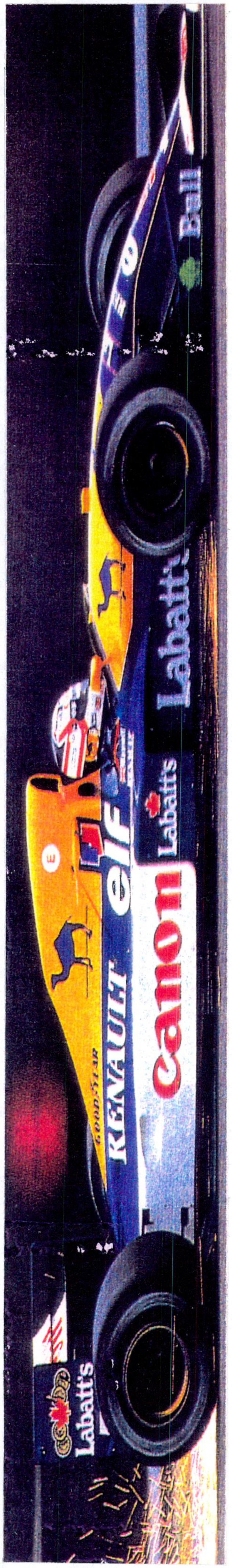

NATIONAL COLLEGE OF ART & DESIGN

DEPARTMENT OF INDUSTRIAL DESIGN

The Design and Influence of Formula 1 Cars on the Design of Road Cars in the Early 1990s.

by **COLMAN BILLINGS**

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INTRODUCTION

The modern car is a machine of ever increasing complexity. Since the beginning of the 1980s companies have produced cars with innovative developments originating in motor-racing such as active computer controlled suspension, effective aerodynamics and computerised engine management systems. What is the background of these developments? What is the process by which these developments become standard on road cars? How many other innovations have not yet been, or can not be, integrated into modern road car design and why? The way to find out is to look at the precipitation of technology from its purest form, which is Formula 1 motor-racing, to mass production via the pinnacle of high performance road car design, the supercar.

The Formula One racing cars of the 1990s are examples of the very best in automotive technical achievement. They are more comparable with jet aeroplanes than road cars. The engines are "thoroughbred" for maximum acceleration and speed. The only function of the car's body styling is to keep it on the ground at speeds greater than those of light aircraft at lift-off as efficiently as possible.

These factors and many others, force the industry to put enormous effort into the research and development of new ideas. To remain competitive the design team must avail of the latest technology and apply it in a way that improves on the past.

During the first quarter of the 20th century racing cars were not so different from road cars. They were very much the same as the road machines driven by rich enthusiasts. Often the only difference would be the removing of excess upholstery, mudguards and retuning of the engine. The highly specialised automobiles built specifically for track use did not evolve until the late twenties when engineers and designers became more specialised in their aims and tracks became available.

These were the days when Grand Prix races were often run on beaches and the only protection the driver had was a pair of goggles. The cars were called "Grand Prix racers". It was not until 1950 at the British Grand Prix that the cars were officially recognised as Formula 1. This meant that all the cars had to comply to a common design specification. Early racing cars were a combination of high power and robust frame. However in just one lifetime, technology has moved so fast that computers have become irreplaceable in the design of the Formula 1 car.

During the course of the twentieth century motor racing (especially Grand Prix racing) has moved progressively further from its origins on beaches or dirt-tracks. Grand Prix, or Formula 1 cars as they became known, became specialised only for track use utilising the perfect road surface for the best performance.

The question may be asked what relevance does Formula 1 racing have to modern road-car design. The racing car is such a specialised machine bearing little visible resemblance to the road car. From the public's point of view, the sport is an exorbitant use of resources to put on a spectacular show. Multimillion dollar advertising deals are normal. The running of a single Formula 1 team costs in the region of six million pounds per year. Fuels used in these cars are highly toxic cocktails of Methanol and Nitromethane - true rocket fuel.

Formula 1 design has leapt far ahead of the road car developments. Because of this technological gap companies that produce innovative elements in a racing car can spend several years developing that for road use. This process of filtration still occurs today. The super-car is an example of this. It is a high performance machine built for speed and showmanship. This is where the latest refinements in motor-racing are first incorporated into a road car.

Due to an almost free hand in terms of production cost, these cars are often highly developed racing machines tamed for road use. The most recent examples by McLaren and Yamaha use Grand Prix car design wherever applicable. They use similar construction methods, many of the same materials, specially designed wheels and an array of Formula One derived performance aids. Maybe it is not surprising then that one of these cars costs in the region of £500,000.

This begs the question is Formula One car design and the benefits gained from it only for the super-rich elite? It has far reaching effects directly and indirectly on the design of all cars. In the past racing cars were used to test new theories. Now developments come in the form of materials research, electronics, aerodynamics; areas that require vast monetary and manpower investment to research. The car industry uses the resources within motor-racing to do this. Companies such as Honda, Renault and more recently McLaren, invest millions every year in research and development of racing technology to road use.

The present level of understanding of aerodynamics comes from Grand Prix car design research. The introduction of turbos, disc brakes, modern tyre materials, engine management systems, suspension geometry and fuel efficient engines stem from Formula One design and experimentation. More subtle effects on mass produced cars are in their marketing and styling. The image of the racing car is used as an aid to boost the perceived value and prestige of the road car in advertising.

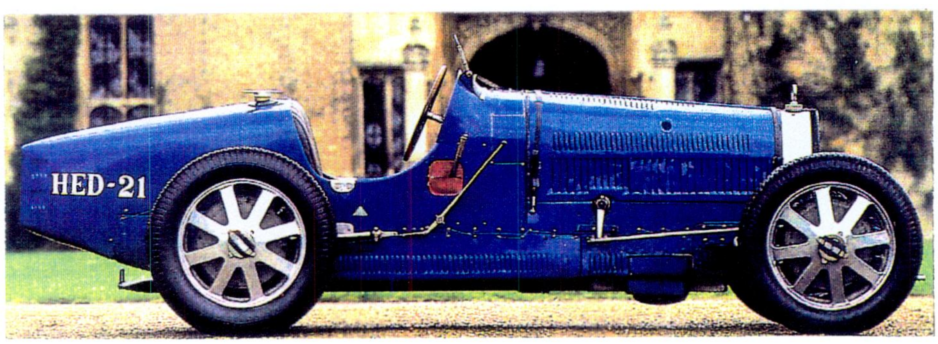
Modern styling features such as aerofoil rear wings, low profile wheels and flamboyant air intakes. They are derived from the image of speed and agression that all racing cars have. Wings were first introduced on the Lotus 49b Grand Prix car of 1968. Now mass produced cars such as the Ford Sierra RS Cosworth also have wings. But the reasoning is different. Now wings and other styling features are used to project more than effect performance.

To more fully understand the connection between the racing car and its effect on the road car the reader must comprehend the development of the racing car and milestones in its evolution that have effected the design of all cars.

CHAPTER 1. THE EVOLUTION OF THE DESIGN OF GRAND PRIX CARS

Ettore Bugatti was one of the great pioneers of motor-racing. His work is one of the stepping stones to the modern day Grand Prix car. Bugatti's greatest creation was the Type 35. This was the first thoroughbred racing car. He was the first to address the problem of power to weight ratio rather than pure power.

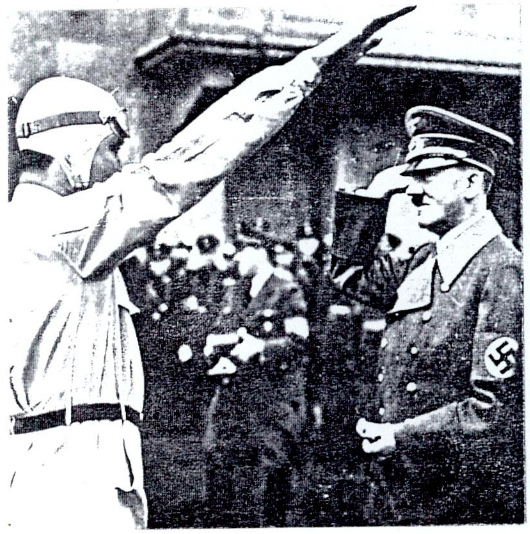
The Type 35 was a major leap in car design. The wheels were made lighter by replacing wire spokes with aluminium castings. The chassis was made lighter by drilling holes through it. The overall car was smaller than its rivals, utilising the concept that intelligent refinement can out perform brute force. This is something that repeats itself during history.



1. The Bugatti Type 35, 1925.

In 1926 and 1927, Bugatti cars (mostly the Type 35 and its variants) won more than 1300 races. Simultaneously, the extremely elegant sports and touring road cars that now command prices measured in millions of pounds were in production at the Bugatti factory. The reasons why Bugatti cars are now held in such high regard are many. The beauty in the styling of most Bugattis must be attributed to Ettore Bugatti's artistic eye. In contrast, the success of Bugatti racers relied very much on Ettore Bugatti's lack of understanding. He designed engines and suspension components that, more often than not, questioned and broke the accepted rules of what is technically correct. Such design innovation transformed the motor-racing industry, improving the breed by forcing technical development of any car producer that wanted to be competative (Burgess-Wise, 1991, P.361-365).

As motor racing became more popular, great Formula 1 cars were seen to be a reflection of their country of origin. Motor racing became political. Germany's Nazi government made available vast sums of money for Formula 1 development schemes. The once innocent pursuit of speed in racing car design became a pawn in world affairs. Thus started the massive financial support that Formula 1 racing still gets today but from different sources.

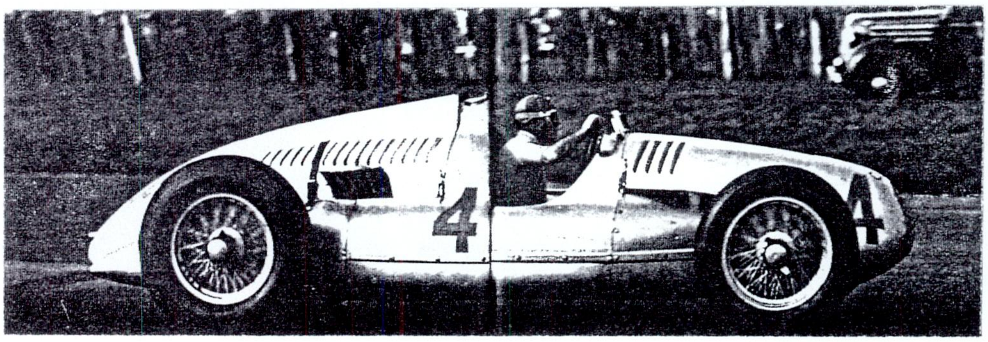


2. Adolf Hitler salutes a Grand Prix driver, 1938.

The thirties were split between the Italian and German cars. Not co-incidentally, the two countries most concerned with propaganda and showing the world their superiority had the most competitive grand prix cars. The late thirties saw the Germans dominating completely to the point where the sole entrants in the Yugoslavian grand prix of 1939 were German Auto Union Type Cs designed by Ferdinand Porsche. The design of the Type C heralded a change in thinking that was not to be developed until the end of the war. The Type C had the engine mounted at the rear giving better weight distribution and body styling that is reminiscent of the Cooper cars of the late 1950s.

The level of financial support supplied by the German and Italian governments to their respective teams is aptly described by Eric Dymock in his book 'Grand Prix Motor Racing':

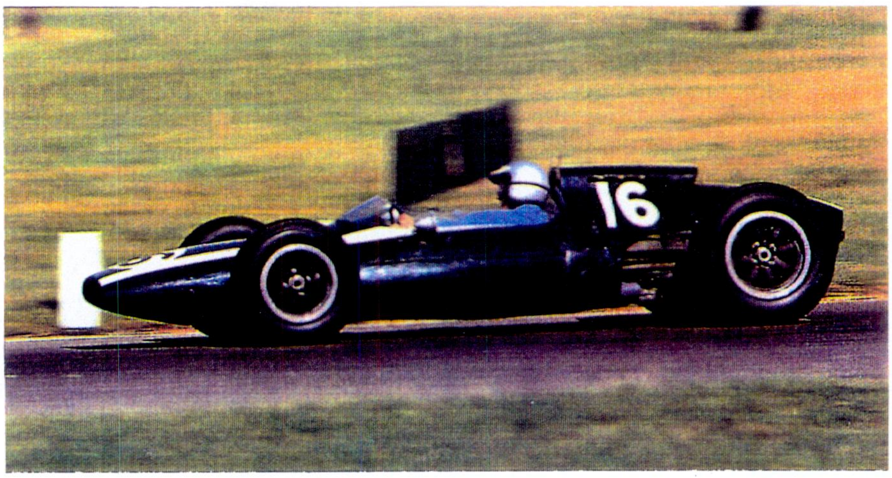
> ... as the torpedoed Athenia began to settle in the icy waters of the North Atlantic, and the first tragic casualties of war were sustained, the chequered flag fell on six years that had taken Grand Prix racing beyond the realms of mere sport into an Olympian arena of international propaganda, where the principal consideration had been prestige and a technological ideology. It had been a struggle between nations the like of which would not be seen again until the space race of the 60s (Dymock, 1983, P.10).



3. The Auto Union Type C, 1938.

For six years after 1939 motor racing stopped completely. It took five years after the end of the war for designers and engineers to begin development again but of cars now 10 years old. The result was the next landmark in Formula 1. The complete rethinking of the car, came in the late fifties. It was the mid-engine revolution. John Cooper designed and developed the first mid-engined grand prix cars from an original machine that was made by welding the front ends of two Fiat 500 Topolinos together.

Similar to Bugatti's design ethic, Cooper's cars were smaller, lighter and therefore faster than their competitors. They had the added advantage of concentrating all the weight of the engine and fuel tank between the front and rear axles which gave them superior roadholding to their competitors. The once masterful Ferrari's lost out to the nimble mid-engined Coopers. Within two years all competitive Formula 1 cars had the engine behind the driver. This mid-engined configuration was found to be the best form for the new winding racing circuits of Europe(Blunsden, 1991, P.281-285).



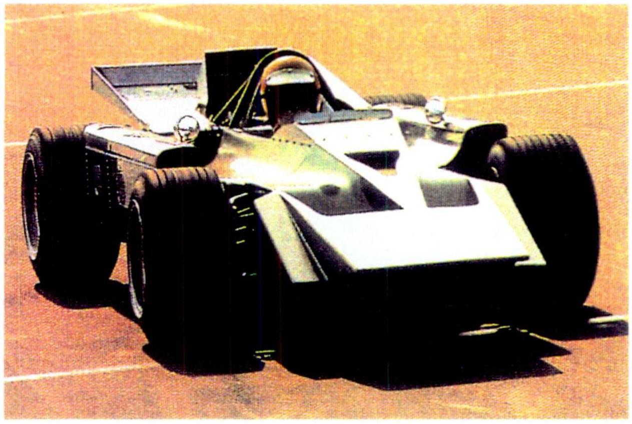
4. The Cooper mid-engined car, 1958.

This was really the beginning of Formula 1 racing as we know it today. From this point on cars have remained very similar geometrically. Subsequent ettempts at creating the ultimate Formula One car are all developments on the mid-engined Cooper format. These have appeared as additions onto his origional concept rather than any radical rethinking of the design problem. This is partly because the type of tracks used have not changed considerably in the last thirty years (enclosed winding circuits), and partly - probably mostly, because of the increasing number of regulations limiting the F1 teams. The governing bodies have, over the last forty years, developed the design regulations to incorporate limitations that are exact, and comprehensive thereby making truly innovative cars almost always illegal before they even reach the drawing-board never mind the track.

Without exception every Formula 1 car maker adapted to this concept. Technological development and the pursuit of performance proved itself the driving force behind Formula 1. Indeed the cars ended up so closely matched by way of chassis, engine and suspension design in the mid sixties that the winner of a race was often decided on the grade of stickyness of his tyres. This forced new tyre and wheel designs to be researched. Much progress was made in the understanding of what exactly happens to a tyre while driving. Road cars later benefitted in the design of efficient tyre treads for improved wet-weather grip. The widespread domination of radial tyres over inferior crossply tyres is also as a result of this research. (Crossply and radial refer to the methods of construction of a tyre. For further information see "Designing Tomorrow's Cars", Walter Korff, 1980.)

The resulting stalemate forced engineers and designers to take a step back and decide objectively what would be the next factor that could bring them success. A racing car is at its slowest when rounding a corner.

Therefore experiments were carried out into four-wheel-drive in an ettempt to gain maximum traction during cornering.



5. An experiment in four wheel drive, 1968.

The bulky mechanical componentry required proved to be too heavy for the relatively small gain in traction. It was discovered that theoretically wings pushing the car down onto the track would aid traction giving the same effect as four-wheel-drive without the weight penalty.

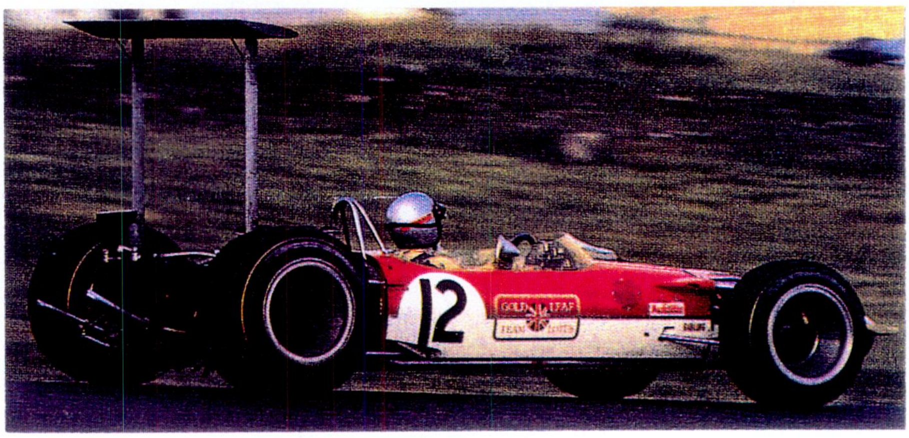
Probably now the most prominent feature of any Formula 1 car, in the late sixties aerodynamics on a car was 'an inexact science'. Early experiments produced more lift than downforce, destroying them. Tentative efforts were made by attaching small wings over the engines of some cars. Some were more effective than others. Some were positively dangerous. This prompted regulations to be made as to what size wings could be. The result was many designers calling their 'wings' 'airducts' for oil cooling (e.g. the 1968 Lotus 49 by Colin Chapman) so that they would not have to comply with the stringent regulations (Dymock, 1983, P.120).

6. The Lotus 49, 1967.

The Lotus 49 development over three years aptly illustrates the direction Formula 1 cars took at that time (1967-1970). The original concept for the car was the slimmest possible monocoque utilising the engine as a structural part of the car thereby saving weight. Similar to the other cars of the time the Lotus body was made as slender and smooth as possible for reduced frontal area denoting less drag and therefore higher speed in a straight line. All the designer's effort went into reducing drag.

7. The Lotus 49, 1968.

Essentially the same car as the original Lotus 49 the 49B of 1969 grew cumbersome aerofoils on its nose and over the engine. While greatly increasing straight line drag, the increased downforce on the tyres improved cornering grip and therefore speed making the Lotus highly effective against its rivals on the now standard tight, winding international racing circuits, mostly made specifically for Formula One cars .



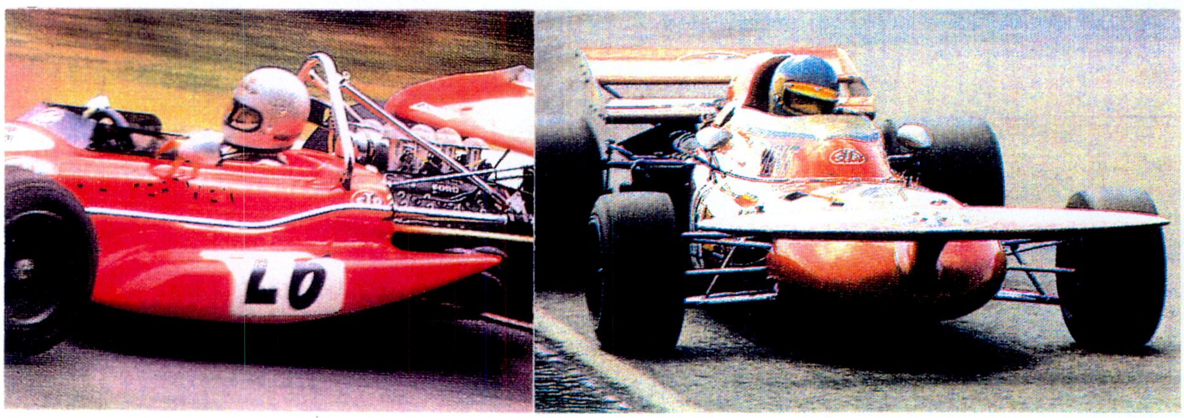
8. The Lotus 49B, 1969.

In search of clean airflow for optimum efficiency the rear wing was positioned high above the car. In theory this was the correct decision (although traditionalists tried to stop the move towards 'winged' cars in an attempt to retain the elegance - as well as a lot of the danger - of the old cars). In practice these aerofoils were very delicate and often folded at racing speeds. The near death experience of the two Lotus works drivers Graham Hill and Jochen Rindt at the Spanish Grand Prix of 1968 showed this with devastating and far reaching effect. Their respective rear wings disintegrated on the crest of the same hill. Had these wings been better engineered by the Chapman team of designers (known for their minimalist use of material to save weight wherever possible) they would probably be evident on today's Formula 1 cars.

9. The Lotus 49C, 1970.

But, because of the now obvious risk to drivers and spectators (the most important limiting factor in Formula 1 design) such outrageous wings were outlawed. Wings had proved themselves necessary though. By 1970 every car had nose and tail wings. The look of the Formula 1 car changed forever. Gone was the slender elegant rocket-like shape replaced by the less pleasing, but more effective, (which in racing terms is all important) wedge shape. No longer flowing through the air - Formula 1 cars now slice the air, cutting it with sharp edges that aesthetically look wrong on anything that doesn't fly. But when performance is the most important design factor aesthetics are cast aside. The aesthetic of the racing car comes from the pursuit of high performance. It is not applied as is done in other design fields such as furniture.

The one thing this new technology (downforce) did was open up new avenues to be explored. After all the very similar cars of the late sixties, the seventies heralded an assortment of concepts as to what was aerodynamically the most effective way of inducing the correct balance of downforce for corners without too much drag during straight sections (driver operated aerofoils were made illegal).

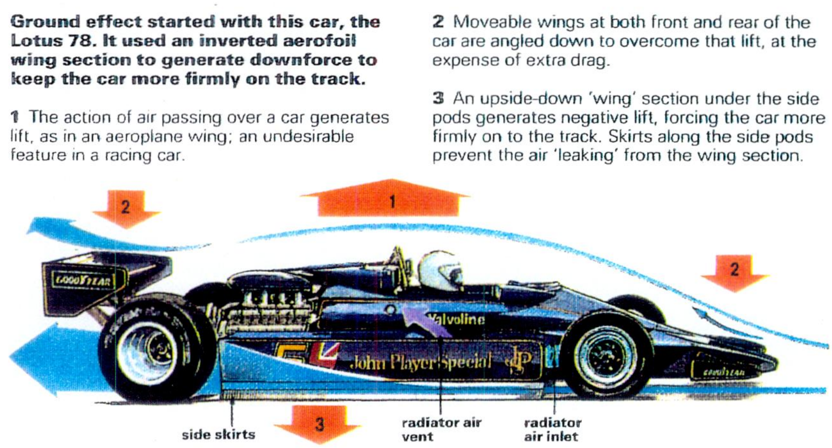


10. Experiments in aerodynamic designs, 1971.

The aerodynamacist became an essential part to every Formula 1 design team. Research programmes into the airflow over different shapes were carried out in earnest. It became necessary that the design of the car body and layout of the internal components should encompass all the aerodynamic mathematics of a light aircraft.

Words that had never been used before in relation to a car became common in Formula 1 circles. Words such as ground effect, lift, down-force, airfoils, induced drag (drag produced as a result of wings generating down-force) and their meanings in terms of the competitiveness of a car became of prime importance. The science of aerodynamics became 'exact'.

As research continued into the effects of airflow over a vehicle travelling at two hundred miles per hour, the cars of the 1970s all became smaller and broader, aided by the development of new materials such as carbon composites, Kevlar, Epoxy resins and high performance rubbers. Drivers were positioned in reclined cockpits as the wings grew and the car bodies lowered. Engines were even developed to be low and wide so as to aid the cars' aerodynamics.

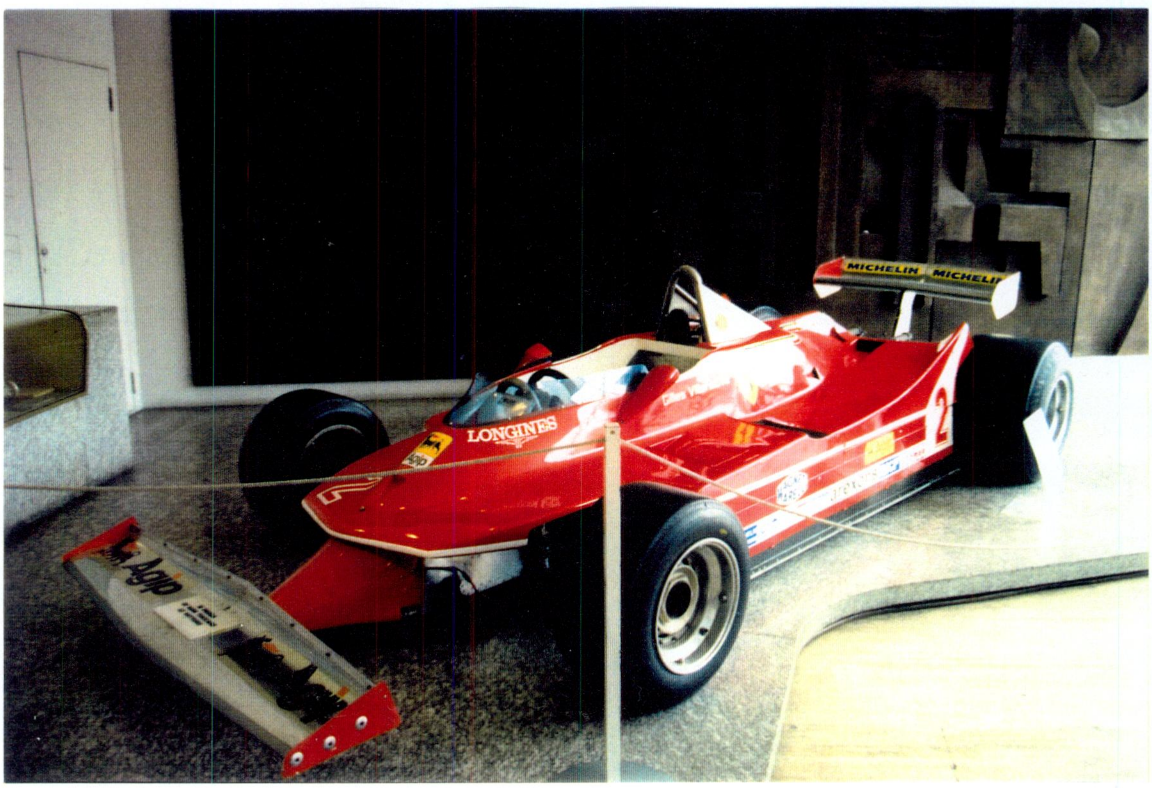


11. Inducing ground effect.

As research into aerodynamics continued it was discovered that if the car itself could become a wing traction would be greatly increased again. In airplane terms 'ground effect' is the additional lift a wing generates while its altitude remains below the length of the wing itself. On a racing track ground effect is where the airflow under the car is used to suck the car onto the road. For this to work the under side of the car must be extremely close to the ground (preferably touching it). The theory being if the 'ground effect' suction force under the car exceeds the weight of the car it could even drive on an upside-down track (although the desired force should be just enough to stick the tyres to the road while cornering at 180mph) (Jeffreys, 1992, INTERVIEW). All modern supercars use this theory by having shaped underbodies that create a vacuum at speed.

12. The Lotus 78, the first ground effect car, 1977.

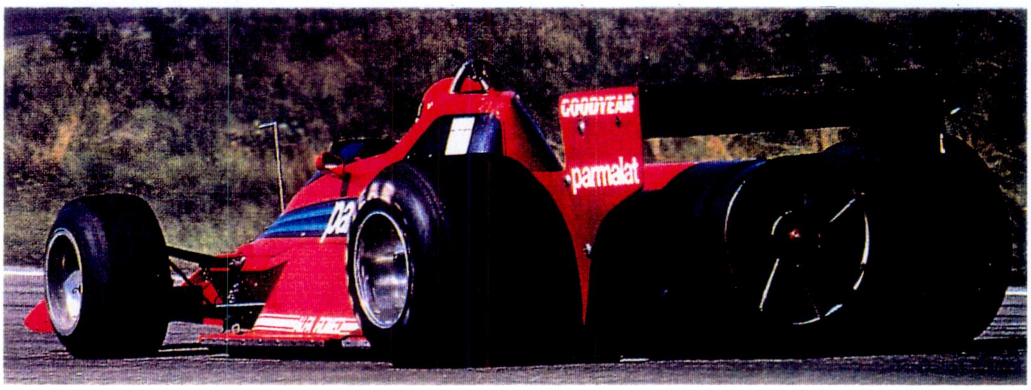
Colin Chapman with Team Lotus introduced the first 'ground effect' Formula 1 car in 1977. It was called the Type 78. The next year it was superseded by the Type 79 which dominated the grand prix season. The car had amazingly high speed cornering ability due to the fact that the faster it went the more it sucked itself onto the road. Chapman took Formula 1 aerodynamic technology to the stage where the whole underside of the car was effectively an inverted wing. Ground effect cars had side-skirts that were to channel the air under the car so that it would go in the desired direction. Originally Chapman had nylon brushes that closed the gap between the sides of the car and the ground. In 1978 there was nothing the authorities could do to stop Chapman's design from powering around the corners of the European circuits at fantastic speeds, unrivalled by anyone. A stylistic interpretation of these skirts are the side skirts attached to many road cars. These have no performance impact but those used on Formula 1 cars that touched the ground did.



13. The skirted Ferrari 312T ground-effect car, 1979.

High speed cornering in a skirted car is extremely dangerous. With any movement in the suspension the skirt may lift, thereby opening the Venturi tunnels under the car and losing a high degree of down-force within a single second. The resultant hardship on drivers (because low travel suspension makes for a bumpy ride) and increasing frequency of high speed crashes from loss of cornering grip worried the governing bodies of the sport. They eventually banned skirts and shaped underbodies on cars in 1982. But, the pace of development was too fast for F.I.S.A. (the governing body over Grand Prix safety.)

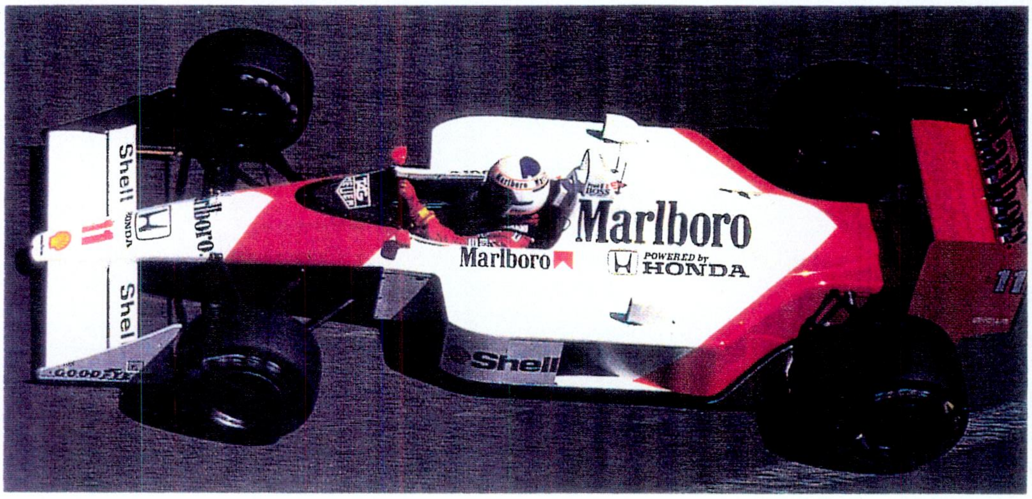
Skirts were abolished and a minimum ground clearance of 6 cm was set. The test to be done on every car was stationary - so Gordon Murray designed a suspension system whereby once the car was moving it dropped from 6 cm to within a centimetre from the ground achieving the desired 'ground effect'. A more unusual approach to the problem was Gordon Murray's design of the BT46B or "Fan Car". It had an enormous fan fitted at its rear running from the engine sucking air from under the car creating a very effective form of ground effect. It won its first and only outing. It was illegalised mostly because it was sucking debris off the track onto other drivers but officially because it used ' a movable aerodynamic device' (Phipps, 1991, P.465). Two smaller but similar fans now assist in generating ground-effect on the McLaren Cars Ltd. "F1" supercar.



14. The BT46B "Fan Car", 1978.

New turbo engined cars outsmarted the regulations again in 1977. The turbo chargers had a far greater effect on performance than F.I.S.A. had calculated so much that a normally aspirated car became an uncompetitive rarity (Turbo boost is when a small turbine actuated by exhaust emission operates a compressor that forces air into the engine's cylinders under pressure.) Instead of the air entering the engine at atmospheric pressure - 1 bar - it could be pumped in at up to 2.5 bar greatly increasing combustion and therefore the power output. Turbos are now used in many high performance road cars to boost power from a small engine.

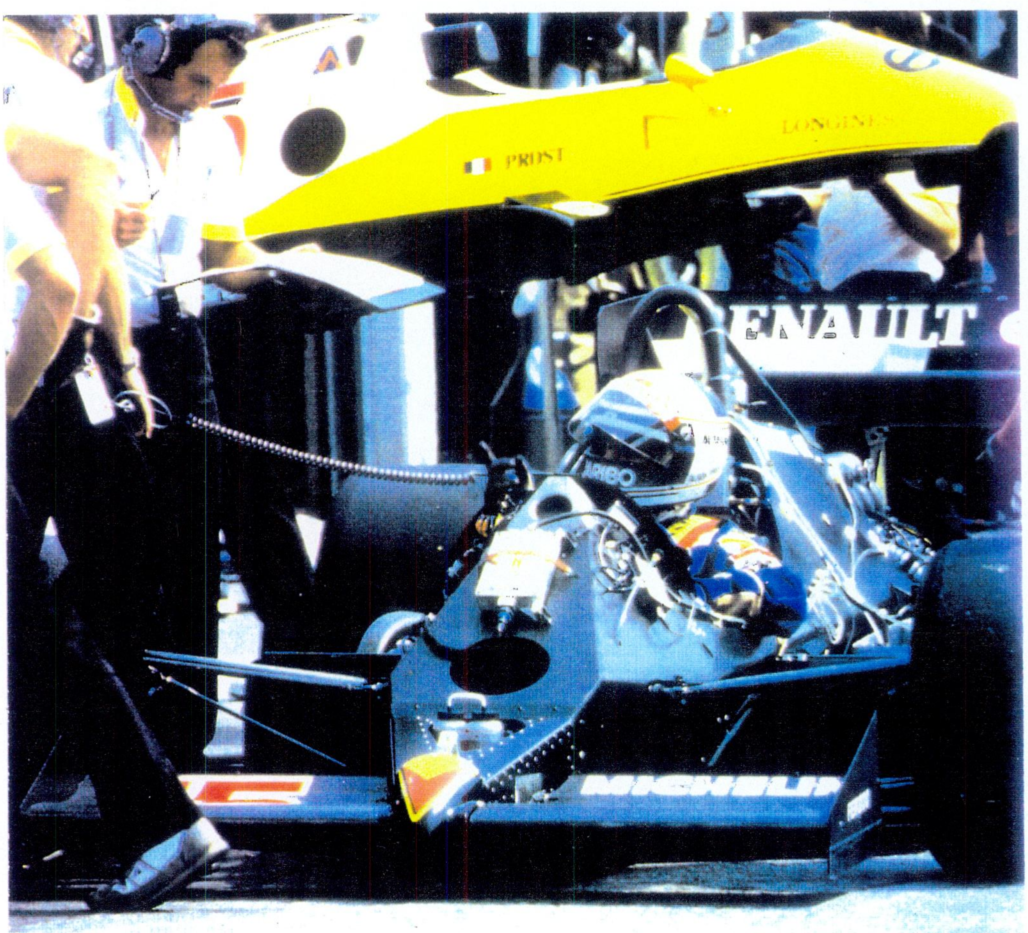
By the late eighties, Formula 1 cars were travelling too fast to be safe again. The authorities finally produced an insurmountable comprehensive book of regulations. Turbos became outlawed in 1989, ground clearance was properly stated, containers of water used by some teams to keep their cars above minimum weight requirements were done away with. The rules for Formula 1 car design were laid down properly for the first time. These are the rules that all Grand Prix teams have to abide by now. They push the teams to develop within strict constraints.



15. The carbon composite, Turbo boosted, McLaren MP 4\4 of 1988. The most successful Formula 1 car ever built.

This is a glorious use of technology. The materials used are carbon-fibre, kevlar, tungsten, chrome alloys. These are all highly expensive, exotic and now necessary for Formula One. The budget is almost unlimited once the car is made competitive. The Grand Prix machine of the 1990s is designed to such a level that specific fuels have been developed to cater for the different teams involved. The engines are disassembled after every race and practice run for absolute perfection in preparation for the car to perform. A computer mounted on the engine controls how the car will behave with respect to fuel consumption and acceleration. The list of technological elements in the design seems endless. But this is the new inner beauty of the Grand Prix car. Performance at any cost is the order.

Therefore research is necessary, technological advancement is necessary, anything less than the best is unacceptable. How else would Formula One remain on the pinnacle of automobile design progression?



16. The complexity of the modern Formula 1 car.

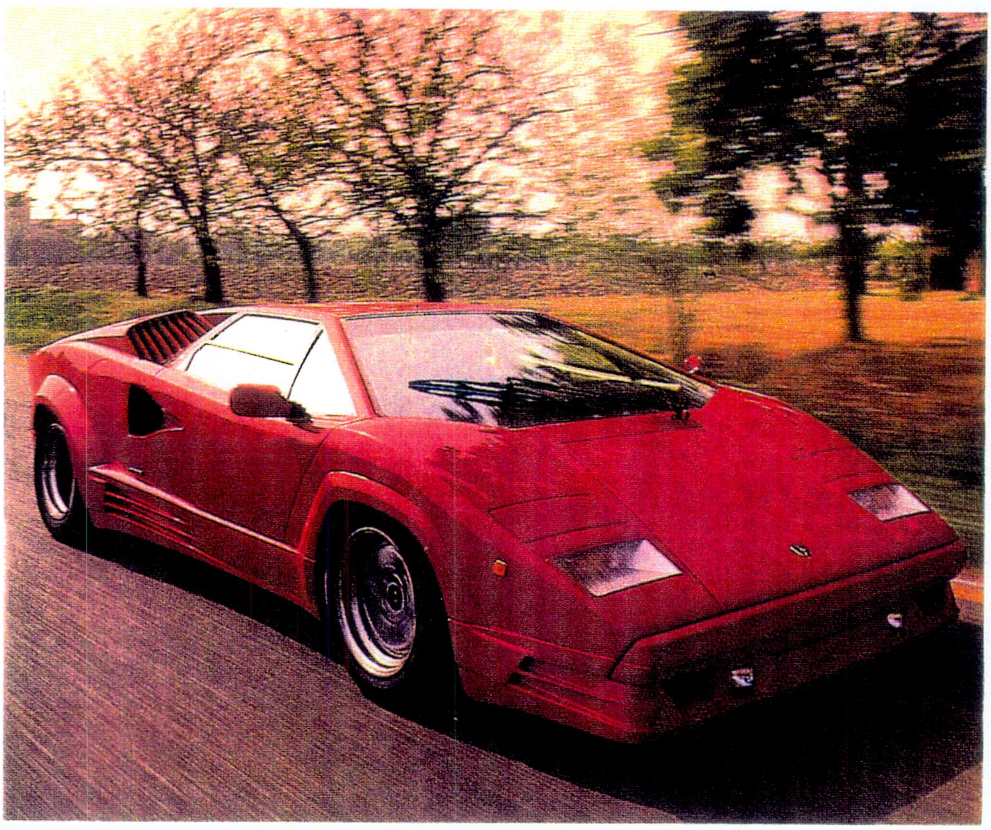
CHAPTER 2. FORMULA 1 TECHNOLOGY IN SUPERCARS OF THE EARLY 1990s

There is a trickle down of technology from the track to the road. This is the primary reason why high volume car manufacturers such as Honda and Renault, became involved in motor sport. They see the research and development possibilities as being beneficial to their road-going products. But to become acceptable to the average road user such technology must be detoxified and tamed.

At the same time, the performance car enthusiast seem to want to be told that his (or her) car is the nearest thing to a road-going racing car. Rarely does the reporter say "Well, at least it looks like it". The reality is that most supposedly high performance cars only look the part. Very few have the racing ability to match the car stylists depiction of it (Glancey, 1993, P.57).

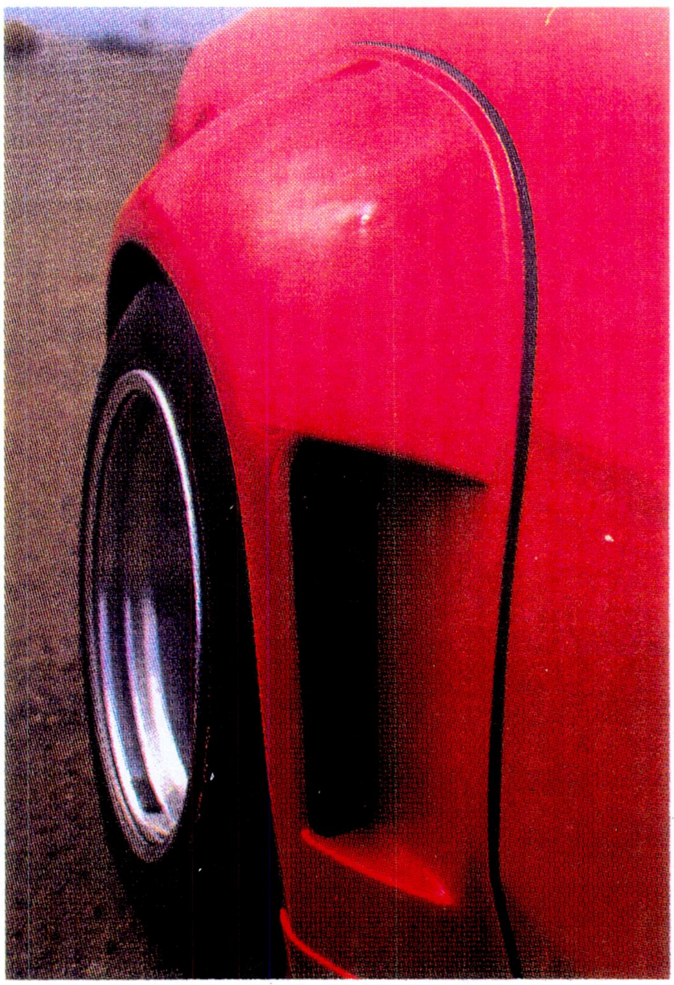
The only cars that have such performance (or anything even resembling it) are Supercars. Usually, mention of the term Supercar conjures up images of an extremely low, wide, two-seater red sports car. This car is gleaming, it has extra wide wheels, extra big engine and an excessively high top speed. It is a Freudian masterpiece. A macho expression of wealth and power (if not sexual prowess).

In the past, due to their track heritage, such cars have been positively user-unfriendly. They look fearsome, but awfully tiresome and uncomfortable to live with. Initially, such characteristics were accepted as being in the nature of the beast. You must suffer the consequences of paying over $150,000 for a high performance car by its overheating repeatedly if you drive slowly. But cars of this type must portray a special image that no other car does. Whereas a BMW looks fast, the supercar must look neck-breakingly fast. All the imagery of speed is used. Imagery that comes from purpose on a racing car becomes a language on a road car(Schmidt, 1992, INTERVIEW).



17. The Lamborghini Countach, 1990. Cliche'.

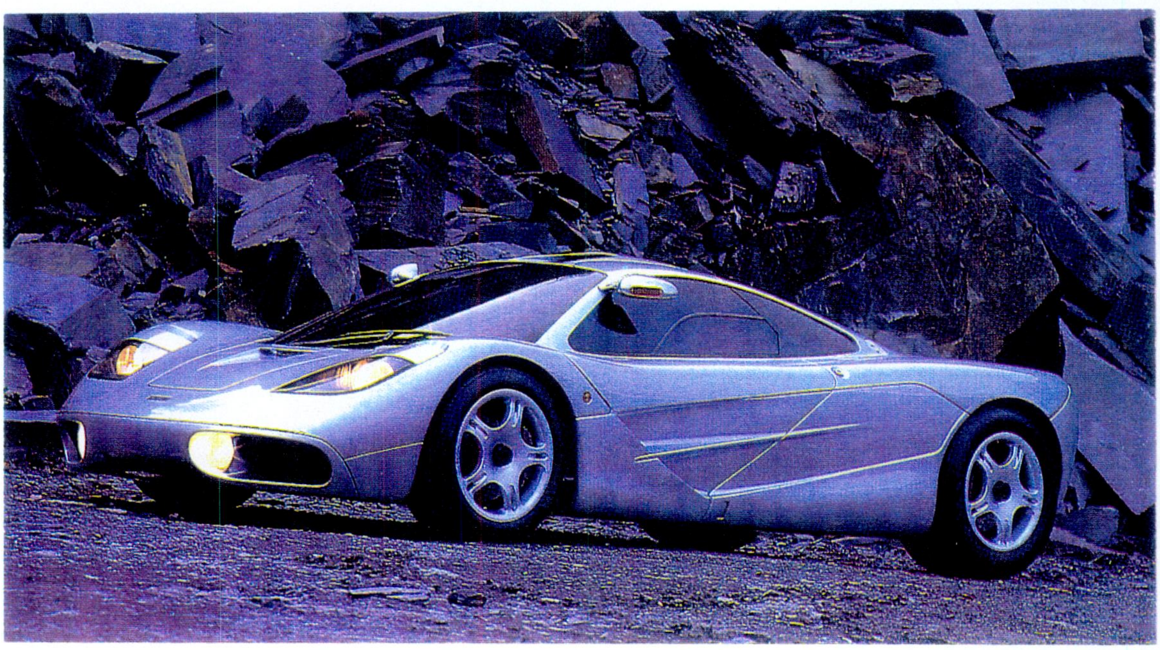
The super-car stands out. Low roof line/steeply raked front windscreen, preferably mid-engined and tyres that look as if they outweigh the car. The clearance between the wheel and the body-work must be minimal. This emphasises the lowness of the car and the tautness of its suspension as well as resembling the imagery of a racing car. Muscular curves are used to emphasise the power of the car - the treatment of the wheel arches adding stance to the powerful wheels. Air intakes are sculpted to produce aggressive shapes. A proportion of these, basically, styling elements are often unnecessary but serve to increase the perceived speed or value of the car.



18. The aggressively styled rear wheel-arch of the De Tomaso Pantera, 1985.

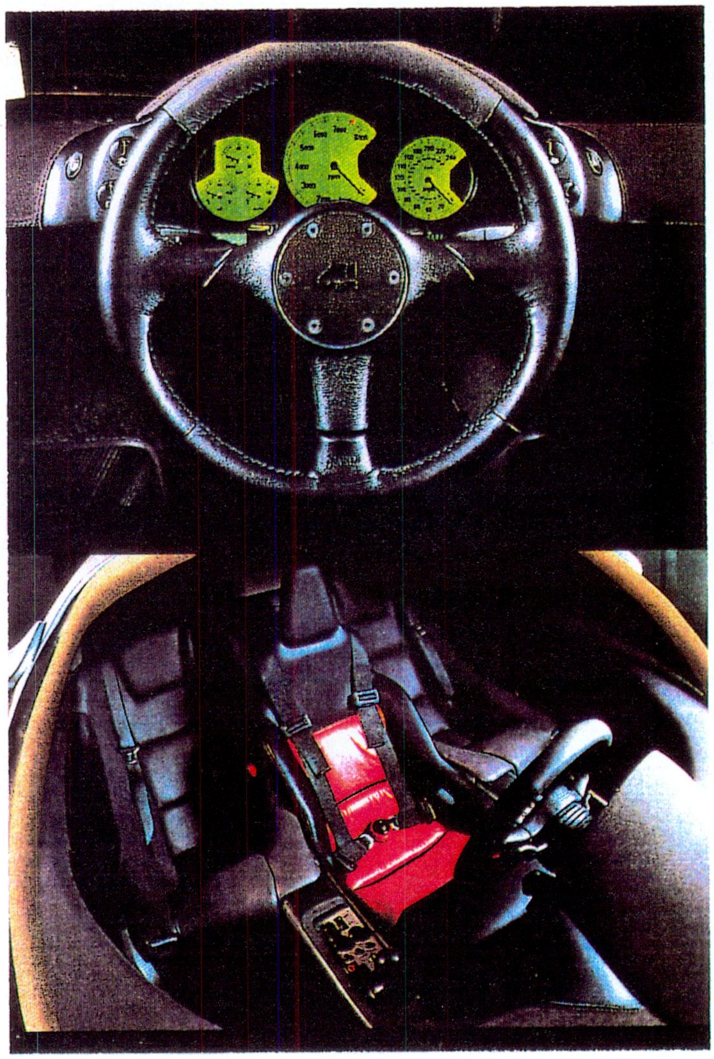
At the moment the forefront of Grand Prix car design is ten years ahead of road car design. In 1981 the first carbon-composite monocoque racing car was produced. It took until 1991 for an equivalent road car to be conceptualised. The recently released McLaren F1 is that car.

As the Grand Prix car heralded great change in racing car design, so the McLaren F1 heralds a new style of Supercar. The McLaren F1 is a different approach to this special breed of car. It removes some of the "flash" hypocrisy, draws attention away from being a glorification of wealth to being an expression of the driving experience. Gone is the plush tan leather interior with huge cushioned seats. Instead, minimalist race specification seats are supplied. Everything looks purposeful.



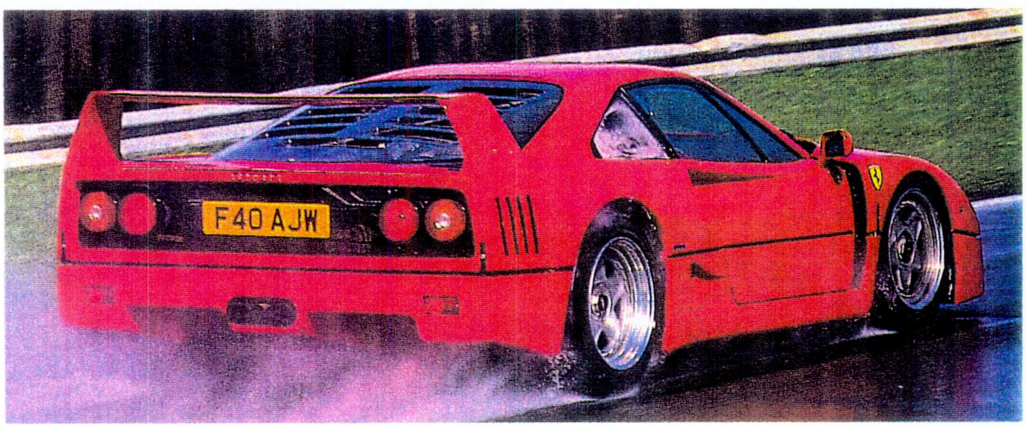
19. The McLaren F1 supercar, 1992.

It is a coming together of people and technology from the world of motor racing to produce the most advanced road car ever built. It incorporates elements tried and tested on the track as well as some that are illegal in racing (Green, 1992, P.113).



20. The interior of the F1, 1992.

Whereas companies such as Ferrari and Lamborghini build on their great traditions, such as using heavy tubular steel chassis, McLaren have no such traditions. No such limitations. McLaren have designed one of the first true supercars where road holding and performance are of the highest priority. The first attempt at this new type of supercar was by Ferrari with F40 in 1987. It was really a rough and uncompromising track racer with slightly raised suspension. It initiated the move to catch up with Formula 1 design. But the proverbial mould was not broken, only cracked. Elements of racing design were used, but not to their fullest capabilities. A small amount of ground effect was produced by the shape of the car's underbody. New carbon composite materials were used reducing weight and increasing strength but in conjunction with an old-style tubular steel role-cage. Racing style seats and seat belts were used but without the adjustment that a true racing car seat would have (Hughes, 1991, P.608).



21. The Ferrari F40, 1987.

At the same time, this has become the most sought after of all mid-engined Ferraris. It illustrated the existence of a market for highly expensive, true drivers' cars. A market where the buyer prefers racing style performance over complex technological gadgetry (such as optional ride-height, four wheel steering, four wheel drive, anti-lock braking, etc.). There is no name for this new breed of car yet but it is a definite departure from the conventional "Supercar".

The McLaren F1 is presently the cutting edge in "supreme-car" (as I have just dubbed it) design. It comes as a result of many years of Formula 1 experience:

> The team has won seven World Drivers' Championships in the last eight years and six Constructors' Championships in the same period (Murray, 1992, P.1).

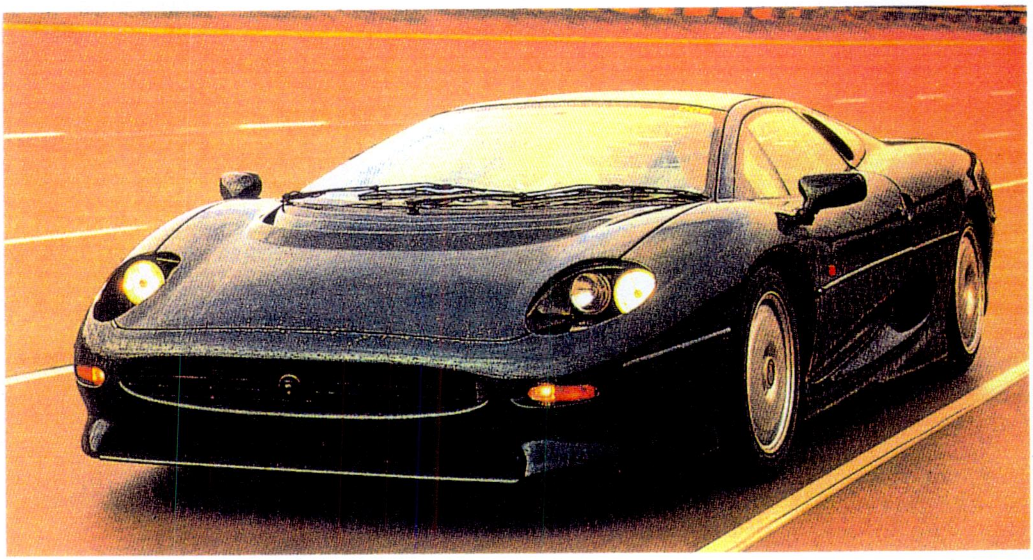
The team at McLaren cars have proved their expertise in developing some of the most innovative cars of the race-track. Now they are doing the same on the road. The McLaren F1 uses many of the performance aids of a Formula 1 car. The structure of this car is all carbon composite in Formula 1 style. This is an expensive time-consuming process, not suitable for lesser-performance oriented mass production. The result is an extremely light and strong unit (Jeffreys, 1992, INTERVIEW).

Aerodynamic aids include fan assisted ground effect. An element not used since Gordon Murray's "Fan Car" of 1978 - the Brabham BT46B.

The Fan Car developed excellent ground effect by sucking itself on to the road with a large fan fitted behind the gearbox (see plate no.14). It was illegalised after its first race for having a moveable aerodynamic aid. No such rule applies to a road car and so Gordon Murray, in his new position as Technical Director of McLaren Cars Ltd., incorporated the fan into the F1 (McLaren, 1992, P.5).

Other aerodynamic aids include an adjustable rear spoiler, computer actuated for increased down force when needed. The computer also controls small flaps to ventilate the car's brake discs. But no technological aid is used purely for the sake of it. The Formula 1 pedigree is evident in that the driver is asked only to drive and let the car deal with the intricate details of valve-timing, fuel efficiency, centre of pressure control, etc. Inefficient over-complicated performance aids such as four wheel drive and optional ride height have been negated by the application of other elements to gain the same results as is the Formula 1 system of design (Dymock, 1980, P.166).

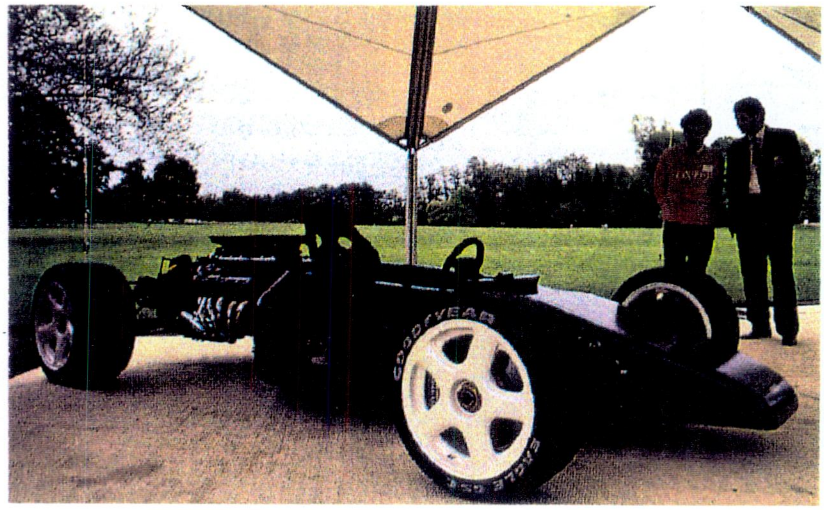
There are only a handful of cars in the same league as the McLaren F1. Even the brand new Jaguar XJ220 (the fastest road car ever produced) does not quite compete with its trucklike dimensions - almost one foot wider than the previous widest car, the Testarossa (87.4in./2220mm) and two feet longer than the average saloon (194.1in./4930mm). The Jaguar's size limits it so much that the car's vast performance could only be achieved on a motorway (Lees, 1992, P.1328).



22. The enormous Jaguar XJ220, 1992.

Yamaha with their experience in supplying engines to Formula 1 teams have produced a Supercar (or "supreme car") to contend with the F1. It is the OX99-11 being built by Ypsilon Technology in Milton Keynes. Unlike the McLaren, the Yamaha uses a real, de-tuned, Formula 1 engine, made legal for the road by changing some features such as fitting a starter motor. Other Formula 1 inspired elements include making the engine a structural part of the car supporting the rear suspension. In fact, the car, with its external aluminium cladding removed, looks remarkably like a Grand Prix car.

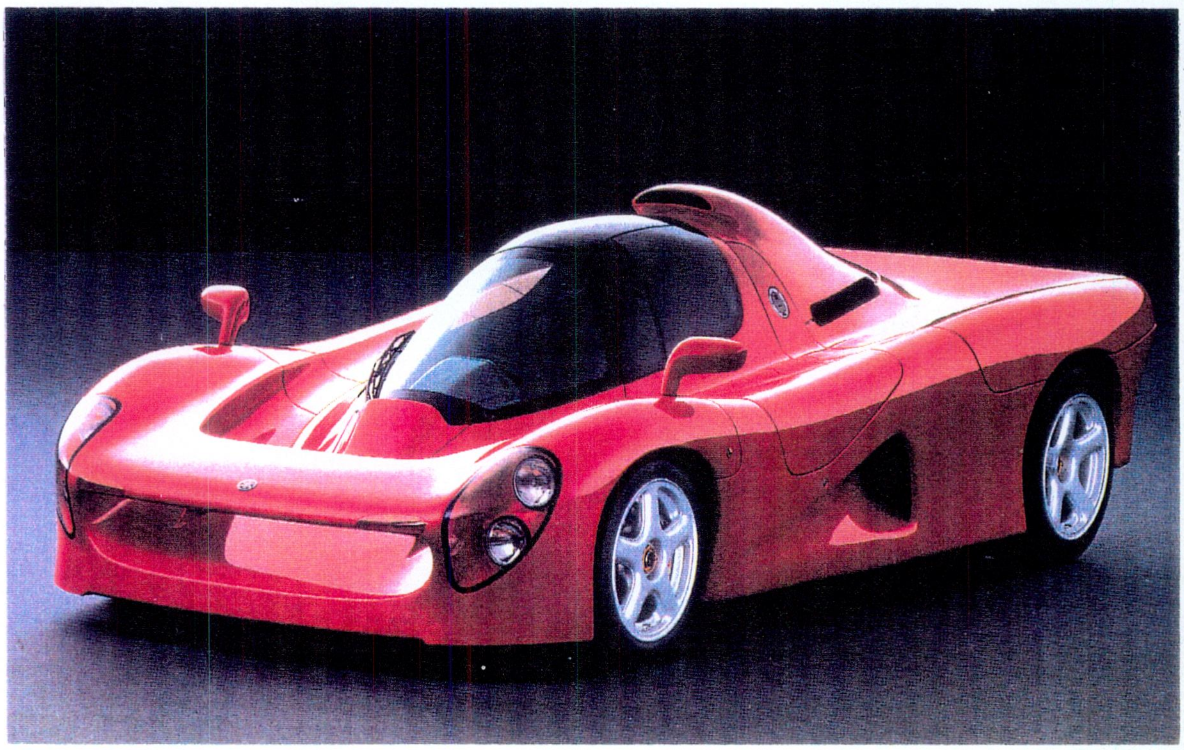
The Yamaha uses more of the imagery of racing than McLaren. Both have a central driving position, but the Yamaha being an in-line two seater can have a far slimmer cockpit (the F1 seats 3). The shape and method of opening the glass hood is reminiscent of a jet fighter plane. This is not surprising as the engineering and ergonomics of Formula 1 cockpit are to similar standards with attempts made to use limited space as efficiently as possible.



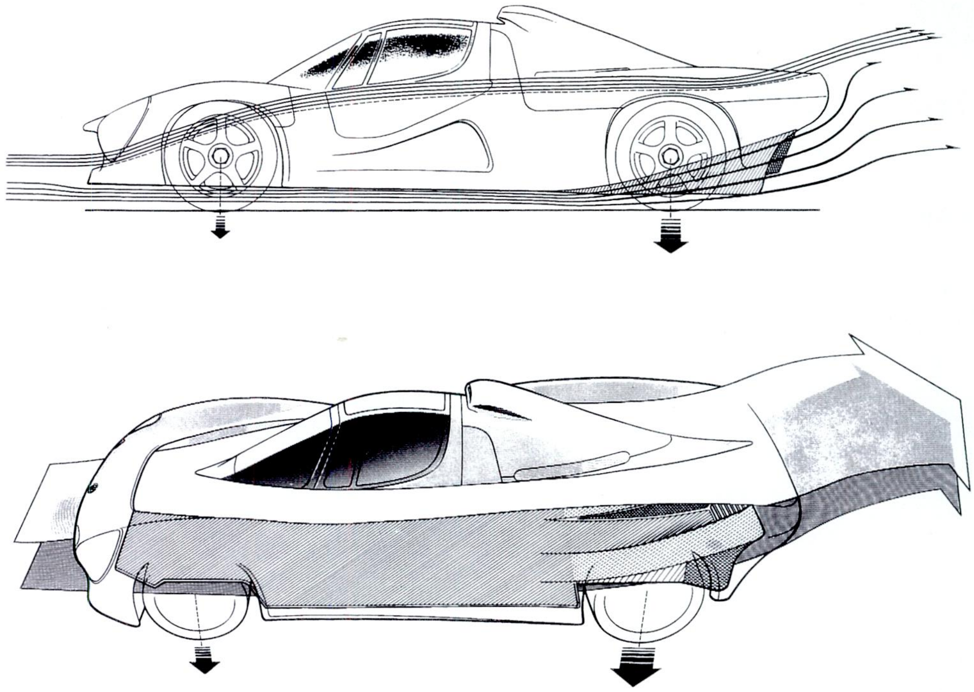
23. The carbon composite chassis of the Yamaha OX99-11 supercar, 1992.

The car, without the computer operated aerodynamic aids of the F1, merely tries to generate downforce by its shape. An integrated wing on the nose channels air over the car much the same as on a racing car. Some ground effect is developed by Venturi tunnels at the rear of the car but these are no more effective than those on the Ferrari F40 (Frere, 1992, P.58).

Technical innovation in pursuit of race bred performance is the specification for this new class of car. The number of features incorporated from the track is phenomenal from computer controlled engine performance down to the compound of rubber used in the uni-directional asymmetrical tyres. These are slightly unreal cars. Their existence cannot rationally be explained. They are no more than highly expensive toys. They can be used on normal roads but there the practicality ends. With only enough baggage room for a spare suit, a driving holiday would be a hardship. If the car is to be used for short trips to and from "the office" then would a well equipped Renault Clio (or something similar) not be a more efficient use of resources for parking and moving slowly in congested traffic? The answer is Yes. But human nature has never been one of rationality. As the market for high performance cars tells, the enjoyment of driving fast in a powerful car has always appealed to certain people.



24. The Yamaha OX99-11 supercar, 1992.



25. The aerodynamically efficient shape of the Yamaha OX99-11, 1992.

This is why high performance automobiles exist. Not because some people need to get places faster but because speed is a thrill. The pursuit of this thrill fuels automotive design. It is the backbone of racing and the reason why advertising space on a competition car can demand such vast sums of money.

It has been found that there are people prepared and able to pay for this thrill. The lack of functional elements such as boot-space makes the Supercar something bought and driven "for the hell of it". No doubt, if you are a car enthusiast the thrill is worth the money. To the non-enthusiast the whole concept could be deemed nonsensical.

Environmentally, these cars are a disaster. With massive engines, often three times the size of a normal saloon car, fuel efficiency is not a factor, with the normal rate being about 16 miles per gallon. Modern mass production cars operate in the region of 30 miles per gallon. Emissions such as Nitrogen and Carbon Monoxide are being stemmed by legislation and supercars are not exempt. With the tightening of restrictions on the use of fossil fuels in road cars, the days of these thundering giants capable of almost four times the legal speed limit may be numbered.

Perhaps it would be more realistic to invest in the future of mass produced cars with their less exorbitant use of resources and performance capabilities. Perhaps not when you consider the fact that car enthusiasts with large amounts of money demand highly prized, rare and powerful cars. There is a market for these race bred machines unaffected by the environmentalists even in the realm of the mass produced car.

CHAPTER 3. THE INFLUENCE OF FORMULA ONE CAR DESIGN ON MASS PRODUCED CARS.

What about mass produced cars? Formula 1 is a world apart. The sport seems to have lost all its relevance to the mass manufacturing motor industry. Due to the extreme environment of the racing car, much of the modern technology has become inapplicable to road use. For example, Grand Prix cars now use carbon composite brake disks for lightness and strength under very high loads. Carbon composite brake disks cannot be used, however, for normal road use due to the material's low friction coefficient when cold. The result is that research will go into similar man-made materials in an attempt to reduce the weight of the disc but to maintain the stopping power (friction coefficient) of mild steel, the material presently used.

This would bring enormous handling benefits to the average car. The heavier the wheel and brake system on a car the more likely the wheel is to bounce over bumps on the road, rather than ride over them keeping in contact with the road surface. The difference to stability that this makes is obvious (Korff, 1980, P.155).

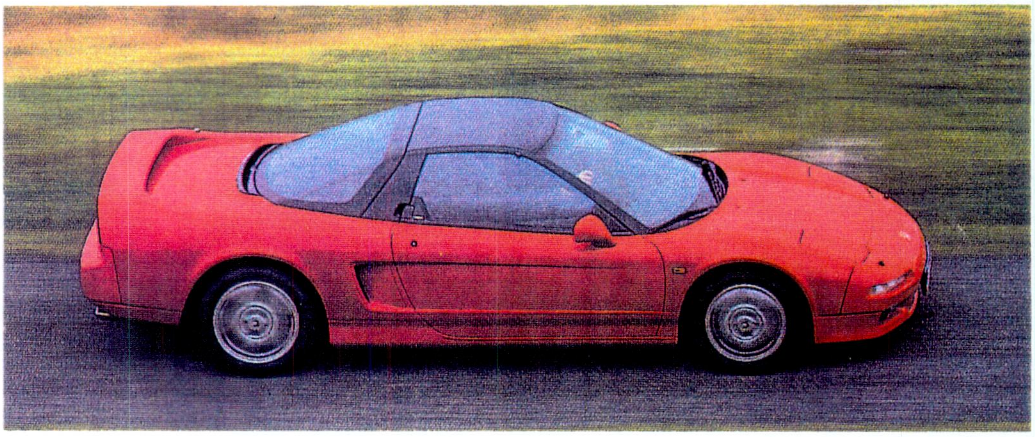
Honda produce some of the most technologically up-to-date cars on the market. The company spans its output from Formula 1 engines to Supercars (the NSX) to volume production cars. To gain most from their company's interests in motor-racing and specialist car manufacture, Honda engineers are rotated between the different disciplines. Until the end of 1992 Honda supplied engines to the McLaren International Grand Prix racing team. A team of Honda engineers would work with McLaren for two years at a time and then be put back to work on road going cars with the idea that they would use some of the knowledge gained from racing. Honda invests in the region of £60 million per annum in its motor-racing programme. The fruits of this investment are evident in the product line from Honda. Formula 1 technology such as computer controlled valve timing is used on all high performance Hondas (Jeffreys, 1992, INTERVIEW).

Motorsport is one area which can be used by car manufacturers for development of engines, suspension, brakes and a host of other bits and bobs. Honda engines have been remarkably successful in Formula 1 and now some of the technology has filtered through to their production cars in the form of the VTEC engine. This 1590cc 16 valve double overhead camshaft (DOHC) variable valve timing and lift electronic control system (VTEC) engine basically features two, rather than the usual one, valve settings (Puddifoot, 1991, P.42).

The valves operate in the cylinder heads of the engine letting in the fuel air mixture and extracting waste gasses during each engine cycle.

In effect this optimises valve timing throughout the rev. range to provide a better spread of torque. Its one way of combining the high revving power of a racing performance engine and the low revving flexibility which is a necessity for a roadgoing car (Puddifoot, 1991, P.42).

The computer chip controls the engine in order to gain the most effective results performance-wise without over stressing any of the components. Performance chips are now available on the open market to upgrade performance from a standard mass produced engine. The results of fitting a high performance chip to a standard car can have drastic effects on engine parts not built to take the extra stress (Howard, 1991, P.54-58).



26. The Honda NSX Supercar, the first road car to use VTEC technology.

Modern supercars use similar engine management systems to make them more user friendly. Cars designed to go at speeds in excess of 150mph used to have difficulty with stalling in congested traffic conditions. With the introduction of computer controlled engines pioneered in Formula 1 this is no longer a problem. It is elements such as this that benefit drivers of all cars without their knowledge. In 1988 refuelling during a race was outlawed in Formula 1. This in turn created a demand for more efficient engines so that cars would not run out of fuel before the end of a race. This development work resulted in forwarding the development of small powerful, lean burn engines, used in modern mass produced cars. Even the compounds of rubber used in modern cars owe their development to racing. The universal change from inferior crossply to radial tyres (crossply have internal plys of material woven diagonally across the centre-line of the tyre - radials have plys more in line with the centre-line of the tyre) in the last ten years is as a result of research into increasing traction on racing cars (Jeffreys, 1992, INTERVIEW).

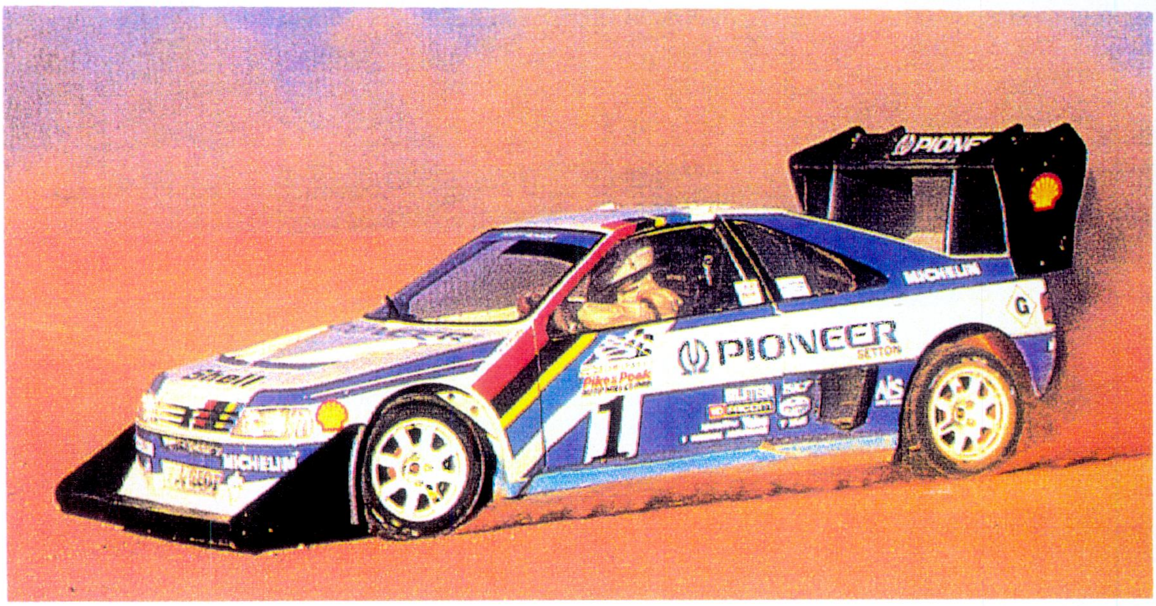
That is not to say that all the elements that go to making a mass produced car are race bred. New developments such as electric motors, four-wheel steering etc. owe more to the problems of moving and manoeuvring at very slow speeds - only found in the street environment. Aerodynamics of the automobile has its origins in motor racing (originally the landspeed record attempts). Originally used as a tool to ease the flow of a car through the air, it quickly developed into a way of keeping the car on the ground.

Such drastic measures are not necessary on a normal car that travels at far lesser speeds; lift-off is not usually a problem on the road. With the emphasis now on fuel efficiency the coefficient of drag (Cd) of the modern car is a new selling point. The 1990 Audi 100 even had its Cd value etched on to one of the rear corner windows. The coefficient of drag comes from research compiled over two hundred years. Initially low speed wind tunnel tests discovered that a flat square plate creates the most drag. Its coefficient was deemed to be 1.00 - the unit by which all other shapes would be judged. Later tests discovered that at higher speeds the drag induced by a flat plate became 1.28. Now all shapes are judged against this. A streamlined shape with a Cd of 0.04 induces one thirty second the drag of a flat plate (Korff, 1980, P.182).

For drag coefficient tests, results to be accurate, all tests should be carried out under identical conditions in the same wind tunnel and with the finished vehicle. Models have better coefficients of drag due to their lack of finite detail and therefore produce inaccurate results for use by salesmen. Other dubious features of modern cars that feign race pedigree are the abundance of aerodynamic aids (Korff, 1980, P.182).

There is a current fashion to place what are known as "tea-tray" wings on the rear boot of many sports saloons. The image being portrayed comes, somewhat, from the "go-fast-stripe" sales pitch. It is supposed to convince the buyer that this small wing will increase the performance of the car. In reality, far more efficiently positioned and designed large wings have been produced such as that used on the rally specification Peugeot 405, and found only to be effective at speeds above 120mph.

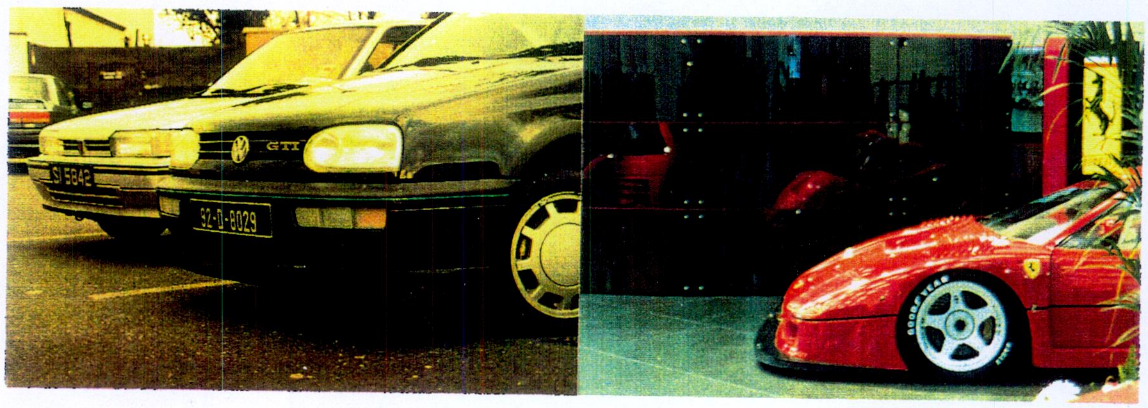
27. Ineffective aerodynamics. Rear spoiler added to a Mercedes Benz 230E.



28. Effective aerodynamics. The rally specification Peugeot 405

Similar pseudo aerodynamic aids such as front air dams and side skirts, although visually lowering the car, technically achieve very little. The concept of the front air dam is the same as the front wing of a Grand

Prix car. The dam should channel air over and around the car in order to stop air going underneath. This creates a vacuum under the car inducing downforce. The concept only works if the bodywork is within eight centimetres of the ground. Otherwise the gap between car and ground is too great, as on mass produced cars, and the air flows turbulently underneath instead of smoothly over and around the car.



29. The difference between styled road car front air-dams and that of a racing car.

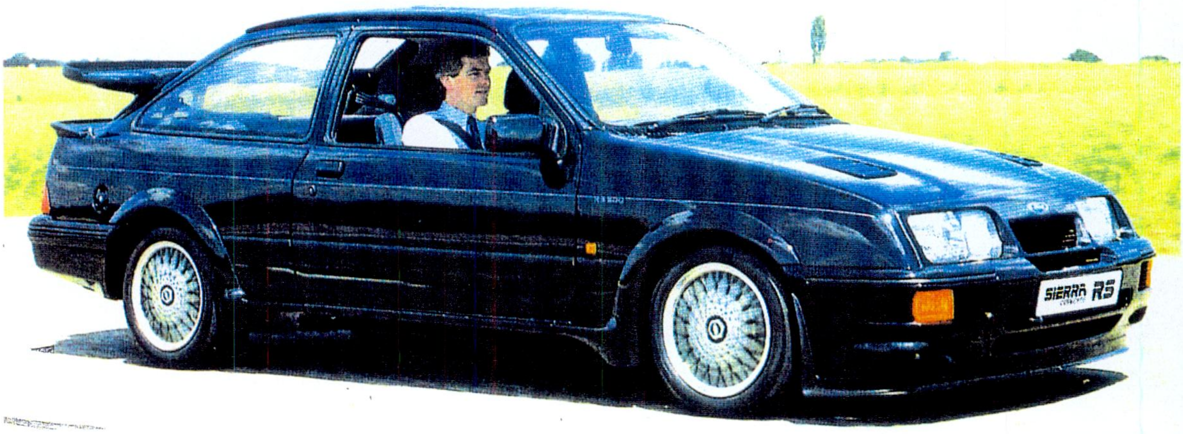
So these sporty add-ons have no real effect other than portraying the correct imagery of performance. They have changed from being essential performance aids to being tools of the motor trade that supposedly boost sales. This is the point at which design becomes frivolous, tacky, cheap. Car styling in itself is a very important element in the production of a new car but the addition of pseudo performance aids reduces the value of the designers' work.

The sad point is that a trend has been set. A market trend being something alien to racing car design, it is only applicable to mass produced cars. The trend is that people now accept these styling frivolities as normal - the public has come to expect them on fast cars, or expect cars that have them to be fast. This poses the question whether people (car enthusiasts) want a car that has high performance or a car that tells everyone it has high performance.

30. A 'spoiled' BMW 5 Series. A flamboyant statement of speed.

An example is the Ford Sierra based Minker. Although it is capable of phenomenal speeds and with performance figures equalled only by supercars, it is an unassuming machine. It does not display its potential in body styling terms. The less powerful Ford Sierra Cosworth is far more flamboyant in its presentation. A wing, add-on side skirts, extended wheel arches, a front air dam and vented bonnet make this car look the part (Bell, 1991, P.62-64).

31. The unadorned Ford Sierra Minker with supercar performance.



32. The Ford Sierra Cosworth RS500. The flamboyant presentation of a less powerful Sierra.

What the consumer does not seem to ask is if a car is well designed then, why should it need all these 'aids'. Technology developed on the track has given the mass produced car its road capabilities. But marketing has twisted that heritage to produce a modern day propaganda campaign. This campaign is not only evident in the car accessories mentioned earlier.

Companies such as Castrol now use their sponsorship of racing in advertising their products. The image portrayed by each company is that the performance of your car could be increased by the use of this product - ranging from spark plugs to engine oil. To enhance the advertisement, a picture of a high performance - preferably racing - car us used. Racing cars, especially Formula 1, have engines machined to within microns of the required dimensions. They are disassembled and rebuilt after every race in order to maintain perfect alignment of every part.

33. Two examples of the use of Formula 1 imagery used in advertising.

Mass produced engines, on the other hand, are not built to such exacting standards due to the expense involved. Choice of oil or spark plug, therefore, has little effect on the resultant performance. But the advertisements have the imagery that sells. The public has let itself be duped by the promise of racing technology for the road being as simple as oil and stick-on aerofoils.

Advertising of supposedly high performance road cars comes in the form of television and magazine articles. Undoubtedly aimed at the male market, aggressive and suggestive language is used, obviously to appeal to the 'macho' thrill seekers. This ploy is especially used in non-motoring magazines where cars are projected as being representative of wealth or driving talent. Whether or not the consumer likes the car seems irrelevant as long as it presents the right image (Long, 1992, P.74-75).

34. Citroen BX GTI and Ford Escort XR3i. Wings (spoilers) are now a styling element of almost all mass produced high performance cars.

The power of the racing car has been projected on to the road car. The road car uses much down graded racing car technology which it then tries to upgrade by flamboyant body styling kits. What has happened to the well designed car?

35. The transformation of a design classic into a pseudo sportscar.

CONCLUSION

The design of the family saloon car is dependent on motor racing research and many of the elements would not be possible without Formula 1. Turbo chargers, for example, are found in most mass produced fast cars. These were orinionally developed to boost Formula 1 engine performance. Fuel efficient, powerful engines were developed as a result of changing regulations in Formula 1. All new engine designs strive for increased efficiency using the same technology. Computer Aided Design (C.A.D.) in terms of aerodynamics and stress analysis has speeded up the design process of the mass production industry thereby reducing cost to the manufacturer. Rubbers developed for racing aided the design of modern road tyres. Engine management systems, suspension geometry, controls geometry, aerodynamics - all come from racing technology.

Even the imagery of the racing car has permeated to the road. Any enthusiast wishing to display the supposedly high performance of his car can buy 'body kits'; styling components that say speed and road-holding. He can buy wheels that look like they should be on a track. Aerofoils, first introduced on Grand Prix cars in 1968, have now become normal, accepted on road cars. The performance aid on the racing car has become the performance aesthetic on the mass produced road car.

The plight of the planet has become a major issue in recent years. The hole in the ozone layer and global warming are subjects everyone knows something about. Everything from paper to automobiles is marketed as being 'environmentally friendly'. In the car industry new lean-burn engines have been developed to use less fuel. Lead free petrol has been introduced and catalytic converters fitted to car exhausts to change toxic fumes into less toxic fumes. Everybody is supposedly doing his bit to help the planet.

Road cars are being mass produced in the 1990s with parts that can be reprocessed and re-used. The emphasis in mass produced car design at this time is on environmental impact. This is a departure from the established process of racing technology filtering down to road cars. Formula 1 has not directed any research towards an environmentally friendly automobile.

The racing car and the Supercar are at tangents to this trend. They are becoming ever more complex and ever less globally responsible. The materials used in such cars are composites and therefore non-reuseable. Superplastics are being developed with mechanical properties similar to composites but can be recycled therefore reducing their impact on the environment. As yet no racing car design has incorporated them.

Formula 1 has its place in the development of car design and the design process. Much of the technology from motor racing has been incorporated into mass production. But, as Formula 1 moves further from its background, as the testbed for road car design competitors are beginning to question its validity.

Ferrari is the most succesful and oldest participant in Formula 1 but its president Luca di Montezemolo has been quoted saying:

> There is nothing forcing us to remain in Formula 1, which must change its rules absolutely to return closer to the technology of mass produced cars.
> The technological level has reached a point where 95% of the solutions which can be applied to racing cars cannot be passed on to the product (road car). Ferrari will never stop racing .... but, if things do not change quickly, we could opt for other types of competition (Anonymous, 1993, P.8).

It seems the future of Formula 1 depends on a re-alignment with its initial goal to improve the design of road cars. Perhaps as mass produced cars become more environmentally friendly pressure will be put on Formula 1 car designers to produce 'green' cars. Formula 1 car design and racing imagery has brought about much of the car as we know it. But that is set to change as road cars and racing cars head on increasingly different courses with one becoming more environmentally responsible and the other becoming irrationally complex in pursuit of ultimate performance.

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