Simon McBeath is an aerodynamic consultant and manufacturer of wings under his own brand of The Wing Shop - www.wingshop.co.uk. In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

How high?

An oft-recurring question is at what height should a rear wing be mounted, especially if the racecar in question has a diffuser

Two seemingly contradictory factors come into play when trying to decide the answer to this question. The simple answer in most cases is that the wing will work best if you mount it as high as the rules permit. That way the airflow reaching the wing is as little disturbed by the rest of the car as possible, and the wing will perform as well as it can in what is still, usually, a compromised location.

However, in *Race Car Aerodynamics*, Joseph Katz cites a number of examples in which wing locations below the permitted maximum height proved beneficial. A dual-element wing on a closed sports prototype-style racecar apparently gave the greatest vehicle downforce when its height was slightly less than half the wing's chord dimension above the rear deck, measured to the wing's trailing edge, with the downforce tailing off at heights either side of this. And a single-element wing on a sedan-based racecar showed best vehicle downforce when at about 0.7 of its chord above the rear deck, again with downforce reducing at higher or lower positions. In other examples Katz illustrates how the presence of a rear wing on various racecar shapes helped to augment the static pressure reductions in the underbody to further improve vehicle downforce. So clearly there were some interesting interactions here that make it worth studying in more detail.

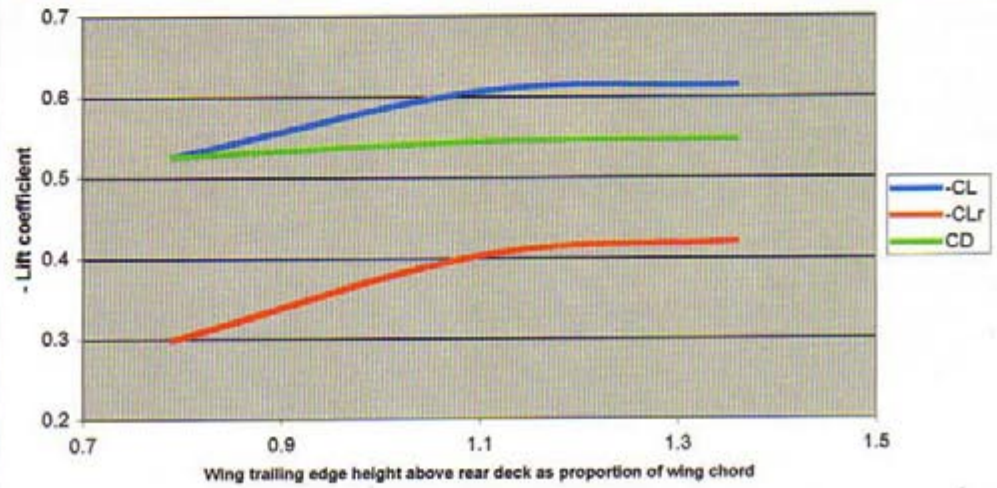
> **Mount [the wing] as high as the rules of your category permit**

ALTERNATIVE HEIGHTS

So when *Racecar* went into the MIRA full-scale wind tunnel with the race-modified Lotus Exige we started examining last month, the opportunity to try some different wing heights was too good to miss. To re-cap briefly on the car being used here, this particular Lotus Exige had been modified by Reverie Ltd with a number of components suitable for GT3 and Britcar-type applications. Featured were a complex front splitter that essentially led into a smooth, flat underside and front dive planes. The standard rear diffuser arrangement was still fitted at test time, as were 40mm wider wheelarches front and rear and a new, more aggressive wing profile than the standard road item at nearly full car width span and incorporating planform curvature. The wing's chord dimension was 230mm.

A set of alternative height wing support plates was manufactured prior to the test to allow reasonably rapid configuration changes to be made. The highest setting corresponded with the maximum permitted height under FIA GT3 regulations. The data derived is plotted in the graph below.

WING HEIGHT VS DOWNFORCE AND DRAG



Whole car and rear end negative lift coefficients at varying wing heights on a race-modified Lotus Exige

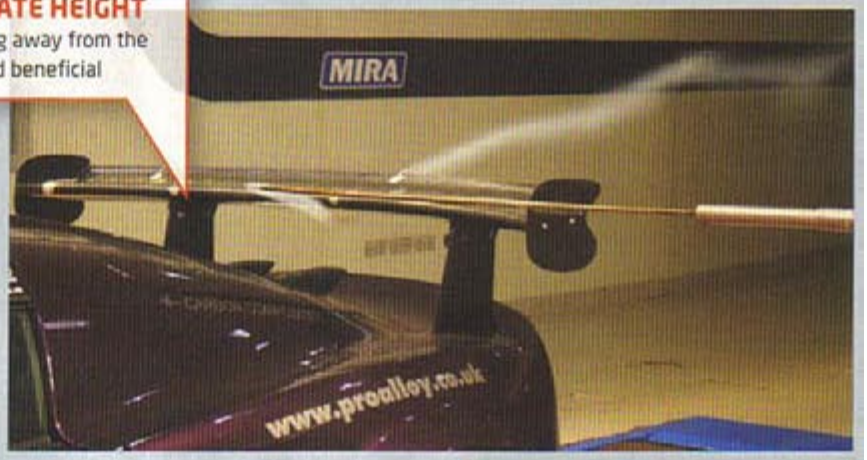
Produced in association with MIRA Ltd

Tel: +44 (0)2476 355000
Email: enquiries@mira.co.uk
Website: www.mira.co.uk

The relationship here seems pretty clear at the wing angle of 10 degrees tested - downforce increased with wing height until its height was slightly greater than its own chord dimension, at which point the gains appeared to flattened off. What is not clear is what would have happened at greater wing heights. Katz plotted data at wing heights up to 5.5 times the wing chord, but, as most regulations prohibit wings to be run that high, this is in many ways academic. However, although this experiment didn't go down to very small wing-to-deck gaps, it seems very improbable there was a peak in vehicle downforce in the 0.5 to 0.7 times wing chord region as Katz had shown. What could have been the reasons for the difference in this case?

It could simply be that the particular shape of the rear deck and the profile of the rear wing produced a downforce peak at a somewhat greater height than Katz had shown, and that downforce could then have declined again if greater heights had been tested. Or it could have been that there wasn't the same degree of interaction between the wing and the rest of the vehicle, and that moving the wing away from the rear deck simply proved beneficial.

LOWEST HEIGHT
The wing angle was kept at 10 degrees for the purposes of the tests



INTERMEDIATE HEIGHT
Moving the wing away from the rear deck proved beneficial

HIGHEST HEIGHT
Downforce increased until wing height was just greater than chord dimension

OBSERVATIONS

Two observations might bear out this hypothesis. Firstly, with a wing above a surface, it follows that, as the wing is brought closer to the deck surface, the wing's suction acts on that surface, and as well as the wing sucking itself downwards, it also sucks the deck surface upwards. This would lessen the overall downward force felt by the wing and the body of which the deck surface formed a part. And the region below a wing in which the static pressure is substantially reduced extends roughly one chord's distance below the wing. Therefore, we might anticipate that overall downforce would decline as the wing-to-deck gap reduced to below this distance.

However, another observation was made in this test session that would undoubtedly have influenced this experiment, and we shall look into this in some detail in next month's column. As it transpired, the diffuser on this car was running stalled because of the presence of the OEM exhaust tailpipes protruding into the central diffuser channel.

> **"Overall downforce declined appreciably as the wing-to-deck gap reduced"**

This would have precluded the possibility of any beneficial interaction between the wing and the diffuser, which might have seen greater downforce generated at a lower wing height.

Clearly, with more time it would have been beneficial to re-run this trial once the diffuser stall was eradicated. Equally, the presence of even this quite potent wing was insufficient to overcome the diffuser stall in this instance. So, all we might reasonably conclude from this trial is that in the absence of beneficial underbody interaction, it would seem that putting the wing as high as the rules allow maximises downforce.

Thanks to Simon Farren at Reverie and friends for exposing their cars to open scrutiny