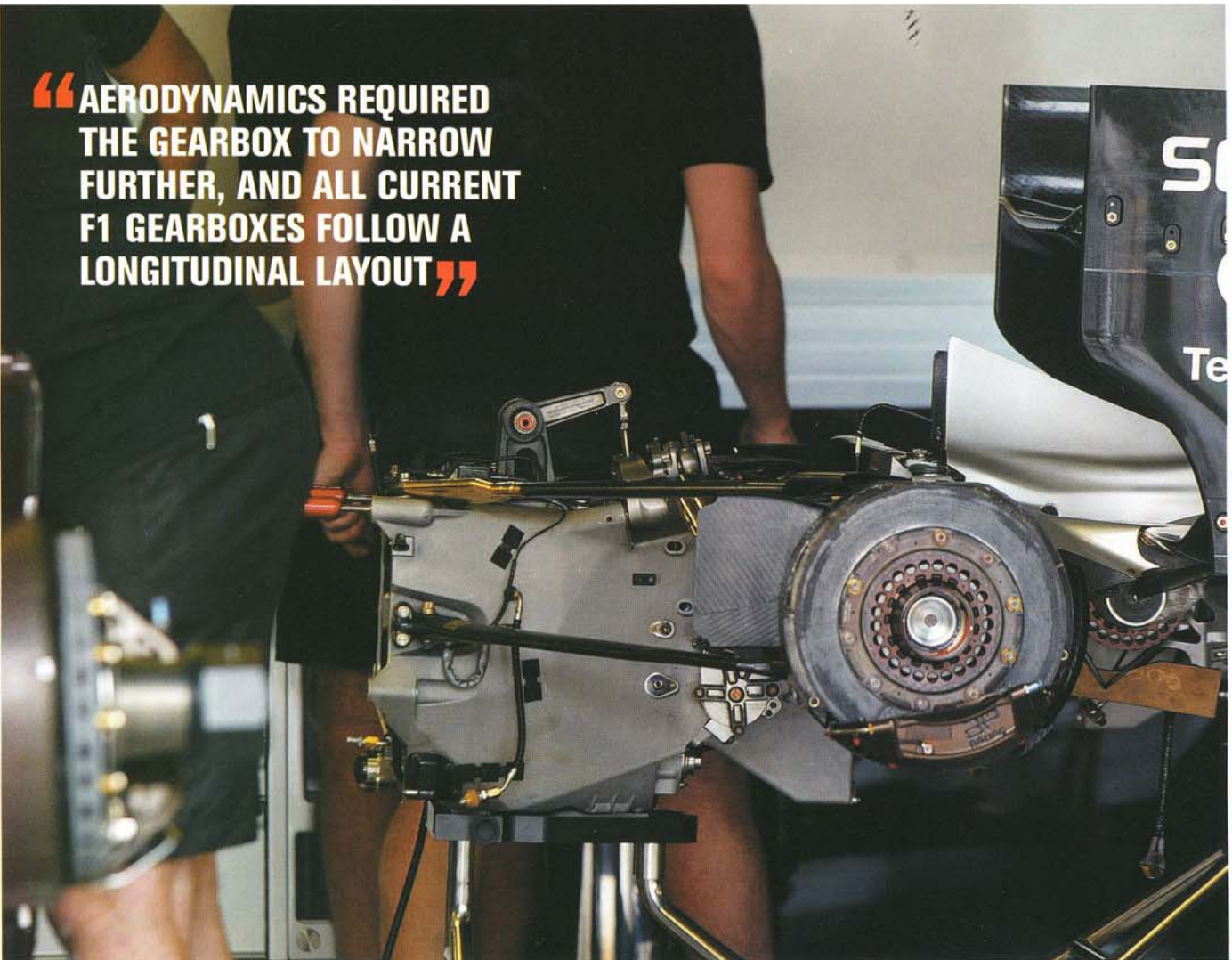


F1 transmission trends

F1 gearbox developments over the past decade have been as spectacular as engine developments, only less talked about. Racecar looks at the latest trends

Words	Simon McBeath
Photos	Sutton Images; Xtrac

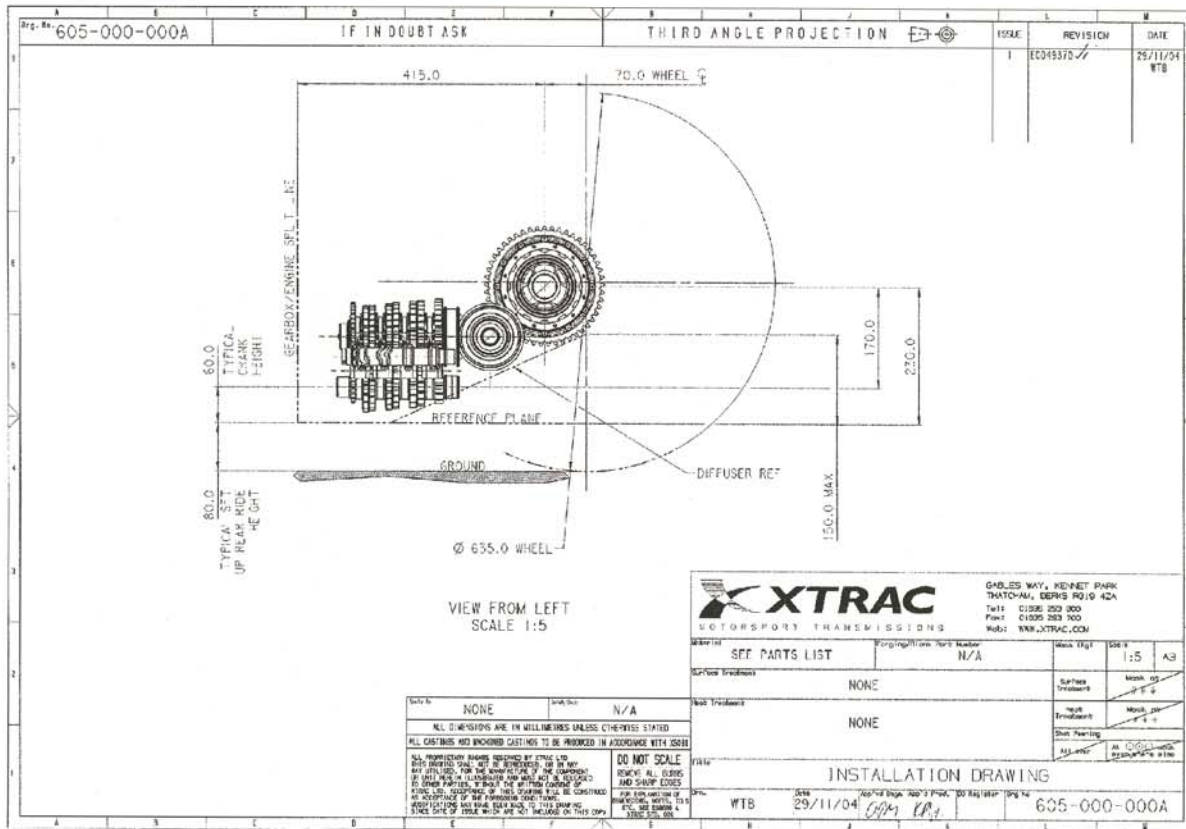
“AERODYNAMICS REQUIRED THE GEARBOX TO NARROW FURTHER, AND ALL CURRENT F1 GEARBOXES FOLLOW A LONGITUDINAL LAYOUT”



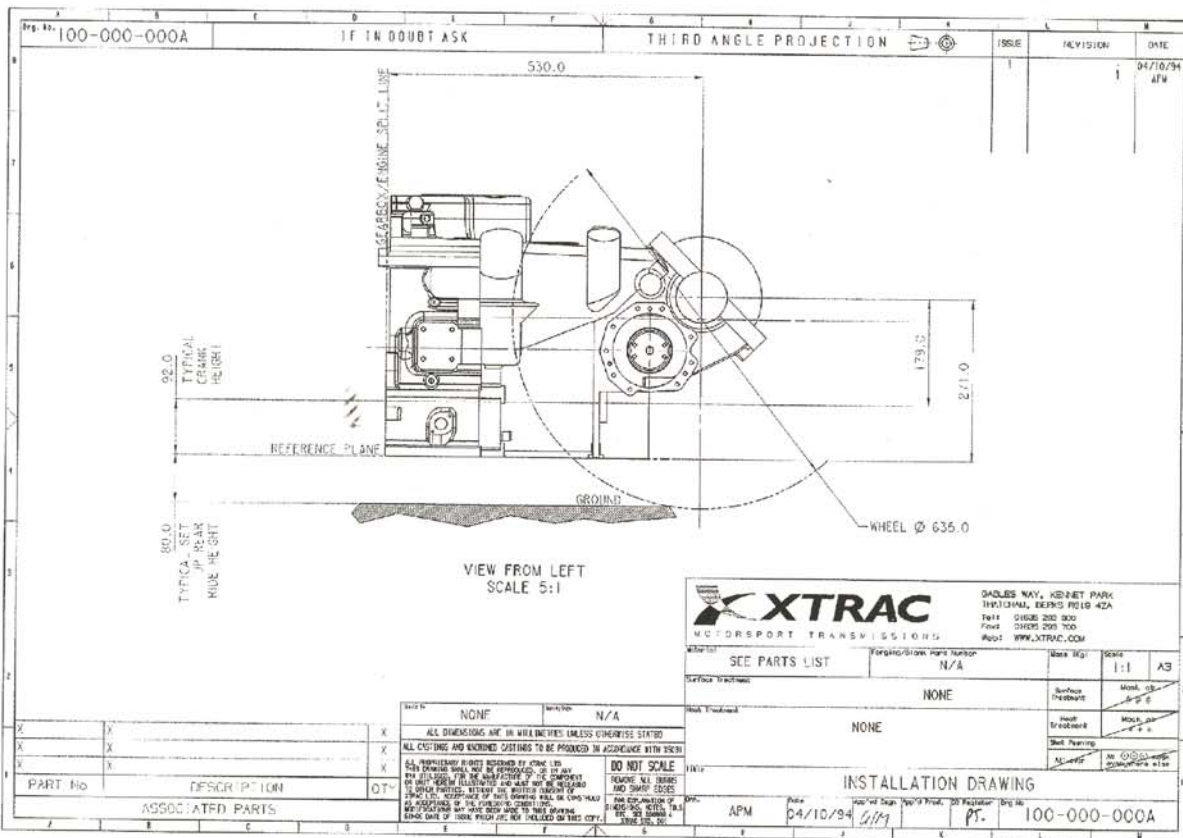
It has been said that the only time a gearbox gets noticed is when it breaks. This does a great disservice to the high-quality engineering that goes into modern racing transmissions, and especially so in Formula 1. Here, engine outputs have climbed back up to almost 1000bhp under the prevailing rules of 2004/05, and yet the gearboxes are smaller, lighter and more efficient than ever, contributing significantly to the cars' performance enhancement.

This progress has been driven by various factors, including: regulation changes; aerodynamics; the quest for weight saving and optimum weight distribution; better detail packaging; and more efficient operation. And the principal facilitators to progress include better materials, improved design and manufacturing technology and, let's not forget, good old-fashioned ingenuity.

To chart some milestones during the past decade or so we spoke to



Some constraints and typical dimensions on a 2004 F1 gearbox



Installation drawing of a 1995 F1 gearbox – the dimensions make an interesting comparison with current models

Adrian Moore at Xtrac Ltd, the renowned Berkshire, UK, racing transmission specialist that has been heavily involved in F1 since the late 1980s. After four years as a design engineer at Xtrac from 1992-96, Moore then spent a year at Ferrari, followed by two years at McLaren ('97 and '98, including design work on the '99 car), after which he returned to the Xtrac fold where he became technical director in 2002. With that history, there can be few people better placed to be our guide.

Layout and packaging

'Nowadays,' says Moore, 'the gearbox is just an inconvenience to the aerodynamics guys, and slightly less so for the suspension guys'. But the regulations also delineate the space the gearbox must occupy. The reference plane (the plane defining the minimum height for any component except the wheels and tyres) dictates the bottom of the gearbox. 'The distance from the reference plane to the engine →



A 22:26 gear ratio set from the early 1990s, in carburised re-melted steel



Same gear ratio set, mid-1990s – by now around 2mm narrower in width



Same ratio again, but 2004 – lighter, smaller and with a new surface finish



Same gear ratio set once again, but this time a typical sportscar gear set

originally had manufacturing problems, they solved them successfully. JB's first carbon case ran in the Arrows A19 that same year. And it was Minardi that first ran an investment cast titanium casing in 1999.

'The main reason for abandoning aluminium and magnesium is that these metals do not have good mechanical properties, in particular stiffness at temperature. That is the big gain with carbon. Its specific stiffness is six times higher than that of magnesium at room temperature, and much better still at high temperature. And if the gearbox can run at higher temperature then the cooler can be smaller, offering an aerodynamic benefit. A secondary benefit is that aluminium and magnesium are essentially not repairable because of the heat treatment they require when they're originally manufactured. Titanium can be repaired, as can carbon.'

One of the larger internal assemblies is the differential, which has seen not only changes in operation principles in the last decade, but

also substantial weight savings. Adrian Moore: 'Pre mid-'90s most teams used the plate-type 'Salisbury' limited slip differential, although there was some dabbling with hydraulic pump diffs. In the mid-'90s the viscous differential probably became universal, mostly made by Xtrac around 1996. Being speed sensitive made them good for reducing wheelspin, but they were far from optimum. Since then everyone has gone to hydraulically-controlled active differentials, and the rules are pretty free now, except there can be no torque biasing for a steer effect [as is allowed by the regulations in World Rally Cars, for example].'

On size and weight though there has been tremendous progress through improvements in design and manufacture. In the case of the diff this has enabled a 12.5kg item in 1998 to slim to less than half that at just over 6kg in 2004. Adrian Moore: 'in that time the basic functionality has stayed similar, but attention to detail has enabled the diff to be made much narrower especially. This allowed →

“CURRENT F1 DOG RINGS ARE JEWEL-LIKE IN COMPARISON, LOOKING IMPOSSIBLY FRAGILE”