
**Formula One racing teams like McLaren are constantly updating the technology they use in order to give them a competitive edge** © www.mclaren.com

# BEYOND FORMULA ONE

The Formula One World Championship is currently speeding through its 60th year. A wealth of race car technologies has been developed in recent years, which are being transferred across industries worldwide. Duncan Bradley, of McLaren Applied Technologies, examines the impact Formula One has had away from the racetrack.

The competitive nature of Formula One (F1) racing has led to the rapid development of a series of innovations both within the sport and elsewhere. Some of the technology generated for speed, development, and safety has found its place in off-track uses. Military, space, and health professionals are increasingly asking F1 teams for help in solving challenges in their own fields.

Racing cars used to be made from similar materials to the average road car: steel, aluminium and other metals. In the early 1980s, however, following a series of high profile crashes and casualties, there was a revolution in Formula One racing. New materials such as carbon fibre composites started to be used to build the chassis.

## LIGHTWEIGHT AND TOUGH

Composites have four key advantages over traditional construction materials: they are lightweight, very stiff, can easily be moulded into different shapes and are extremely strong. Today, carbon fibre composites are used in constructing most of the chassis of an F1 car, including the monocoque (a single-unit body and chassis), suspension, wings and engine cover, as well as other components such as the gear box (see below).

## MOULDING COMPOSITES

So how exactly is the race car made? Take a look inside any Formula One team factory and you will see roll after roll of carbon fibre material, ready to be laid out in sheets and cut down to size. All components are made in a clean room, to prevent, say, oil and grease transfer from fingertips, which would affect a component's final strength. Different weaves of carbon fibre can also be used, depending on the required strength and size of a component. The carbon fibre sheets also come pre-impregnated with a resin.

Once the material is cut, several sheets are placed inside a mould, and oriented in pre-determined directions to maximise the strength of the final body part and introduce the exact structural requirements. The mould is heated under high pressure and temperature and the impregnated resin flows into surrounding fibres.

After cooling, a pre-cut aluminium honeycomb core material is placed on top and the sheet returns to the oven. With the aluminium core in place, several layers of carbon fibre are laid on the other side of the aluminium layer, baked in the oven for a final time and then cooled. The part is then quality tested prior to assembly.

**McLaren's autoclave facility at Woking produces moulded carbon fibre/aluminium honeycomb composites. In 2008 McLaren produced six chassis, in the 2009 season the number has been reduced to five due to testing restrictions. Each chassis takes aproximately five weeks work, with teams working around the clock to finish** © www.mclaren.com

Now, across the industry, design teams are using advanced analysis software to optimise complex carbon fibre parts, be they wafer-thin sections or bulkheads to maximise material and mechanical performance. Clearly race car production comes at a price but the long-standing focus on low-volume, high-value manufacture means design teams can now do almost whatever they want with carbon fibre. So why stop at Formula One racing?

In 2003, McLaren Automotive and Daimler introduced the Mercedes-Benz SLR McLaren to the sports car market. The vehicle housed a wealth of cutting-edge automotive technologies drawn from McLaren and Mercedes-Benz's F1 experience, including a novel brake-by-wire system and hand-built 5.4 litre supercharged, all-aluminium V8 engine. Although cost and durability were clearly more of an issue in this market (the car had to last longer than a few Formula One races) the entire body was still fabricated from carbon fibre composites.

## SAFETY FIRST

It's not just cars that have benefited from McLaren's experience with composites. Modern race cars have been purposefully built with energy absorbing materials to cushion the force of an impact, to deform or crumple, so helping to improve safety. A honeycomb aluminium structure sandwiched between the stiffer carbon fibre layers is designed to buckle and crumple in a controlled way so the force of any impact is absorbed. Now, Formula One engineers have used this very same technology to help save the lives of military personnel.

Recent conflicts have seen a high number of mine and car bomb blasts targeting military vehicles. Although well-armoured, the blasts can propel a jeep vertically and cause the troops inside to suffer serious injury or death. Engineers at McLaren Applied Technologies joined forces with US-based VSSL to design and build a Blast Shock Mitigating Seat for the US Office of Naval Research (see alongside). The shell of the prototype seat has the very same Formula One aluminium honeycomb structure placed beneath it to absorb the force of a five-pound blast upwards (see above). The honeycomb structure is designed to reduce the potentially fatal 50G vertical acceleration of a mine blast to a survivable 20G acceleration.

During prototype development, finite element analysis was used to simulate the design, predict performance and identify potential problems, enabling a quick turnaround from first concept to prototype. When analysis revealed that the seat was unstable during angled blasts, an under-seat cross strap was developed to resolve this issue.

In practice, the seat is mounted on steel panels within the jeep, designed to withstand ordinary service loads but buckle during a high-energy impact. Once the panels buckle, the seat pan engages the honeycomb structure, protecting the occupant from the force of a blast. The engineers are confident their prototype will protect the occupant from a five-pound charge, helping them to survive the impact of the blast.

Using a combination of McLaren's rapid prototype techniques and manufacturing methods, the project was completed to a working demonstrator for testing in 11 weeks. A number of blast seats have since been built for long-term testing with the US Office of Naval Research.

**From just over two metres away, a 9 mm bullet was fired at the material at a speed of 1135 ft per second. The composite panel remained intact, protecting any potential occupant**

**Blast Shock Mitigating Seat. Carbon fibre and Kevlar composite side panels were developed using similar manufacturing techniques as those found in the F1 industry were introduced to provide military personnel with ballistic protection**

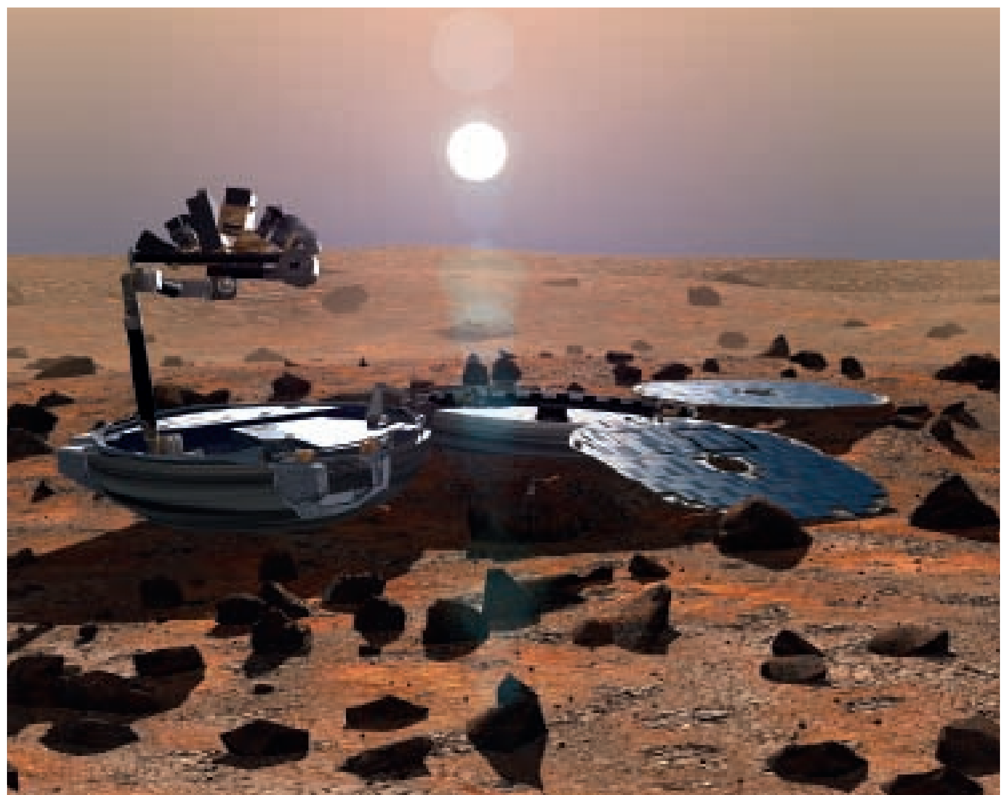
*Military, space, and health professionals are increasingly asking F1 teams for help in solving challenges in their own fields.*

## FINAL FRONTIER

McLaren's expertise in carbon fibre composites has also found its way into space. Searching for signs of life on Mars, the Beagle 2 probe was launched in 2003. The critical problem for the Beagle 2 team was to design a lander shell light enough to be sent into space but tough enough to protect the densely packed instruments inside. The team faced a number of challenges: violent vibrations during take-off and landing, the intense cold of a five-month, 56 million mile journey through space, and extreme conditions on the planet's surface.

Finding materials to cope with these demands was no mean feat but, drawing on carbon fibre composite experience, McLaren engineers developed an eight-layer protective shell to house Beagle 2's sensitive equipment. Sandwiching layers of carbon fibre between an aluminium and glass-fibre honeycomb structure, the engineers were able to create a structure that was both light enough for space travel but rigid enough to affix sensitive instruments. Furthermore, the material provided sufficient insulation to protect heat-sensitive equipment from the planet's cold surface.

Sadly, communication was never established with Beagle 2 after its release from the Mars Express satellite in December 2003, although collaboration between Beagle 2's space scientists and McLaren's engineers proved worthwhile. The F1 engineers have since worked on other space exploration projects (including Japan's Hinode satellite) developing composite materials to meet the extreme demands of space research.

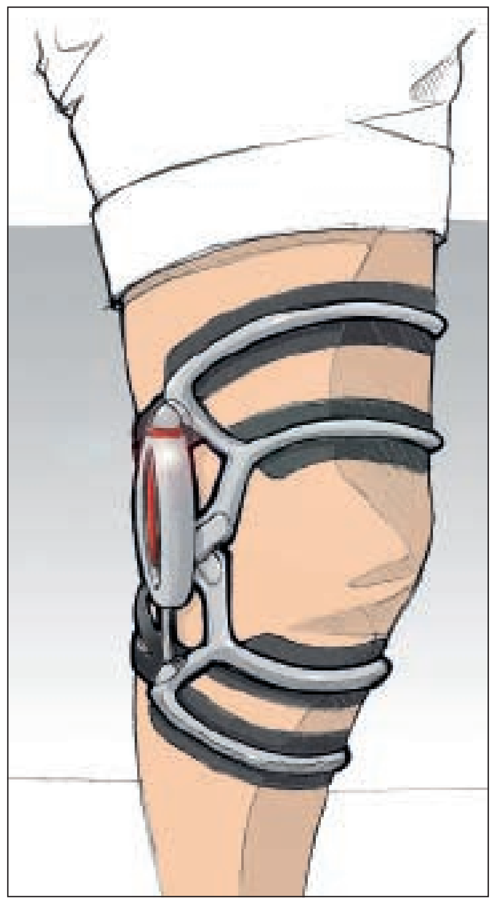


**Beagle 2's outer skin was made of Kevlar, also used in Formula One racing since the 1970s and found in anything from the car's bodywork to the driver's safety clothing. The material is extremely heat resistant and can also remain strong at temperatures down to -196°C, making it suitable for protecting the equipment from the freezing on Martian surface**

## ABSORBING SHOCKS

Formula One innovation has not been limited to carbon fibre composites. The technology that F1 companies use to optimise contact with the racetrack to achieve top speed has also proved transferable. To stop the car bouncing off surfaces, hydraulic dampers are used to absorb the energy of bumps and keep the car on the road. Elements of this technology are being used on lightweight leg support to help reduce damage and injuries to knees.

The knee brace has been tested on US Marines who regularly get injured while standing in fast-moving inflatable boats. As the boat repeatedly hits the water, the Marines' knees absorb the impact, an experience similar to jumping off a 2.5m wall every few seconds. The brace helps control the bending of the knee and realigns the leg before impact.



The brace itself is lightweight, strong and robust. It has a polycentric hinge that mimics the knee joint and a hydraulic damper to regulate the bending of the knee. The hydraulic damper is in turn controlled by software that allows the damper to be tuned to the user and their particular circumstances. In one form, the damper can be tuned to help reduce the shock load of the marines, while in another application the knee brace can assist recovery of a leg injury by limiting travel until fully healed. In practice, the software continually adapts as the joint heals, gradually allowing more and more movement and reducing the assisted support.

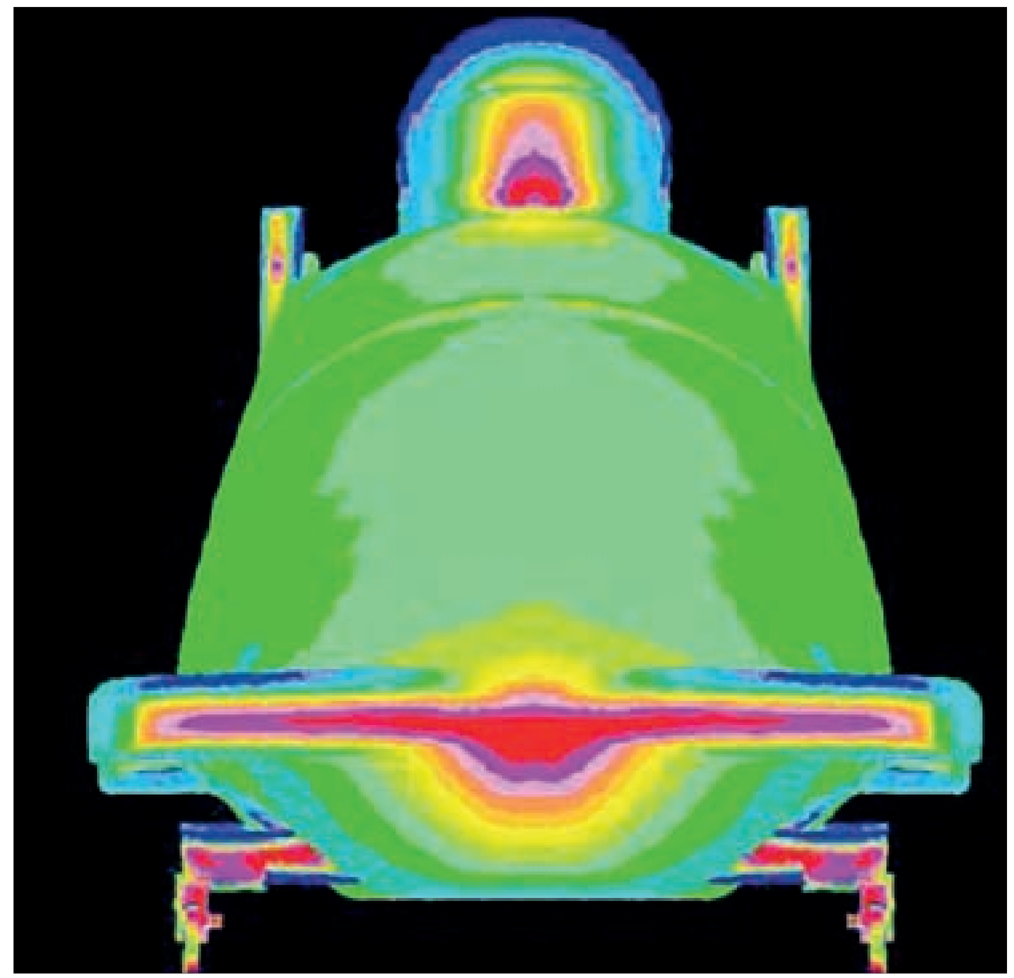
## WINTER SPORTS WINNER

Formula One technology recently featured in the Women's World Bobsleigh Championships. Approached by UK Sport, the Government-owned fund provider, McLaren Applied Technologies was asked to modify the existing bobsleigh belonging to the UK women's team in order to boost performance.

McLaren engineers fitted to the bobsleigh remote monitoring devices (telemetry) used in race cars and ran a real-time data log of the vehicle as it hurtled down the run. In a race, the F1 car may be recording up to 500 channels of engineering data and driver inputs through the telemetry system. It is a vital part of understanding how to maximise the performance of both driver and car. Applied Technologies used some of this equipment to help optimise the bobsleigh. A chassis dynamics rig was used to mimic the actual run to see where the bobsleigh vibrated and help locate where improvements could be made to the performance.

Following the telemetry studies, the engineers went on to suggest a range of structural, material and set up changes to the bobsleigh. The front and rear suspension have resonant frequencies around 25Hz which were reduced by approximately 15% through improvements in the runner carriers and better-fitted rubber bump stops. This had a significant improvement on ride characteristics. The bobsleigh was also stripped of its many previous coats of paint (a weight saving of more than 4kg) and fully resprayed.

Before McLaren Applied Technologies' efforts, the team was running at several places below the leading teams. Following the makeover, the team went on to win the Women's World Bobsleigh Championships in Lake Placid, USA, in 2009.



## MEDICAL INTERVENTION

Three years ago, a pharmaceutical company approached McLaren with a question: could F1 telemetry and data analysis be used in human drugs trials? The more data that is collected, the more accurate the predicted race performance becomes. This helps race engineers make the right call when unexpected events happen, such as a crash elsewhere on the track.

The answer was that racing telemetry could help drug trials and engineers at McLaren Applied Technologies started work on developing a remote patient monitor for pharmaceutical research and development.

The current system is based around a mobile phone-sized collector device, although future versions will be smaller. The collector interfaces with a number of vital sign sensors on the patient, depending on the study. Typical physiological data collected includes heart rate, temperature, respiration levels, blood pressure and glucose levels. Patients also have an interactive diary where they can provide more objective information, such as how they are feeling.


During a race, large amounts of data, from engine speed and oil temperature to steering angles and tyre temperatures, are collected via sensors from the car. This data is transmitted to the track-side and McLaren's Technology Centre where it is used to find the best car set-up and race strategy in order to win the race © www.mclaren.com

Dedicated software on the collector captures and sends this data from the sensors to a remote server for storage anywhere in the world. Importantly, the server can also pass back instructions to the collector to, say, increase data recording or re-set the system. Data is sent from the server to several portals where, for example, clinical trial sponsors or investigators can access the information. The patient data is much richer than currently available to clinicians and available in near real-time, meaning that more efficient medicines can be developed faster.

Data analysis forms a crucial part of the system. Algorithms originally developed to prepare McLaren's drivers for a race can be loaded into the system to derive additional vital signs or detect, for instance, arrhythmias and other adverse events.

While the original system was to be used to monitor the reaction of patients to drugs in pharmaceutical trials with a view to designing better medication, other applications are possible. The system could be used to help sufferers of asthma, heart and lung disease, and obesity. By simply wearing sensors a couple of times a week, a myriad of real-time data could be collected from these patients as they go about their daily lives. These could then be analysed, enabling them to better manage their prescriptions and their lifestyles. It can also be taken into the workplace to monitor employees under rehabilitation, or even those employed in hazardous areas such as up telegraph poles or when working underground.

McLaren Applied Technologies took approximately one year from a clean sheet of paper to understand the medical telemetry industry, to see where value could be added and to build a working, end-to-end system demonstrator ready for commercialisation.

## FUTURE APPLICATIONS

So what does the future hold for Formula One technologies? F1 never stands still in its pursuit of maximising performance, so new technologies and new ways of working are continually developed. A typical race team accumulates huge amounts of data, real and virtual, to help predict and optimise engineering technology, making the right decision at the right time to maximise their winning chances.

The future of F1 technology in everyday products may not be just about producing novel materials; it is more likely to combine several aspects to achieve a desired step-change in innovation that perhaps would not be possible in another industry sector. The human telemetry device is a prime example: collecting the data with clever hardware is one thing, but making the data accessible and useful so clinicians can make the right decisions is another skill. However, both skills can in principle be found during the race.

While carbon fibre technologies are perhaps what it is best known for, the F1 development programme has created a number of other useful technologies that work behind the scenes which could help maximise the performance of an everyday product in the same way it maximises the performance of a racing car.

Further information: **www.mclaren.co.uk**

**BIOGRAPHY – Duncan Bradley**

Duncan Bradley is the Senior Industrial Designer at McLaren Applied Technologies. Duncan has been working in technology innovation for 13 years, covering a diverse selection of industry sectors, including medical devices, power tools, high performance engines, consumer products, FMCG and elite sports equipment. Duncan supports the McLaren Group in design, brand, engineering and commercialisation of technology-based projects outside the racing or sports car sectors.

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