INTRODUCTION TO FORMULA 1 CAR

Formula One (also **Formula 1** or **F1**) is the highest class of single-seat auto racing that is sanctioned by the Fédération Internationale de l'Automobile (FIA). The FIA Formula One World Championship has been the premier form of racing since the inaugural season in 1950, although other Formula One races were regularly held until 1983. The "formula", designated in the name, refers to a set of rules, to which all participants' cars must conform.[2] The F1 season consists of a series of races, known as *Grands Prix* (from French, originally meaning great prizes), held throughout the world on purpose-built F1 circuits and public roads.

The results of each race are evaluated using a points system to determine two annual World Championships, one for drivers, one for constructors. The racing drivers are required to be holders of valid Super Licences, the highest class of racing licence issued by the FIA.[3] The races are required to be held on tracks graded 1 (formerly A), the highest grade a track can receive by the FIA.[3] Most events are held in rural locations on purpose-built tracks, but there are several events in city centres throughout the world, with the Monaco Grand Prix being the most obvious and famous example.

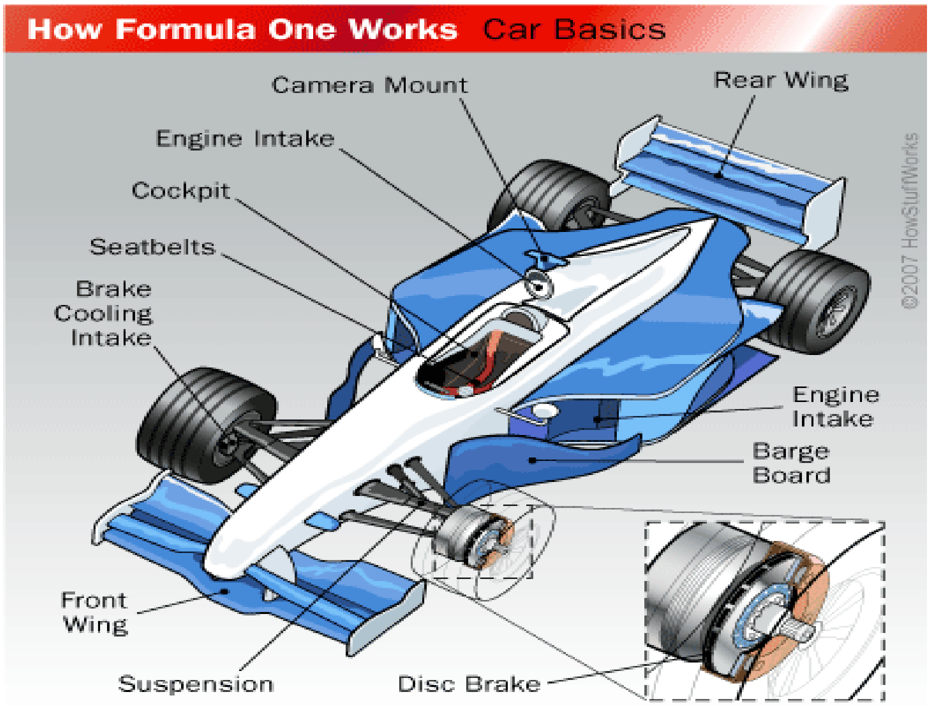
Formula One cars are the fastest road course racing cars in the world, owing to very high cornering speeds achieved through the generation of large amounts of aerodynamic downforce. Formula One cars race at speeds of up to 360 km/h (220 mph) with engines currently limited in performance to a maximum of 15,000 RPM. The cars are capable of lateral acceleration in excess of five g in corners. The performance of the cars is very dependent on electronics – although traction control and other driving aids have been banned since 2008 – and on aerodynamics, suspension and tyres. The formula has radically evolved and changed through the history of the sport.

History

The Formula One series originated with the European Grand Prix Motor Racing (*q.v.* for pre-1947 history) of the 1920s and 1930s. The formula is a set of rules which all participants' cars must meet. Formula One was a new formula agreed upon after World War II during 1946, with the first non-championship races being held that year. A number of Grand Prix racing organisations had laid out rules for a world championship before the war, but due to the suspension of racing during the conflict, the World Drivers' Championship was not formalised until 1947. The first world championship race was held at Silverstone, United Kingdom in 1950. A championship for constructors followed in 1958. National championships existed in South Africa and the UK in the 1960s and 1970s. Non-championship Formula One events were held for many years, but due to the increasing cost of competition, the last of these occurred in 1983.[7]

Juan Manuel Fangio's 1951 first formula 1 car

COMPONENTS USED IN FORMULA 1 CAR



1) ENGINE
2) RADIATOR
3) GEARBOX AND TRANSIMISSION
4) AIRINTAKE AND AIRBOX
5) DISC BRAKE
6) CAR FLOOR(PLANK)
7) SUSPENSION
8) TYRES
9) STEERING WHEEL
10) COCKPIT
11) FRONT WINGS AND RARE WINGS
12) OIL AND COOLANT SYSTEM
13) FUEL

The Engine

All of the cars in F1 will be fitted with 1.6 litre turbocharged engines in 2014, Ferrari, Mercedes and Renault will between them supply all of the teams until 2015 when Honda arrives to supply McLaren, and depending on which team is awarded the empty slot on the grid in 2015 potentially Ford as well.

The engines are six cylinder units arranged in a V, the exact same principle found in many production cars such as the smaller engined Ford Mustangs for example. In Formula 1 specifications the engines will make around 600bhp, which in pure output terms does not sound like all that much, it is only about 150bhp more than a World Rallycross Championship car produces for example. But the F1 engines are far more efficient, smaller and much lighter.

But engine designers from the likes of Ferrari, Honda, Mercedes and Renault should have no problem creating an engine that can produce this performance after all both Ferrari and Mercedes produce street cars with more power.

“Contrary to popular belief, the engine is not the easiest part of the Power Unit to design as the architecture is very different to the old V8s. On account of the turbocharger the pressures within the combustion chamber are enormous – almost twice as much as the V8. The crankshaft and pistons will be subject to massive stresses and the pressure within the combustion chamber may rise to 200bar, or over 200 times ambient pressure” explains a Renault engineer. “The pressure generated by the turbocharger may produce a ‘knocking’ within the combustion chamber that is very difficult to control or predict. Should this destructive phenomenon occur, the engine will be destroyed immediately.”

This we are told by just about everyone in the F1 paddock, will happen in the 2014 season, quite a lot.

Fuel Injection

All Power Units must have direct fuel injection (DI), where fuel is sprayed directly into the combustion chamber rather than into the inlet port upstream of the inlet valves. The fuel-air mixture is formed within the cylinder, so great precision is required in metering and directing the fuel from the injector nozzle. This is a key sub-system at the heart of the fuel efficiency and power delivery of the power unit.

One of the central design choices of the ICE was whether to make the DI top mounted (where the fuel is sprayed at the top of the combustion chamber close to the spark plug) or side mounted (lower down the chamber). Nobody has revealed which option they have gone for – yet.

Interestingly the option still remains to cut cylinders to improve efficiency and drivability through corners. Not quite traction control but not far off it.

Turbocharger

Turbocharger uses exhaust gas energy to increase the density of the engine intake air and therefore produce more power. Similar to the principle employed on roadcars, the turbocharger allows a smaller engine to make much more power than its size would normally permit. The exhaust energy is converted to mechanical shaft power by an exhaust turbine. The mechanical power from the turbine is then used to drive the compressor, and also the MGU-H.

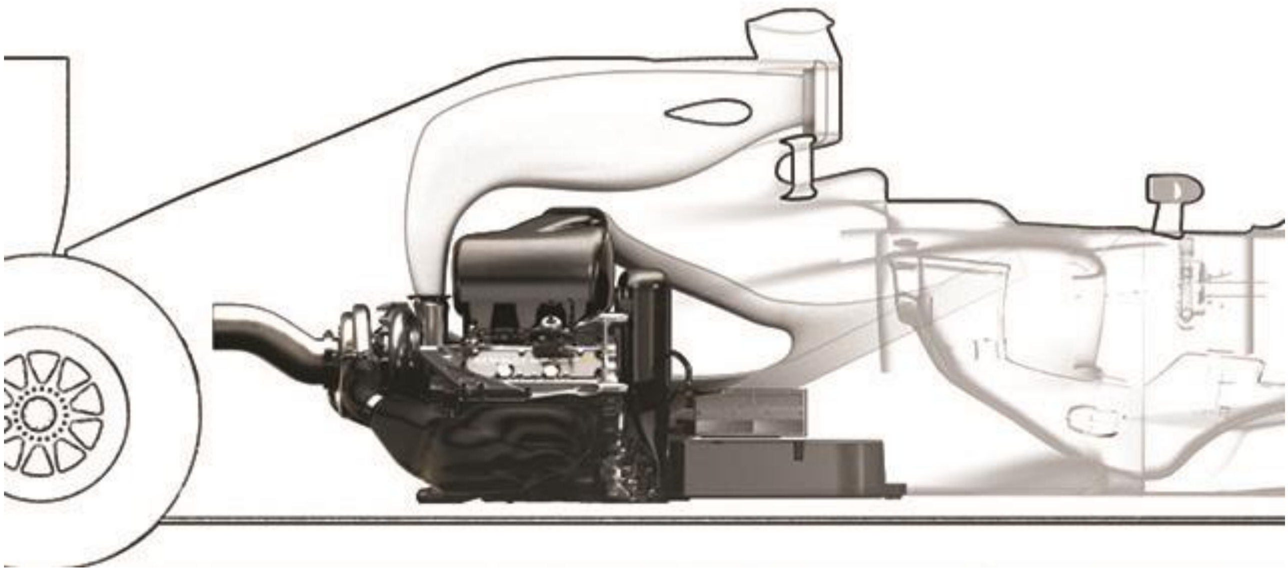
At its fastest point the turbocharger is rotating at 100,000 revolutions per minute, or over 1,500 times per second, so the pressures and temperatures generated will be enormous. Some of the energy recovered from the exhaust will be passed on to the MGU-H and converted to electrical energy that will be stored and can later be re- deployed to prevent the turbo slowing too much under braking.

As the turbocharger speed must vary to match the requirement of the engine, there may be a delay in torque response, known as turbo lag, when the driver gets on the throttle after a period of sustained braking. One of the great challenges of the new power unit is to reduce this to near zero to match the instant torque delivery of the V8 engines.

Intercooler

The intercooler is used to cool the engine intake air after it has been compressed by the turbocharger. The presence of an intercooler (absent in the normally aspirated V8 engines), coupled with the increase in power from the energy recovery systems makes for a complicated integration process since the total surface area of the cooling system and radiators has significantly increased over 2013. Indeed the availability of F1 specification radiators is currently nil, due to the many changes and updates made by teams over the winter. This has prevented at least one team making it to the first test. Integration of the intercooler and other radiators is key but effective cooling without incorporating giant radiators is a major challenge and key performance factor in aerodynamic terms.

Wastegate



On conventional turbo engines, a waste gate is used in association with a turbocharger to control the high rotation speeds of the system. It is a control device that allows excess exhaust gas to by-pass the turbine and matches the power produced by the turbine to that needed by the compressor to supply the air required by the engine. On the F1 engines, the turbo rotation speed is primarily controlled by the MGU-H (see the hybrid section) however a waste gate is needed to keep full control in any circumstance (quick transient or MGU-H deactivation).

“The waste gate is linked to the turbocharger but sits in a very crowded area of the car. The challenge is therefore to make it robust enough to withstand the enormous pressures while small enough to fit” explains the Renault engineer. “On a plane there are certain parts that are classified as critical if they fail. By this measure the waste gate is the same: if it fails the consequences will be very serious.”

The Hybrid System

Energy efficiency will reach levels never seen in the sport before, with two types of energy propelling the cars. The internal combustion engine will produce power through consumption of traditional carbon-based fuel, while electrical energy will be harvested from exhaust and braking by two motor generator units. The two systems (MGU-H & MGU-K) will work in harmony, with teams and drivers balancing the use of the two types of energy throughout the race.

MGU-K

The MGU-K is connected to the crankshaft of the internal combustion engine, generally mounted underneath the oil tank in a recess at the back of the chassis – seen here on the Red Bull RB9

Under braking, the MGU-K operates as a generator, recovering some of the kinetic energy dissipated during braking. It converts this into electricity that can be deployed throughout the lap (limited to 120 kW or 160bhp by the rules). Under acceleration, the MGU-K is powered from the Energy Store and/or from the MGU-H and acts as a motor to propel the car.

Whilst in 2013 a failure of KERS would cost about 0.3s per lap at about half the races, the consequences of a MGU-K failure in 2014 would be far more serious, leaving the car propelled only by the internal combustion engine and effectively uncompetitive.

Thermal behaviour is a massive issue as the MGU-K will generate three times as much heat as the V8 KERS unit; in 2013 KERS units regularly suffered failures when track temperatures exceeded 40C. The cooling of these systems could become one of the key performance differentiators in 2014.

MGU-H

The MGU-H is connected to the turbocharger. Acting as a generator, it absorbs power from the turbine shaft to convert heat energy from the exhaust gases. The electrical energy can be either directed to the MGU-K or to the battery for storage for later use. The MGU-H is also used to control the speed of the turbocharger to match the air requirement of the engine (e g. to slow it down in place of a waste gate or to accelerate it to compensate for turbo lag.)

So it is both energy recovery and anti lag in one!

The MGU-H produces AC current, but the battery and MGU-K is DC current so a highly complex convertor is needed.

Very high rotational speeds are a challenge as the MGU-H is coupled to a turbocharger spinning at speeds of up to 100,000rpm. Bearing design and again cooling are critical.

Battery

Heat and Kinetic Energy recovered can be consumed immediately if required, or used to charge the Energy Store, or battery.

The stored energy can be used to propel the car with the MGU-K or to accelerate the turbocharger with the MGU-H. Compared to 2013 KERS, the ERS of the 2014 power unit will have twice the power (120 kW vs 60 kW) and the energy contributing to performance is ten times greater.

The battery has a minimum weight of 20kg to power a motor that produces 120kW. Each 1kg feeds 6kw (a huge power to weight ratio), which will produce large electromagnetic forces. The battery is mounted behind the driver and underneath the fuel cell.

The electromagnetic forces can impact the accuracy of sensors, which are particularly sensitive. Balancing the forces is like trying to carry a house of cards in a storm – a delicate and risky operation.

However a battery is not mandatory, indeed in 2013 one team used a system with both ultra capacitors and a battery to get a performance boost. In WEC where the same rules are in force, flywheel and capacitor storage is used. Both are legal in F1.

PERFORMANCE OF THE ENGINE DURING THE RACE

A standard lap

Under acceleration (e g. down the pit straight) the internal combustion engine will be using its reserve of fuel. The turbocharger will be rotating at maximum speed (100,000rpm). The MGU-H, acting as a generator, will recover energy from the exhaust and pass to the MGU-K (or the battery in case it needs recharging). The MGU-K, which is connected to the crankshaft of the ICE, will act as a motor and deliver additional power to pull harder or save fuel, dependent on the chosen strategy.

At the end of the straight the driver lifts off for braking for a corner. At this point the MGU-K converts to a generator and recovers energy dissipated in the braking event, which will be stored in the battery.

Under braking the rotational speed of the turbo drops due to the lack of energy in the exhaust which, on traditional engines, leads to the curse of the turbo engine – turbo lag. This phenomenon occurs when the driver re-accelerates: Fuel injection starts again and generates hot exhaust gases which speed up the turbo, but it needs time to return to full rotational speed where the engine produces 100% of its power. To prevent this lag, the MGU-H acts as a motor for a very short time to instantaneously accelerate the turbo to its optimal speed, offering the driver perfect drivability.

Over the course of the lap, this balance between energy harvesting, energy deployment and (carbon) fuel burn will be carefully monitored.

‘The use of the two types of energy needs an intelligent management,’ Technical Director for new generation Power Units, Naoki Tokunaga, explains. ‘Electrical energy management will be just as important as fuel management. The energy management system ostensibly decides when and how much fuel to take out of the tank and when and how much energy to take out or put back in to the battery.

‘The overall objective is to minimise the time going round a lap of the circuit for a given energy budget. Obviously, if you use less energy, you will have a slower lap time. That’s fine. However, what is not fine is to be penalised more than the physics determines necessary. In the relationship between fuels used versus lap time, there is a borderline between what is physically possible and the impossible – we name it ‘minimum lap-time frontier’.

‘We always want to operate on that frontier and be as close to the impossible as we can. The strategy is subject its own limits, namely the capacity of the PU components and the Technical Regulations. The power output of the engine subject to its own limits, plus MGU-K power and the energy the battery can deliver to it are all restricted by the rules. It is a complex problem. The solution is therefore determined by mathematical modelling and optimisation – we call it ‘power scheduling’.

‘As a result, there will be a complex exchange of energy going on between the components in the system network, at varying levels of power over a lap. This is completely invisible to the driver as it is all controlled electronically by the control systems. The driver will be able to feel it but no driver intervention is normally required, so they can concentrate on the race in hand. Of course, there will be certain driver-operated modes to allow him to override the control system, for example to receive full power for overtaking. Using this mode will naturally depend on the race strategy. In theory you can deploy as many times as you want, but if you use more fuel or more electrical energy then you have to recover afterwards. The ‘full boost’ can be sustained for one to two laps but it cannot be maintained.’

The fact that the driver does not control the balance between fuel and energy does not lessen the involvement of the driver in any way, and in fact his job will be more complicated than in previous seasons. He will still be fighting the car to keep it under control during hard braking, managing braking to avoid under steer into a corner, applying delicate control over the throttle pedal mid-corner, sweeping through complex corners, throwing the car into high speed corners. In terms of driving style, there may well need to be some adjustments.

‘The throttle response will be different so the driver will need to readjust for this,’ Tokunaga explains. ‘Effectively, once the driver applies full throttle, the control systems manage the power of PU, with the aim to minimise the time within the given energy.

However full throttle no longer means a demand for full engine power. It is an indication to the PU given by the driver to go as fast as possible with the given energy. He will still need to adjust for the different ‘feel’ of the car with the energy systems.’

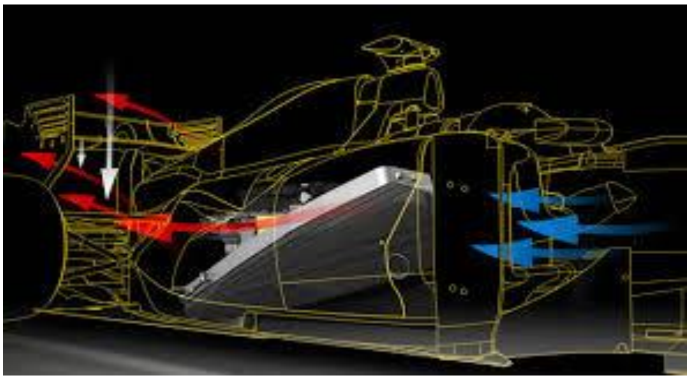
Race strategy and race management will also be more flexible than in the past and the optimum solution will vary vastly from circuit to circuit, dependent on factors including percentage of wide open throttle, cornering speeds and the aerodynamic configuration of the car.

‘In essence, engine manufacturers used to compete on reaching record levels of power, but now will compete in the intelligence of energy management,’ Tokunaga surmises.

A hot lap

In 2014, the fastest car on a Saturday will still start on pole since the sessions will be run ‘flat out’. The cars will still be limited by the fundamental fuel flow restriction of 100kg/h but the 100kg fuel limit will be irrelevant since very little fuel is burned over one lap. The driver will therefore be able to use 100% of the allowed fuel flow and the entire energy budget from the battery store for his qualifying lap. However, should he choose to use all the energy on one lap, he will not be able to complete two flat out timed laps and will instead have to wait until the store recharges. This will lead to some even tenser sessions and a number of different strategic calls.

Radiator (engine cooling)



Radiators are heat exchangers used for cooling internal combustion engines, mainly in automobiles but also in piston-engined aircraft, railway locomotives, motorcycles,stationary generating plant or any similar use of such an engine.

Internal combustion engines are often cooled by circulating a liquid called *engine coolant* through the engine block, where it is heated, then through a radiator where it loses heat to the atmosphere, and then returned to the engine. Engine coolant is usually water-based, but may also be oil. It is common to employ a water pump to force the engine coolant to circulate, and also for an axial fan to force air through the radiator.

In automobiles and motorcycles with a liquid-cooled internal combustion engine, a radiator is connected to channels running through the engine and cylinder head, through which a liquid (coolant) is pumped. This liquid may be water (in climates where water is unlikely to freeze), but is more commonly a mixture of water and antifreeze in proportions appropriate to the climate. Antifreeze itself is usually ethylene glycol or propylene glycol (with a small amount of corrosion inhibitor).

A typical automotive cooling system comprises:

- a series of channels cast into the engine block and cylinder head, surrounding the combustion chambers with circulating liquid to carry away heat;
- a radiator, consisting of many small tubes equipped with a honeycomb of fins to convect heat rapidly, that receives and cools hot liquid from the engine;
- a water pump, usually of the centrifugal type, to circulate the liquid through the system;
- a thermostat to control temperature by varying the amount of liquid going to the radiator;
- a fan to draw fresh air through the radiator.

The radiator transfers the heat from the fluid inside to the air outside, thereby cooling the fluid, which in turn cools the engine. Radiators are also often used to cool automatic transmission fluids, air conditioner refrigerant, intake air, and sometimes to cool motor oil or power steering fluid. Radiators are typically mounted in a position where they receive airflow from the forward movement of the vehicle, such as behind a front grill. Where engines are mid- or rear-mounted, it is common to mount the radiator behind a front grill to achieve sufficient airflow, even though this requires long coolant pipes. Alternatively, the radiator may draw air from the flow over the top of the vehicle or from a side-mounted grill. For long vehicles, such as buses, side airflow is most common for engine and transmission cooling and top airflow most common for air conditioner cooling.

Radiator construction

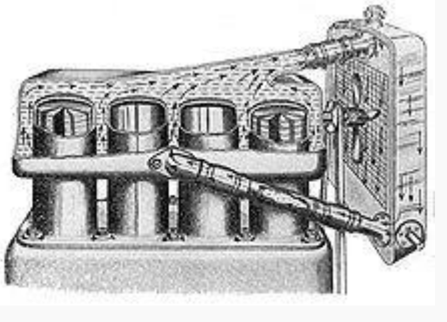
Automobile radiators are constructed of a pair of header tanks, linked by a core with many narrow passageways, giving a high surface area relative to volume. This core is usually made of stacked layers of metal sheet, pressed to form channels and soldered or brazed together. For many years radiators were made from brass or copper cores soldered to brass headers. Modern radiators have aluminium cores, and often save money and weight by using plastic headers. This construction is more prone to failure and less easily repaired than traditional materials.

Honeycomb radiator tubes

An earlier construction method was the honeycomb radiator. Round tubes were swaged into hexagons at their ends, then stacked together and soldered. As they only touched at their ends, this formed what became in effect a solid water tank with many air tubes through it.[1]

Some vintage cars use radiator cores made from coiled tube, a less efficient but simpler construction.

Coolant pump



Thermosyphon cooling system of 1937, without circulating pump

Radiators first used downward vertical flow, driven solely by a thermosyphon effect. Coolant is heated in the engine, becomes less dense, and so rises. As the radiator cools the fluid, the coolant becomes denser and falls. This effect is sufficient for low-power stationary engines, but inadequate for all but the earliest automobiles. All automobiles for many years have used centrifugal pumps to circulate the engine coolant because natural circulation has very low flow rates.

Heater

A system of valves or baffles, or both, is usually incorporated to simultaneously operate a small radiator inside the vehicle. This small radiator, and the associated blower fan, is called the heater core, and serves to warm the cabin interior. Like the radiator, the heater core acts by removing heat from the engine. For this reason, automotive technicians often advise operators to turn ***on*** the heater and set it to high if the engine is overheating, to assist the main radiator.

Temperature control

Waterflow control

Car engine thermostat

The engine temperature on modern cars is primarily controlled by a wax-pellet type of thermostat, a valve which opens once the engine has reached its optimum operating temperature.

When the engine is cold, the thermostat is closed except for a small bypass flow so that the thermostat experiences changes to the coolant temperature as the engine warms up. Engine coolant is directed by the thermostat to the inlet of the circulating pump and is returned directly to the engine, bypassing the radiator. Directing water to circulate only through the engine allows the temperature to reach optimum operating temperature as quickly as possible whilst avoiding localised "hot spots." Once the coolant reaches the thermostat's activation temperature, it opens, allowing water to flow through the radiator to prevent the temperature rising higher.

Once at optimum temperature, the thermostat controls the flow of engine coolant to the radiator so that the engine continues to operate at optimum temperature. Under peak load conditions, such as driving slowly up a steep hill whilst heavily laden on a hot day, the thermostat will be approaching fully open because the engine will be producing near to maximum power while the velocity of air flow across the radiator is low. (The velocity of air flow across the radiator has a major effect on its ability to dissipate heat.) Conversely, when cruising fast downhill on a motorway on a cold night on a light throttle, the thermostat will be nearly closed because the engine is producing little power, and the radiator is able to dissipate much more heat than the engine is producing. Allowing too much flow of coolant to the radiator would result in the engine being over cooled and operating at lower than optimum temperature, resulting in decreased fuel efficiency and increased exhaust emissions. Furthermore, engine durability, reliability, and longevity are sometimes compromised, if any components (such as the crankshaftbearings) are engineered to take thermal expansion into account to fit together with the correct clearances. Another side effect of over-cooling is reduced performance of the cabin heater, though in typical cases it still blows air at a considerably higher temperature than ambient.

The thermostat is therefore constantly moving throughout its range, responding to changes in vehicle operating load, speed and external temperature, to keep the engine at its optimum operating temperature.

On vintage cars you may find a bellows type thermostat, which has a corrugated bellows containing a volatile liquid such as alcohol or acetone. These types of thermostats do not work well at cooling system pressures above about 7 psi. Modern motor vehicles typically run at around 15 psi, which precludes the use of the bellows type thermostat. On direct air-cooled engines this is not a concern for the bellows thermostat that controls a flap valve in the air passages.

Airflow control

Other factors influence the temperature of the engine, including radiator size and the type of radiator fan. The size of the radiator (and thus its cooling capacity) is chosen such that it can keep the engine at the design temperature under the most extreme conditions a vehicle is likely to encounter (such as climbing a mountain whilst fully loaded on a hot day).

Airflow speed through a radiator is a major influence on the heat it loses. Vehicle speed affects this, in rough proportion to the engine effort, thus giving crude self-regulatory feedback. Where an additional cooling fan is driven by the engine, this also tracks engine speed similarly.

Engine-driven fans are often regulated by a viscous-drive clutch from the drivebelt, which slips and reduces the fan speed at low temperatures. This improves fuel efficiency by not wasting power on driving the fan unnecessarily. On modern vehicles, further regulation of cooling rate is provided by either variable speed or cycling radiator fans. Electric fans are controlled by a thermostatic switch or the engine control unit. Electric fans also have the advantage of giving good airflow and cooling at low engine revs or when stationary, such as in slow-moving traffic.

Before the development of viscous-drive and electric fans, engines were fitted with simple fixed fans that drew air through the radiator at all times. Vehicles whose design required the installation of a large radiator to cope with heavy work at high temperatures, such as commercial vehicles and tractors would often run cool in cold weather under light loads, even with the presence of a thermostat, as the large radiator and fixed fan caused a rapid and significant drop in coolant temperature as soon as the thermostat opened. This problem can be solved by fitting a **radiator blind** to the radiator which can be adjusted to partially or fully block the airflow through the radiator. At its simplest the blind is a roll of material such as canvas or rubber that is unfurled along the length of the radiator to cover the desired portion. Some older vehicles, like the World War I-era S.E.5 and SPAD S.XIII single-engined fighters, have a series of shutters that can be adjusted from the driver's or pilot's seat to provide a degree of control. Some modern cars have a series of shutters that are automatically opened and closed by the engine control unit to provide a balance of cooling and aerodynamics as needed.[2]

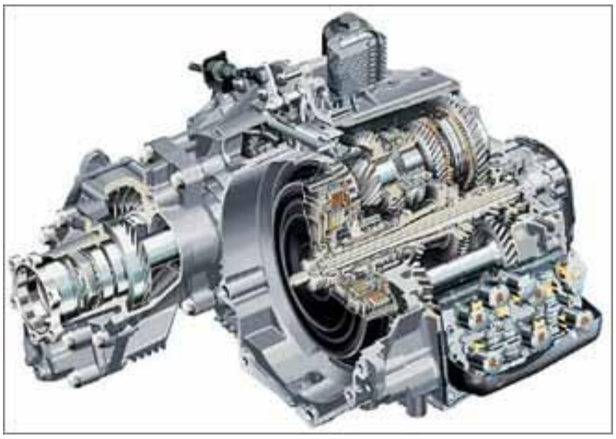
Engine coolant

Before World War II, engine coolant was usually plain water. Antifreeze was used solely to control freezing, and this was often only done in cold weather.

Development in high-performance aircraft engines required improved coolants with higher boiling points, leading to the adoption of glycol or water-glycol mixtures. These led to the adoption of glycols for their antifreeze properties.

Since the development of aluminium or mixed-metal engines, corrosion inhibition has become even more important than antifreeze, and in all regions and seasons.

Gearbox



Changing gears in a Formula One car is very much a fingertip exercise - drivers simply flick a paddle behind the steering wheel to change sequentially up or down.

Formula One cars use highly sophisticated semi-automatic, seamless shift gearboxes. Aside from when pulling away, the driver is not required to manually operate the clutch, nor is he required to lift off the accelerator when changing up through the gears. Instead, when another gear is selected the shift is completed ‘seamlessly’ (via a clever a system which uses two shift barrels), meaning the driver suffers from no loss of drive. As such, gear changes are not only significantly faster than they were with the traditional gear lever and clutch pedal approach (taking a matter of milliseconds), but the driver can also keep both hands on the steering wheel at all times.

But despite such high levels of technology, fully automatic transmission systems, and gearbox-related wizardry such as launch control, are illegal - a measure designed to keep costs down and place more emphasis on driver skill.

Gearboxes, which are electronically controlled with hydraulic activation, attach to the back of the internal combustion engine. But they do more than simply transfer the torque from power unit to wheels - they also form part of the structure of the rear of the car, with the rear suspension bolting directly onto what is usually a high-strength carbon main case.

The rules stipulate that F1 gearboxes must consist of eight forward gears (the ratios having been selected ahead of the season) plus reverse, and although this may seem like a large number compared to a road car, it allows the teams to use the same transmission at low-speed Monaco as at high-speed Monza.

As with power units, the teams are restricted in the number of gearboxes they can use per season, with the rules mandating that a single gearbox must be used for six consecutive events. Every unscheduled gearbox change results in a five-place grid penalty.

Tyres

A modern Formula One car is a technical masterpiece. But considering the development effort invested in aerodynamics, composite construction and engines it is easy to forget that tyres are still a race car's biggest single performance variable and the only point of contact between car and track.

Traditionally, an average car with good tyres could do well, but with bad tyres even the very best car did not stand a chance. Things aren't quite as clear cut in the current era - since 2007 every team receives tyres from a single supplier - but tyres are still a huge performance differentiator with newer, fresher tyres usually offering a significant advantage over worn rubber. As a result teams and drivers will carefully manage tyre usage over a race weekend to ensure they have enough sets of fresh tyres left for the race.

Despite some genuine technical crossover, race tyres and road tyres are at best distant cousins. An ordinary car tyre is made with heavy steel-belted radial plies and designed for durability - typically a life of 16,000 kilometres or more (10,000 miles). The current Formula One tyres are designed to last for anything between 60 and 120 kilometres depending on the compound - and like everything else on an F1 car, are lightweight and strong in construction. They have an underlying nylon and polyester structure in a complicated weave pattern designed to withstand far larger forces than road car tyres. In Formula One racing that means anything up to a tonne of downforce, 4g lateral loadings and 5g longitudinal loadings.

The racing tyre is constructed from a blend of very soft, natural and synthetic rubber compounds which offer the best possible grip against the texture of the racetrack, but tend to wear very quickly in the process. If you look at a typical track you will see that, just off the racing line, a large amount of rubber debris gathers (known to the drivers as 'marbles' because of their slipperiness). All racing tyres work best at relatively high temperatures at which point the tyres become 'stickier', although different compounds often have very different optimum working temperature ranges.

The development of the racing tyre came of age with the appearance of 'slick' untreaded tyres in the late 1960s and early 1970s. Teams and tyre makers realised that by omitting a tread pattern on dry weather tyres, the surface area of rubber in contact with the road could be maximised. Formula One cars ran with slicks until the 1998 when ‘grooved’ tyres were introduced to curb cornering speeds. The regulations specified that all tyres had to have four continuous longitudinal grooves at least 2.5 mm deep and spaced 50mm apart. These changes created several new challenges for the tyre manufacturers - most notably ensuring the grooves' integrity, which in turn limited the softness of rubber compounds that could be used.

The 2009 season brought the much-welcomed return to slick tyres, following the FIA’s decision to use new aerodynamic regulations rather than rubber as a way of keeping cornering speeds under control.

The rubber compounds used at each race are determined by the tyre supplier (currently Pirelli) according to the known characteristics of the track. Two different compounds of dry tyre are available to each team at every Grand Prix weekend - one harder 'prime' tyre and one softer 'option' tyre. Every driver must make use of both specifications during the race. The actual softness of the tyre rubber is varied by changes in the proportions of ingredients added to the rubber, of which the three main ones are carbon, sulphur and oil. Generally speaking, the more oil in a tyre, the softer it will be. However, whilst softer tyres generally tend to be quicker than harder ones, they’re also less durable.

These are the seven F1 tyre compounds supplied by Pirelli for the 2016 season.[17][18]

Compound name	Colour		Tread	Driving conditions	Dry type*	Grip	Durability
Ultra soft	Purple		Slick	Dry	Option	5 – Most grip	1 – Least durable
Super soft	Red		Slick	Dry	Option	4	2
Soft	Yellow		Slick	Dry	Prime/Option	3	3
Medium	White		Slick	Dry	Prime/Option	2	4

Hard	Orange		Slick	Dry	Prime	1 – Least grip	5 – Most durable
Intermediate	Green		Treaded	Wet (no standing water)	N/A	N/A	N/A
Wet	Blue		Treaded	Wet (standing water)	N/A	N/A	N/A

Current F1 tyre suppliers Pirelli have a range of five dry-weather compounds: ultrasoft (purple sidewall markings), super soft (red markings), soft (yellow markings), medium (white) and hard (orange).

Intermediate (green) and wet-weather (blue) tyres have full tread patterns, necessary to expel standing water when racing in the wet. However, sometimes conditions are too wet for even the full wet tyres to cope with. One of the worst possible situations for a race driver remains 'aquaplaning' - the condition when there is so much moisture on the surface of the track that a film of water builds up between the tyre and the road, meaning that the car is effectively floating. This leads to vastly reduced levels of grip. The tread patterns of modern racing tyres are mathematically designed to scrub the maximum amount of water possible from the track surface to ensure the best possible contact between the rubber and the track. At full speed the Pirelli intermediate tyre can disperse up to 25 litres of water per second, while the full wet tyre can disperse 65 litres per second.

Formula One tyres are normally filled with a special, nitrogen-rich air mixture, designed to minimise variations in tyre pressure with temperature. The mixture also retains the pressure longer than normal air would.

Air intake and Airbox

The air intake and air box is one of the most distinctive features of a modern F1 car. Situated just above the driver's head, the oval-shaped air intake hole dictates not only the shape of the engine cover but also the flow of air into the engine. In this latest feature from Renaults sport F1 we explain what it does in detail, but also what goes on underneath the bodywork and inside the engine.

Airbox

The airbox and intake system govern the maximum amount of air pumped by the engine, and therefore the amount of fuel it can burn and the level of power that it can produce. The air intake we see above the driver's head is just the tip of the iceberg with regards to the engine's inlet system. At high speed, the air is pushed into the hole above the driver's head and down into a hollow tube that opens out to a horn shape at its base, where the air filter is situated. The air arrives at the air filter at a pressure higher than atmospheric as a consequence of the dynamic pressure created by the car's velocity. An efficient air 'horn' will keep as high a percentage of this dynamic pressure as possible before the air meets the air filter.

The air filter's job is then to stop any airborne particles or foreign material such as sand or grit from entering the engine. The 'clean' air is ingested into the eight trumpets where the throttles are located. If the throttles are closed, the air will go no further, but if the throttles are open, the air will pursue its journey and be mixed with the fuel. Ultimately this fuel-air mixture passes into the combustion chamber via the valves, where it is ignited by the spark plug and drives the piston down, creating torque.

Air system so important for car performance

Air – or rather oxygen – is an essential part of the combustion process and having enough airflow at maximum possible pressure will maximize the amount of torque produced. Delivering this optimum therefore depends on the constituent parts of the system. Firstly, the shape of the airbox governs how much air can be taken into the engine unit. If the inlet is too small, the engine will be 'starved' of air and therefore produce less power. If it is too large, however, the engine will not be more efficient on a linear scale – more air does not mean more power; exactly the correct amount must be introduced. This relates back to trying to try to keep the total pressure as high as possible. To achieve this we need to keep as much dynamic pressure created from the car speed as possible. This is of course a compromise with the adverse effect on the aerodynamics of having a giant airbox, which would create turbulence for the rear wing so we look to the airbox to keep as high a percentage of dynamic pressure as we can.

The air filter also needs to be very robust. Have too tight a filter and the flow of oxygen is hindered, or the total pressure drops. But have too little and you run the risk of having foreign bodies enter the engine, which can cause irreparable damage to the pistons and other engine internals. For this reason, engine suppliers work on the 'tightness' of the air filter but also on its capability to retain debris.

Technical regulations governing air filters

Surprisingly, there are very few technical regulations governing air filters. The principal ones forbid any system that decreases the temperature of the engine intake air, and the restriction of any systems that increase the volume of oxygen ingested above the percentage found in air (20%). Then there are the general aerodynamic prescriptions, which is actually why you see a lot of variations in the designs of air intakes: some are round, while others are split by a central pillar. Even between Renault Sport F1's teams the designs are very different according to each team's priorities. But in any case, there can be no compromise on the air filter characteristics, which need to protect the engine.

Teams and engine manufacturers therefore work in unison to develop the air horn and airbox as it is another area where aerodynamic and engine performance can be found.

The design of the airbox and air filter evolved over the history of the current V8 engine

The evolution of the airbox has been mainly driven by aerodynamics. The shape has evolved to suit drag reduction systems and narrower bodywork, but has also been affected by the installation of coolers close to the rear end of the air duct. In the era of the F-Duct we also saw some big changes, while nowadays with DDRS the air from the intake is used for aero purposes down to the rear wing.

The insulation of the airboxes has also moved forward since the bodywork of the cars has become tighter. Tighter bodywork gives less opportunity for the heat to escape so preventing the overheating of the air that goes into the engine becomes crucial as lower temperatures ultimately mean more power.

For the air filter, a fair bit of work has been done to improve the quality of the air ingested by the engine by running clever systems to separate debris up front rather than at the base of the air horn. Furthermore, when engine life was extended, the air filter was developed in parallel: a better filtration means a higher average power output.

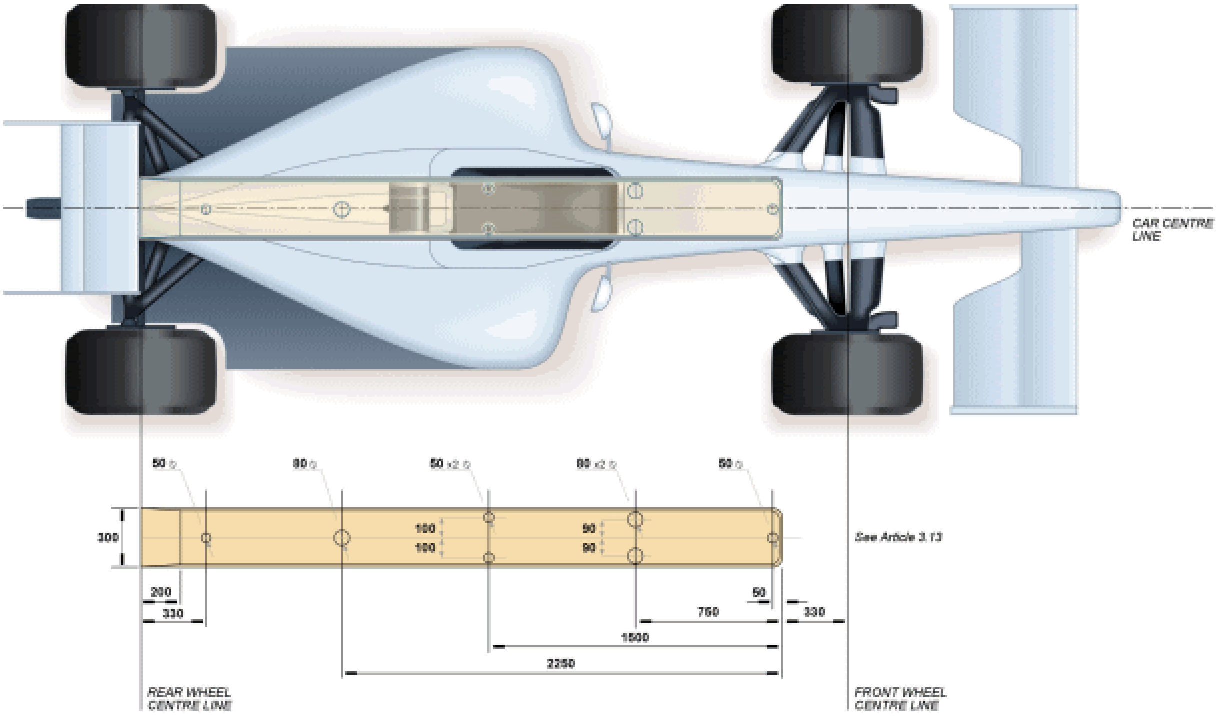
Without the engine freeze, what would we be seeing now with regards to airbox design

It is very difficult as it is closely linked to the internals, but it is fair to say that these boxes would certainly have been much more complex, possibly incorporating variable geometry, for example. It is even possible to think we could have had different designs changing race to race. We could have developed a single throttle butterfly system at the top of the airhorn beneath the roll hoop – in fact we looked into this at one point, but the benefits of having eight separate throttles rather than one were more advantageous, especially due to the extra weight of the latter.

FACT!

At the end of the straight at the Shanghai circuit where the car is travelling at close to 330kph with DRS open, the air pressure hitting the air filter will be close to 1,070 millibar – normal ambient air pressure is around 1,020 millibar. This means the engine produces around 5% more power – equivalent to 40 bhp – than at 'walking speed'.Also the combination of the air pressure inside the air horn and resonance generated by the high frequency wave of the engine pitch is such that the physical structure of the air horn needs to be adequate – or robust enough – to cope with the airbox wall deformation. To give an example of how much it physically deforms, if you were to film inside the air horn with a high speed camera you would pick up a change of approx. The Renault Sport F1 air filter is also based on those used in desert rallies – fine enough to stop fine dust and sand, but overall open enough not to restrict maximum power.

Car floor (plank)



A wooden or any other homogeneous material strip that was fitted front-to-back down the middle of the underside of all cars in the mid-1990s to check that cars were not being run too close to the track surface, something that was indicated if the wood was worn away. It must be made out of a material with a specific gravity of between 1.3 and 1.45 (to prevent excessively heavy or hard planks producing a performance benefits and lowering the car center of gravity). Skid block may comprise of no more than three pieces, the forward one of which may not be any less than 1000mm in length. Plank must be fixed symmetrically on the car centre line in such a way that no air may pass between it and the surface formed by the parts lying on the reference plane. The lower edge (facing ground) of the front end of the skid block may be chamfered at an angle of 30° to a depth of 8mm, and trailing, rear edge may be chamfered over a distance of 200mm to a depth of 8mm.

When measured through six pre-cut 5cm diameter holes, plank has to have a tolerance of just 1mm on its 10mm thickness. Seven precisely placed holes in the plank allow the cars reference plane to sit directly and exactly on right place on the FIAscrutineering platform, for legality checks over the course of a GP weekend. Any holes made into it must conform to a FIA template (see picture below). Four further 10mm diameter holes are permitted provided their sole purpose is to allow access to the bolts which secure the Accident Data Recorder to the survival cell.

If plank is consumed too much, car can be disqualified. Skid block or 'plank' must run along the reference plane. It is not considered part of the floor for measurement purposes, and is there only to enforce a minimum ride height.
Plank was introduced with intention of FIA to reduce aerodynamic capabilities andbottoming of the cars, following Austrian Roland Ratzenberger death in qualifying for the San Marino Grand Prix in 1994 driving his Simtec, and Ayrton Senna in a Williams car at the San Marino Grand Prix same year during the race.

Steering wheel

1. Pit lane speed limiter
2. Differential +
3. Engine push
4. Gear up-shift
5. Traction control +
6. Engine push setting switch
7. Clutch lever
8. Traction control
9. Team info in-lap
10. Burn out
11. Multifunctional switch
12. Lambda
13. Diagnostic
14. Wing angle info switch
15. Clutch
16. Differential selective switch
17. Team radio
18. Traction control -
19. Gear downshift
20. Engine break
21. Differential -
22. Neutral
23. Display page change

The steering wheel is the critical interface between driver and car. From here, through the use of various switches, buttons and dials, he can make numerous changes to his machine - all without ever having to lift off the throttle.

Early Formula One cars used steering wheels taken directly from road cars. They were normally made from wood (necessitating the use of driving gloves), and in the absence of packaging constraints they tended to be made as large a diameter as possible, to reduce the effort needed to turn. As cars grew progressively lower and cockpits narrower throughout the 1960s and 1970s, steering wheels became smaller, so as to fit into the more compact space available.

The introduction of semi-automatic gearchanges, operated via the now familiar 'paddles' on the back of every steering wheel, marked the beginning of the move to concentrate controls as close to the driver's fingers as possible. Today the clutch is also operated by a similar paddle.

The first buttons to appear on the face of the steering wheel were the 'neutral' button (vital for taking the car out of gear in the event of a spin), and the on-board radio system's push-to-talk button. Today, excepting the throttle and brake pedals, few Formula One cars have any controls other than those on the face of the wheel. Buttons tend to be used for 'on/off' functions, such as engaging the pit-lane speed limiter system, while rotary controls govern functions with multiple settings, such as engine maps, fuel mixture and even the car's front-to-rear brake bias - all functions the driver might wish to alter to take account of changing conditions during the race. Among the most recent additions are controls relating to the car's energy recovery systems (ERS) and the drag reduction system (DRS) on the rear wing.

The steering wheel is also used to house instrumentation, normally via a multi-function LCD display screen and - more visibly - the ultra-bright 'change up' lights that tell the driver the perfect time for the optimum gearshift. Race control can also communicate with the driver via a compulsory, steering-wheel mounted GPS marshalling system. This displays warning lights, with colours corresponding to the marshals’ flags, to alert drivers to approaching hazards, such as an accident, on the track ahead.

The steering wheels are not designed to make more than three quarters of a turn of lock in total, so there is no need for a continuous rim, instead there are just two 'cut outs' for the driver's hands.

Cockpit

At the heart of the modern Formula One car is the 'monocoque' (French for ‘single shell’), or 'tub'. It incorporates the driver's survival cell and cockpit, and also forms the principal component of the car's chassis, with engine and front suspension mounted directly to it. Its roles as structural component and safety device both require it to be as strong as possible. Like the rest of the car, most of the monocoque is constructed from carbon fibre - up to 60 layers of it in places - with high-density woven laminate panels covering a strong, light honeycomb structure inside.

At the heart of the monocoque lies the survival cell and within that the cockpit. For safety reasons, no fuel, oil or water lines may pass through the cockpit and the driver must be able to get out within five seconds without having to remove anything except seatbelts and steering wheel (which he must be able to refit within another five seconds). The width of the cockpit must be 50 centimetres at the steering wheel and 30 centimetres at the pedals. The temperature inside the cockpit averages 50 degrees Celsius.

To ease a driver’s escape, the dimensions of the cockpit opening have grown over the years. Currently it must be 850mm long, at least 350mm wide at the pedals and 450mm wide at the steering wheel, with the rear half wider still at 520mm. The rear 375mm of the cockpit’s side walls must rise upwards at an angle of at least 16 degrees (to reduce the risk of injury in the event of one car flying over the top of another) and the edge of the cockpit must be enclosed in an energy-absorbing material with a thickness of at least 100mm.

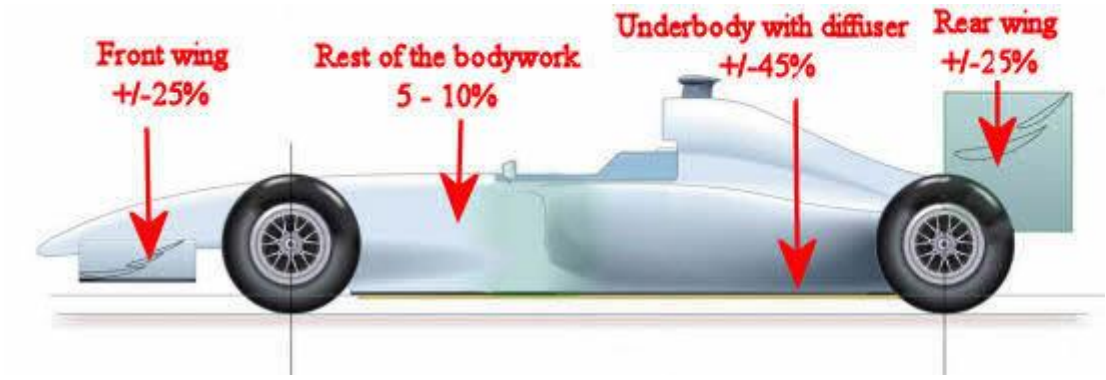
The survival cell is surrounded by deformable crash-protection structures which absorb energy in an accident and features a roll-over hoop behind the driver's head, made of metal or composite materials. The survival cell's flanks are protected by a 6mm layer of carbon and Zylon, a material used to make bullet-proof vests, to prevent objects such as carbon fibre splinters entering the cockpit.

The driver's seat is a single plastic cast, tailored to provide optimal support. Since 1999, rules have stipulated it may not be installed as a fixed part of the car. Instead it must be possible to remove the driver and seat as one after an accident, thus eradicating the risk of spinal damage. Compulsory since 1972, today F1 seat belts comprise a six-point harness, which can be released by the driver with a single hand movement.

All Formula One cars must be equipped with a fire extinguisher system. This automatically spreads foam around the chassis and engine area in the event of fire and can also be operated manually by either the driver or marshals. Also required in the cockpit is a master switch that deactivates the car's electronics, fuel pumps and rear light.

An accident data recorder is also compulsory. Linked to a medical warning system, it registers important information such as speed and deceleration to tell medics how severe the impact was. In addition, there is a cockpit display with red, blue and yellow lights which informs the driver about any warning flags being waved around the circuit.
that during his high-speed crash at the Canadian Grand Prix in 2007, Robert Kubica was subjected to more than 28 times the acceleration of gravity? This meant that his body effectively weighed two tons instead of 73 kilograms. Millions of spectators expected the worst, but thanks to the strict safety precautions in Formula One racing Kubica suffered only minor bruises monocoque, about 30 square metres of carbon-fibre mats are processed, in which the individual fibres are five times thinner than a human hair?

Aerodynamics



Ask any engineer in the pit lane and they'll tell you that the most important consideration in F1 car design - the difference between designing a championship-challenging machine or a tail ender - is aerodynamics.

In simple terms, F1 aerodynamicists have two primary concerns: the creation of downforce, to help push the car's tyres onto the track and improve cornering forces; and the minimisation of drag, a product of air resistance which acts to slow the car down.

Although always important in race car design, aerodynamics became a truly serious proposition in the late 1960s when several teams started to experiment with the now familiar wings. Race car wings - or aerofoils as they are sometimes known - operate on exactly the same principle as aircraft wings, only in reverse. Air flows at different speeds over the two sides of the wing (by having to travel different distances over its contours) and this creates a difference in pressure, a physical rule known as Bernoulli's Principle. As this pressure tries to balance, the wing tries to move in the direction of the low pressure. Planes use their wings to create lift, race cars use theirs to create negative lift, better known as downforce. A modern Formula One car is capable of developing 3.5 g lateral cornering force (three and a half times its own weight) thanks to aerodynamic downforce. That means that, theoretically, at high speeds they could drive upside down.

Early experiments with movable wings and high mountings led to some spectacular accidents, and for the 1970 season regulations were introduced to limit the size and location of wings. Evolved over time, those rules still hold largely true today.

By the mid-1970s 'ground effect' downforce had been discovered. Lotus engineers found out that by cleverly designing the underside of the car, the entire chassis could be made to act like one giant wing which sucked the car to the road. The ultimate example of this thinking was the Brabham BT46B, designed by Gordon Murray, which actually used a cooling fan to extract air from a sealed area under the car, creating enormous downforce. After technical challenges from other teams it was withdrawn after a single race. Soon after rule changes followed to limit the benefits of 'ground effects' - firstly a ban on the skirts used to contain the low pressure area, then later a requirement for a 'stepped floor'.

In the years that have followed aerodynamic development has been more linear, though ever increasing speeds and various other factors have led the sport’s regulators to tweak and tighten the regulations on several occasions.

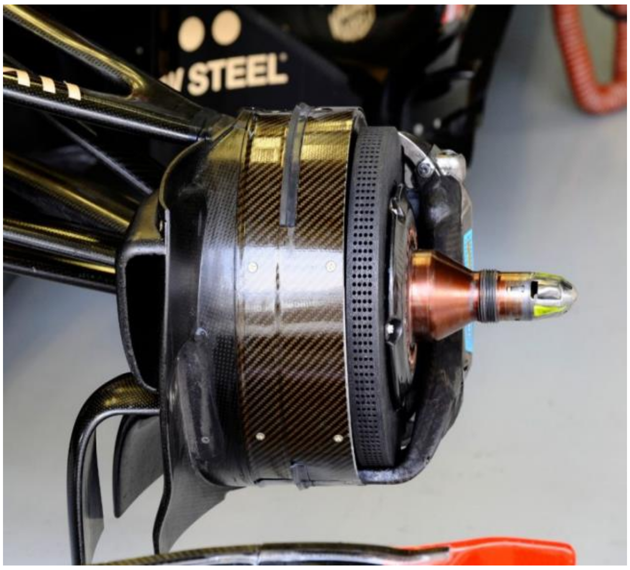
As a result, today’s aerodynamicists have considerably less freedom than their counterparts from the past, with strict rules dictating the height, width and location of bodywork. However, with every additional kilogram of downforce equating to several milliseconds of lap time saved, the teams still invest considerable amounts of time and money into wind tunnel programmes and computational fluid dynamics (CFD) – the two main forms of aerodynamic research.

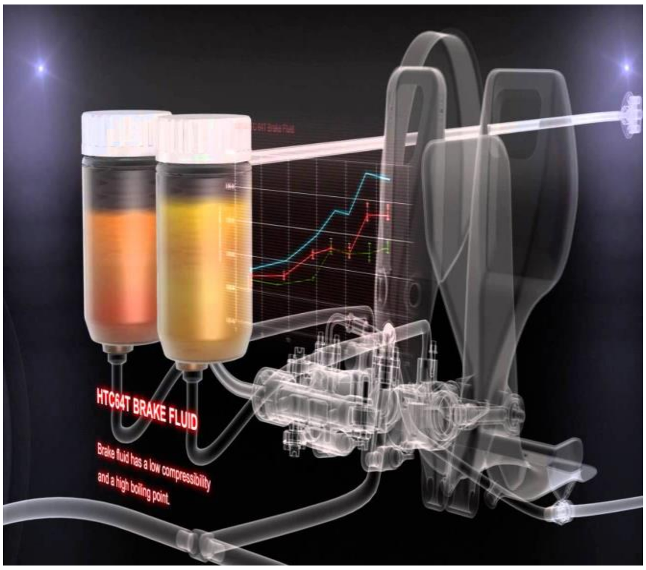
The most obvious aerodynamic devices on a Formula One car are the front and rear wings, which together account for around 60 percent of overall downforce (with the floor responsible for the majority of the rest). These wings are fitted with different profiles depending on the downforce requirements of a particular track. Tight, slow circuits like Monaco require very aggressive wing profiles to maximise downforce, whilst at high-speed circuits like Monza the amount of wing is minimised to reduce drag and increase speed on the long straights.

Every single surface of a modern Formula One car, from the shape of the suspension links to that of the driver's helmet - has its aerodynamic effects considered. This is because disrupted air, where the flow 'separates' from the body, creates turbulence which in turn creates drag and slows the car down. In fact, if you look closely at a modern car you will see that almost as much effort has been spent reducing drag and managing airflow as increasing downforce - from the vertical endplates fitted to wings to prevent vortices forming to the diffuser mounted low at the rear, which helps to re-equalise pressure of the faster-flowing air that has passed under the car and would otherwise create a low-pressure 'balloon' dragging at the back. But despite this, designers can't make their cars too 'slippery', as a good supply of airflow has to be ensured to help cool the various parts of the power unit.

The ingenuity of F1 engineers means that every now and then a loophole will be found in the regulations and a clever aerodynamic solution will be introduced. More often than not these devices, such as double diffusers, F-ducts and exhaust-blown diffusers, will be swiftly banned, but one innovation that has been actively endorsed is the DRS (Drag Reduction System) rear wing. This device, which was introduced to encourage more overtaking, allows drivers to adjust the angle of the main plane of the rear wing to reduce drag and increase straight-line speed, though it may only be used on specific parts of the track and when a driver is within one second of the car ahead in a race.

Brake system





No braking system may be designed to prevent wheels from locking when the driver applies pressure to the brake pedal.Article 11.5.1 of the 2016 FIA Technical Regulations

- Formula One car must have one brake system operated through a single brake pedal.
- The system must comprise two hydraulic circuits - one for the front wheels and one for the rear. Should one circuit fail the other must remain operational.
- Anti-lock braking systems (ABS) are not allowed - brake pressure must be controlled by the driver’s physical input only and not by any other system.
- The only exception is the electronic rear brake control system, which is teams can use to compensate for the effect of Energy Recovery Systems (ERS) on the rear axle.
- The rear brake control system is allowed provided that the driver brake pedal is connected to a hydraulic master cylinder that generates a pressure source that can be applied to the rear braking circuit if the powered system is disabled.
- Each wheel must have no more than one brake disc of 278mm maximum diameter and 28mm maximum thickness. Each disc must have only one aluminium caliper, with a maximum of six circular pistons, and no more than two brake pads.
- The size of the air ducts used to cool the brakes is strictly controlled and they must not protrude beyond the wheels. The use of liquid to cool the brakes is forbidden.

Fuel

Surprising but true, despite the vast amounts of technical effort spent developing a Formula One car, the fuel it runs on is surprisingly close to the composition of ordinary, commercially available petrol.

It was not always so. Early Grand Prix cars ran on a fierce mixture of powerful chemicals and additives, often featuring large quantities of benzene, alcohol and aviation fuel. Indeed some early fuels were so potent that the car's engine had to be disassembled and washed in ordinary petrol at the end of the race to prevent the mixture from corroding it!

Over the years more and more regulations have been introduced regarding the composition of fuel, a move driven in part by the oil companies' desire to have demonstrable links between race and road fuel.

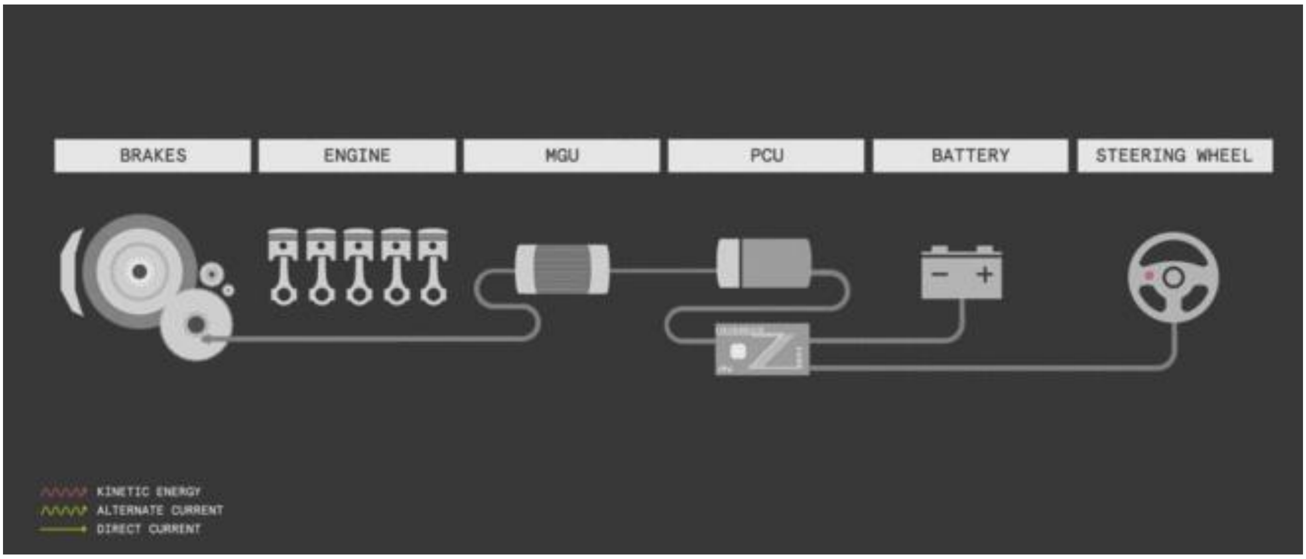
The modern fuel is only allowed tiny quantities of 'non hydrocarbon' compounds, effectively banning the most volatile power-boosting additives. Each fuel blend must be submitted to the sport’s governing body, the FIA, for prior approval of its composition and physical properties. A 'fingerprint' of the approved fuel is then taken, which will be compared to the actual fuel being used at the event by the FIA's mobile testing laboratory.

Since 2014, each car has been limited to 100kg of fuel per race. All of Formula One racing's fuel suppliers engage in extensive testing programmes to optimise the fuel's performance, in the same way any other component in the car will be tuned to give maximum benefit. This will likely involve computer modelling, static engine running and moving tests.

The car's engine oil is also worth a mention. Not only does it reduce wear on components, but it also helps to perform a vital diagnostic role, being closely analysed after each race or test for traces of metals to help monitor the engine's wear rate.

Advanced technology used in formula 1 car

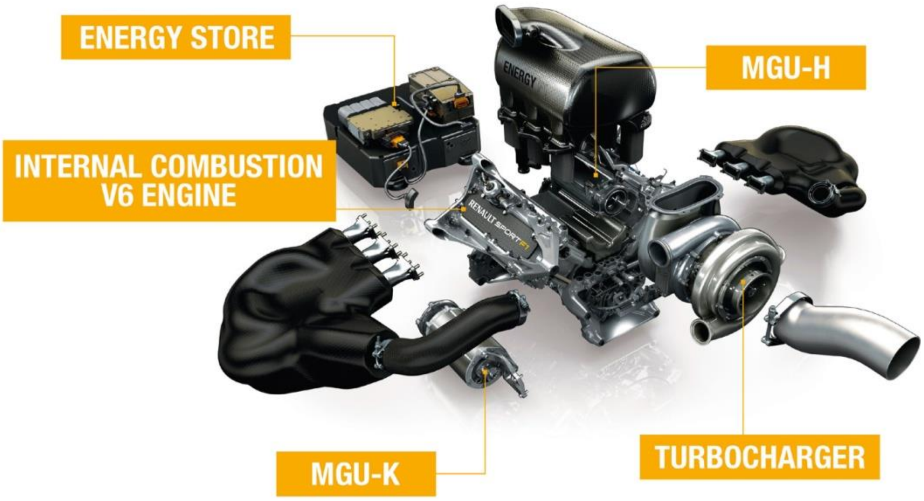
Working of a kinetic energy recovery system



F1 is the laboratory for normal, daily used cars. In the below article, I will explain how the ERS (Energy Recovery System) works and its benefits. Previously known as KERS (Kinetic Energy Recovery System), which was first introduced in 2009, the ERS can be simplified as follows:

We all remember when we were kids the toy cars that we used to have. Remember how we used to drag the car backwards several times and then leave it on the floor and the car used to quickly accelerate from our hands? We all remember that, right? The car accumulates the energy in something called the “flywheel” from dragging the car backwards and releases it once we leave it on the ground.

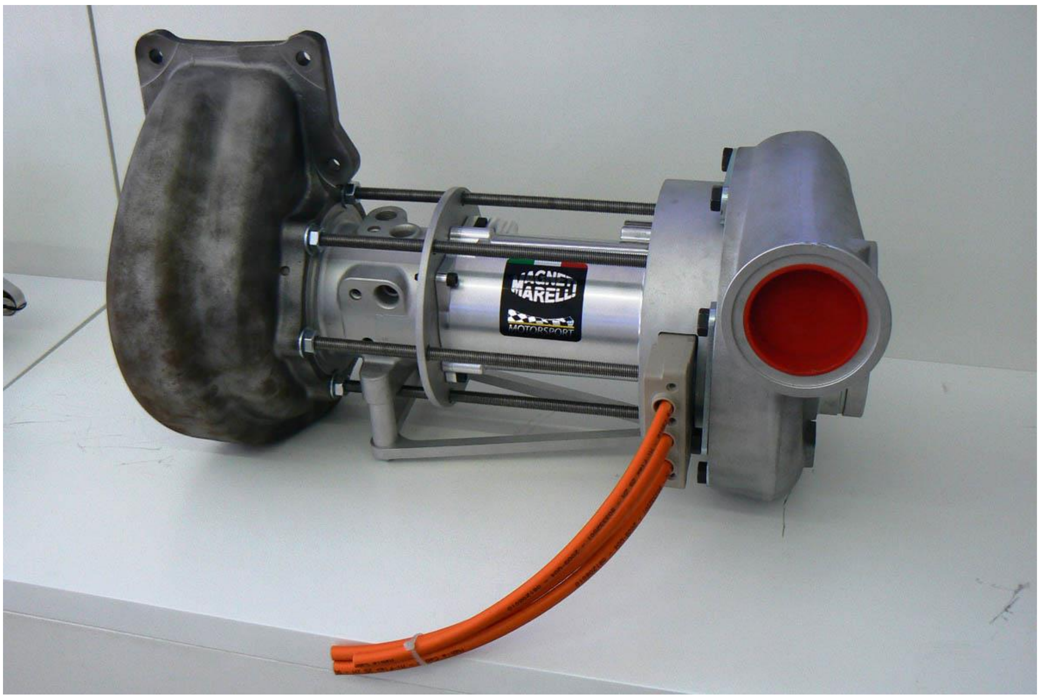
The ERS is more complicated than that, but the example was to make you remember and understand how every moving object in physics generates energy. What ERS does is to store this energy and release it once needed. It is now called Motor Generator Units or MGU.



The Motor Generator Units convert mechanical and heat energy to electrical energy and vice versa.

The two parts of ERS are: Motor Generator Unit – Kinetic (MGU-K), and Motor Generator Unit – Heat (MGU-H), plus an 'energy store' (ES) and control electronics. Renault describes its energy store as a "battery". Other manufacturers call their engines now the "Power Unit". The new ERS must weigh between 20 to 25kg.

MGU-K, like KERS, uses a motor-generator to deliver power (120kW) for acceleration and extract energy instead of friction brakes for deceleration. MGU-K works like an upgraded version of KERS, converting kinetic energy generated under braking into electricity (rather than it escaping as heat). It also acts as a motor under acceleration, returning up to 120kW (approximately 160hp) power to the drivetrain from the Energy Store.



MGU-H also uses a motor-generator, connected to the turbocharger. Energy extracted can be used to feed the MGU-K directly, stored for later use by the MGU-K, or stored to be feed back into the turbocharger. MGU-H is an energy recovery system connected to the turbocharger of the engine and converts heat energy from exhaust gases into electrical energy. The energy can then be used to power the MGU-K (and thus the drivetrain) or be retained in the ES for subsequent use. MGU-H also controls the speed of the turbo, speeding it up (to prevent turbo lag) or slowing it down in place of a more traditional waste gate.

The 2.4 liters normally-aspirated V8 engines of 2013 produced around 750hp, with an additional 80hp available for around six seconds per lap from KERS. The 2014 V6s put out around 600hp. However, the two ERS systems (ERS-K and ERS-H) will give drivers an additional 160hp (120kW) or so for approximately 33 seconds per lap while previously, KERS used to give the driver around 80hp.

Safety equipment

When operated, the fire extinguishing system must discharge 95% of its contents at a constant pressure in no less than 10 seconds and no more than 30 secondsArticle 14.1.4 of the 2016 FIA Technical Regulations

- All cars must be fitted with a fire extinguishing system that will discharge into the cockpit and engine compartment in the event of a fire. It must be operable by the driver when he is seated normally with his seat belts on and must function even if the car's main electrical circuit fails or if the car is inverted.

- There must also be a switch to trigger the fire extinguishing system from outside the cockpit. Its location on the bodywork is indicated by a red letter "E" inside a white circle.

- There must be a circuit breaker switch in the cockpit that the driver can use to cut all the car's main electrical circuits. This is marked on the dashboard by a red spark in a white-edged blue triangle. There must be an additional switch that marshals can operate from a distance with the use of a special hook. This switch is located at the base of the car's main roll-over structure.

- All cars must have two rear-view mirrors, whose size and location must comply with strict requirements. Drivers must demonstrate to the FIA the effectiveness of the mirrors by identifying special letter and number boards placed at various distances behind and to the sides of the car whilst seated in the cockpit.

- Seatbelts are compulsory in Formula One racing. Drivers must wear two shoulder straps, one abdominal strap and two straps between the legs. These must comply with strictly specified FIA standards.

- All cars must have a red light on the rear of the car in a specific location defined by the FIA regulations. The driver must be able to switch this light on at any time. This is usually done in poor weather conditions in order to make the car more visible to following drivers.

- The cockpit of the car must be equipped with three areas of special padding to protect the driver's head in the event of an impact. These are situated immediately behind and to the sides of his head.

- In order to minimise the risk of leg injury during an accident, additional areas of padding must be fitted each side of, and above, the driver's legs within the cockpit.

- In order to easily extract a driver from a car in the event of an accident its seat must be removable with the driver in place and his seatbelts fastened. The seat must be secured by no more than two bolts, which can be released using a standard tool issued to all rescue crews.

- All cars must be fitted with wheel retention devices to prevent a wheel coming off the car in the event of the fastener either being left loose or becoming loose.