

Carbon Neutral Motorsport

The FIA, Formula 1's governing body, have been carbon neutral since 1997. They work closely with universities to calculate the precise amount of carbon produced by the sport. This includes running the cars over test and practice sessions, and covers all race weekends. It also includes the transportation of personnel across the globe to attend races. Once calculated, the FIA work with reforestation projects in Mexico, and are therefore carbon neutral. As of 2008, the annual figure to be traded off was 20,000 tonnes of carbon

In the late 1990's the structure of qualifying sessions saw the cars being limited to fewer laps in an attempt to make the sport more interesting decreasing the amount of time available for a team to qualify for good grid positions, and to improve the perception of a wasteful image. Also, motorsport in general is turning towards the idea of biofuels. Formula 1 is trailing fuels, teams currently having to run a fuel comprising at least 6% biofuel.

Cars are constantly becoming lighter currently weighing in at around 700kg. Long life components are being introduced in many areas of the car, and a standard ECU is in place across the grid. Although the main priority is to stop teams spending so much money, this also means they will not be using up so many resources, there will be less raw materials used up in producing endless components and this essentially saves energy.

The FIA Foundation, is an organisation that campaigns for road safety all around the world. The Foundation researches issues regarding public safety, the impact of cars on the environment, the future in sustainable transport and of course safety within motorsport as well. They issue grants and fund initiatives across the globe and get involved with activities such as reducing the number of road related deaths in Africa, and raising awareness of crash structures and safety ratings in the UK. Those are just two examples of the many projects the FIA Foundation gets involved with, and it's all working towards reducing the impact on the environment and on society of both road and sports cars.

Formula 1 and the environment

Racecar Engineering, Sam Collins, Jun 23, 2012



Although Formula 1 is not a sport that associated with greenness in the public consciousness, it actually has a strong track record of delivering environmentally relevant technology and capability. Success in Formula 1 is all about efficiency; the teams attempt to wring every drop of performance from a fixed set of resources to allow them to gain a competitive advantage over their rivals. In doing so, they create and develop technology which allows wider society to enjoy improved performance from fewer resources. This paper explores the positive environmental aspects of Formula 1 in general and the green credentials of Lotus F1 Team in particular to reveal the positive role that this unique sport plays in delivering a more sustainable future.

“Formula 1 has a long history of providing technological development that has much wider implications than simply making fast racing cars. The trickle down of useful technology has, however, been incidental to the aims of the sport. In recent years by contrast, the sport has taken a conscious decision to structure its regulations to ensure that the technology it delivers is of immediate and direct relevance to the future improvement of road car efficiency. Lotus F1 Team has played, and continues to play a constructive role in the creation of these regulations. Back in our factory, we have delivered many smaller scale initiatives to ensure that our direct activities have a reduced carbon footprint. So, whether on the small stage of our operations at Enstone or on the wider stage of the strategic direction for Formula 1, Lotus F1 Team is committed to promoting and supporting initiatives that ensure that our activities contribute to a greener future for society.” Eric Boullier, Team Principal Lotus F1 Team

2014 Regulations

Although the current generation of F1 cars has already embraced hybrid technology with KERS (Kinetic Energy Recovery System), the sport is poised for a technological revolution in 2014 which will push environmentally relevant technology right to the fore. The entire thrust of the sport in 2014 will be to deliver cars that are capable of racing at today's speeds whilst using around 40% less fuel than we currently consume. Furthermore, built into the regulatory roadmap is a fuel consumption descender that will require the teams to deliver competitive racing with less fuel each year thereafter. Of course, it is impossible to deliver on these challenging targets without technological change.

The teams and the governing body of the sport (the FIA) have jointly constructed a fresh set of regulations that allow the teams to invest in many new technologies that will be of substantial use to the wider road car industry. The new regulations will see the capacity of the engines slashed from 2.4litres to just 1.6litres. At the same time, acceleration performance will be maintained by permitting a much larger hybrid system into the cars - more than doubled in its authority compared to the current cars.

In addition to capturing the kinetic energy available during braking (this is the traditional way that a hybrid works), the cars will also be allowed to capture the heat energy that is currently wasted in the engine exhaust. There is nothing especially new about this; exhaust heat recovery has been performed by turbochargers in many applications for around 100 years. However, there is a twist on the exhaust heat recovery rules for 2014 that allow a novel and properly useful technology to be developed. The new rules permit the turbocharger system to be linked to an electric motor/generator unit. Why is this useful? Turbochargers have always offered efficiency gains, but these gains come with a price. Because it takes a certain amount of time to spin up to full speed when it is needed, the turbocharger does not deliver the instant power that is required when a driver puts his foot down. Lots of different tricks have been used over the years to try to reduce the so called "turbo lag" that prevents a turbocharged engine from delivering rapid power changes.

The 2014 rules propose to solve this problem by linking the turbo to an electric motor/generator. With this solution, the electric motor can rapidly spin up the turbo when instant power is required. Similarly, when the turbo has more energy than it needs (at the end of a straight say), then it can be used to drive the linked generator unit, allowing electrical energy to be generated and stored in a battery when it can be used later on. Although proposed many times at a theoretical level, this elegant engineering solution has never been pursued in a real application. It is a difficult challenge, and it is exactly the sort of

technological problem that Formula 1 is brilliant at solving. In two years' time, our sport will be running the first working e-turbo units in racing conditions.

It is widely expected that once the technology is mastered it will be an ideal candidate to allow future road cars to continue to move down the fuel efficient path of downsizing the internal combustion engines while scaling up the turbocharger. The regulations for the 2014 power unit are bulging with similar, highly relevant technologies. It is the first time that the sport has chosen a pathway that is consciously aligned with the development roadmap for the road car industry and these regulations provide a blueprint for how to embed social relevance into the DNA of the sport.

Aerodynamics

It is not immediately obvious how the intense aerodynamic development of small racing cars, festooned as they are with drag producing wings, can be of any relevance to society. However, the investment that the teams have made in aerodynamic development continues to drive technology that is of significant environmental importance.

All the teams make a large investment in aerodynamic competence as the car with the best aerodynamic package generally wins the championship. Although our racing cars look nothing like road cars, buildings, wind generators or airplanes, all of these fields require significant aerodynamic expertise, and all of them benefit to some degree from the rapid development of aerodynamic understanding that Formula 1 engenders.

For example: Wind Tunnels. For many years, to be successful, a Formula 1 team must have mastered the skills necessary to maximise the "ground effect" downforce that can be generated between the underside of the car and the road. Pursuit of this downforce has given rise to many, many millions of pounds of investment by the teams in wind tunnel technology that allows this tricky area of design to be accurately exploited. Although neglected for many years by the mainstream road car industry, the aerodynamic importance of the region between the underside of the car and the ground has recently come to the fore, as it is clear that careful design in this region can yield substantial fuel consumption benefits through drag reduction. Major road car manufacturers are now using precisely the same wind tunnel technology pioneered and perfected by Formula 1 ten years earlier to allow them to exploit this benefit.

The development of Wind Tunnel technology, important though it has been, pales into insignificance alongside the rapid growth of Computational Fluid Dynamics (CFD). With a wind tunnel, experiments are made by blowing wind over a real object in a controlled environment and measuring the aerodynamic forces that arise.



In CFD, the same experiment may be conducted in the form of a computer simulation. Although the equations that govern these computations have been understood since the 1930s, they are complex to solve and require the sort of computing power that has only become truly practical in the last 15 years or so.

A huge range of industries benefit from the mastery of aerodynamic design that a successful CFD programme enables. It is probably no surprise that the aerospace, road car and wind turbine industries use CFD in their design process. It might be less obvious that it also brings significant advantage in hundreds of other industries. In fact, in any application where there is any sort of fluid (gas or liquid) flow, CFD can bring benefit. Climate modelling, the force of wind on a building, the way in which medicine is distributed in an inhaler, efficient air conditioning design, transport of gas or liquids in pipelines; the list of applications is truly enormous. All of these applications benefit, to a greater or lesser extent from the investment that Formula 1 has made in the growing technology of CFD.

For a sustained period of around 20 years, the teams in Formula 1 have ploughed money into the development of CFD, as it has been clear for a long time that mastery of this tool would be a prerequisite for success in the sport. Teams have sponsored the development of improved CFD techniques at top universities and they have also put money directly with the providers of commercial CFD codes to ensure that the considerable challenge of accurately simulating the aerodynamic behavior of a Formula 1 car has turned from an aspiration to a reality. It would be wrong to pretend that the development of subsonic CFD codes has been the sole responsibility of the Formula 1 industry, but no serious observer of the industry would deny that the combined investment of the teams has been very significant.

An example of the positive role that Formula 1 plays in this field can be seen in the relationship that Lotus F1 Team enjoys with Boeing and CD-adapco. At Lotus F1 Team, the aero department makes use of two sets of CFD codes to run virtual simulations on our cars. One code is commercially available from CD-adapco, while the other code is available through our partnership with Boeing. The Boeing code is highly specific and used for the design of aircraft, but it has significant application within Formula 1. Development of this code at Lotus F1 Team, in partnership with Boeing, has produced industry-leading optimisation software. The potential benefit to Boeing of this development is not trivial: For example, a 1% reduction in drag will reduce an airline's direct operating costs by 14% due to reduced fuel usage will result in lower CO2 emissions.

Aerodynamics Dr. Mori Mani, Senior Technical Fellow in CFD for Boeing explains: "With the reduced-cycle time CFD has the potential to become a primary contributor to vehicle design, as opposed to being primarily an analysis tool. In particular, the collaboration between Lotus F1 Team and Boeing has helped to accelerate further this type of numerical design, as well as improve the robustness of the tool suite through analysis of the challenging F1 geometry, which is typically more complicated than aircraft geometry."

A case study was carried out by Lotus Renault GP for Nissan to demonstrate the power of this newly developed optimisation technique for road car design. Nissan provided the team with a virtual model of an existing Nissan road car as a test case and using this new CFD software we were able to optimise the external shape of the car and reduce drag by over 4%. This figure was then confirmed by Nissan using a different CFD code. This 4% drag reduction is a significant improvement and is achieved through geometry changes not easily identified using conventional CFD codes. In this example the wider benefit of this novel CFD technology is clearly contributing to the design of more fuel-efficient cars. In addition to the development of this optimisation tool, further more general enhancements have been made to Boeing's code by Lotus F1 Team and Boeing.

One example involved a revision to the algorithms, which increased the speed of the code by a factor of six. Therefore, every six hours spent using the old code takes only one hour using the new code. The savings in resources are obvious, but importantly the time saved allows more design cycles to be run, refining the design and leading to even greater efficiency of the end product. Likewise, Lotus F1 Team works closely with our commercial code supplier, CD-adapco, making suggestions and recommendations to help drive the code development in directions that benefit not only Lotus F1 Team but other users of this software as well. Unlike the Boeing code, this code is less specialised with a wider range of users and beneficiaries. Dr. Bill Clark, Sr. VP of Operations for CD-adapco says, "CD-adapco

has many Formula 1 customers, but our unique relationship with Lotus F1 Team is truly forward looking. The technology we are working on with the team today will recoup environmental and performance benefits for many industries in the years to come.”

This mutual vision will also be needed to face upcoming challenges beyond external aerodynamics such as engine downsizing, turbocharging, and energy recovery systems. “The competitive nature of Formula 1 and the desire to extract greater levels of performance from the car has undoubtedly helped to develop the capabilities of CFD software at an ever-increasing rate,” says Daniel Bell, Senior Lecturer in Thermo-fluids at Oxford Brookes University. “Methods developed by Formula 1 teams for applying CFD to simulate performance can be seen filtering down into passenger car development where more complete and detailed simulations are helping to improve safety at the same time as efficiency.”



Fuel

A common misconception about Formula 1 is that on-track performance is a function solely of power. In fact, performance comes from a number of different sources, and one of those is fuel consumption. If you can lower fuel consumption while still generating the same performance, you improve the car’s efficiency. Achieve this in Formula 1 and your car will possess a performance advantage in racing conditions since less fuel needs to be carried, which reduces overall weight and improves performance.

Fuel consumption and the efficient conversion of fuel into energy, are therefore major development priorities for engine and fuel manufacturers. It is for this reason that Lotus F1 Team’s close working relationship with TOTAL is of such importance, especially with the ban on refuelling in 2010, which means cars must carry enough fuel to last the entire race

distance. “In 2010 the ban on refueling means that we don’t want to carry any more fuel than absolutely necessary to keep the weight of the car to a minimum,” explains Eric Boullier. “TOTAL has therefore been working extremely closely with us to ensure that our race fuels achieve high efficiency per unit of mass.” Total engineers also seek to minimise friction wherever it can occur in the car, not only in the engine, but also into the gear box, oil pumps, hydraulic pumps, transmissions and bearings by adapting and optimising lubricants and greases for the needs of each mechanical component.

However, the benefits don’t just apply to the racetrack because what TOTAL learns from Formula 1 is transferred directly to its commercial products. One way to achieve maximum performance from the lowest quantity of fuel is to combine the fuel with certain additives to help reduce the level of friction on the pistons. Additives also help clean the engine and avoid deposits in the combustion chamber, and minimises friction which leads to reduced fuel consumption. It is the same additives developed for Formula 1 fuel that are used in TOTAL’s commercial fuel in road cars.

Formula 1 fuel has been strictly regulated since 1996, when the FIA imposed unleaded fuel that had to meet the Euro 95 standard applied to pump fuel for normal road cars. Prior to this date, Formula 1 had used leaded fuel and chemical additives with very high octane ratings for maximum power. Since specifying the use of ‘pump fuel’, the FIA’s focus for the evolving regulations on fuel has been environmental, and Formula 1 has operated in advance of standards in force for production cars: in 1999, fuel already conformed to the production standards for 2000; in 2001, fuel met 2005 standards; and since 2004, fuel has met production standards that have been applicable since 2009. Recent regulations for Formula 1 fuel has seen the introduction of a percentage of bio-fuel, such as ethanol, which is of great relevance for TOTAL because European law now requires that commercial fuel also includes a percentage of bio-fuel. At the same time European car manufacturers are focused on producing smaller cars with low CO₂ emissions. What TOTAL learns through its involvement in Formula 1 has therefore been applied to its commercial fuels. The research has focused on ensuring the balance of bio-fuels in the formulation leads to usable fuels with clean combustion in the engine to reduce as much as possible the levels of unburned fuel, thus improving efficiency and lowering fuel consumption and CO₂ emissions.

Motorsport and Emissions Reduction

Race Engine Technology Monitor

The MSA BTCC instigated a world first in 2009 when it began testing the CO₂ outputs of its race cars.

For 2009 the race cars will have to show that their CO₂ emissions are at or below the levels of their production car counterparts, based on rolling road testing which uses a specifically designed two part drive cycle.

The BTCC have devised a drive cycle which is suitable for the race cars, which due to issues such as gearing would not even run on the conventional Euro 4 production car drive cycle. The drive cycle consists of a 300 second warm up phase, followed by a 330 second sampling phase.

The tests are conducted in one of Jaguar Land Rover's state-of-the-art emissions test laboratories at Land Rover, Solihull, on a Hatton Systems 900 kW rolling road using the latest Horiba gas analyzing equipment. The car is manually driven on the rolling road to a very exacting tolerance of ± 2 kph with a maximum 1 second delay to ensure consistency.

The move is significant for the BTCC and for the motorsport industry as a whole in the context of a world which is becoming increasingly unsympathetic towards perceived energy wastage and air pollution.

In particular in the UK the purchasing decisions of the car buying public are increasingly influenced by the CO₂ output of any given vehicle due to the country's tax regime.

The close link between production and race cars in the BTCC is obvious and one can envisage marketing departments keen to use motorsport to re-enforce the low CO₂ outputs of their production cars.

Peter Riches, Technical Manager, BTCC, told Race Engine Technology that if the motorsport industry didn't self-regulate soon on emissions there could be a repeat of what happened with noise pollution.

'In the past as an industry we didn't do enough quickly enough to control noise pollution at circuits and as a result we had harsh restrictions imposed, and we now have a situation where testing and racing time is severely limited at certain circuits.

By starting to self-regulate early on emissions we can avoid imposed regulations which can only be helpful.'

The implications are clear; noise problems only carry as far as they can be heard, but emissions is a worldwide issue of massive concern to governments and the general public.

BTCC Series Director Alan Gow conceived the idea in September 2007:

'We could have gone down the easier path of simply mandating the use of bio-fuels or adopting a less technically challenging 'panacea'. But the BTCC wants to see emissions levels

genuinely reduced and that is why we are taking this route – in other words tackling CO2 emissions directly at their source; namely the engines themselves. This is of course the beginning of a long term strategy from the BTCC and we hope in future to push our race cars' CO2 levels to beneath those of their road-going equivalents.'

Riches explained in more detail how the future might take shape:

'Really what we are doing now is to baseline the emissions of the 2009 field, and to show that over a representative drive cycle the race cars are at least as clean as the road cars. Where we go from here is very much open. The desire for reduced emissions and improved efficiency is very real. As a series our primary aim is to be entertaining but we also have to be technically relevant. In the future this could see a move away from Super 2000 regulations; potentially we could be looking at reducing CO2 levels by using supercharged engines with a smaller capacity. We are also keen to incorporate energy recovery systems. Of course we also need to keep operating costs down for the teams, in particular given the strains which the credit crunch is putting on advertising and sponsorship revenues.'

Mark De Jong of EEMS, Energy Efficient Motorsport, who have supported and fully endorse the BTCC's emissions testing program:

'Energy efficiency is a topic which is high on many agendas. High performance motorsport engineers have always contributed to innovation in the motor industry, and this initiative will stimulate their natural instinct to innovate in this area. The short term objective is to show that no race car has worse emissions than its road going equivalent. Longer term, it gives BTCC the option to set ever more challenging targets and make energy efficiency even more important.'

BTCC teams have welcomed the move, a sign that it will help to attract sponsors who want to be associated with the glamour of motorsport but not with a sport which is adversely affecting the environment.

Future BTCC regulations could bring in maximum CO2 outputs, or dictate weight penalties to more polluting cars; there are limitless possibilities.

Of course the vast majority of race engines are already designed to be efficient in terms of converting fuel into power, particularly in endurance racing, where the Holy Grail is always to go longer between stops, but there is a potential mood change which could see a big shift in emphasis towards CO2 output reduction and energy recovery.

Alan Gow again:

'this initiative is a meaningful demonstration of our credentials to motor manufacturers, environmental groups, sponsors, the Government, motorists and the BTCC's many millions of fans.'

The BTCC are clearly intent on taking a lead with self-regulation of CO₂ output, and it's easy to see why.

There is of course a risk that in the short term this move could be interpreted as a "green wash"; at present the regulations have been set up such that everyone will be able to pass without too much trouble; whether the teams would be so happy if expensive reworking of their engines was required is doubtful, as is whether or not teams who fail the tests will face any penalties.

The BTCC is effectively easing everyone into the area of CO₂ testing and that's probably sensible. Whether or not this is taken up on a wider stage in professional motorsport will eventually be dependent on the manufacturers for whom the industry is just one marketing tool.

Vauxhall's recent announcement of their withdrawal from the BTCC in 2010 indicates how high financial pressures are at present, and makes the environmental aims of the BTCC and the MSA even braver and even more necessary.

RET was recently invited to Jaguar Land Rover's PCC – Product Compliance Centre – at their Solihull plant to witness the CO₂ emissions testing of the 2009 BTCC race cars.

The PCC consists of two rolling road dynamometers. Hatton Systems Ltd are responsible for the dynamometer equipment and control systems and HORIBA for the gas analysing technology.

Vehicles running on carbon based fuels (gasoline, diesel, LPG etc) fill their tanks by volume – gallon or litre. It's generally easier to meter fuel by volume than to weigh it. Vehicle exhaust emissions are regulated and have to be measured. This is done by measuring volumes rather than trying to weigh the gases.

If a carbon fuel burns efficiently carbon dioxide and water are produced. Inefficient combustion is cleaned up by a vehicle's catalyst; with everything working as expected 99.9% of the fuel is emitted as carbon dioxide. This has become a measure of a vehicles 'greenness', the lower the amount of carbon dioxide emitted, the greener the vehicle is perceived to be.

For the BTCC test program, carbon dioxide emissions are measured over a drive cycle which has been specified for the purpose.

While the vehicle is being driven through the drive cycle, exhaust gases are measured using a special type of flow meter. This is referred to as a Constant Volume Sampling system (CVS). This overcomes the problem with pulsating flows by diluting the exhaust with as much clean air as necessary to stop condensation of the water vapour and to maintain a constant volume at the flow meter.

A sample of the diluting air is taken throughout the test period and analysed for carbon dioxide. The proportion of carbon dioxide found in the sample is applied to the volume of diluted exhaust gas measured by the CVS which gives the volume of carbon dioxide emitted during the test period. Multiplying the volume by the density of carbon dioxide and dividing by the distance travelled during the test period gives a result for carbon dioxide in g/km.

The proportion of carbon dioxide in the sample gas – the sample concentration – is obtained by the use of a fast response and highly accurate emission analyser such as the top of the range HORIBA MEXA-7000.

The HORIBA MEXA systems make use of the NDIR (Non-Dispersive Infra-Red) technique. Carbon Dioxide has a strong absorption at a specific wavelength region of the infra-red spectrum. The analyser works by measuring the intensity of this absorption and comparing it that of a known CO₂ calibration gas.

A sample of the ambient air used to dilute the exhaust gas and a sample of the diluted exhaust itself are piped to the CVS system and stored in special bags. From here they are sent into the analyser which measures the concentration or amount of carbon dioxide in each bag. The mass of carbon dioxide can then be obtained.

Obtaining the concentration of other emissions components follows the same systematic flow but uses different methods, which include;

THC	Total Hydrocarbons	Flame Ionisation Detector
CO	Carbon Monoxide	NDIR
NO _x	Nitrous Oxides	Chemiluminescence
O ₂	Oxygen	Paramagnetic Oxygen Analysers

There is a clear need for very accurate emissions analysis systems in automotive testing. It is further clear that by investing in the HORIBA MEXA system at the PCC facility.

TEST-EQUIPMENT

Emission Testing in Motorsport

Amid all the hype over the past few years of Global Warming or as it has been re-branded now, Climate Change, it won't surprise anyone that motorsport has come in for its own fair share of criticism. Viewed by some as a waste of resources, the sport is now fighting back and where once the word 'power' was king, 'efficiency' now replaces it. But from a motorsport perspective, 'efficiency' can mean many different things but in the final analysis and in today's world it all comes down to one thing - fuel consumption or as the politicians would now like us to refer to it as - carbon dioxide (CO₂).

In 2009, the organisers of the British Touring Car Championship made great play over the emissions testing of all their competing cars. Monitoring only carbon dioxide emissions (and dutifully simply ignoring all of the real toxics coming out of the exhaust) and using one of the best emission test facilities in the UK, the programme concluded that while racing cars could be made to be as 'efficient' as road cars, running a test cycle that both could achieve sensibly, the EU CO₂ emissions target for the immediate future of 120 gm/km, simply does not equate with a racing car (or indeed a road car) doing 10 - 15 miles per gallon. Sadly, the real numbers of the work will never be published but in doing it, the BTCC have somehow inadvertently highlighted the real difficulties of measuring vehicle emissions, especially those from competition cars.

The idea behind any kind of emissions testing is to test the vehicle under the conditions in which it is most likely to be used. Thus for road going vehicles we have a mixture of urban and highway duty cycles covering speeds around and up to 50 km/h and 120 km/h respectively. Following a similar argument for race vehicles typical speeds would need to be anywhere between 110 km/h and say, 240 km/h. I don't know about you, but sitting in 150 mph racer is scary enough but strapping that onto a dynamometer and repeating it within the confines of a vehicle test cell is perhaps more than the nerves may be able to take. And don't forget, front wheel drive vehicles are fundamentally unstable on chassis rollers and so

any testing of this type would require the vehicle to be well and truly tied down!



Competition engines also tend to be highly dynamic. Rapid changing of engine speeds and loads would need a dyno not just capable of absorbing the 300 bhp of a modern BTCC car, but also the capability of controlling those loads to the required accuracy. The only vehicle dynamometer with very low inertia, fast response and the ability to absorb power as well as motor the vehicle, (to simulate the incidence of heavy braking when the inertia of the vehicle reacts against the engine) is an AC unit. Each vehicle would still have to undertake 'coast-down' testing to replicate frictional losses and a suitable drag coefficient determined to simulate the aerodynamic forces. All in all quite a lot of what I would call unnecessary effort to achieve what would appear to be very little. Of course, we could transfer all of this to a transient engine test bed, a la that found with Formula One engine manufacturers, but that's getting a little out of hand, isn't it?

Undertaking a test cycle simulating a race vehicle running between 110 km/h and 130 km/h swapping between 5th and 6th gears was therefore hardly representative but the BTCC, I suppose, did produce the opportunity to compare results with their OE counterparts. No, the only sensible way of measuring any emissions on a race car would be to do it on track with some kind of mobile sensor or analyser. While I hear that one emissions analyser company may be interested in picking up the gauntlet again to develop an on-board emissions measuring system, wouldn't it be easier simply to measure the fuel consumption and, since the amount of carbon in any fuel can be accurately established, calculate back?

Written by John Coxon, ret-monitoring.com.

Perform a **SWOT** analysis on the introduction of emissions monitoring within motorsport series. You should consider the impact of monitoring on the different levels in motorsport and also how this might impact on the perception of motorsport by society and the motor industry.

Strengths

Weaknesses

Opportunities

Threats
