Underpinning the Winning Formula at Vodafone McLaren Mercedes

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Having won more than 150 Grand Prix, and secured 11 Drivers' and eight constructors' world titles, McLaren is one of the most successful teams in the history of Grand Prix motor racing. Every two weeks during the Grand Prix racing season, Vodafone McLaren Mercedes competes against its fiercest rivals in front of a worldwide audience of 160 million people.

At the time of writing (July 2007), Vodafone McLaren Mercedes had a clear lead at the top of the FIA Formula 1 Constructors' World Championship; while its drivers, Lewis Hamilton and Fernando Alonso, were lying in first and second place in the drivers' standings. Rookie Hamilton had also secured consecutive podium finishes in the first nine of the season's races – something no other Grand Prix driver had ever achieved in their first year of racing.

Optimising Aerodynamics

"Formula 1 is a product excellence business that's all about innovation and technology," says Jonathan Neale, Managing Director, McLaren Racing. "We're competing for first place in an environment where the difference between first and tenth is about 0.6 seconds, so we're constantly seeking fractions of a second in performance improvement. On average we'll make a change to the car every 20 minutes during the course of a season, and to do that, simulation is vital in making efficient changes to the car.

VODAFONE MCLAREN MERCEDES

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Courtesy of Vodafone McLaren Mercedes

"One of the key parameters in differentiating a Formula 1 car is its aerodynamics. The car with the driver in it weighs about 600kg, and at speeds over 150mph the car generates enough downforce to be able to run it upside-down. To optimise the aerodynamics we do a lot of design work and track testing, but computational fluid dynamics (CFD) in particular has been an area of major advance for us in recent years."

CFD is used to simulate airflows over a Grand Prix racing car to help with developing its shape – primarily to create downforce. This helps to provide enhanced grip, particularly during cornering (braking, turn-in and exit) when the driver relies on grip to carry as much speed as possible through the corner. Another major objective is to minimise drag around the car to maximise its top-end speed. CFD can also help to increase understanding of the behaviour of the car in yaw (crosswind, cornering), steer (with the front wheels turned) and roll (ride-height variations).

Like many Grand Prix racing teams, Vodafone McLaren Mercedes had been using CFD for a number of years when, in 2005, it appointed SGI as its official supplier for CFD supercomputing, storage and visualisation equipment. Vodafone McLaren Mercedes' initial purchase included an SGI® Altix® supercomputer, visualisation solutions, SGI® InfiniteStorage and the SGI® InfiniteStorage shared file system CXFS™. The company has subsequently added to this investment, with the addition of (and ongoing enhancements to) two further SGI Altix supercomputers, and the introduction of the SGI® InfiniteStorage Data Migration Facility (DMF).

Transforming Development and Testing

"The challenge of Formula 1 is that the drive for improvement is relentless," explains Dr Mark Taylor, Head of CFD, McLaren Racing. "The beauty of CFD is that it allows us to model scenarios that enable us to get the performance we need in a range of circumstances. The car has to be quick in fast, medium and slow corners, and in a range of track conditions, and we use CFD to model these and analyse the effects of differing ride height, steer angle etc. Without CFD we'd have to do this in our wind tunnel, but as this is a finite resource, time we spend fine-tuning the car means we have less time to investigate other ways of making it go faster.

"As an example, CFD makes it very easy to set up different problems based around the same geometries. So, if we're developing the car for Monza, which is a low downforce configuration where we're looking for very high straight line speed, we tend to focus on making the car as efficient and as low drag as possible. We're able to simulate that in CFD well before we need to go to the wind tunnel or the track. The same goes for when we need to optimise the car at much higher downforce levels – for example for Hungary or Monaco.

Underpinning the Winning Formula

"The biggest impact that CFD has is on our wind tunnel testing programme, where the expansion of the SGI platform over the last few years has meant that the quality of components we send to the tunnel is much higher. We have a much better knowledge of the impact a component will have on the performance of the car before we wind tunnel test it, which improves the quality of wind tunnel testing and means we tend to get more performance out of it. CFD really helps to improve our understanding of the car, with the result that more components coming from CFD are positive and end up being used on the car.

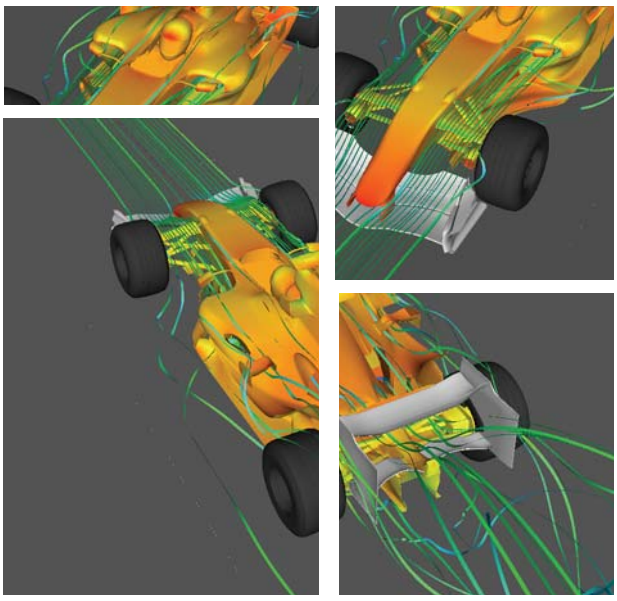
"Another major impact is from test to test. When we design parts in CFD and they go to the tunnel, if they're positive they go to the car. But sometimes we don't get the feedback we expect from the track. The drivers may tell us that a particular component isn't working quite the way we expected, or could be made to work in a better way. This feedback then comes right back to CFD, where we explore it to see if we can understand and relate what the drivers are saying to what we're seeing in CFD. When that happens, we design a new solution based on the drivers' input. Frequently, if we can prove the concept works in CFD, we'll have the part made and sent to the track straightaway; while sometimes it will go through a wind tunnel test and then a track test. This is how we're able to maximise the impact of the aerodynamic simulations we're carrying out in CFD on what actually happens at the track."

Managing Models with Hundreds of Millions of Cells

Because Vodafone McLaren Mercedes apply CFD to very large meshes of the order of hundreds of millions of cells, this creates very large data files. The issue then is how to handle all the data. Vodafone McLaren Mercedes wanted a facility that would ensure that all the data for an entire year's car programme would be available at all times, without clogging up their scratch storage facility. To achieve this, the company introduced the SGI InfiniteStorage Data Migration Facility (DMF) in January 2007.

DMF enables cases that are older than a certain length of time to be automatically taken offline to a tape facility – making the much faster scratch disk space self-managing. The system automatically takes the oldest files off first, but the CFD team are still able to access them from the tape library at any time. So, if an engineer wants to look at something from 12 months ago, they can access the file and it is automatically pulled back from tape without any input from the engineer.

"DMF has been a huge benefit, enabling us to look at results from throughout the year – which is very effective in terms of how our programme works," continues Mark Taylor. "Sometimes you develop a part through CFD and the wind tunnel, but it can be some time before it appears at the track – so it's great that we can recall old results when we want to understand what's happening at the track



Courtesy of Vodafone McLaren Mercedes

"SGI are our high performance partner of choice for CFD supercomputing and visualisation, because we share the same high levels of innovation, strong execution, and desire for a long-term relationship."

–Jonathan Neale, Managing Director, McLaren Racing

or at a particular race. DMF also gives us a lot of room for expansion, so we can run larger and larger and also more transient cases, without having to worry about filling up our disks. The data is all managed back onto the tape library as required – and we can just concentrate on getting the best results we can!

"When we had our second phase of expansion of the SGI platform, in a sense it was proving too successful, because we were generating an even larger amount of high quality results which we wanted to retain for input into the design process as we moved forward. Without DMF we were having to delete files that we would have preferred to have kept for the duration of the design programme. But when we introduced DMF we were able to retain all of the data for the entire year's programme, which has been very effective in building up our design knowledge over the programme.

"As we develop forward, we'll also be able to look back at the results for our MP4-20, MP4-21 and MP4-22 cars, which will be important because the rules are remaining quite stable next year, so the current MP4-22 will actually feed through a lot into the development of our next car, the MP4-23. Also looking forward, as track testing is having to be reduced, there's even more emphasis on simulation to deliver increased performance. So we would expect that as the testing restrictions continue, the competitive advantage we receive from CFD will only increase."

Increasing Competitive Advantage

Through its partnership with Vodafone McLaren Mercedes, SGI has been able to deliver a range of benefits including:

- An immediate fourfold increase in productivity
- A strong technical partnership that has impacted on car performance (one component of McLaren's process was, for example, accelerated by a factor of two following input from SGI)
- An extremely high level of global technical expertise, able to deliver under pressure, and with detailed understanding of McLaren's engineering context
- The strong partnership with relevant ISVs and hardware partners needed to deliver application performance

One example of the results of these capabilities – in a programme related to the development of a new front wing module – was that in less than a week, Vodafone McLaren Mercedes was able to run its first track test on the design of the wing, run the results through CFD analysis, build and test a new part in its wind tunnel, fly the new module to the test track and fit it to the car – producing a 0.2 seconds improvement in lap times.

Courtesy of Vodafone McLaren Mercedes

"Formula 1 is a high technology, innovative business, and Vodafone McLaren Mercedes is at the forefront of that, because we're a high performance organisation – as racers," concludes Jonathan Neale. "SGI meanwhile are our high performance partner of choice for CFD supercomputing and visualisation, because we share the same high levels of innovation, strong execution, and desire for a long-term relationship. In that respect, both as a product and a value set, there's a very good match."

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