



Aerodynamic Development and Validation of the Morgan Plus 4 through CFD Simulation

Dylan Huw Davies

Andrew Noble and Tim Tudor

Wales Institute for Science & Art

MSc Motorsport Engineering

Introduction

The Morgan Plus 4 has a limited aerodynamic development. This project validated a computational fluid dynamics (CFD) workflow and applied it to the Morgan, focusing on diffuser and splitter design. The goal was to convert lift into downforce while meeting Motorsport UK Blue Book regulations.

Methodology

Validation was carried out using the DrivAer benchmark model, which provides more realistic wake structures than the older MIRA reference. Experimental data confirmed the CFD workflow achieved Cd error within $\pm 3\%$. A mesh-independence study with Body-of-Influence refinement and five prism layers ($y^+ \approx 100$) ensured stable aerodynamic coefficients and accurate near-wall resolution. Polyhedral meshes improved orthogonal quality by 40% and halved computational cost compared with tetrahedral.

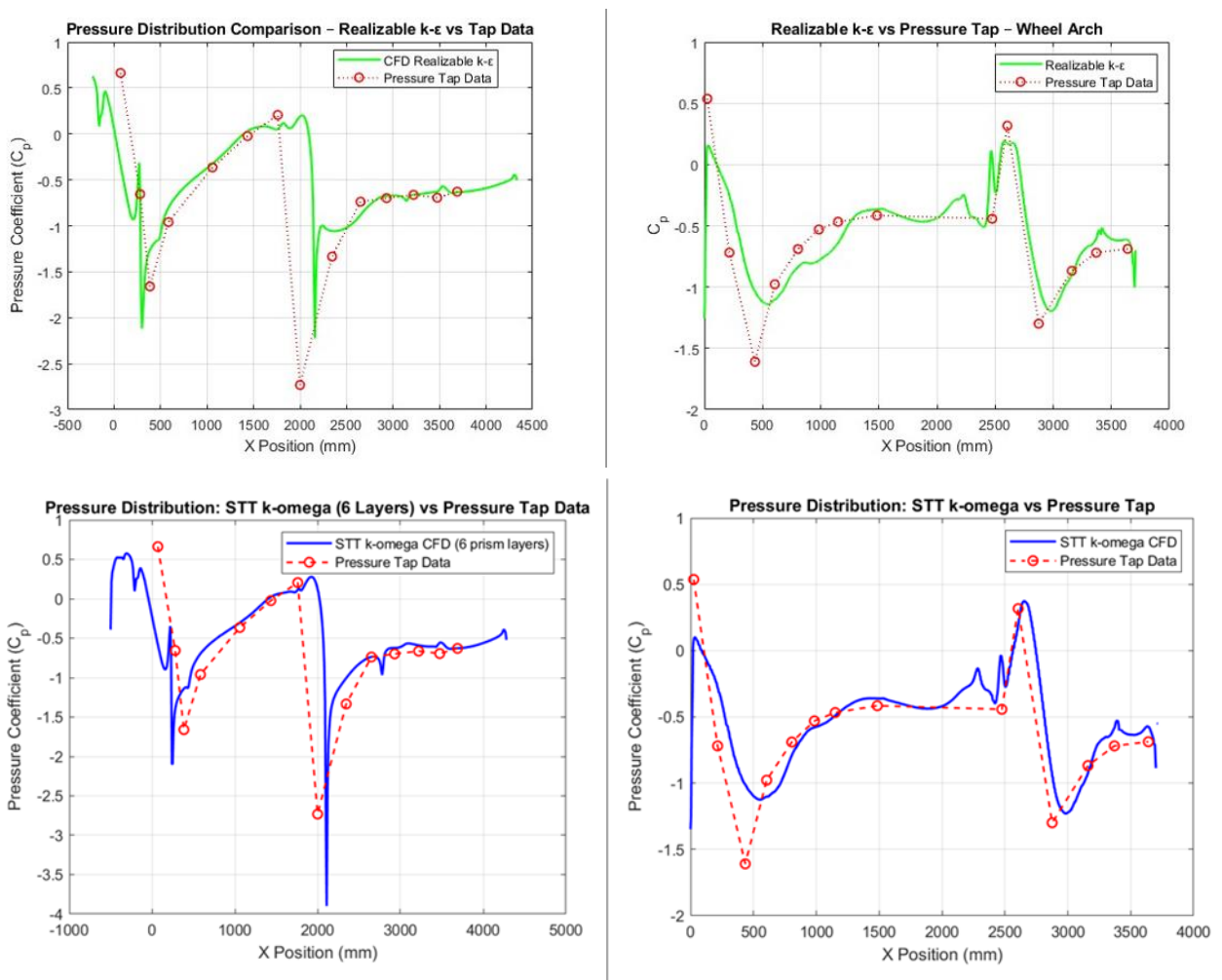


Figure 1: realizable k- ϵ , SST k- ω Models. Top and Arch pressure data comparison. Five turbulence models were tested: standard and RNG k- ϵ , realizable k- ϵ , SST k- ω , and Spalart-Allmaras. The realizable k- ϵ model was selected as the best balance between accuracy and convergence stability as seen in figure 1. Once validated, the workflow was applied to the Morgan Plus 4 CAD. Refinement zones were placed around wheel wakes and separation

regions, allowing the simulations to capture diffuser stall, roof separation, and wake development with confidence.

Baseline Results

The baseline Morgan produced $C_d = 0.467$ and $C_l = +0.058$, meaning the car generated lift. Flow separation occurred at the diffuser ramp, over the roofline, and around the wheel arches, producing a wide, turbulent wake (figure 2). These behaviours match established aerodynamic literature: Katz (1995) and Marklund (2013) showed that steep diffuser ramps stall prematurely, while Buscariolo et al. (2020) highlighted that diffuser geometry strongly controls underbody recovery. Together, these findings confirm the Morgan's poor baseline performance.

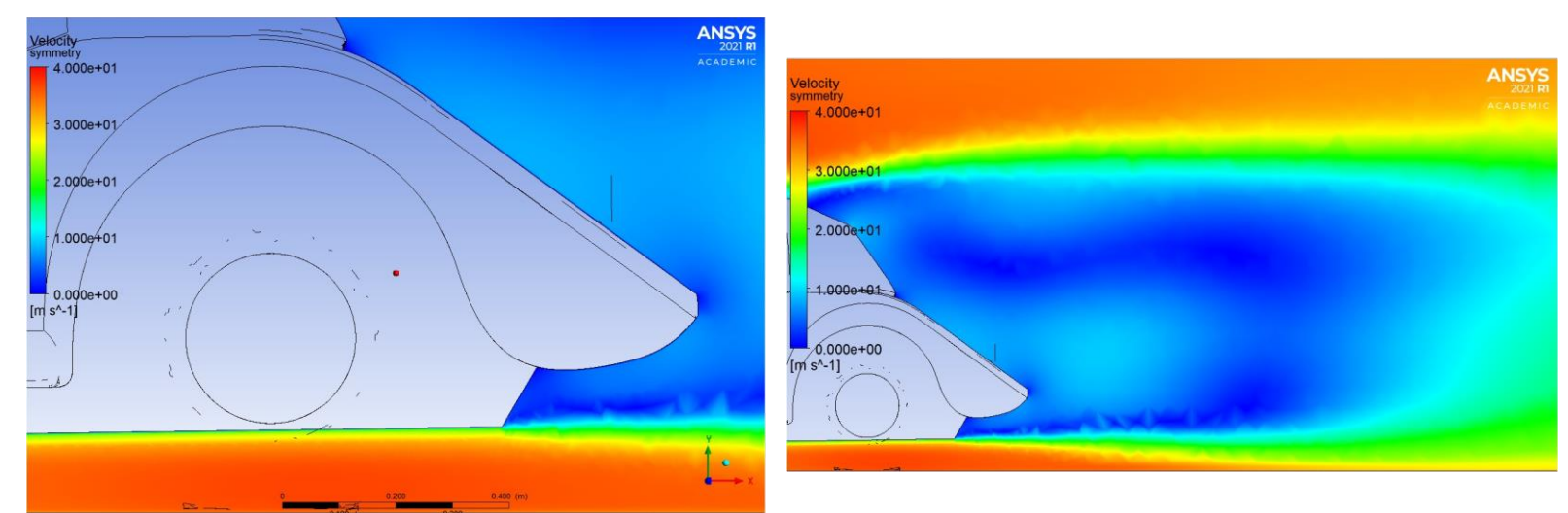


Figure 2 Baseline Analysis of rear diffuser location and wake region

Redesign Results

Redesigning the diffuser by extending its ramp and adding strakes converted lift into mild downforce, with C_l reduced from $+0.058$ to -0.022 and drag lowered by 1.9%. Strakes partitioned the flow and delayed stall, improving wake stability. An aerofoil-profile splitter (NACA 4412) further increased performance, reducing drag to 0.446 (-4.5% vs baseline) and generating $C_l = -0.147$ (-353%). Adding an air dam in front of the flat splitter produced the most stable configuration, with $C_l = -0.273$ (-571%) and $C_d = 0.490$ ($+4.9\%$).

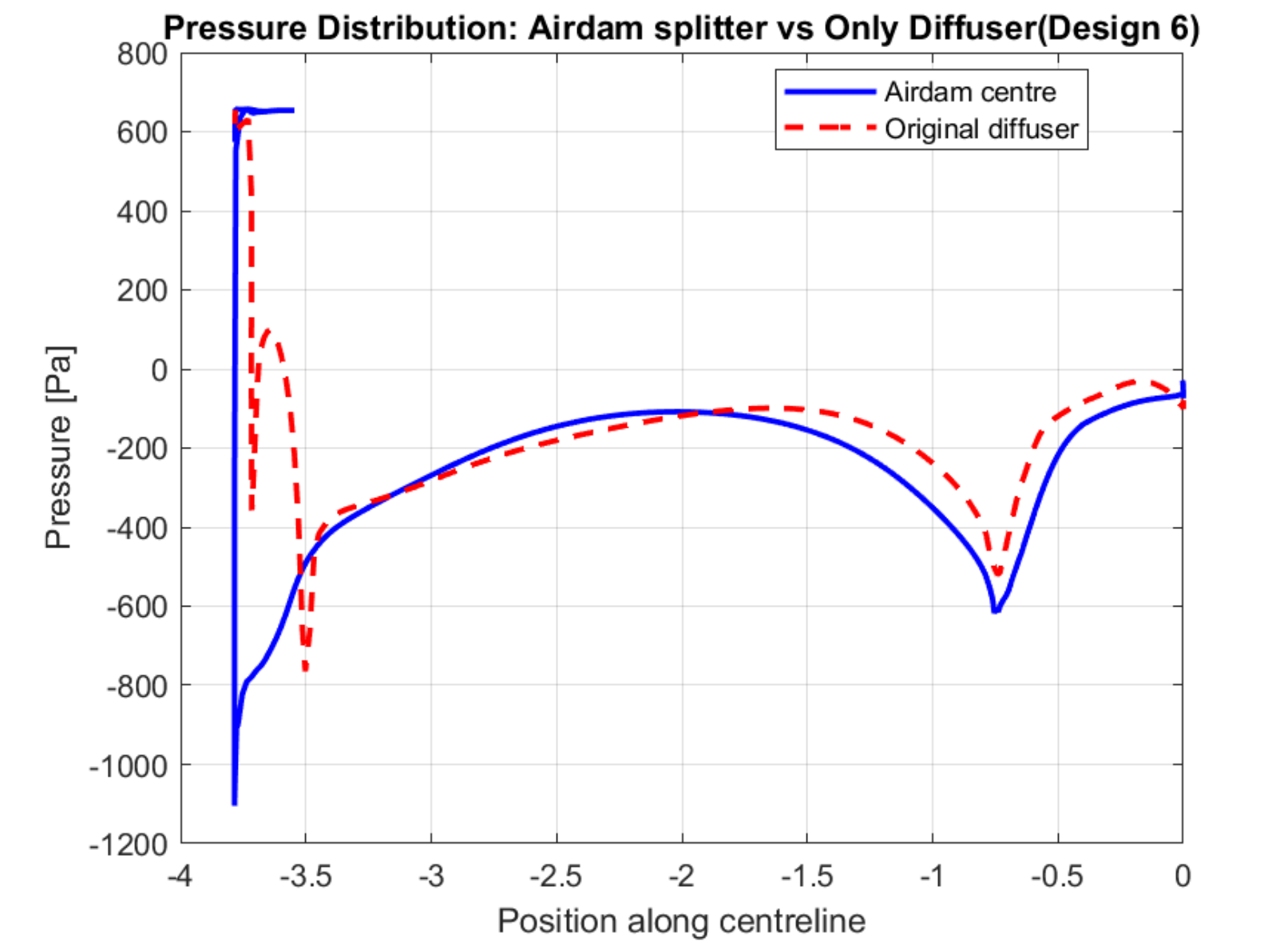


Figure 3 Flat splitter affect on diffuser around -1 to -0.5

Zhang et al. (2022) emphasised that splitters and diffusers must be developed together to sustain suction across the underbody. The Morgan redesign confirmed this principle, and a positive relationship was present between the two.

Conclusion

The CFD workflow was validated on the DrivAer model and applied to the Morgan Plus 4. Underbody redesign successfully eliminated lift and delivered net downforce with only a modest rise in drag. Compared to the baseline as seen in table 1.

Table 1 Results

Case	C_d	C_l	% ΔC_d	% ΔC_l
Baseline	0.467	0.0577	–	–
Diffuser + Strakes	0.458	-0.0222	-1.9%	-138%
Aerofoil Splitter	0.446	-0.147	-6.8%	-355%
Air Dam + Splitter	0.49	-0.273	4.90%	-496%

Limitations and Future Work

The main limitations were static modelling without pitch or roll dynamics, packaging restrictions that prevented larger diffuser expansion ratios, and limited pressure tap resolution compared with full-surface mapping. Future work should include diffuser angle sweeps, rake testing, and exhaust-assisted diffuser blowing to further energise the underbody. A complete CAD underbody and wind tunnel validation would also strengthen the CFD-experiment link, as recommended by Plogmann et al. (2023) and Zaareer et al. (2023).

Acknowledgements

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References

Heft et al. (2012); Qin et al. (2024); Katz (1995); Cooper et al. (1998); Buscariolo et al. (2020); Zhang et al. (2022); Plogmann et al. (2023); Zaareer et al. (2023).