Front end drag and aero balance

Our last look at VUHL's 05; front end and surface pressure mapping

The VUHL 05 concept from the Echeverria brothers Iker and Guillermo fits the same 'lightweight sportscar for road and track' genre as the Lotus 2-11, the Ariel Atom, the BAC Mono and the Caterham AeroSeven concept. UK-based Collins Advanced Engineering, run by brothers Jenner and Jilbruke Collins, were carrying out development work for VUHL, enabling *Racecar Engineering* to host the 05 in a MIRA wind tunnel session, as per **Picture 1.**

Briefly recapping, the 05's baseline configuration at this early stage of the car's aero development produced the data shown in **Table 1** at the wind tunnel's maximum speed of roughly 35m/s (80mph or 126km/h).

So, moderate drag (it is an open sports car) was accompanied by modest but genuine downforce with a forward bias relative to the static weight distribution of 37-39 per cent front. Rear wing re-location, reported in the last issue, enabled improved aerodynamic balance and higher overall downforce to be attained, albeit at a drag level a few per cent higher.

Front end modifications

Some covers were then applied in succession to the front end of the car to examine the responses – see **Picture 2.** First, the front light clusters were covered, and the changes (deltas or Δ values) are shown in **Table 2** as 'counts', where 1 count = a coefficient change of 0.001. The effect then of smoothing over these areas was really quite small, the most significant aspect being that balance was shifted slightly further forwards. A very small drag improvement was also achieved.

Second, the cutouts in the airdam ahead of the front wheels were covered over, and the changes relative to the configuration above are shown in **Table 3.**

Perhaps surprisingly, drag increased slightly with this modification but, most significantly, front downforce increased by 84 counts, or 77 per cent in this instance. Rear downforce declined by 25 counts, which together with the front gains meant that almost 100 per cent of the downforce was now on the front. Whether this modification would be deemed beneficial would depend on development aims, because obtaining an aerodynamic balance with this front end would require a stronger rear end package than was available for this session, which in turn would most likely add more drag.

Third, the upper surfaces of the outer sections of the front splitter were covered over, with the results in **Table 4.** This time some front downforce was lost, the 50 count reduction representing 25.9 per cent, meaning the splitter was still generating nearly three quarters of its original downforce from the centre section and the unmodified underside (where most of a splitter's downforce comes from). What was interesting though was the 18 count drag reduction, which put the other way around means that these sections of the splitter and airdam were creating 50 counts of downforce for 18 counts of drag. By way of comparison, various splitter extensions we have examined in the past have yielded front downforce gains for minimal if any drag change.

Obtaining balance with this front end would require a stronger rear end

Table 1 – baseline data on the VUHL 05

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Baseline	0.533	0.135	0.102	0.032	75.6	0.253

Table 2 – the effects of covering the light clusters

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
Lights covered	-2	+1	+7	-6	+4.6%	+4

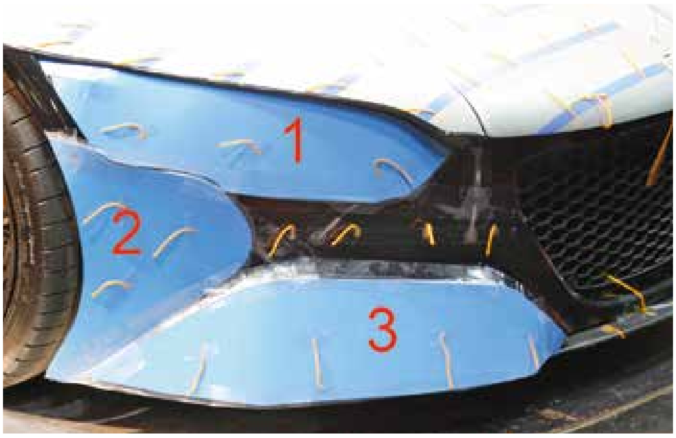
Picture 1: This month the VUHL 05 front end is modified, and surface pressures are measured via the loom of capillary tubing seen emerging from under the car

Table 3: the effects of covering the cutouts in the front airdam

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
Cutouts covered	+7	+58	+84	-25	+19.5	+104

Table 4 – the effects of covering over the outer sections of the front splitter

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
Outer splitter covered	-18	-43	-50	+7	-5.3%	-70



Picture 2: These three cover panels were applied in the order shown, with very interesting results

Picture 3: Two of the 46 pressure tappings attached to the VUHL; each features a pinhole open to atmosphere which is connected by capillary tubing to the pressure scanner

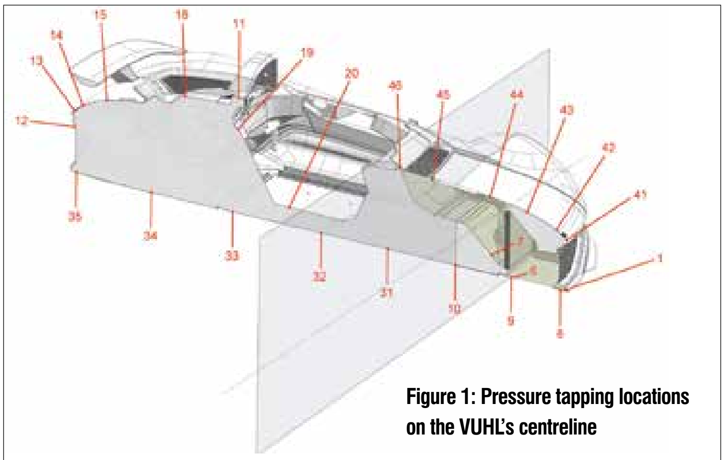


Figure 1: Pressure tapping locations on the VUHL's centreline

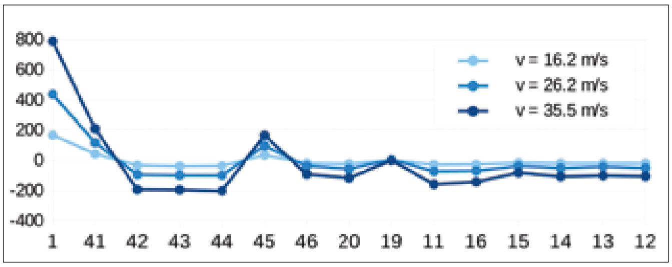


Figure 2: Pressures (pascals, Pa) on the VUHL's upper centreline profile at three different speeds

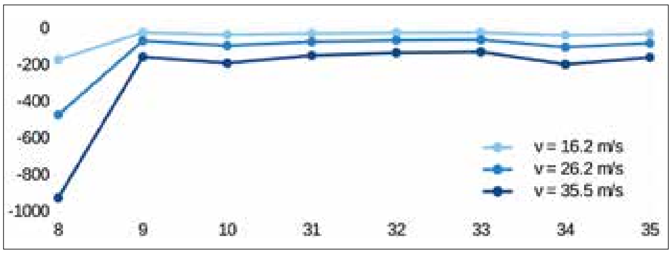


Figure 3: Pressures on the lower surface at three different speeds

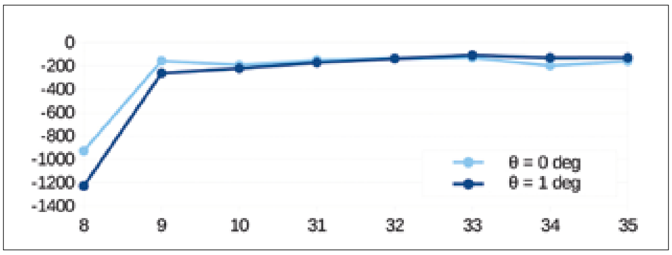


Figure 4: Pressures on the lower surface at 35m/s in zero rake and 1 degree rake configuration

Feeling the pressure

Although not something we normally have time for in our half day sessions, diligent preparation by Collins Advanced Engineering and exceptional cooperation from the wind tunnel crew saw, for this occasion only, a 46-port static pressure monitoring loom applied to points of interest on the car and logged by MIRA's pressure scanner and data acquisition system, as shown in **Picture 3**. The primary objective was to correlate with Collins' CFD analysis, and *Racecar Engineering* hopes to delve into these correlations, together with the track test data, in a future issue. Meanwhile, space allows us to cast a few glimpses at the data from these pressure tappings.

Figure 1 shows the locations of the pressure taps on the car's centreline, and **Figures 2 and 3** show the measured pressures (in pascals) on the upper and lower surfaces along the centreline at three wind speeds. In **Figure 2** the most obvious aspect is the increase in the magnitude of the pressures with increasing speed, be they positive (increases) or negative (decreases) relative to ambient pressure. Next, we can see how the positive pressure on the front of the car reversed to suction over the forward, convex part of the bonnet and then reversed again to positive ahead of the Gurney located in front of the grill that sits in front of the front screen. Then, as intended, the pressure behind the Gurney at the base of the screen was in fact slightly negative to enable the aforementioned grill to function as a cooling exit, an unusual choice at this location; the presence of the Gurney appeared to assist this function.

Moving on to **Figure 3** and the lower surface, again the change in pressure magnitude with speed is clear, as is the negative pressure under the forward part of the splitter. Notice, too, that even at the relatively high ground clearance the VUHL was running (110mm front and rear in this configuration) the suction under the forward part of the splitter (**Location #8**) was actually somewhat greater than the positive pressure on its forward upper surface (**Location #1**). The pressure remained negative through the entire underbody, demonstrating the benefit of a tidy, smooth underbody even at relatively high ground clearance and with zero rake. And although the centreline did not include the rear diffuser profile, **Location #34**, just ahead of and laterally offset slightly from the diffuser transition, showed an additional modest 'suction peak'.

Finally a quick glimpse at the change in underbody pressures with 1 degree of rake, (simulating heavy braking) is instructive, as **Figure 4** shows. Here we see how the suction under the front of the car was increased as far aft as **Location #31** by the reduced front ground clearance, but also that the magnitude of the suction in the diffuser region (**Locations #33 to 35**) was reduced in the raked case, presumably as the result of the increased ground clearance at the rear in this configuration.

Next month we'll move onto another new project.

Racecar Engineering's thanks to Iker Echeverria at VUHL, and Jenner and Jilbruke Collins at Collins Advanced Engineering. And special thanks to the MIRA wind tunnel crew for their extra assistance prior to this session.

CONTACT

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In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

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