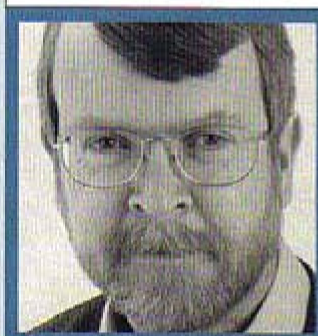

FIRST PRINCIPLES

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

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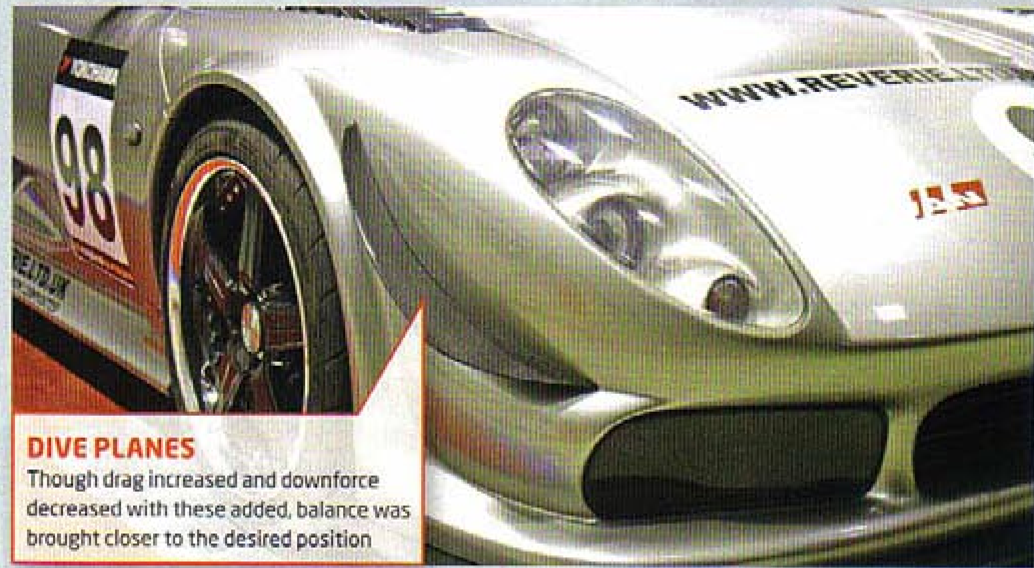
Balance issues revisited

Attaining an aerodynamic balance can involve sacrifices



All photos: Simon McBeath

DIVE PLANES
Though drag increased and downforce decreased with these added, balance was brought closer to the desired position

Aerodynamic balance on a racecar is crucial. No matter what the total downforce is, if it doesn't allow for the desired handling balance throughout the speed range, together with the ability to transmit power and braking forces while maintaining stability, a racecar is unlikely to be quick. We have seen in the past that front-wheel drive Touring Cars benefit from forward-biased downforce, but a mid-engined car with rear-wheel drive will need an aerodynamic balance pretty close to its front-to-rear static weight split.

The Britcar Noble M400 of Paul Cundy we have been looking at recently started our wind tunnel session at MIRA short of front-end downforce. Last month we saw some splitter modifications that achieved efficient gains in this area and some useful shifts in the aerodynamic balance. This month we examine the effects of some modifications we first saw in V18N4 on an IMSA Jaguar XJR-16, as applied to the Noble. It's rarely safe to assume that similar modifications will have similar effects on different cars, even if they are broadly similar in layout, and in this case re-visiting the modifications helps in understanding what's going on.

REFERENCES
This was the set up on the IMSA Jaguar XJR-16 that was used as the basis for the trial

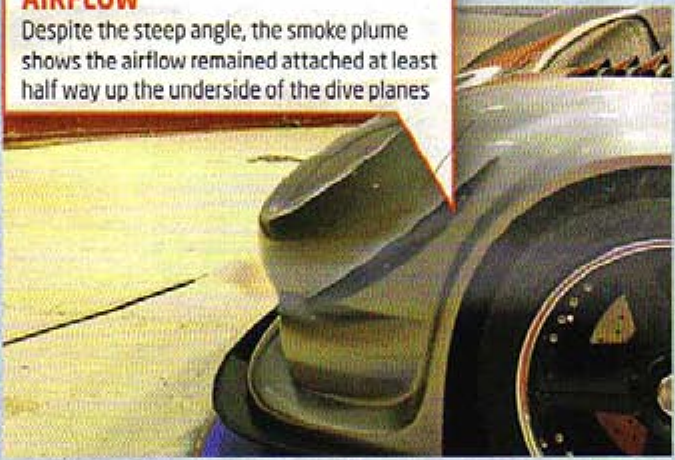
TABLE 1
The effects of adding a 25mm Gurney to the front edge of the radiator exit duct on a Noble

	CD	-CL	-CL front	-CL rear	% front	-L/D
Without Gurney	0.510	0.542	0.182	0.360	33.58	1.063
With Gurney	0.513	0.521	0.194	0.327	37.24	1.016
Change, counts	+3	-21	+12	-33	+3.66	-47

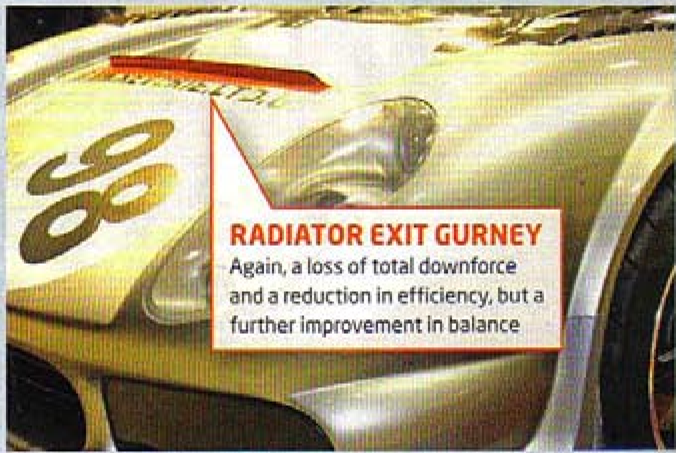
RADIATOR DUCT EXIT GURNEY

A fairly tall Gurney, approximately 25mm high (see photo overleaf), was taped across the forward edge of the radiator exit duct, and coefficients 'with' and 'without' are shown left in Table 1.

Fitting the Gurney to the



AIRFLOW
Despite the steep angle, the smoke plume shows the airflow remained attached at least half way up the underside of the dive planes



RADIATOR EXIT GURNEY
Again, a loss of total downforce and a reduction in efficiency, but a further improvement in balance

radiator exit created a 3.9 per cent loss of total downforce and a 4.4 per cent reduction in efficiency (-L/D), relative to the 'without Gurney' configuration. However, front downforce increased and the balance shifted to the front and into the target range of 35-38 per cent front.

If we go back to the similar modification carried out on the IMSA Jaguar, when a somewhat wider but less tall Gurney was attached at the same effective place, the changes to coefficients and balance were as shown in table 2 (below). Comparing the change in counts of drag and downforce rather than their proportional effect on the whole car (the IMSA Jaguar produced a *lot* more downforce and drag than the Noble), we can see that in the case of the IMSA car there was actually a small decrease in drag, though the drag change is very small on both cars. There was rather more than double the change to overall downforce, and the front end saw a small downforce increase while the rear end saw a moderate downforce increase. So the generic pattern of changes was similar, and it's therefore safe to expect similar patterns from this modification on other closed wheel GT and prototype cars with front radiators ducted this way.

But what are the mechanisms at work here though? The simplest explanations are that the Gurney has slightly elevated the static pressure ahead of itself and over the forward upper surfaces, while the flow aft of the Gurney has been robbed of some total pressure (energy), which sees the rear wing producing less downforce. Clearly, different size (width and height) Gurneys could be tried in this location as balance adjusters, and their effect on cooling could also be studied in track testing. However, a more efficient means of achieving a similar balance shift might be to fit a smaller Gurney (if one were in use) to the rear wing, or to reduce rear wing angle slightly.

FRONT DIVE PLANES

The dive planes fitted to the Noble were of roughly similar plan area to those on the IMSA Jaguar highlighted in V18N4. However, they were set at a pretty steep angle on the Noble, though at similar height to the Jaguar relative to the front upper bodywork. The coefficients 'with' and 'without' dive planes on the Noble are shown in table 3.

In this instance, drag increased by 2.2 per cent with the fitting of dive planes, and overall downforce reduced by 1.1 per cent, the combination dropping efficiency by over three per cent. The effect on balance was marked,though, and this was one of the most significant modifications in getting the balance into the target zone.

Compare the changes created by the fitting of two different configurations of dive planes to the Jaguar, shown in table 4.

So the generic pattern was the same in all cases, even if the extent of the changes varied. We can conclude then that by adding dive planes like those featured here has the following effects:

- Drag increases, front downforce increases and rear downforce decreases in relation to the 'aggressiveness' of the dive planes
- -L/D decreases
- Balance shifts to the front

Common factors here were that all the dive planes examined were quite large, and all terminated above the wheel centres. Smoke visualisation on the Noble showed the wake from the dive planes merged with that from the side mirrors and impinged on the outer portions of the rear wing. Further study would usefully cover smaller dive planes mounted lower down on the car in hopes that less adverse interaction with the rear wing would arise. Nevertheless, dive planes are potent balance shifters when required.

Thanks to Simon Farren at Reverie, Paul Cundy, Richard Gould, Phil Brett and Adrian Winch.

TABLE 2

The effects of adding a small Gurney to the front edge of the radiator exit duct on an IMSA Jaguar

	CD	-CL	-CL front	-CL rear
Adding Gurney, counts	-3.5	-48.5	+4.0	-52.5

TABLE 3

The effects of fitting steep dive planes to a Noble

	CD	-CL	-CL front	-CL rear	% front	-L/D
Without dive planes	0.502	0.527	0.128	0.400	24.29%	1.050
With dive planes	0.513	0.521	0.194	0.327	37.24%	1.016
Change, counts	+11	-6	+66	-73	+12.95%	-34

TABLE 4

The changes arising from fitting dive planes at two different angles to an IMSA Jaguar

	CD	-CL	-CL front	-CL rear	% front	-L/D
With 'default' dive planes, counts	+8	-52	+36	-89	+1.60%	-89
With steep dive planes, counts	+21	-21	+102.5	-125	+3.31%	-35