Utilising the Fine Margins: Enhancing the Aerodynamic Efficiency of a Hyper-efficient Solar Vehicle

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Durham University Solar Car
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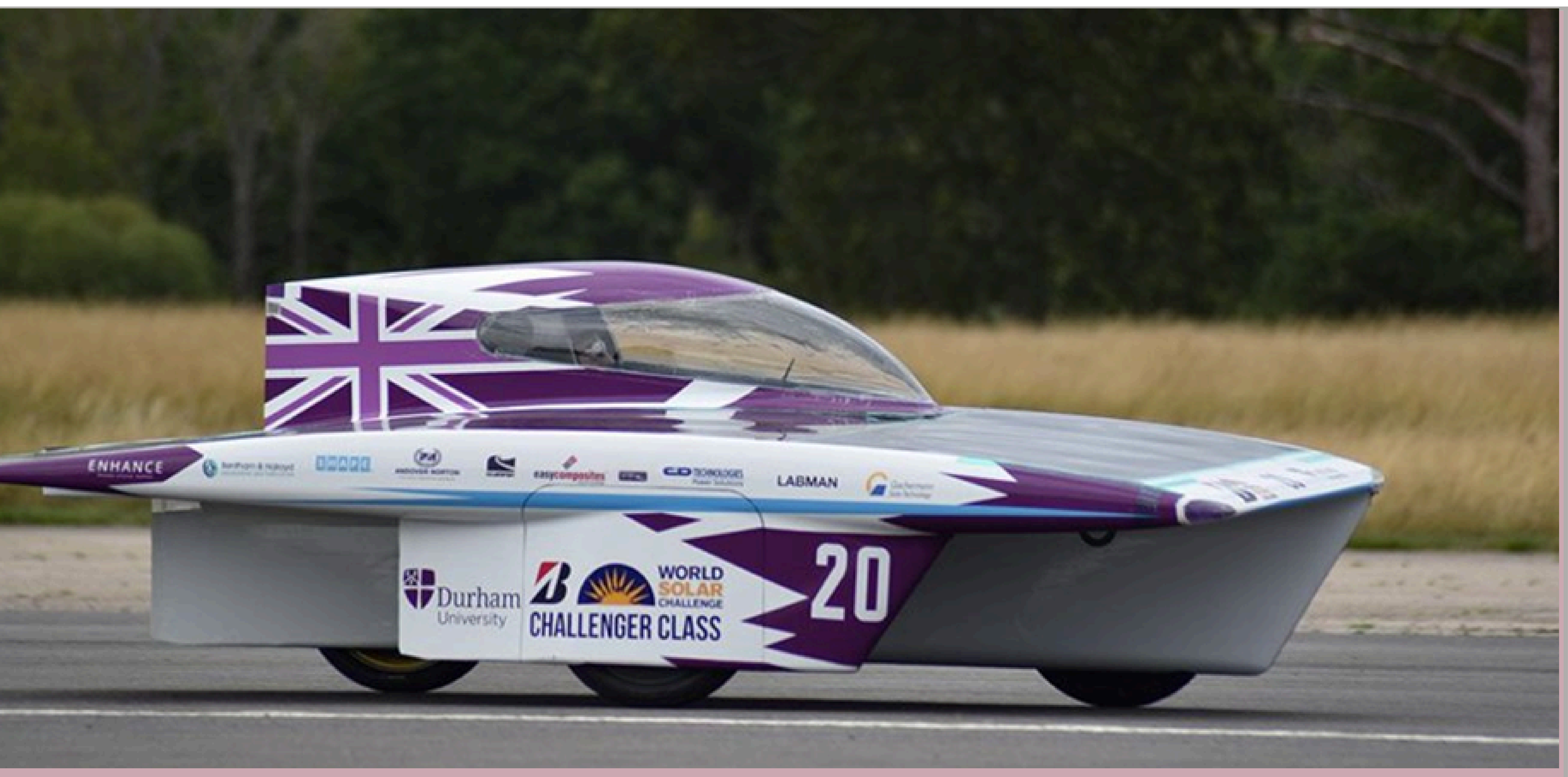
An investigation into the efficiency of several aerodynamic features in reducing the drag of the Durham University Solar Car



01. Introduction

Following a recent emphasis on the importance of designing and developing increasingly efficient road vehicles, there has been an increase in the amount of resarch into the renewable transport sector. One solution that is currently being put forward is the development of solar cars - traditional electric vehicles powered by solar energy. These solar vehicles are designed with aerodynamic efficiency at the forefront, relying on near-optimal levels of efficiency to minimise power losses.
One such solar car,the Durham University Solar Car, is a solar powered race car, designed by students to compete in endurance races powered by the sun, with the aim of developing sustainable technology for future benefit in a more mainstream application.
This research project investigates the benefit of aerodynamic features in order to improve the performance of the Durham University Solar Car. A multitude of proposed aerodynamic features have been investigated and evaluated for their expected benefit in reducing the aerodynamic drag of the solar car. The best performing component has then been evaluated in further detail through the generation of a 3D model that has been analysed using a computational fluid dynamics (CFD) software in order to more accurately calculate its specific benefit to the solar car.

02. Methodology

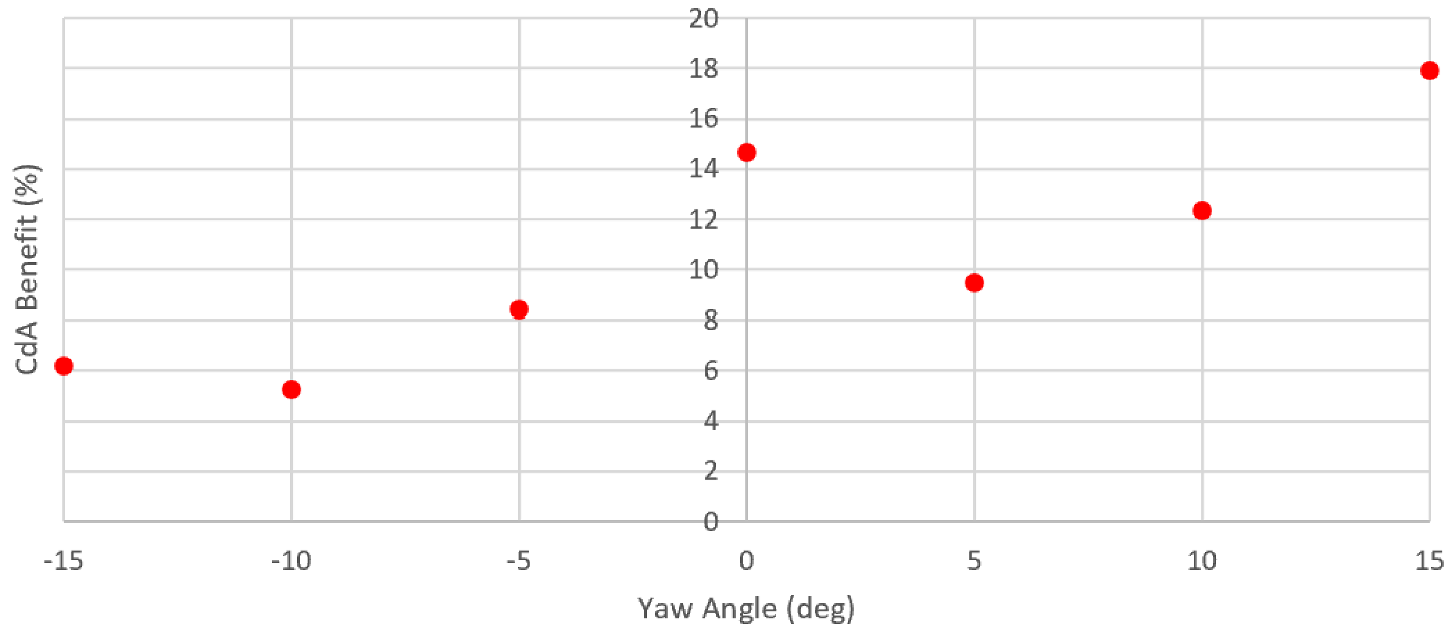
In the initial phase of the project, a rough evaluation of several proposed features was developed using known data and relevant literature. The features were modelled as ideal components in order to establish the baseline calculation necessary for a comparison between components.
Subsequently, a more in depth analysis was undertaken on the best performing feature in order to calculate a more accurate numerical value for the aerodynamic benefit, based on the implementation of the component within a model of the full car.
Throughout the project, discussions were undertaken with members of the wider Durham University Solar Car to understand the context in which the component would be utilised, as well as make decisions on feasibility of the various proposed solutions.

03. Results/Findings

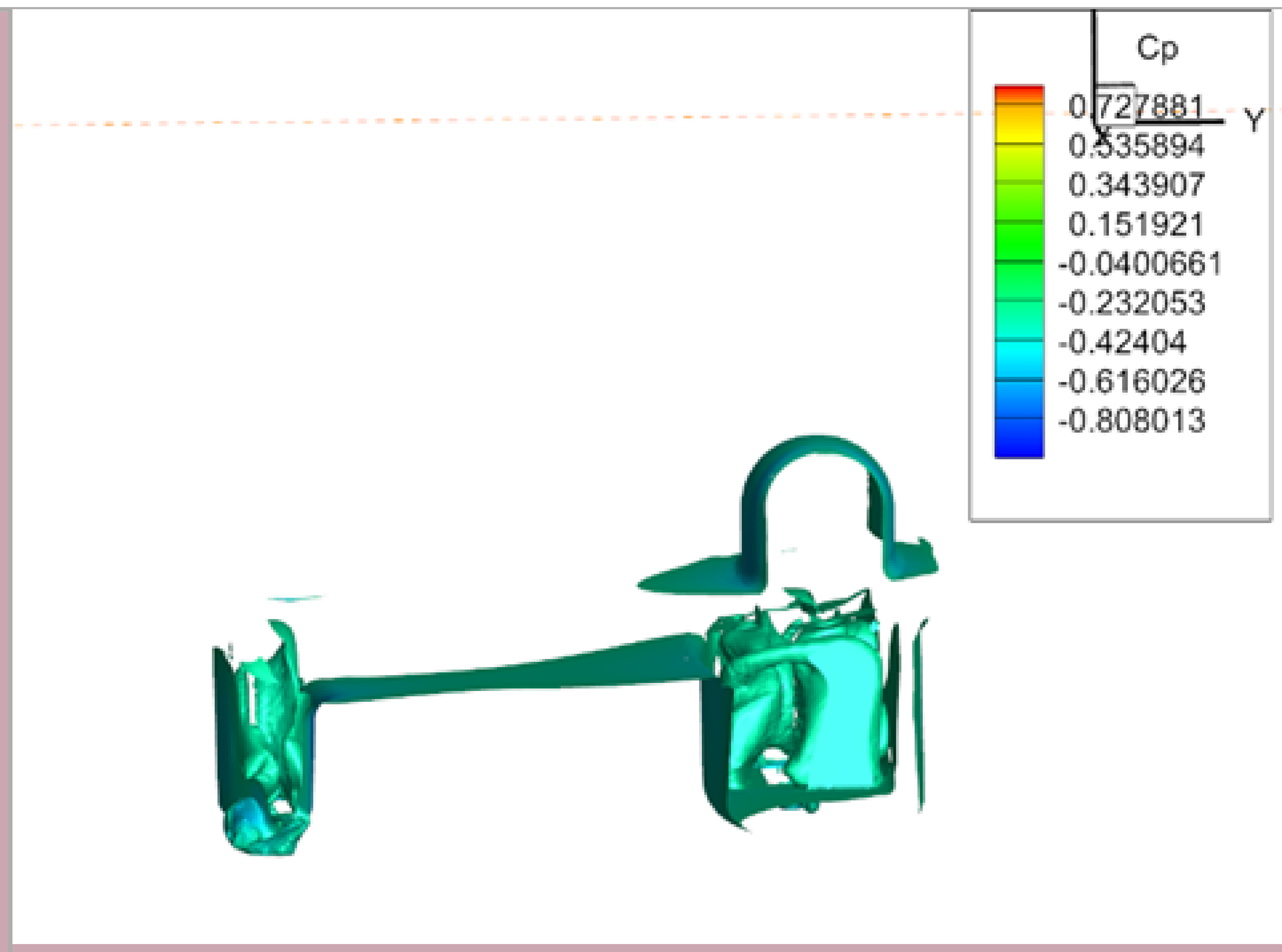
It was found that there was a substantial benefit for all 3 components considered in the report.
The active components, namely the canopy fin and trailing edge flaps, were both found to improve performance under crosswind conditions, and an optimal angle for which to deploy the features was deduced using the initial calculation.
The passive component, the wheel housings, produced the most significant aerodynamic benefit, with an expected aerodynamic improvement of 16%, more than 3 times that of each of the other 2 components, and was consequently chosen for further investigation.
The more extensive examination yielded a benefit of 10.5% for the solar car with wheel housings, supporting the significant initial benefit calculated

04. Analysis

On the whole, there is a significant benefit offered by the wheel housings for every yaw angle considered.
The two most substantial benefits are found at the 0 and 15 degree yaw cases.



The drag reduction provided by the wheel housings is likely a result of a reduction in the pressure drag produced by the separation of the airflow as it interacts with the tyre. Pressure drag results in the creation of a low-pressure void, which literally 'sucks' the vehicle rearwards, as well as vortices, which require a significant amount of energy to generate.
There is an observed trend in the CdA benefit with yaw angle, with increasing drag reduction at increasing yaw angle. This trend is a result of the increased presence, and therefore reduction, of vortices at yaw angles, further highlighting the significance of the wheel housings in reducing pressure drag in the vehicle.



05. Conclusion

All 3 aerodynamic components provided a substantial benefit to the performance of the Durham University Solar Car.
The wheel housings, following their further investigation in the solar car geometry, contributed a benefit of 10.5%, considerably improving the aerodynamic efficiency of the vehicle. This benefit resulted from a significantly reduced amount of pressure drag experienced by the vehicle, and it is reasoned that there would be a similarly beneficial effect on a conventional road vehicle as well.
Given an opportunity for a further exploration of the benefit provided by the wheel housings, there would be an opportunity to develop a 3D scale model of the component for use in the wind tunnel in order to improve the accuracy of the values calculated in this report.
Additionally, there is an opportunity to further optimise the design of the wheel housings by examining the distance of the housings offset from the wheel, as well as the height of the wheel housings around the wheel.
Both of the other features, the canopy fin and the trailing edge flaps, also achieved a considerable benefit, and further investigation could also provide valuable insight into the potential benefit they have to offer.