



Aerodynamic Development & Optimisation of an MCR Open Sports Series Front Wing

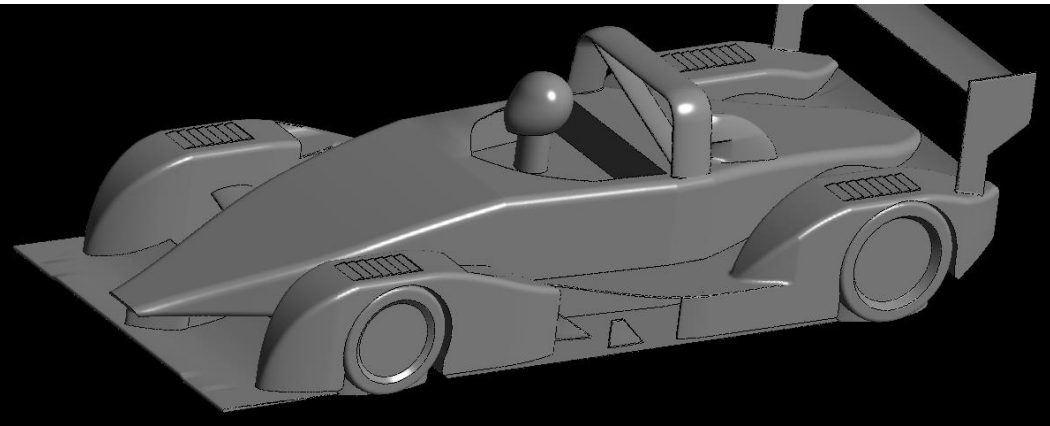
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Introduction

The prominent utilisation of wings within motorsport has long been thought to be of a standard practise. Controlling the fluid flow to produce a downward vertical force.

The project focuses on the design and optimisation of a multi-element front wing concept, using an S1223 high lift profile (Selig, et al., 1995) for an OSS sports prototype race car, through validated CFD numerical analysis.

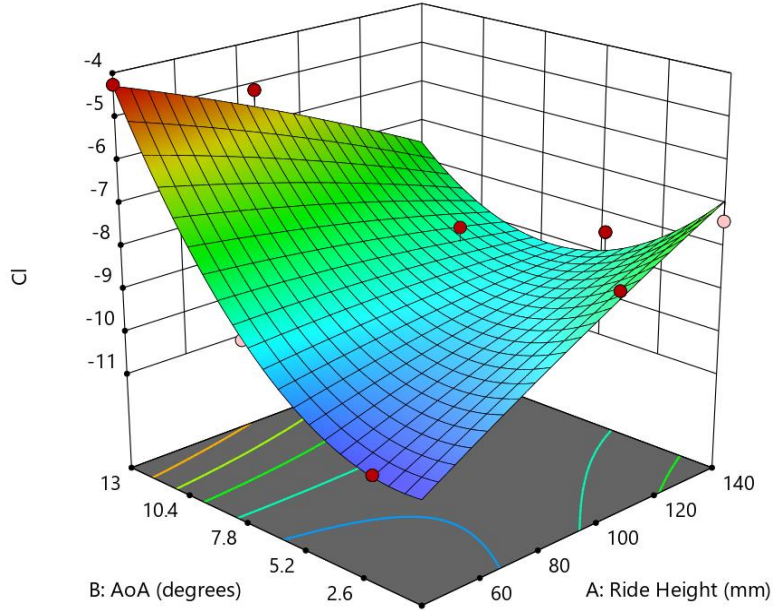


JHTT02 Baseline Geometry

The main ambition is to further maximise the generated frontal downforce, compared to the baseline splitter geometry, however, maintain aerodynamic efficiency and balance to increase the working window of the concept, thus making a more predictable vehicle.

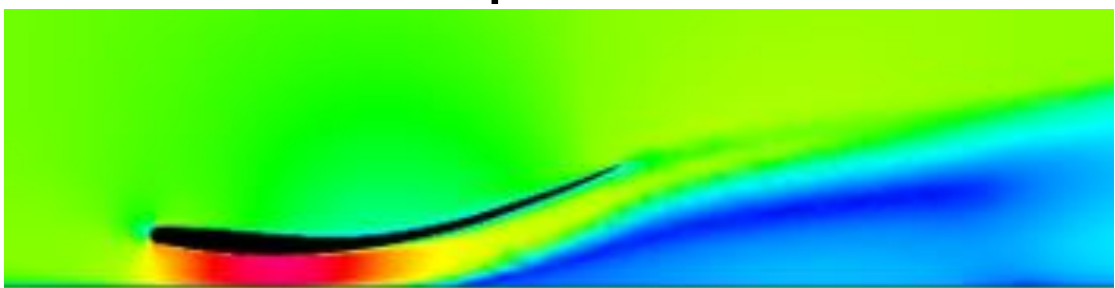
Isolated Main Plane Testing

Utilising a design of experiment approach, the interaction between height above ground plane and angle of attack were investigated, finding that a 60mm height and 1.47° incline angle were optimal for the isolated main plane.

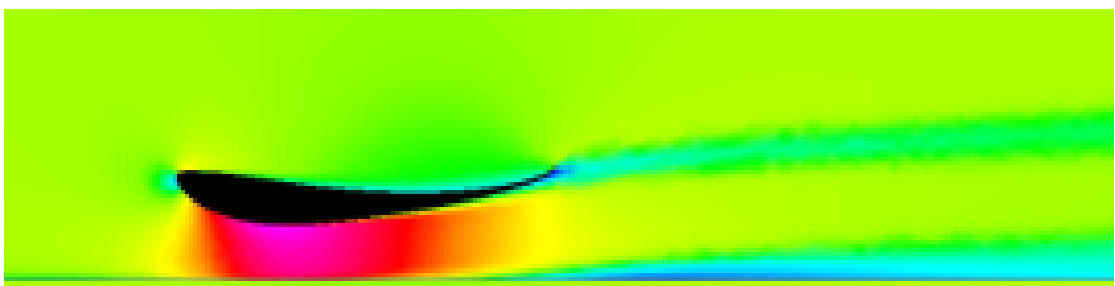


DOE Variable Interaction Response Plot (CI)

Post-processing results display an increased velocity with greater pressure differential compared to that of the baseline splitter.



JHTT02 Baseline Splitter

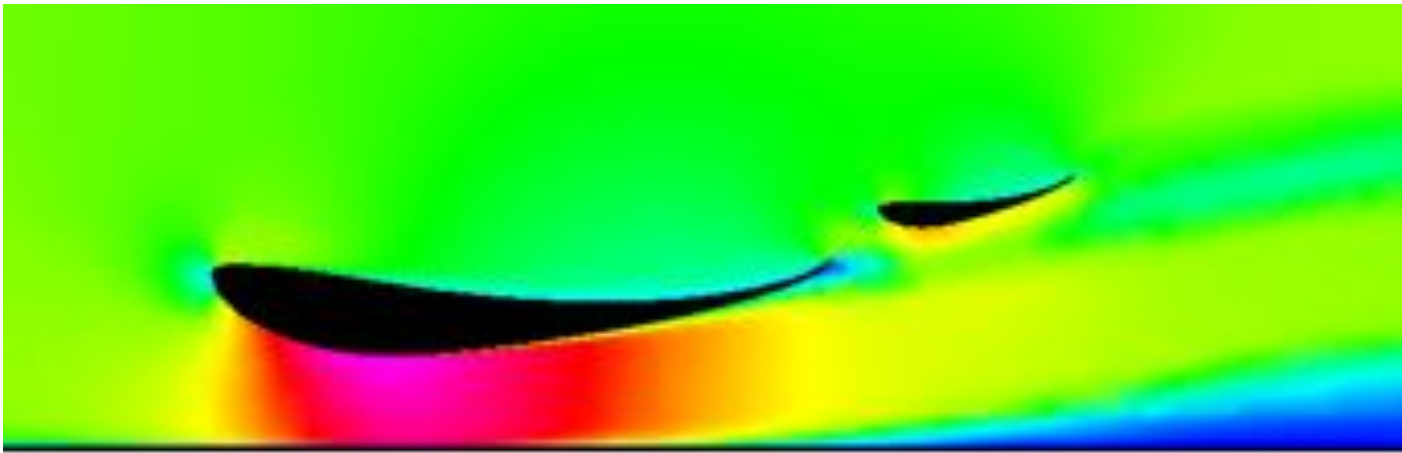


S1223 Main Plane Velocity Contours at Optimised Attitude

Isolated Multi-Element Testing

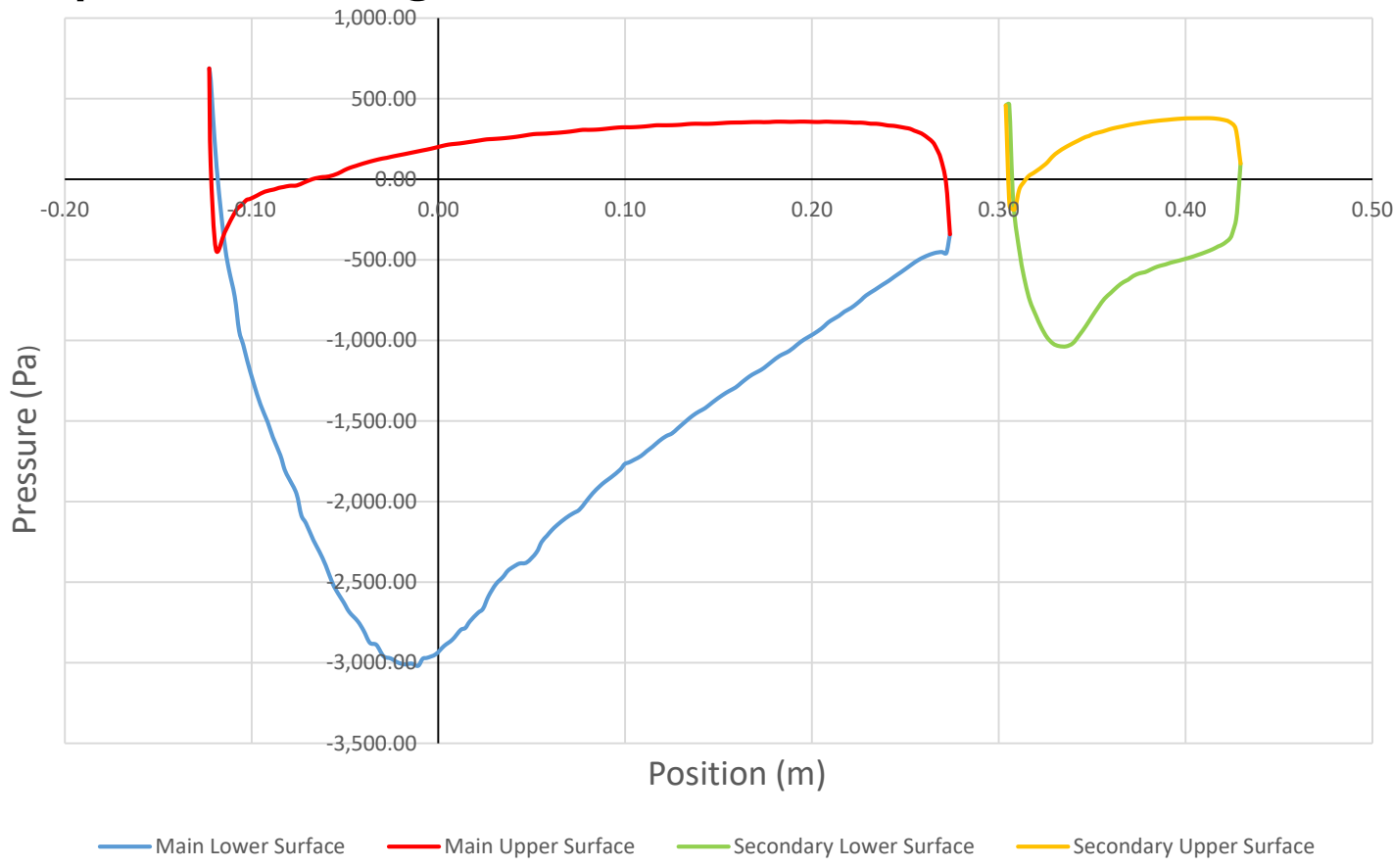
The investigation of a secondary element carries with it further variables of consideration, being, **Height, Angle of Attack, Positive and Negative Overhang and Chord Length**, relative to the main plane, as informed by the previous study.

DOE was once again implemented to map the interaction between the given variables.



S1223 Multi-Element Velocity Contours at Optimal Attitude

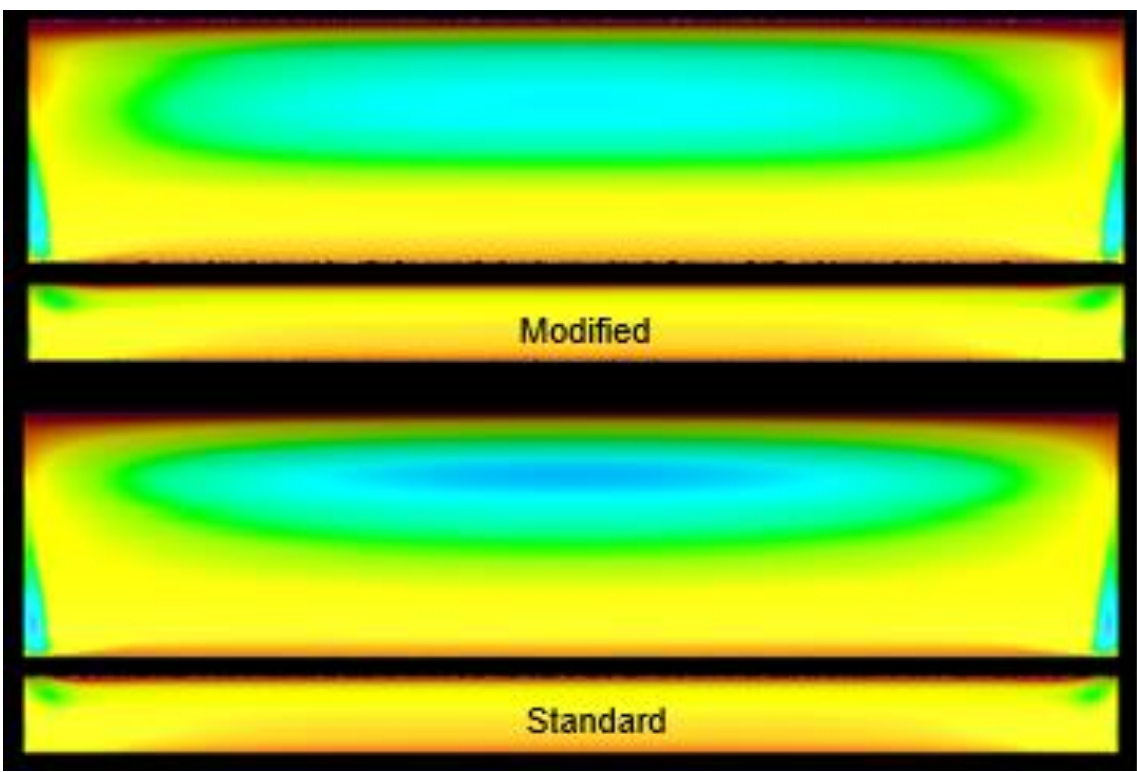
It was found that the increase in mass expansion allowed a greater negative pressure to be developed below the main plane, generating a greater gain in pressure differential, though a substantial increase was divulged, efficiency remained within an acceptable range.



S1223 Multi-Element Wing Pressure Distribution

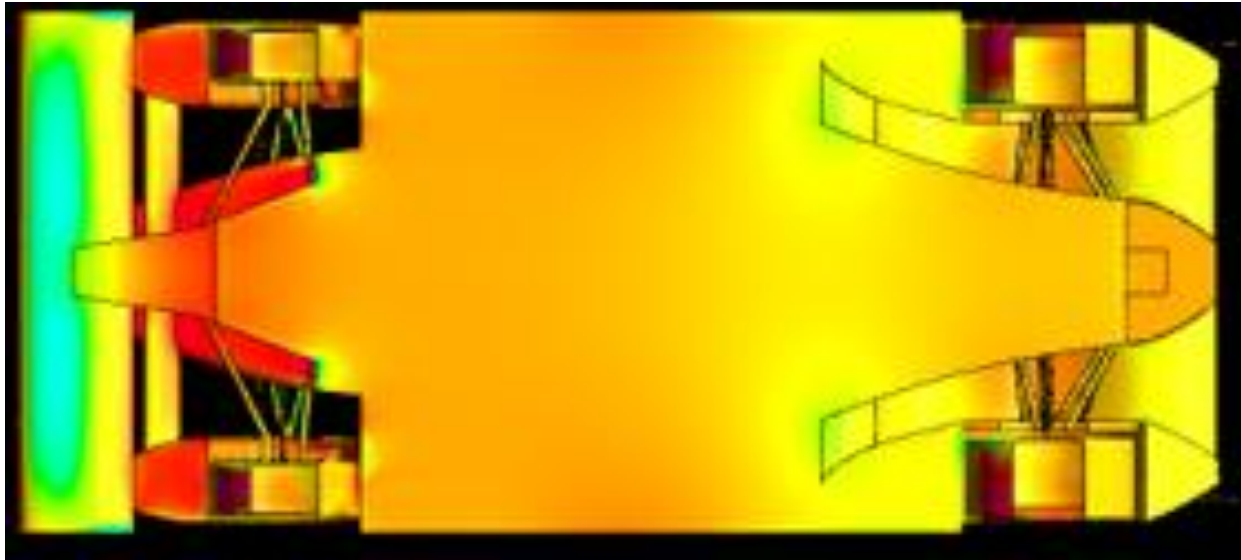
Vehicle Implementation

Analysis of initial full vehicle testing highlighted a pressure distribution issue. The optimised compound wing geometry as informed from the DOE studies was minorly modified to distribute the negative pressure with greater uniformity to allow a wider performance window when considering vehicle dynamic attitude changes.



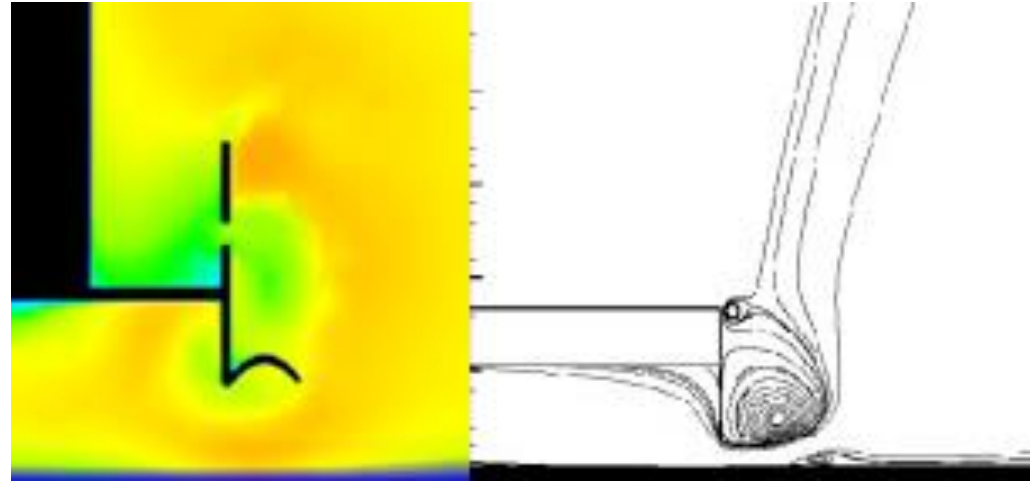
S1223 Multi-Element Wing Pressure Distribution

Additional modifications were made to the nose cone and pontoon structures to accommodate the newly developed wing concept.



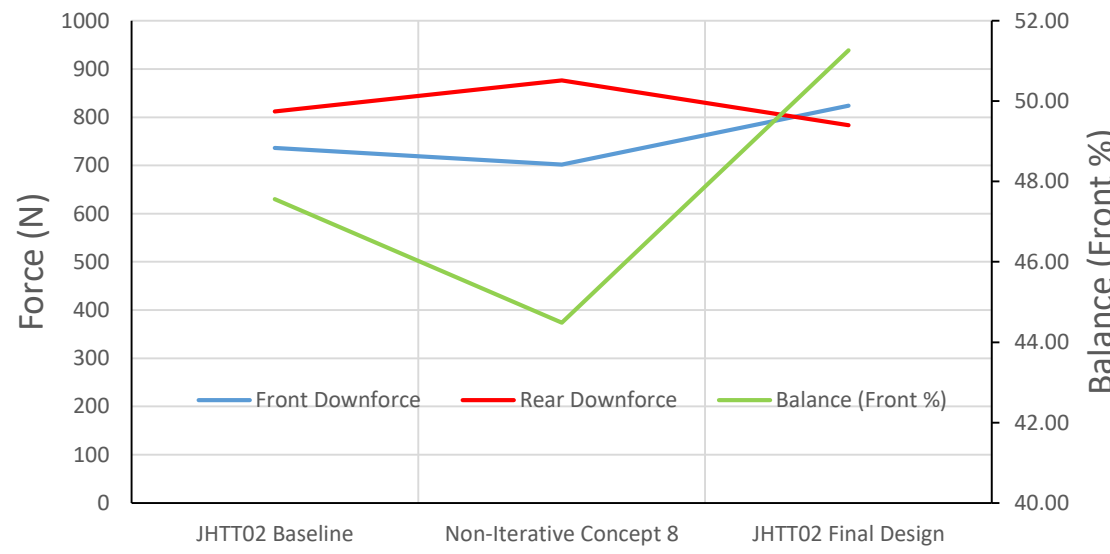
Vehicle with Compound Wing Underside Pressure Contours

To further optimise the working area of the wing, a study into end plate implementation was conducted.



End Plate Vortex Formation (Jung, et al., 2012)

Results from the study correlated well with (Jung, et al., 2012), concluding that redirecting the trajectory of the developed vortices proved beneficial. The finalised design has increased levels of downforce, though at the expense of increased drag force. However, the centre of pressure (Cp) location was favourably biased towards the front.



Front & Rear Downforce + Balance

Conclusion

The findings from the project show that the compound wing design allows for superior control over Cp as well as a substantial increase in downforce. Studies also highlight the importance of end plate design in increasing the working area of a wing.

Acknowledgements

I would like to thank John Iley for taking time out of a busy schedule and providing guidance throughout this project.

References

- Selig, M. S., Guglielmo, J. J., Broeren, A. P. & Giguere, P., 1995. *Summary of Low-Speed Airfoil Data*, Virginia Beach: SOARTECH PUBLICATIONS
- Jung, J. H. et al., 2012. *Endplate effect on aerodynamic characteristics of three-dimensional wings in close free surface proximity*. *International Journal of Naval Architecture and Ocean Engineering*, 4(4), pp. 477-487.