscous	Total
floor	6.980495	2.5184498	9.4989448	0.020923572	0.0075488866	0.028472459
side	24.303585	1.650249	25.953834	0.072848389	0.0049465122	0.077794901
top	98.348648	3.6842511	102.0329	0.29479357	0.011043299	0.30583687

Net	129.63273	7.8529499	137.48568	0.38856553	0.023538698	0.41210423

Lift- 0.38877404

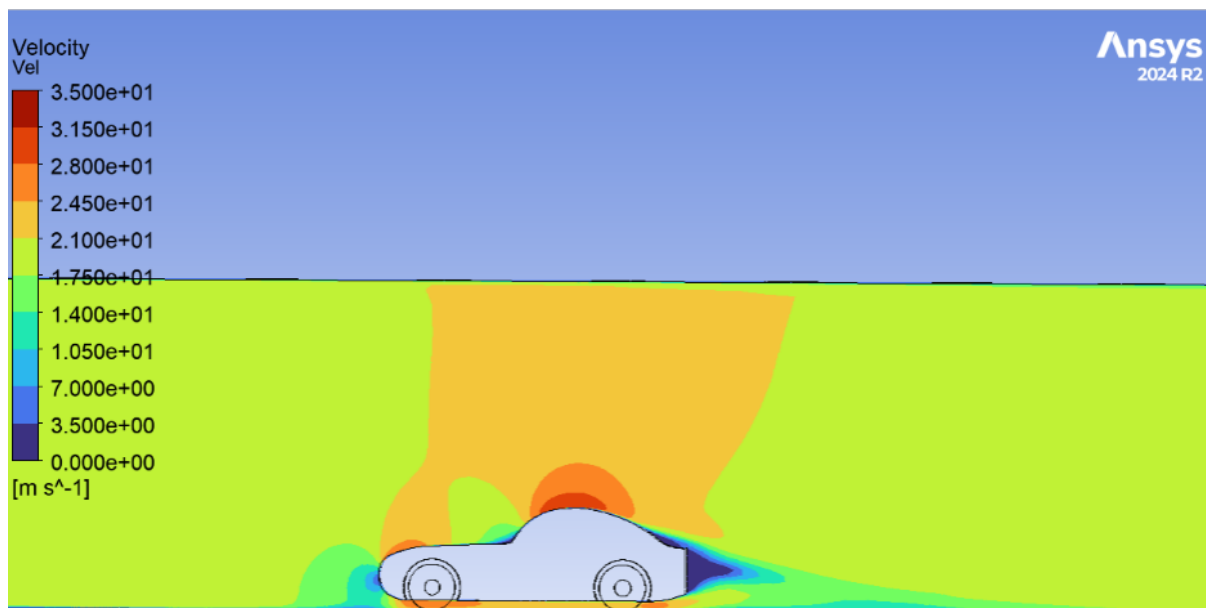
Figure 101: Design 1 Results Forces Lift

Forces - Direction Vector (0 1 0)						
Forces [N]						
Zone	Pressure	Viscous	Total	Coefficients Pressure	Viscous	Total
floor	-241.00266	-0.11199251	-241.11465	-0.72238952	-0.00033569014	-0.72272521
side	-30.60598	0.48889056	-30.117089	-0.0917394	0.0014654171	-0.090273983
top	400.27127	0.66275638	400.93403	1.1997867	0.0019865684	1.2017732

Net	128.66264	1.0396544	129.70229	0.38565774	0.0031162954	0.38877404

Velocity

Figure 102: Design 1 Velocity Contour



Pressure

Figure 103: Design 1 Pressure Contour

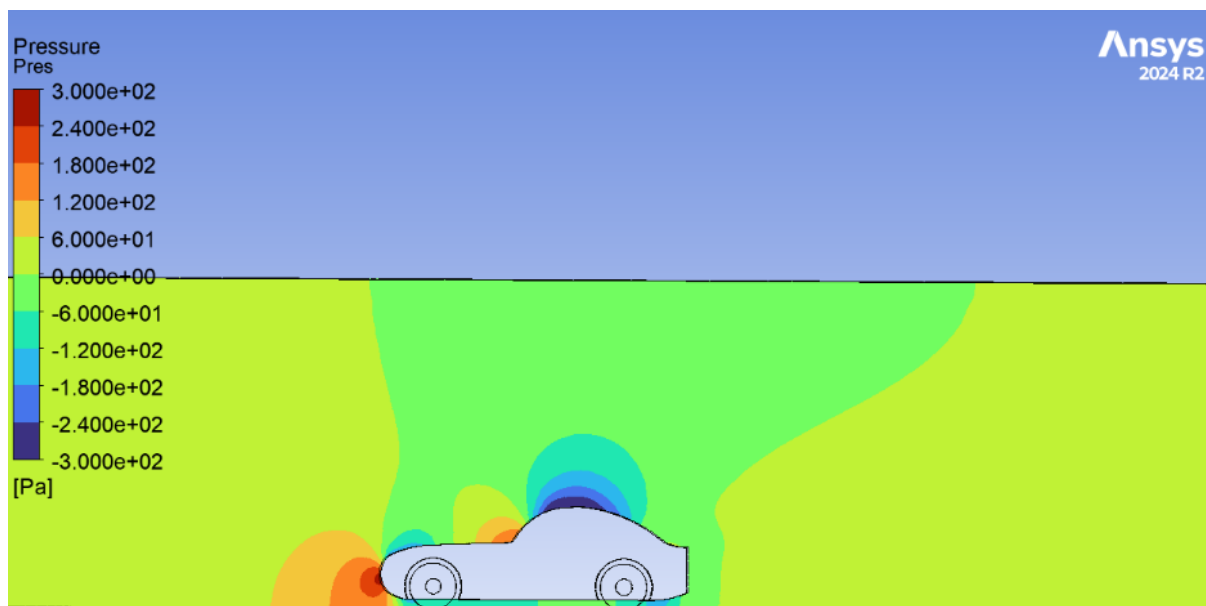
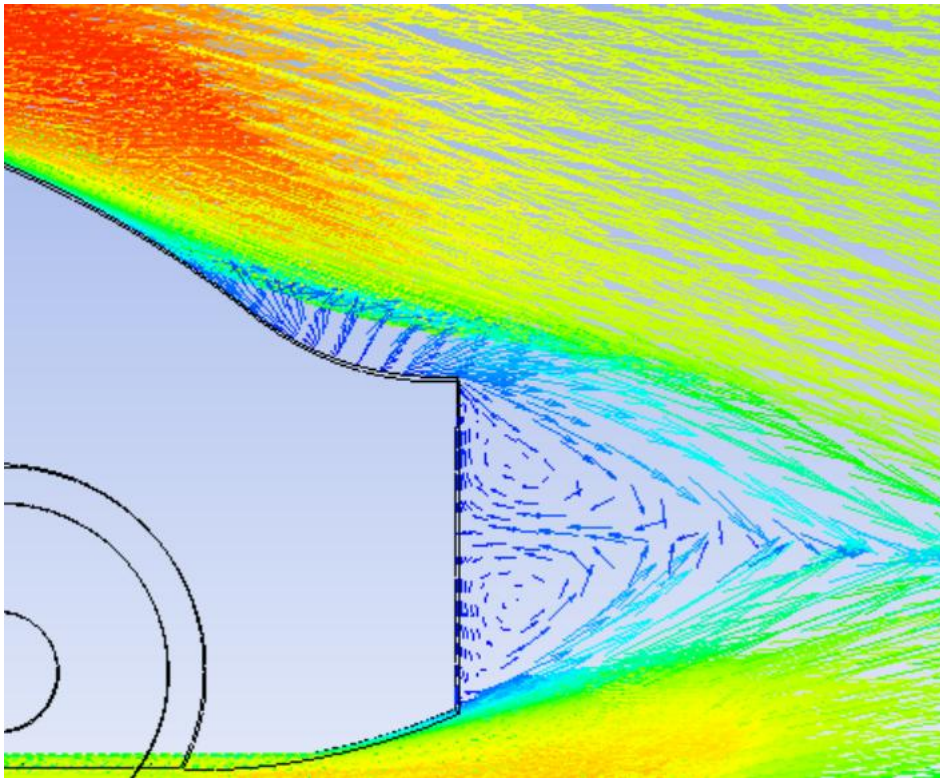


Figure 104: Design 1 Vector Wake Region



6.7.2 Design 2

Figure 105: Design 2 Velocity Vector

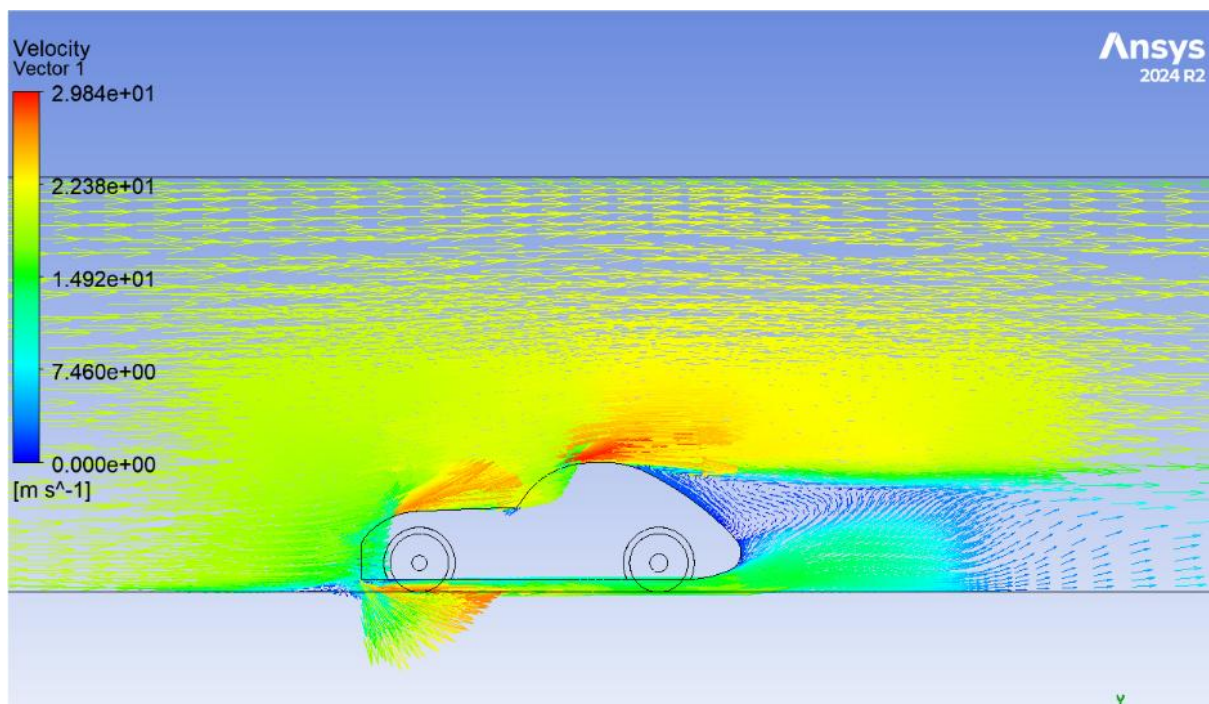


Figure 106: Design 2 Pressure Contour

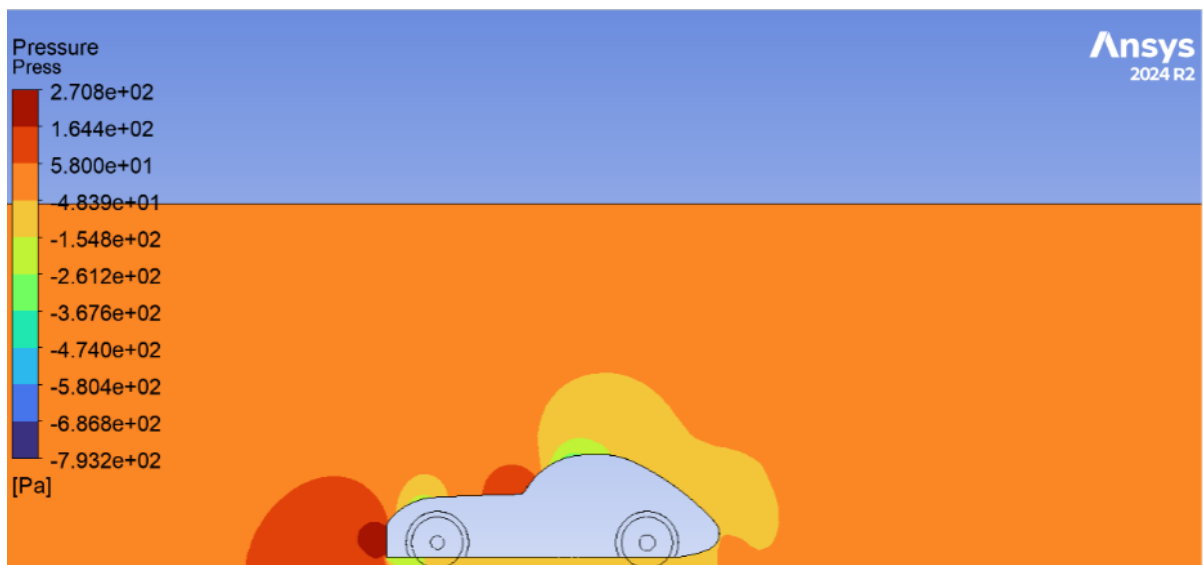


Figure 107: Design 2 Velocity Contour

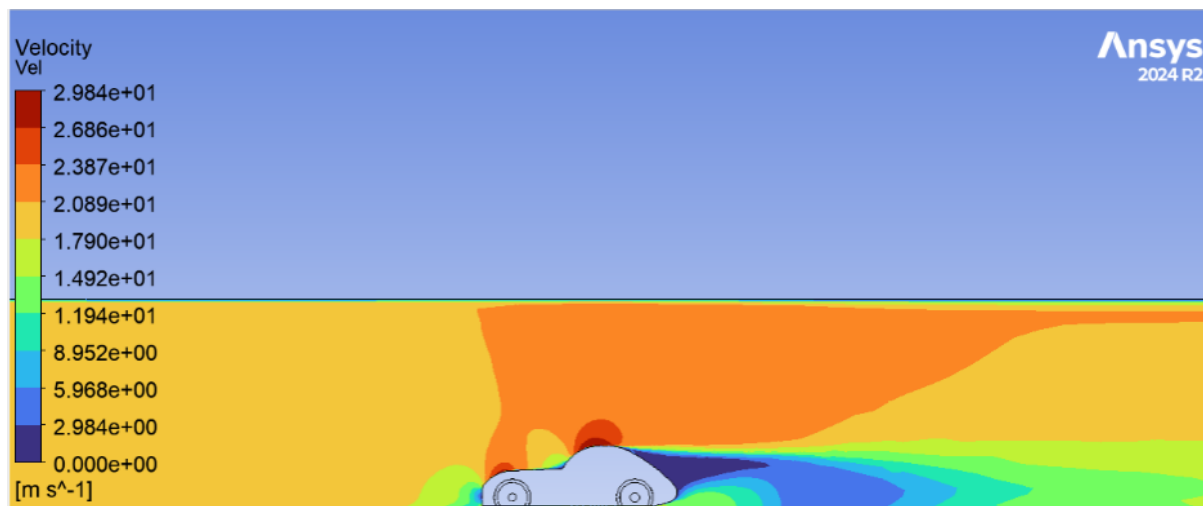


Figure 108: Design 2 Drag Plot

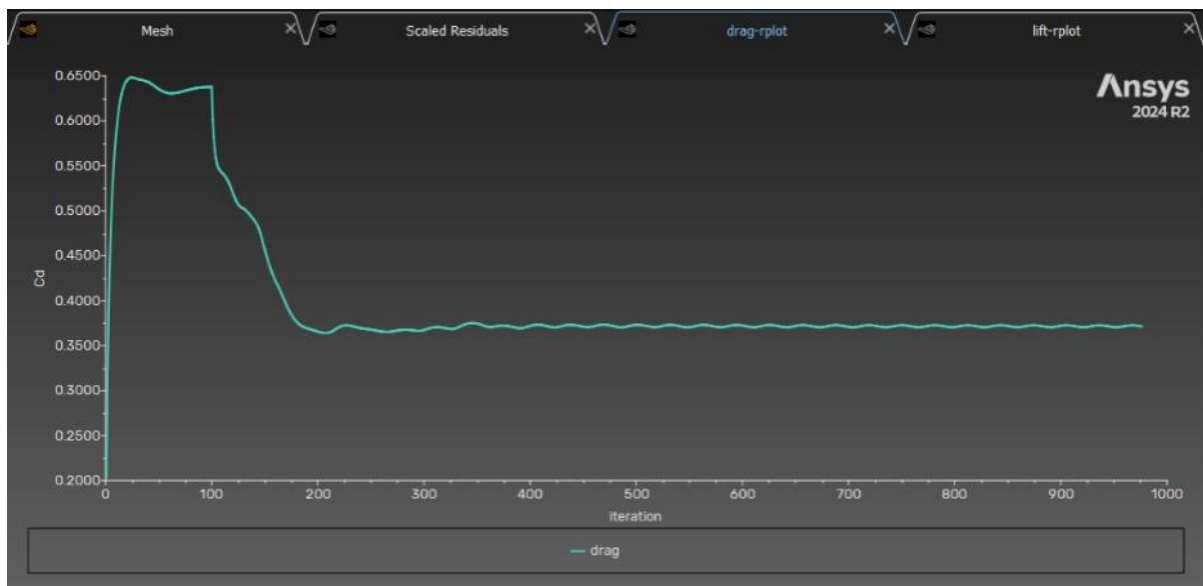
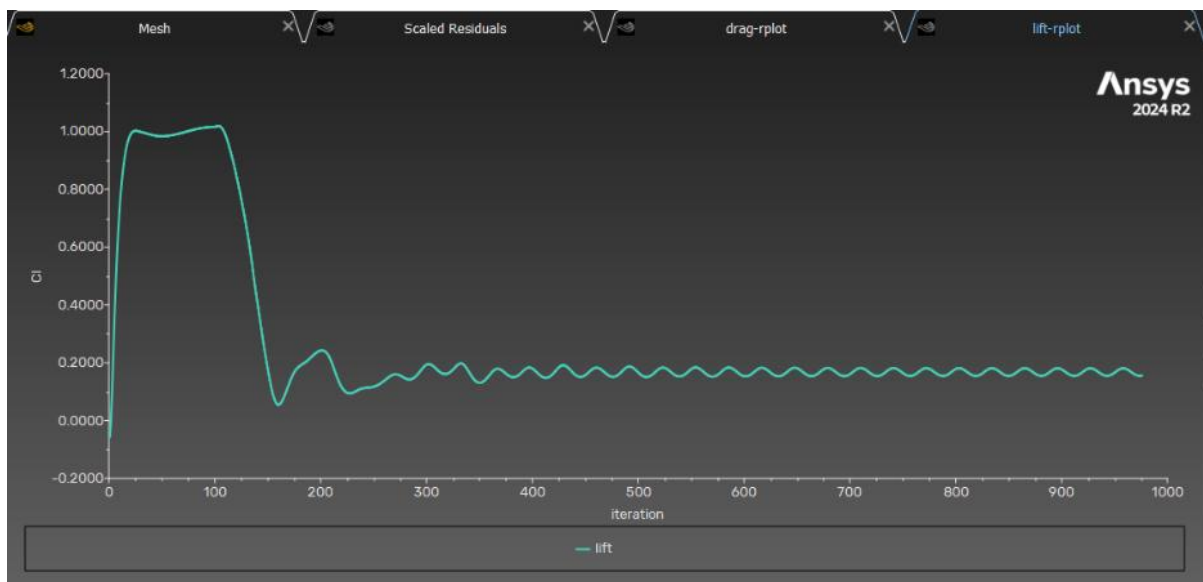


Figure 109: Design 2 Lift Plot



6.7.3 design 3

Figure 48: design 3 velocity vector

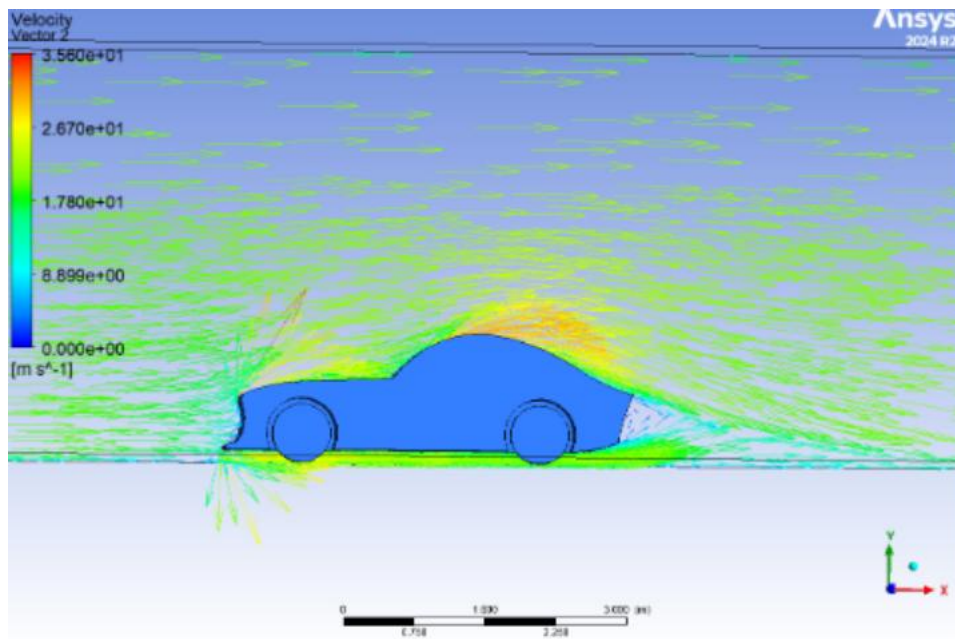
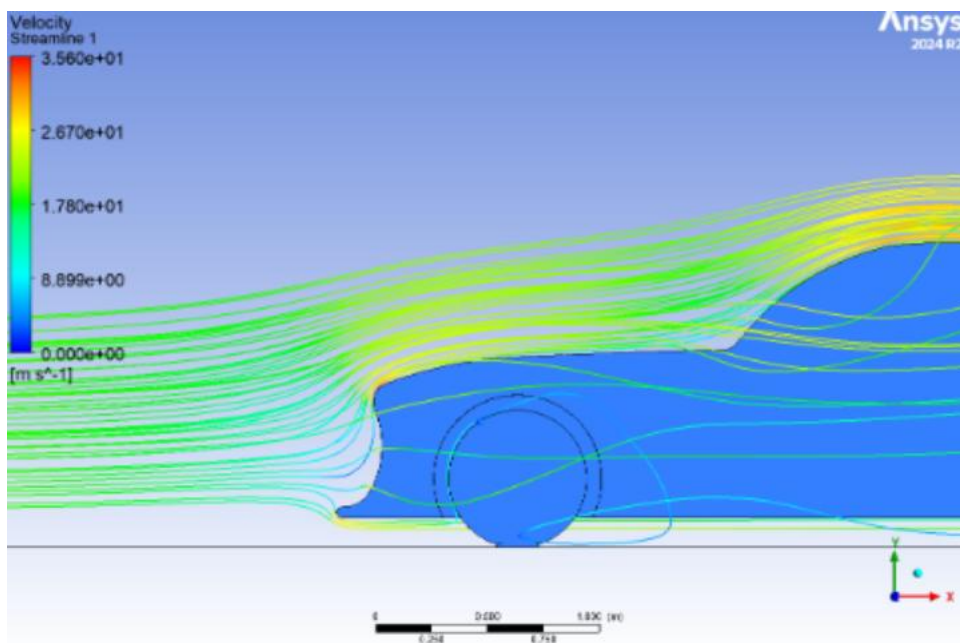


figure 49 design 3 velocity streamline



Drag - 0.40236109

Lift - 0.313797

6.7.4 Design 4

Figure 50: Design 4 (Results)



Drag- 0.42461285

Figure 51: Design 1 Result Forces Drag

Forces - Direction Vector (1 0 0)						
Zone	Forces [N]			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
gfloor	30.568264	3.071259	33.639523	0.094270719	0.0094715813	0.1037423
gside	20.945026	2.4776764	23.422703	0.064593223	0.0076410075	0.072234231
gtop	78.039963	2.5829573	80.62292	0.24067063	0.0079656875	0.24863632
Net	129.55325	8.1318927	137.68515	0.39953458	0.025078276	0.42461285

Lift- -0.012557652

Figure 52: Design 5 Result Forces Lift

Forces - Direction Vector (0 1 0)						
Zone	Forces [N]			Coefficients		
	Pressure	Viscous	Total	Pressure	Viscous	Total
gfloor	-344.31177	-0.035093784	-344.34686	-1.0618371	-0.00010822716	-1.0619454
gside	-18.368574	0.11022587	-18.258348	-0.056647597	0.00033993007	-0.056307667
gtop	358.18353	0.34972721	358.53326	1.1046168	0.0010785381	1.1056954
Net	-4.496809	0.4248593	-4.0719497	-0.013867893	0.001310241	-0.012557652

6.8.1 Batch 2 (2403677 - Alex)

This batch focused on the general bodywork of the new design. Seeing what will work with differing front and rear ends, where the air separates on the rear and bottom of the car and how the air reacts to the wheel wells.

6.8.2 Design 1 (2403677 - Alex)

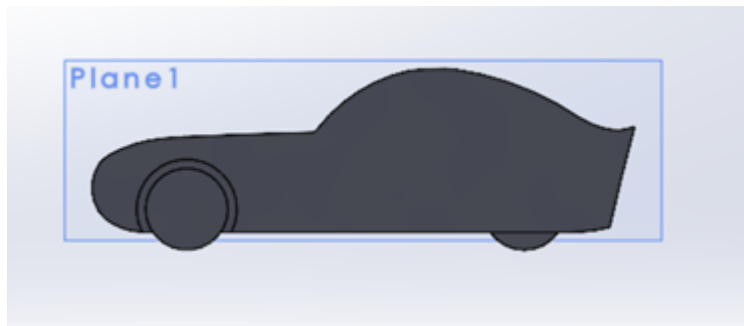


Figure 110

Drag = 0.2413

Lift = 0.2413

With covering the rear wheel wells, It helped keep the flow on the underbody more stable in turn increasing the negative pressure which means more downforce.

6.8.3 Design 2 (2403677 - Alex)

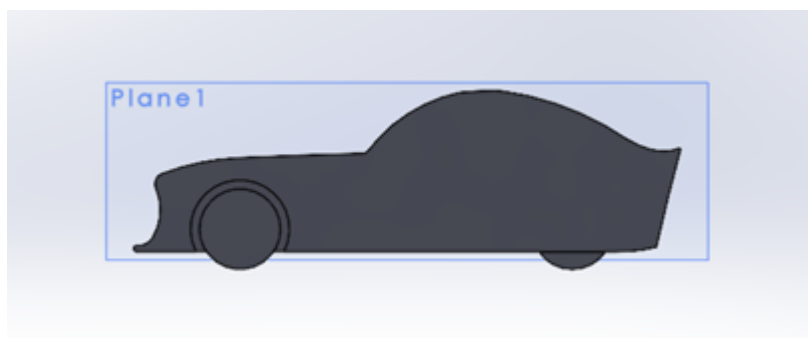


Figure 111

Drag = 0.4186

Lift = 0.3027

With the front splitter extending the length of the underbody, in theory this design would create more ground effect but in but due to the splitter not guiding any air under the car, the results came out as less negative pressure under the car.

6.8.4 Design 3 (2403677 - Alex)

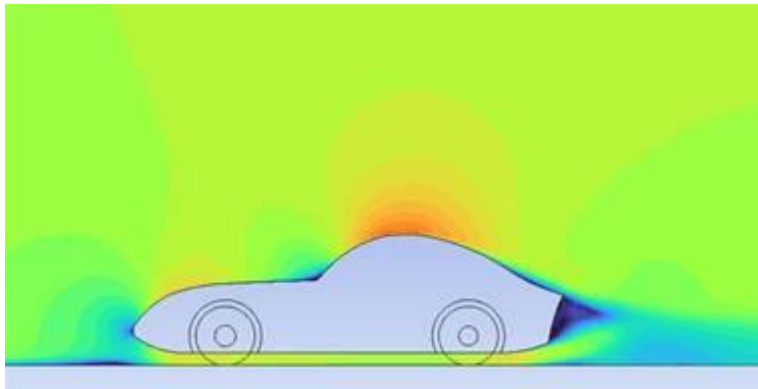


Figure 112

Drag = 0.3976

Lift = 0.5945

With more curve on this front splitter, the engineers hoped more air on the underside would increase the amount of negative pressure under the car which it did but with the increased surface area of the front end meant more air would be pushing against it. In addition, the rear spoiler of the car was removed as it was creating much more negative lift that anticipated and it would have impeded with future design plans for a wing. Even with this fact the team decided to continue with this design, and it had lower downforce and the team could test front splitter angles.

6.9.1 Batch 3 Rear (2403677 - Alex)

This batch focused on finalising the angles of the front and rear diffuser, trying to maximise the negative pressure under the car without causing any separation.

All rear end test were conducted with 0 degrees front angle

6.9.1.1 Design 1 (2403677 - Alex)

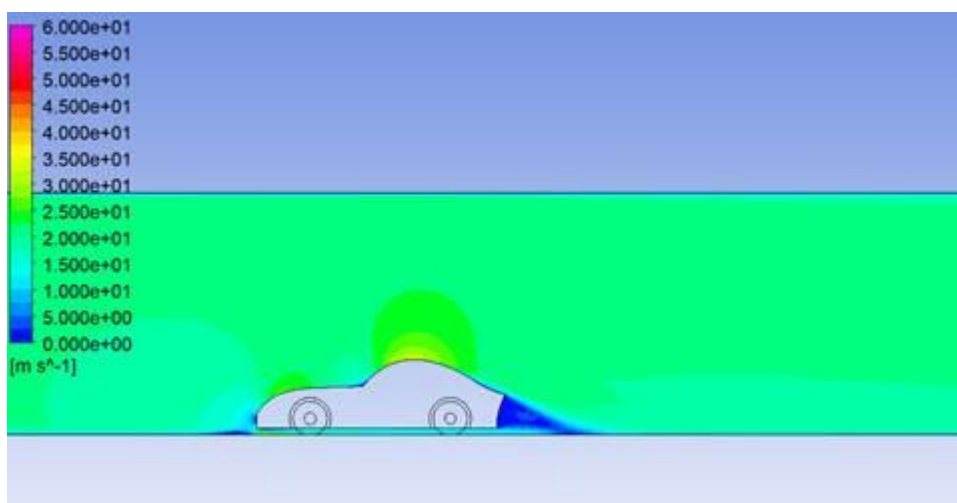


Figure 113

Flat rear

Drag = 0.4219

Lift = 0.5586

6.9.1.2 Design 2 (2403677 - Alex)

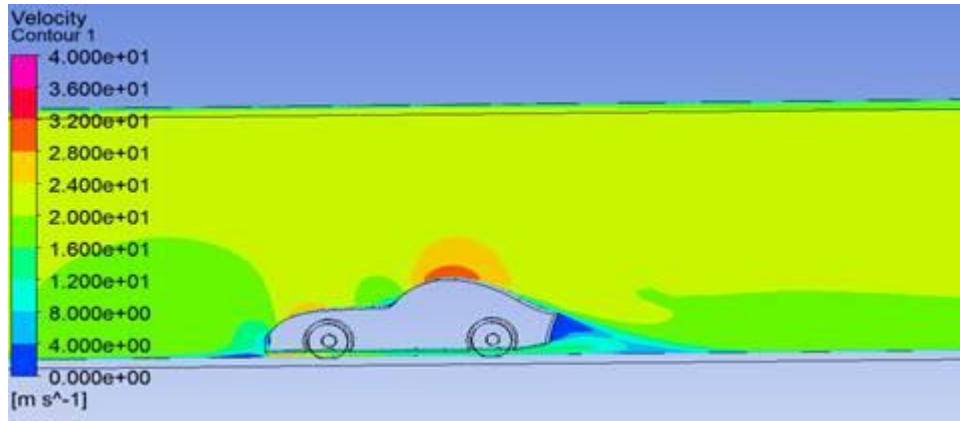


Figure 114

5 degrees with 10mm kick point

Drag = 0.4401

Lift = 0.5310

6.9.1.3 Design 3 (2403677 - Alex)

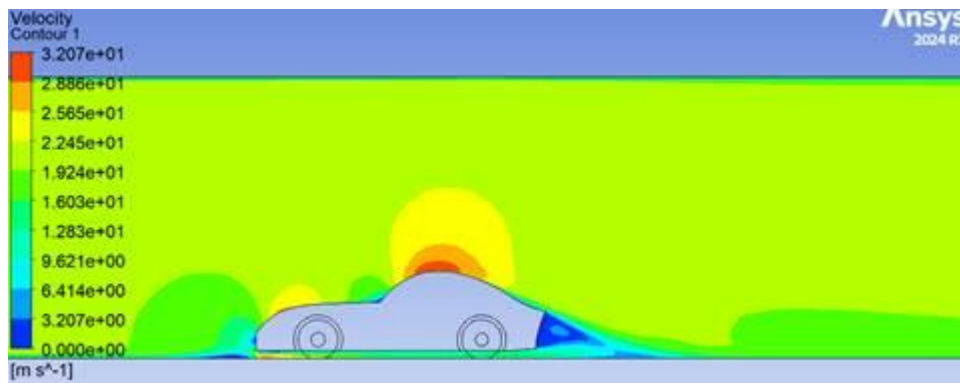


Figure 115

10 Degrees with 10mm kick point

Drag = 0.4405

Lift = 0.4990

6.9.1.4 Design 4 (2403677 - Alex)

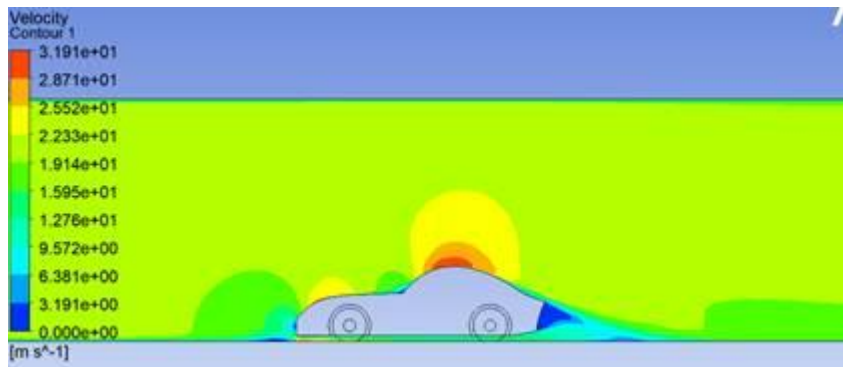


Figure 116

15 Degrees with 15mm kick point

Drag = 0.4479

Lift = 0.4906

6.9.1.5 Design 5 (2403677 - Alex)

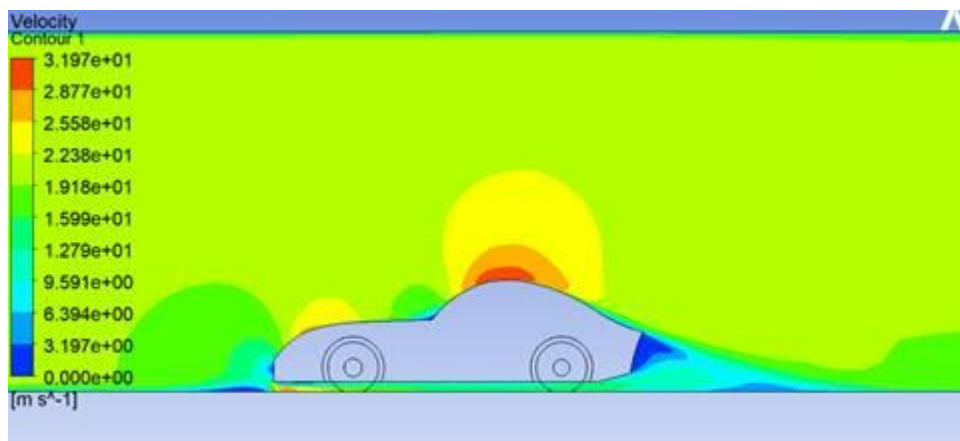


Figure 117

20 Degrees with 20mm kick point

Drag = 0.4393

Lift = 0.4934

6.9.1.6 Design 6 (2403677 - Alex)

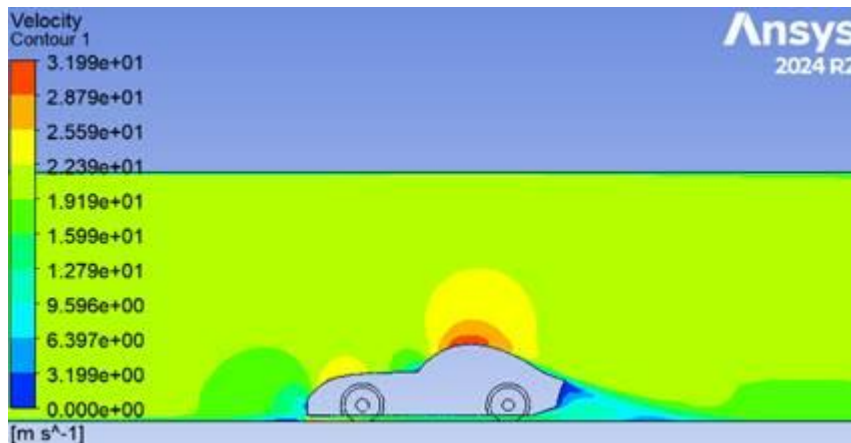


Figure 118

22 Degrees with 22mm kick point

Drag = 0.4353

Lift = 0.4705

6.9.1.7 Conclusion (2403677 - Alex)

With the rear angle getting bigger, the drag slightly decreases with the lift decreasing a lot. This is because the space between the airflow on the floor and on the rear of the car is greater meaning it has more room to create a negative pressure zone.

6.9.2.1 Batch 3 Front (2403677 - Alex)

All front-end test were conducted with 0 degrees rear angle

6.9.2.2 Design 1 (2403677 - Alex)

5 Degrees with 10mm kick point

Drag = 0.4547

Lift = 0.6936

6.9.2.3 Design 2 (2403677 - Alex)

10 Degrees with 10mm kick point

Drag = 0.4403

Lift = 0.7757

6.9.2.4 Design 3 (2403677 - Alex)

15 Degrees with 10mm kick point

Drag = 0.4418

Lift = 0.8837

6.9.2.5 Design 4 (2403677 - Alex)

20 Degrees with 10mm kick point

Drag = 0.4418

Lift = 0.9303

6.9.2.6 Conclusion (2403677 - Alex)

With the front angle getting steeper it increases the area which that the air pushes against it, this pushes the car upwards which is more than the increase in negative pressure it creates. A front end with minimal front angle would be optimal.

Outlined earlier in the report, Ansys files are quite fragile so in finalizing this batch of simulations the files corrupted with no way of getting the work back. With the time restraints the team could not go back and re simulate all the models to get photo evidence to back up the data.

6.10 Aero device research (2404454 – Dominic)

6.10.1 Single Element and multi element Rear Wings: Key Characteristics

6.10.1.1 Design & Physical Characteristics

Single-element wings feature a simple design, they have a single continuous airfoil surface that is very lightweight, inexpensive, and easy to manufacture with easy adjustability. They produce moderate downforce with low drag due to their clean flow structure and low profile. However, they are likely to an early stall at higher angles of attack, which limits their maximum downforce and causes a sharp rise in drag. This makes them ideal for street cars or tracks where minimising drag for top speed is the priority (NablaFlow, n.d.).

Multi-element wings utilise two or three stacked airfoils to generate significantly higher downforce, with triple-element designs producing roughly twice that of a single-element wing while maintaining a better downforce-to-drag ratio. Although they are heavier, more complex, and more expensive, their key advantage is stall resistance. The elements work together to keep airflow attached at extreme angles, delivering stable, predictable handling. This makes them essential for high-downforce applications like Formula 1 and endurance racing where maximum grip is required (NablaFlow, n.d.).

feature	Single element	Double element
weight	Very lightweight	Much heavier

Complexity	Very simple design with smaller endplates	Slightly more complex with bigger end plates
downforce	Decent downforce with small tunability	Higher downforce with much more tunability
drag	Low drag	Higher drag
Best for	Balanced performance / street	Race cars, high-G tracks

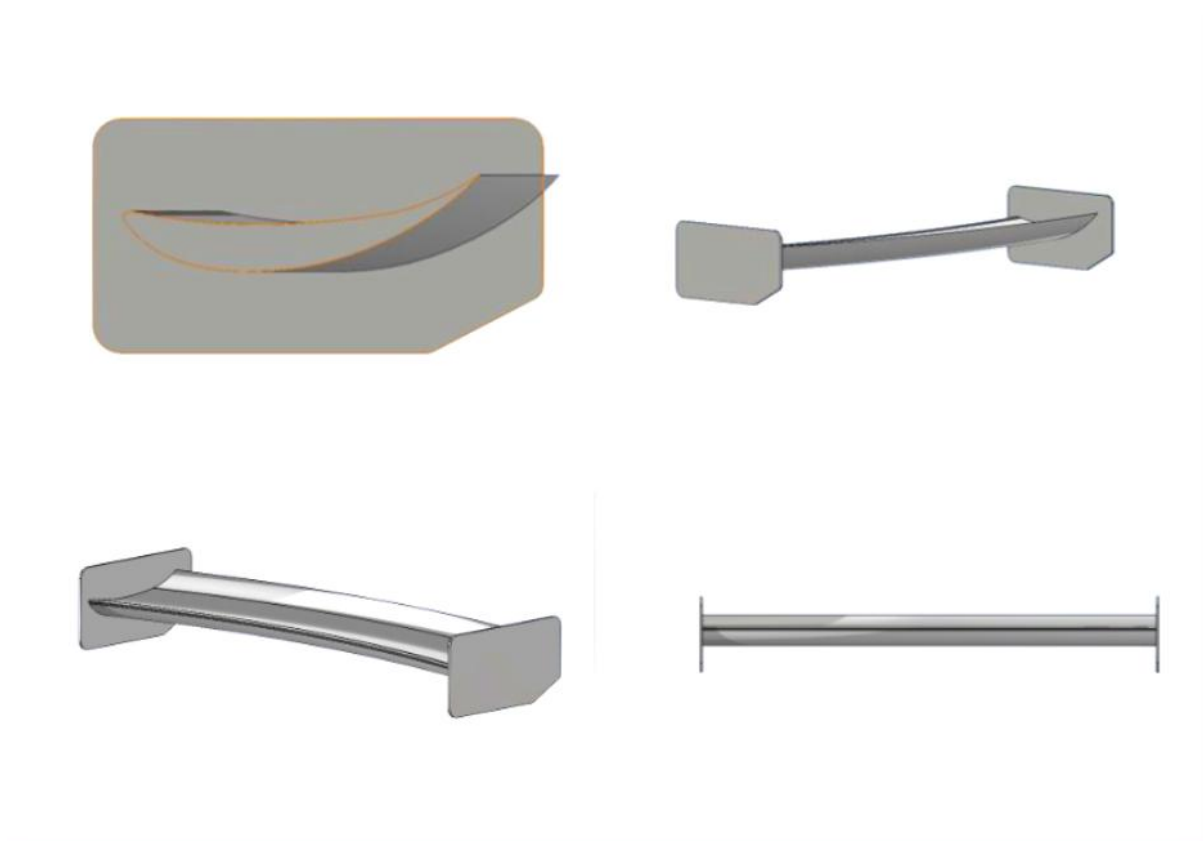
Table 8: Wing Characteristics

6.10.2 Wing choice

Choosing a single element rear wing would be the best suited option for the car, with its low power having too much drag will affect the top speed of the car and the car itself won't be able to get to a high enough speed for the dual element to be worth the extra drag, weight and cost.

6.10.3 Quick wing designs

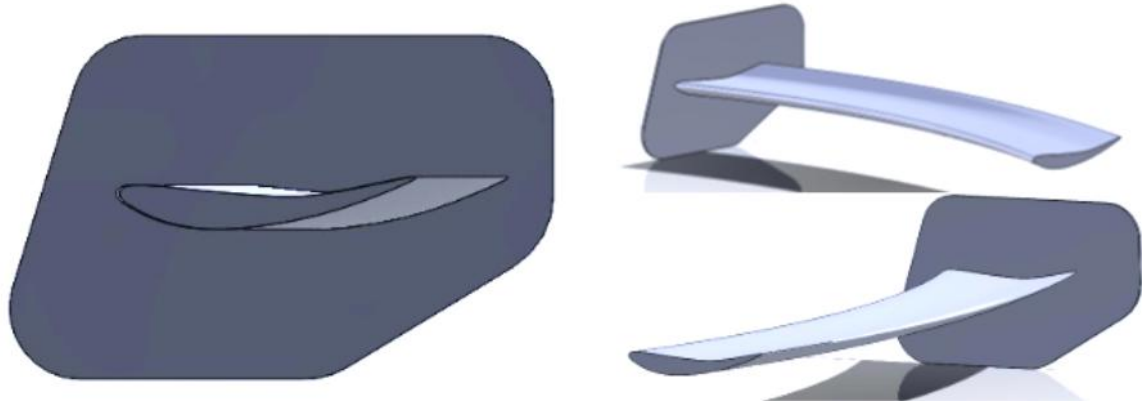
Figure 119: Wing Design 1



Curved high-camber arc wing, Strong camber with planform curvature will result in higher downforce and better flow attachment in yaw.

Simple arc and wing profile design for lower cost to manufacture and better predictability

Figure 120: Wing Desing 2

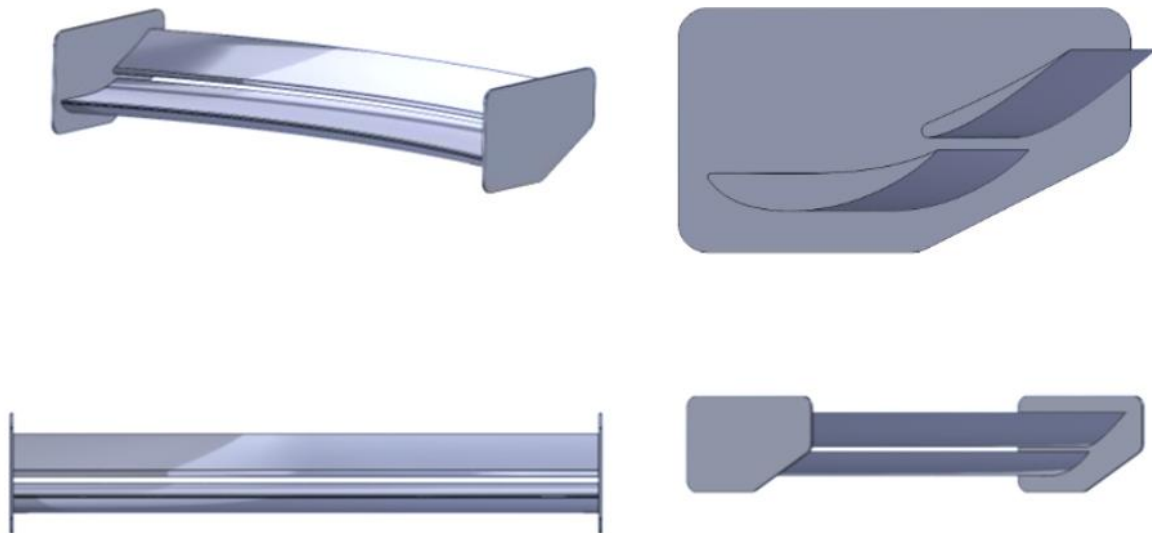


A smooth, elongated shape that narrows toward the tips

Gentle upward camber for downforce generation and better flow seperation

Curved top profile to improve airflow in yaw

Figure 121: Wing Design 3



Dual element wing for much higher downforce generation and better air separation

Wide top radius for better downforce in yaw

Much taller and longer than the other designs due to the second wing plate

These three designs were made using information from Campbell-Brennan, J., 2020

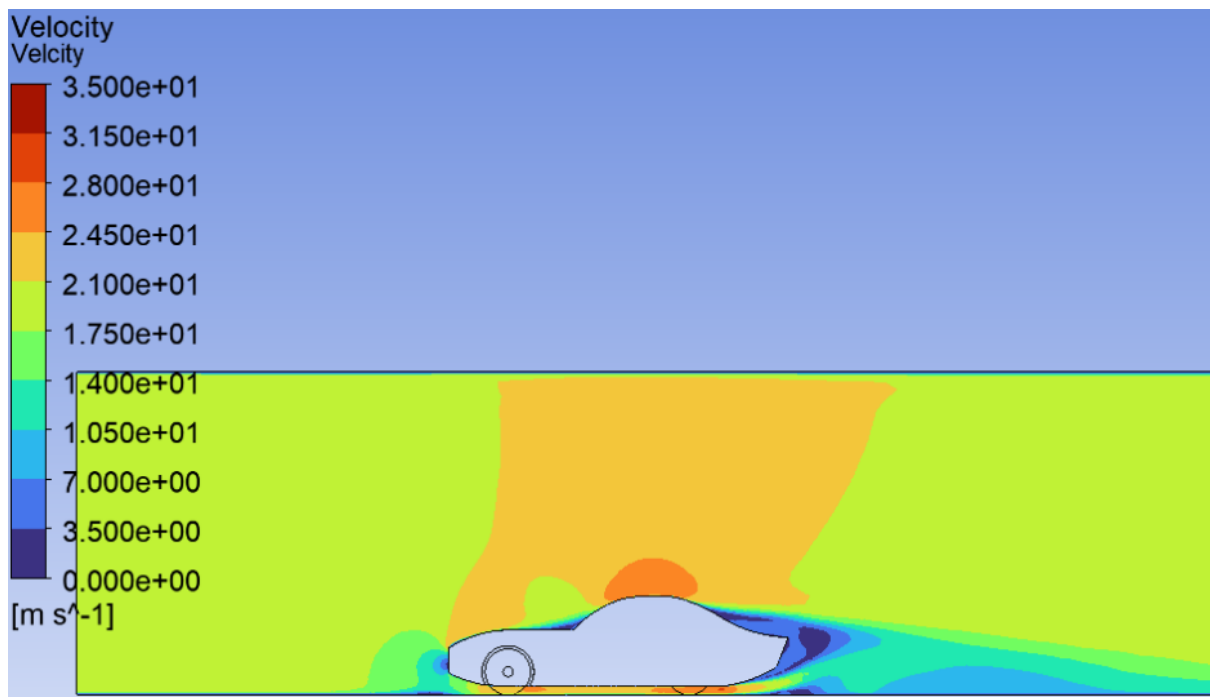
7.0 final design and aero considerations (2403677 – Alex)

7.1 final design data

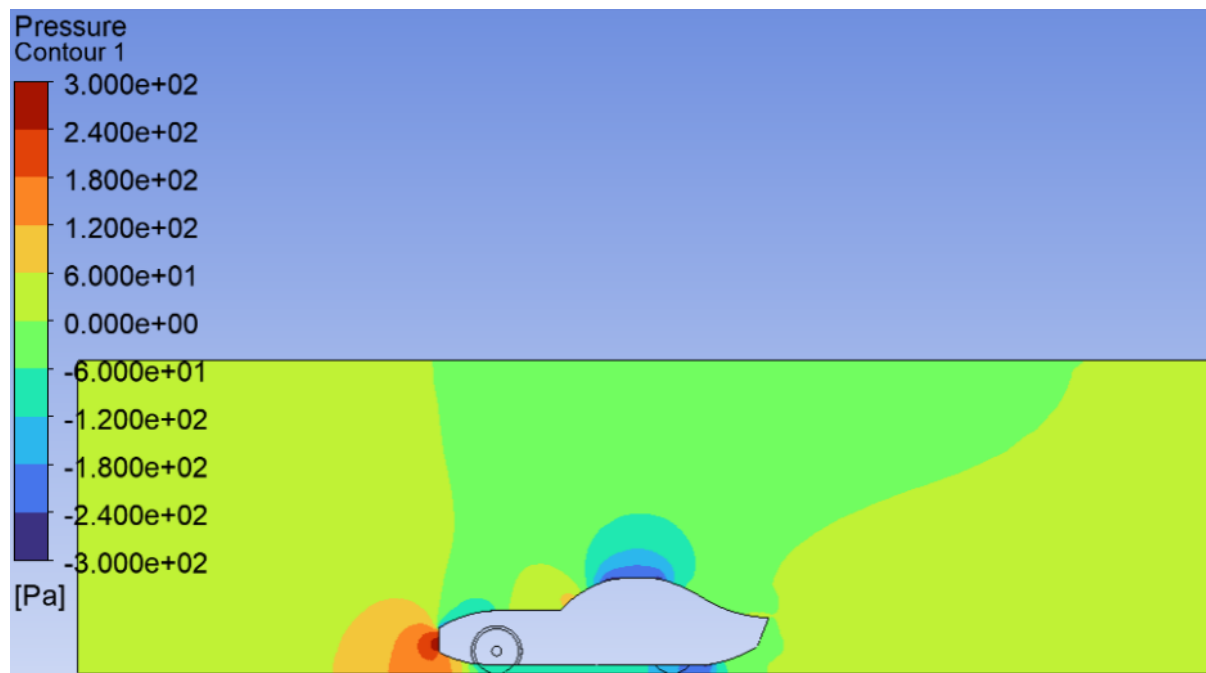
The team created a final design with consideration for a rear wing, we worked to make the airflow stay attached for as long as possible to make a wing easier to mount and position lower

7.2 Final design 1

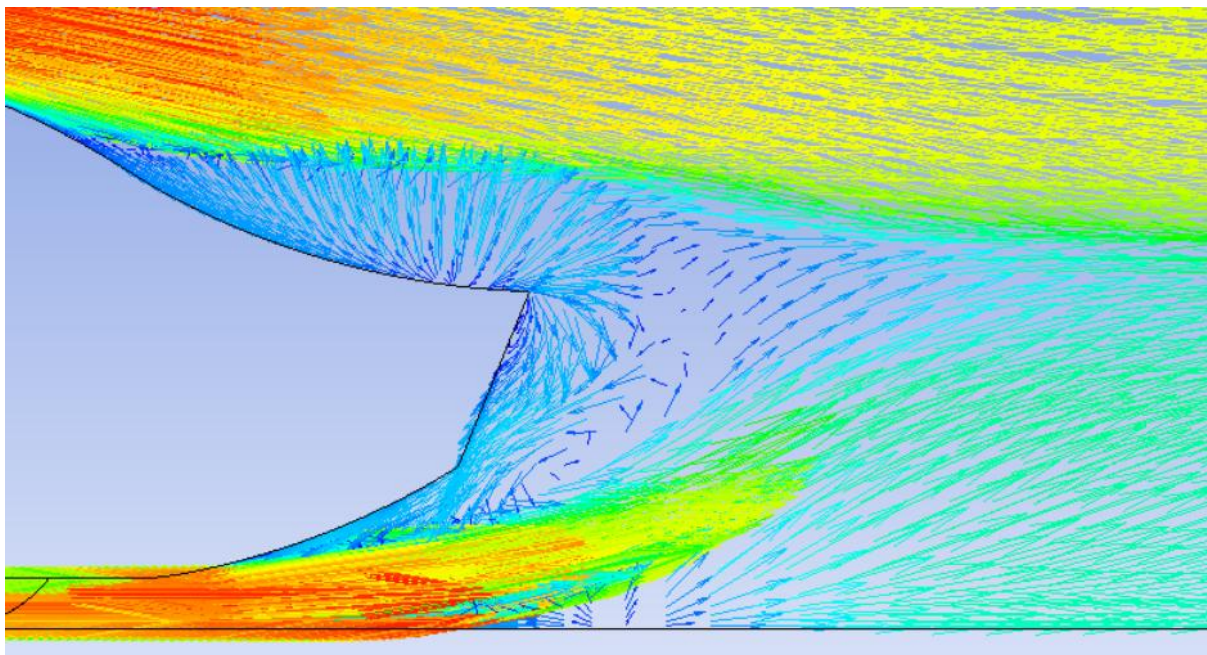
Velocity



Pressure

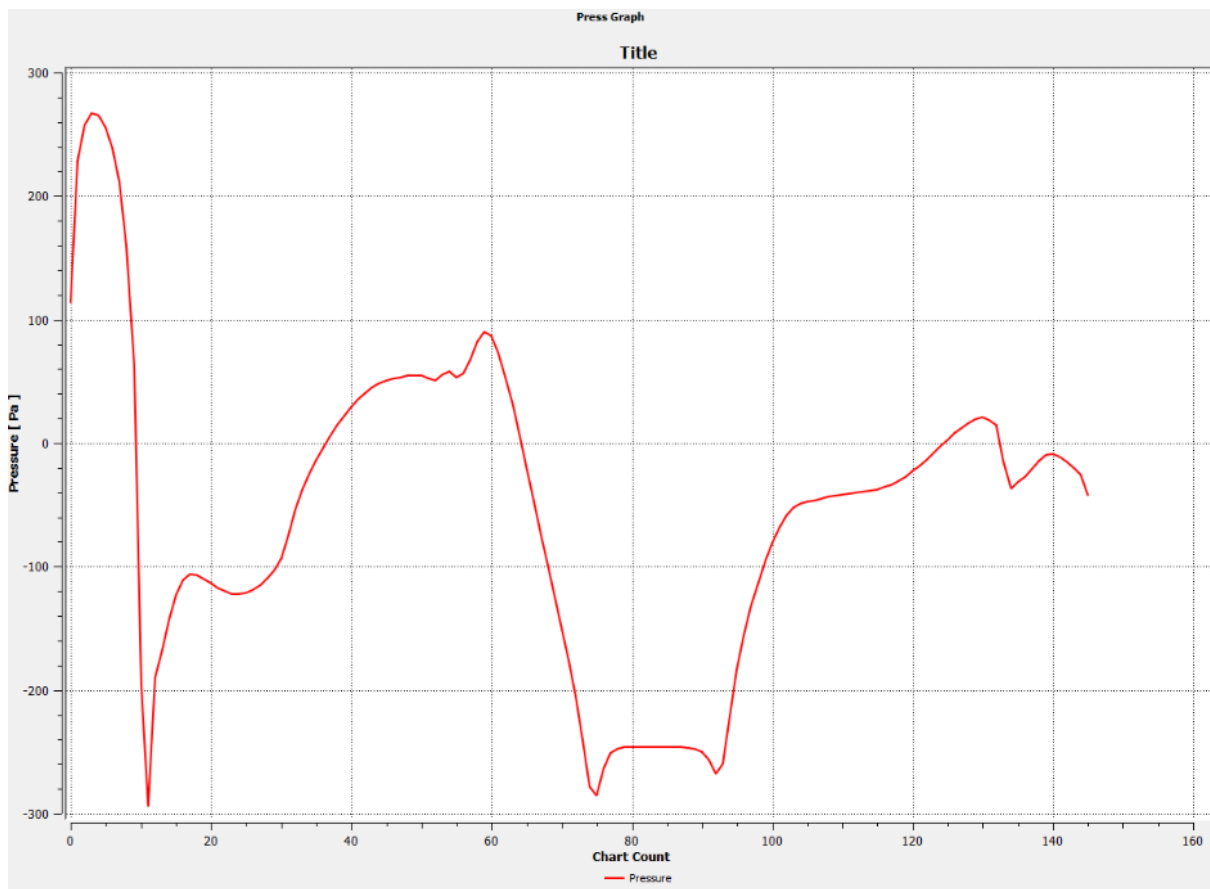


Velocity

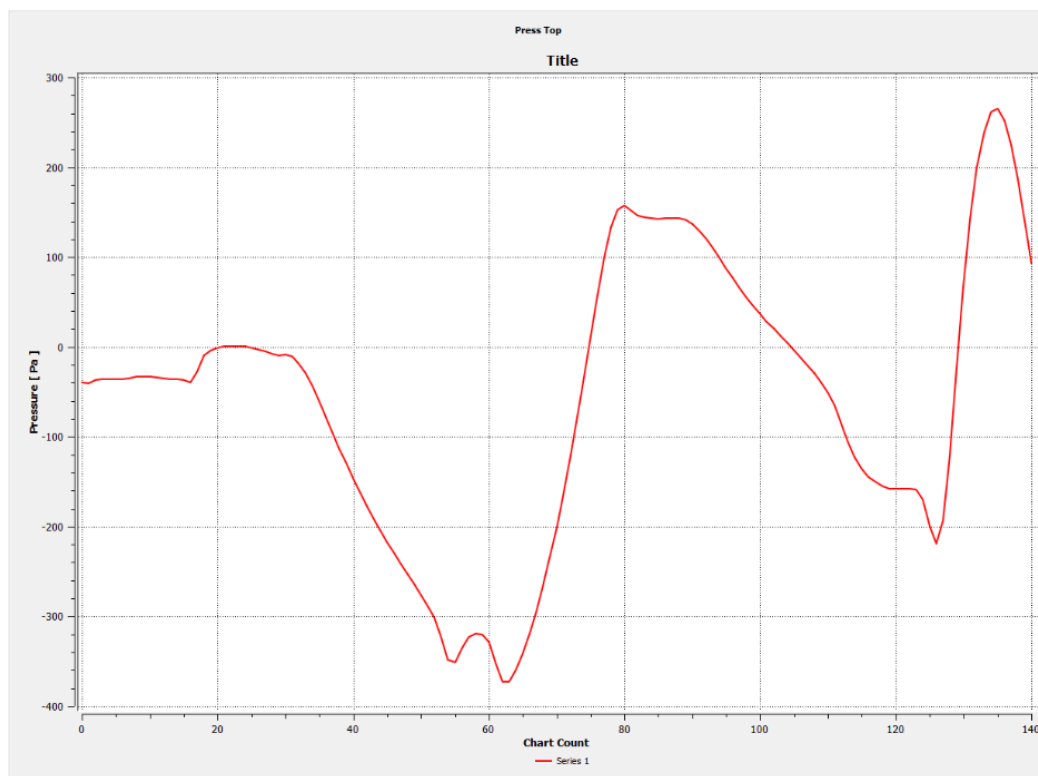


Pressure Graph Top

Figure 122: Design 4 pressure distribution Top

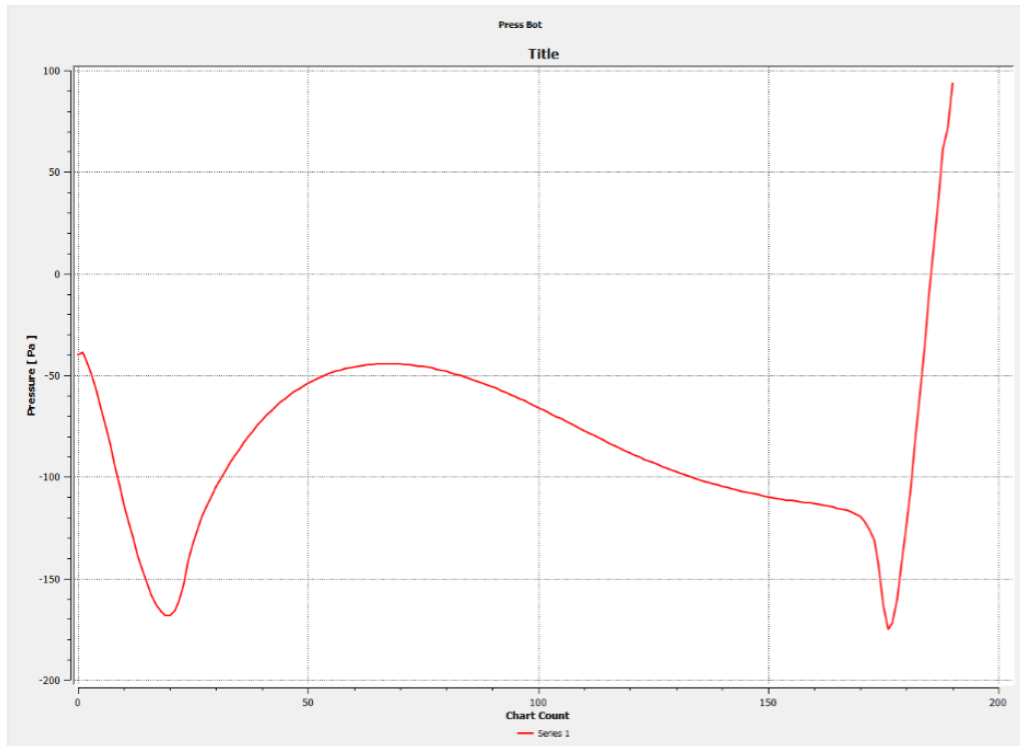


Pressure top backwards



Pressure bottom backwards

Figure 123: Design 4 pressure distribution Bottom Backwards



final design refinement

we refined the final design to get better values for the pressure around the sides of the car and to get more accurate pressure points, this also gives us an opportunity to test how the car reacts horizontally and test other aero devices like side skirts

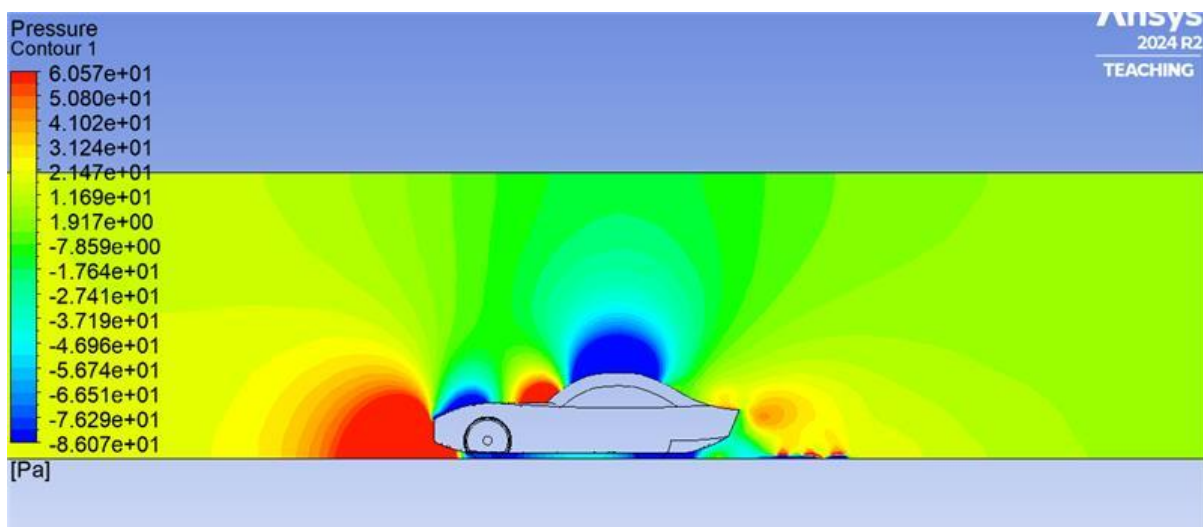


Figure 124

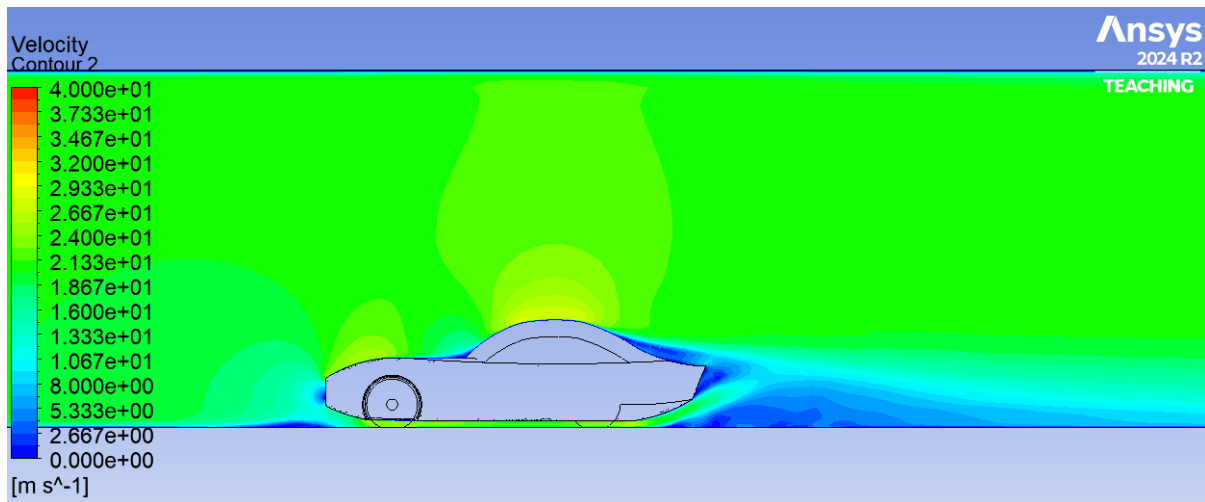
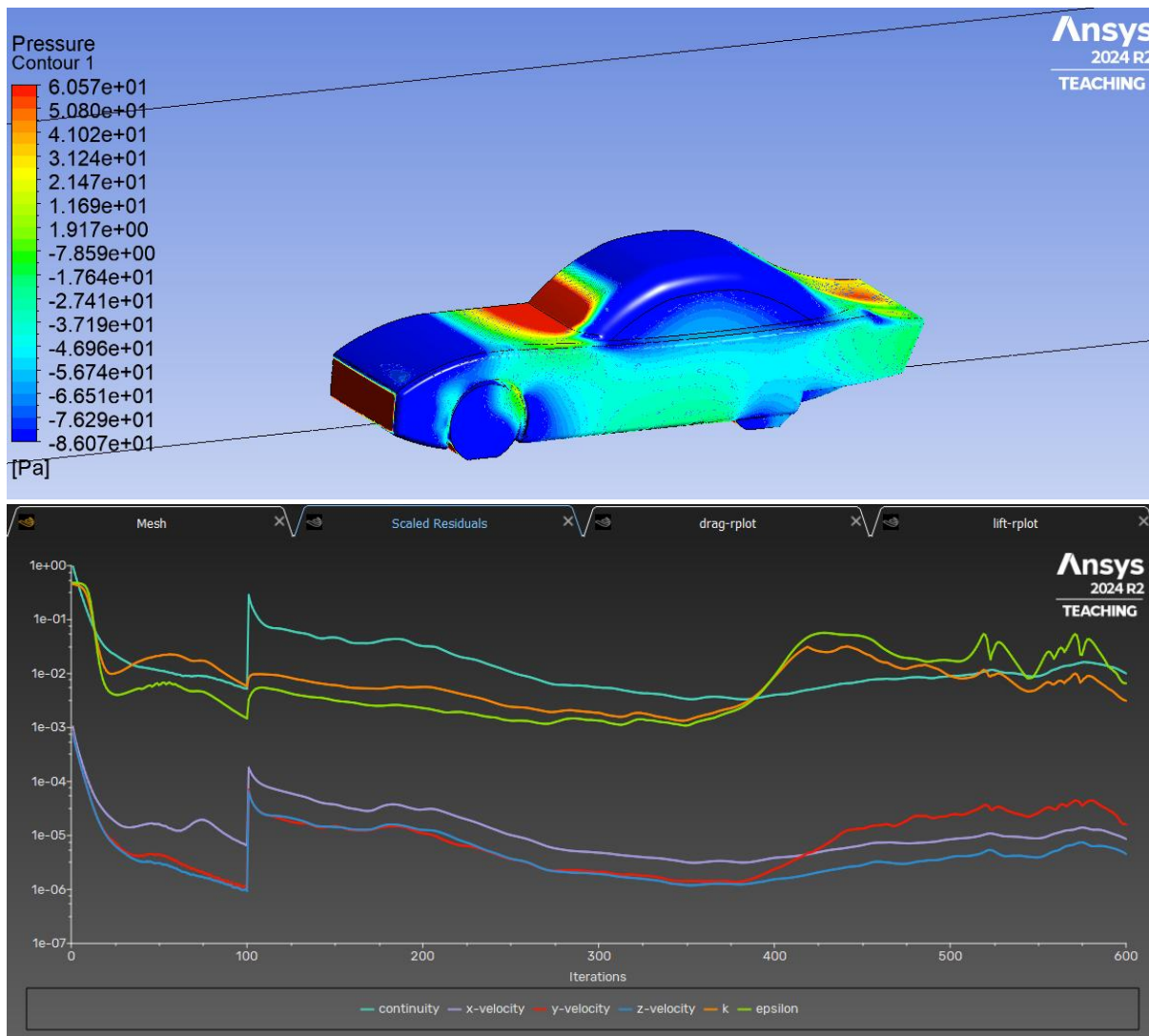


Figure 125





Drag = 0.31064764

Lift = 0.27176632

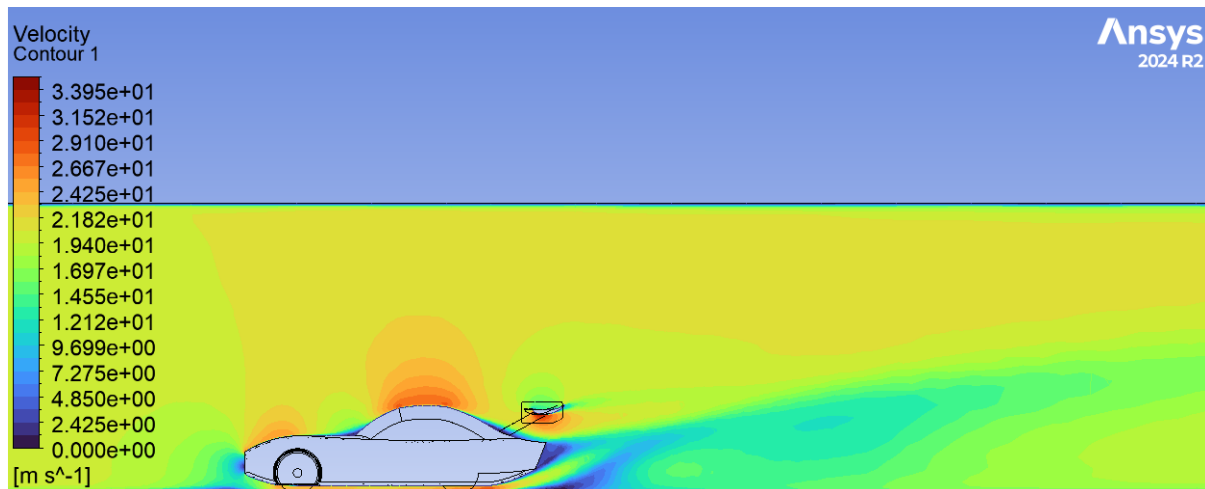
Center of Pressure (COP) = -1.524 (origin point at the middle of the car roughly at the front tires)

Efficiency = -0.874837871

Looking at the images, it is clear that the separation is minimal and the drag is in line with an exceptionally efficient road car. Due to the roll cage we were not able to adjust the roofline much however we made it work.

7.2 adding wings

Wing design 1 (final morgan design + rear wing)



drag 0.387351

Lift -0.66504241

Cop 5.82855

The first wing design increased the drag by 0.07670336 but lowered the lift by 0.93680873

7.3.1 Final Design (2403677 – Alex)

Collating all the tests carried out the team created one final design that uses the best parts of each of the designs and that the bodywork fulfils all the requirements that the team laid out at the start of the design process.

The design hits all the teams outlined objectives, reaching a within variation of accepted Coefficients of drag and lift compared to the original Morgan Plus 4 designs. Velocity and pressure all around the car improved and what the team was looking for this design has hit the targets while still fitting onto the original body work of the Morgan Plus 4.

7.3.2 Future considerations (2403677 – Alex)

If time constraints weren't a problem, the team would continue on the development of the body work by researching into aero devices that accompany the bodywork, such as a rear wing to increase downforce, aero devices that decrease the negative lift on the top of the car, research into cooling devices such as vents and different radiator positions the help the overheating issue.

7.4 time constraints (2403677 – Alex)

Due to time constraints we were unable to test any other wings that were designed, there is a clear positive direction in adding aero devices to the car and we would be able to design a very capable track car without any constraints

8.0 Conclusion

8.1 Plus 4 Team Conclusion

For each individual component developed for the Morgan Plus 4 there were considerable improvements in terms of theoretical performance with a decrease in both lift and drag where targeted with each component. A key issue the Morgan Plus 4 team discovered was that it was far easier to create downforce towards the rear of the car in comparison to the front of the car, this development caused potential further improvements to the rear of the car to stagnate whilst in the hunt for increased front downforce.

Unfortunately, due to crashing errors and potentially the methodology behind the meshing process in ANSYS, the Morgan Plus 4 team has been unable to successfully run the full Morgan Plus 4 design (as of the submission of this report) to determine an exact reduction in drag, reduction in lift and center of pressure. Regardless of this we are confident that should all designs be implemented in a real-world scenario there would be an improvement in both lift and drag however the undetermined center of pressure is a risk of the car potentially having a large amount of understeer when under aerodynamic load.

8.2 Concept Team Conclusion

Concluding the Concept Teams Design process, it must be noted that a significant reduction in the coefficient of drag by roughly 1000 counts has occurred. Furthermore, an exponential decrease in the coefficient of lift equates to an increase in downforce. When compared to the baseline Morgan Plus 4 cars, with its convertible roof up and down. Even though this is a massive improvement for the Morgan car, it must be noted that this approach, if taken, is a highly expensive resolution. Engineers within the concept have faced difficulties when designing a fully custom concept car, as the engineers started with no experience creating a concept car. This contributed to delayed design testing and data acquisition. With these problems, the concept team was able to find success even without being able to complete further work that was

possible.

8.2.1 Concept Data Comparison

	Final Concept	Baseline Morgan	
		Morgan Roof Up	Morgan Roof Down
Coefficient of Drag	0.387351	0.406	0.454
Coefficient of Lift	-0.66504241	0.066	-0.020

Table 9: A Comparison of Final Concept Design to the Baseline Morgan Plus 4 Car

8.3 Optimal Development Approach

After analysing and concluding the data, the engineering team determined that the Morgan plus team development approach is the optimal solution compared to the concept team. This is primarily due to the cost efficiency. Moreover, the Morgan Plus 4 team has a more feasible implementation with respects of manufacturing new aerodynamic parts. Modifications can be directly applied to the existing platform, reducing the overall complexity and production cost of the project. In contrast the concept team would require greater development due to entirely new designs resulting in significant higher manufacturing costs and an overall increased resource demands.

9.0 References

2400990 Ryan Williams References

2304962 Luca Gray References

2405602 Ethan Davies References

2404454 Dominic Walton References

2518952 Thomas Holland References

2403677 Alexandros Griffiths References