



An Investigation into Flow Management Methods to Control Front Wheel Wake on Open Wheel Race Cars

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Introduction

The aim of the project is to successfully characterise the generation and propagation characteristics of front wheel wake on open wheel cars in a computational domain (CFD), validated by an Ahmed Body study.

The initial focus is on the potential for utilising brake ducts, in a thermally deformable manner, to influence the flow around the front wheel assembly.

Secondly, the project focuses on the influence of upstream components on the wake management, looking at front wings, primarily the differing approaches seen between Formula 1 2018 and 2019 regulation changes.

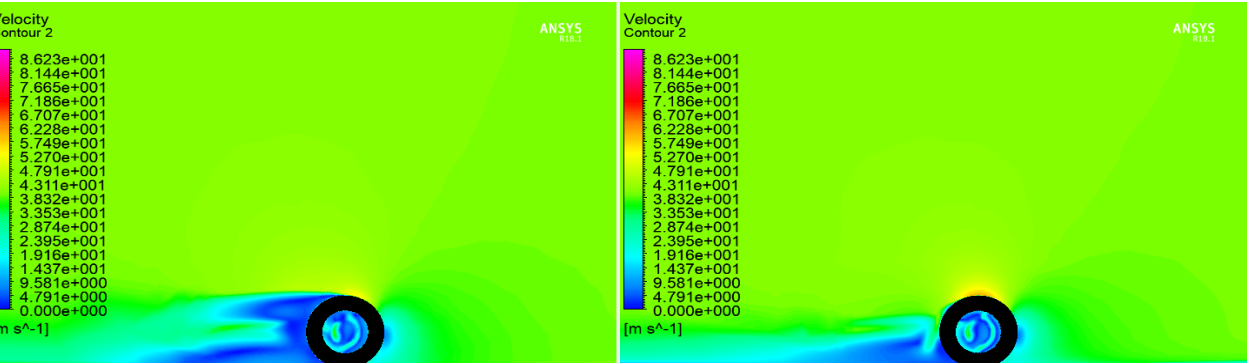
Brake Duct Testing

In conjunction with a project by Tiegen Lillicrap looking at thermal deformability of composites, studies were made into potential benefit from altering geometries.

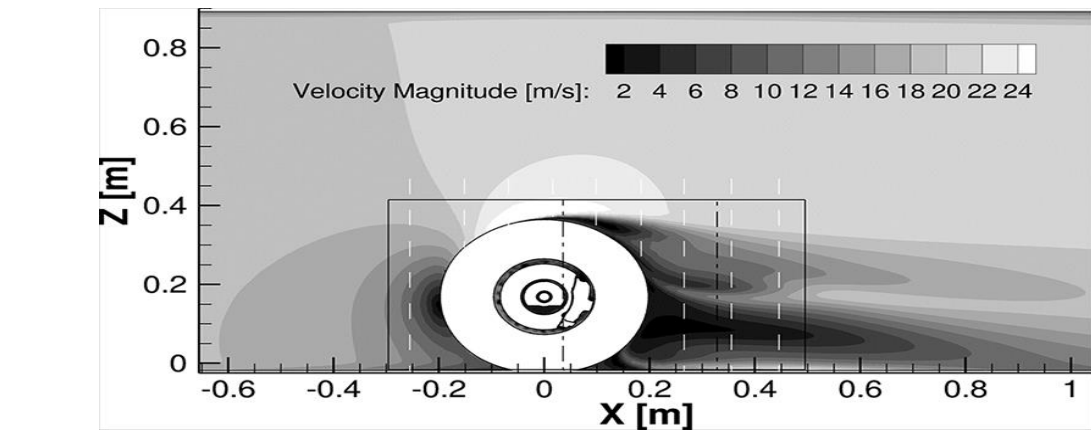
The study yielded poor results, due to the additional turbulence induced by the geometry changes, forcing the decision to abandon this area of study.

Wheel Wake

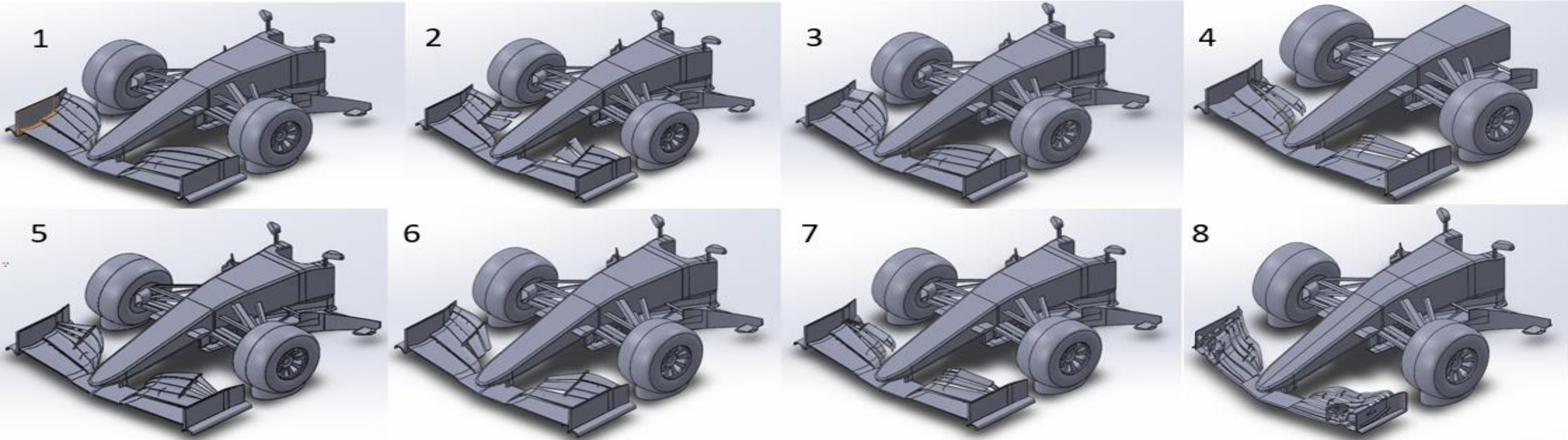
CFD testing found excellent correlation to published works of the wake structure when the wheel was modelled as a rotating entity.



Comparison of rotating (left) and static (right) wheel wake profiles from CFD testing



Investigated Front Wheel Wake of F1 car (Axereo-Cilies & Iaccarino, 2012)

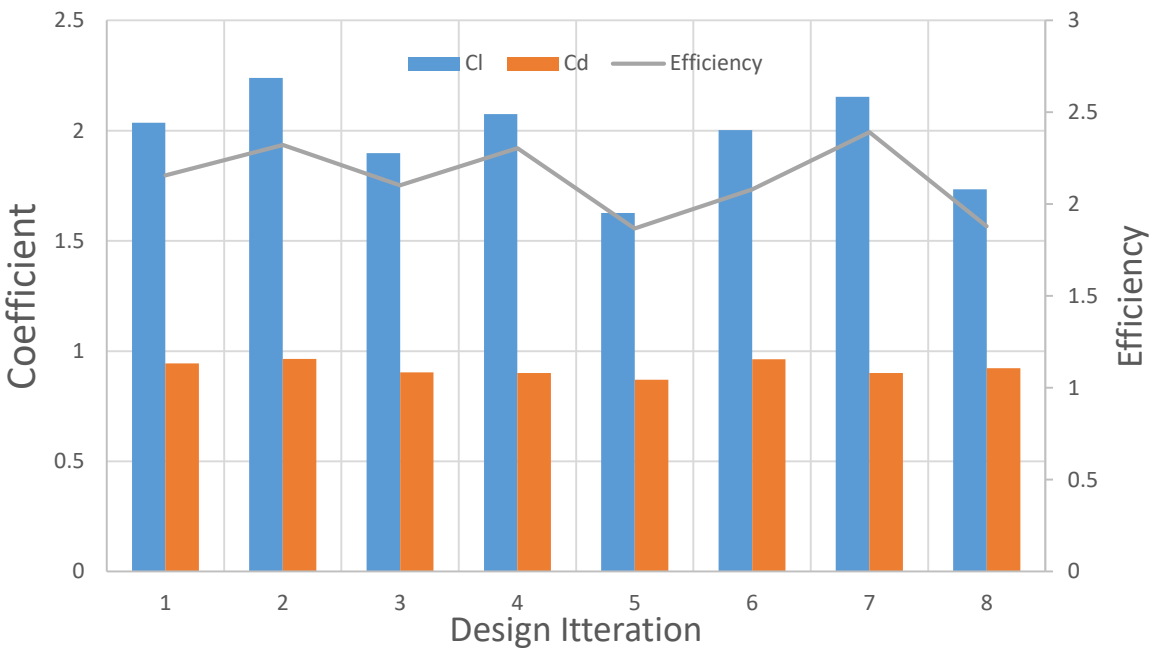


Front Wing Design Concepts

Front Wing Testing

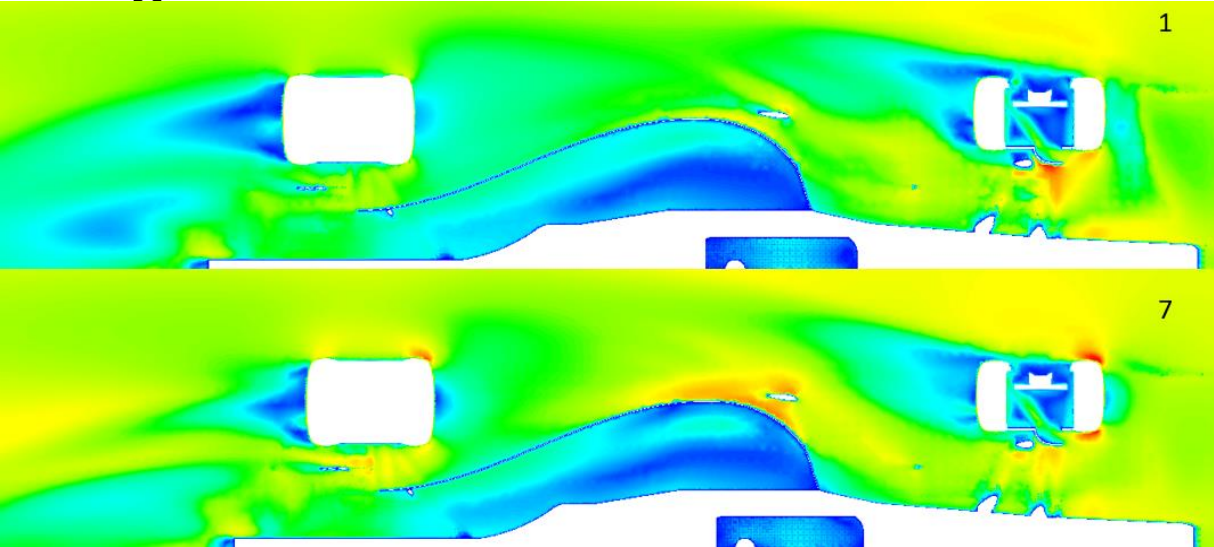
Geometries based on current F1 designs and novel concepts, shown above, were tested in CFD.

Full car testing yielded significantly varied results of C_l , C_d and CoP, with an outwash generating front wing proving the most effective and efficient philosophy to follow.



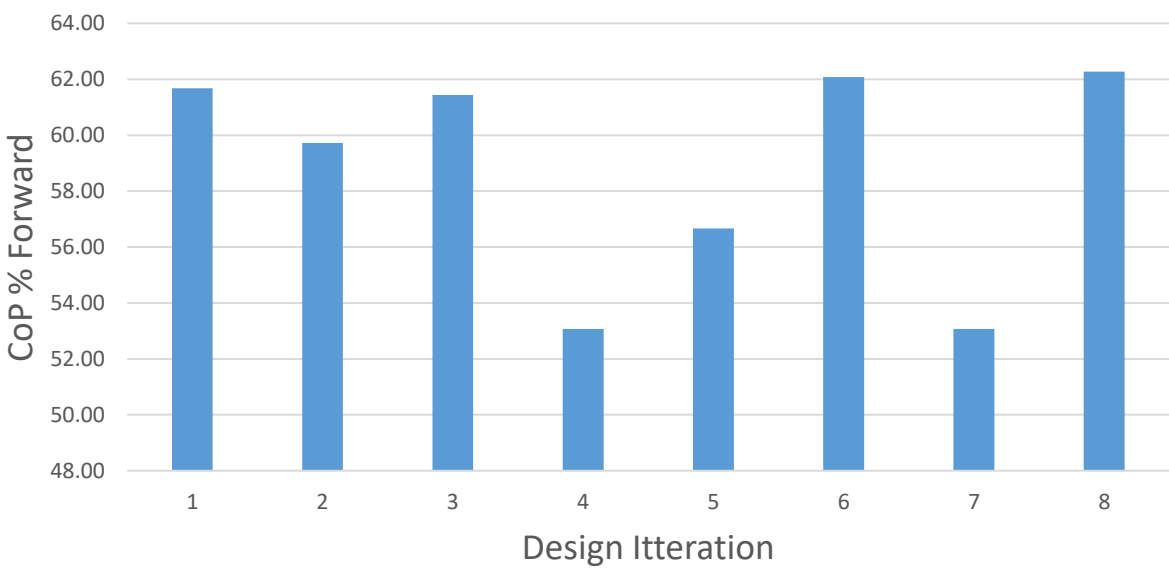
Full Car Front Wing Testing Results

Wheel wake was found to be far better managed by generating an outwash condition with the front wing.

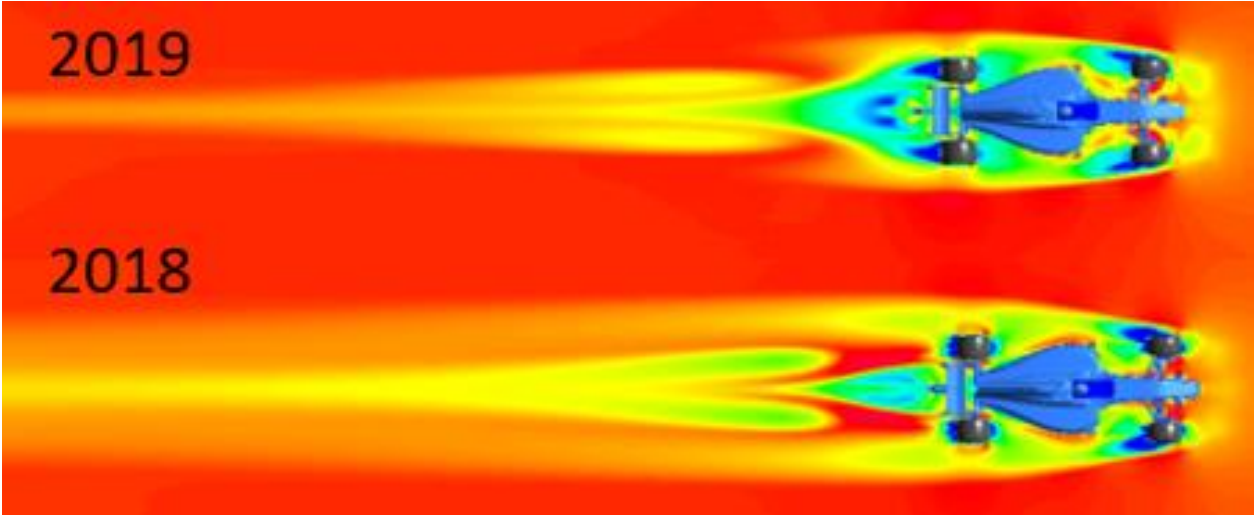


Comparison of Wake Structures between outwash and non-outwash Designs

Wing design was found to have a significant influence of the effectiveness of the floor/diffuser, with up to a 10% CoP change seen.



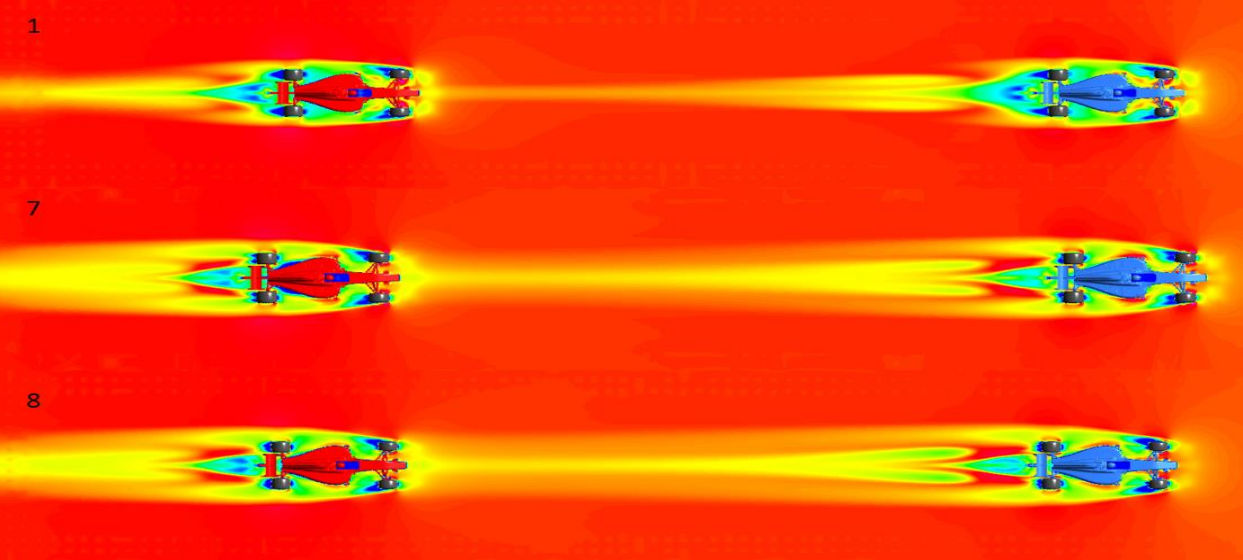
Full Car Front Wing Centre of Pressure Testing Results



2018 and 2019 Baseline Geometry Wake Comparison

Testing found significant differences in the wake structures of the geometries based on the outgoing 2018 cars, and the intended 2019 design, highlighting the importance of upstream control over wheel wake. Outwash on the 2018 car is clearly visible, giving wider wake structure. Contrastingly, the reduced outwash, and less controlled front wheel wake on the 2019 car yielded a much narrower wake.

Testing was conducted to determine the loss of C_l and C_d values on a following car. Degradation of up to 20% on C_l and 16% on C_d was found.



Comparison of Wake Structures and impact on following vehicle.

Acknowledgements

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References

Ahmad, N. & Gaylard, E., 2010. Mesh Optimisation for Ground Vehicle Aerodynamics. *CFD Letters*, 2(1), pp. 54-65.

Axereo-Cilies, J. & Iaccarino, G., 2012. An Aerodynamic Investigation of an Isolated Rotating F1 Wheel Assembly. *Journal of Fluids Engineering*, 134(12), pp. 101-121.

Lanfrut, M., 2005. *Best Practice Guidelines for Handling Automotive Aerodynamics with Fluent*, Darmstadt: Fluent Deutschland GmbH.