F1 RACING

The amazing world of F1™ technology

Modern F1 could not exist without computers...

IF EVER A point illustrated the importance of computers to Formula 1, it's that you can't even fire up an F1 car without a laptop. The unquestionable fact is that advances in IT have made the cars faster, safer and among the most aerodynamically sophisticated machines on this planet.

The influence of technology touches every corner of this beautifully complex sport. Huge supercomputers the size of five fridges perform billions of calculations within hours just so engineers can decide which of a hundred front wing endplates will work best. Mobile servers are lugged to every race to provide a mobile office for over 60 people, 20 times a year. Gigabytes of data travel through virtually bulletproof laptops before being beamed back to a team's base on the other side of the world, only milliseconds after they've been collected. It's a totally different sport to the one Juan Manual Fangio starred in back in 1950.

But one of the great things about Formula 1 is that it is always relentlessly and unashamedly moving forward. Without some of the truly mind-blowing equipment we celebrate in this supplement, that simply wouldn't be possible.

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Contents

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THE ROOM WHERE IT ALL BEGAN

After getting their entry to Formula 1 approved, the Caterham F1 Team (then operating under the Lotus Racing banner) had just 22 weeks to make the first race of the 2010 season. Needing serious computing help, and fast, they ended up here at Cambridge University...

Getting Trulli and Kovalainen on the grid for the first race of 2010 was an incredible feat

A Formula 1 car normally takes up to nine months to make, from initial sketches through to the machine being fired up for the first time. So you can imagine the task facing Caterham F1 (then called Lotus Racing) in September 2009, when they first learned that they had been given an entry for the 2010 season. They had four staff, no equipment – and 22 weeks until the first race of the season in Bahrain.

That they made the grid for that grand prix – and managed to secure the 'best of the new teams' tag by the end of the 2010 season – is an incredible story in itself. But instrumental to those two cars being designed and made was this intriguing-looking blue room at Cambridge University. Without it and its giant Dell supercomputer, the team could never have made it to that first race of the season.

The HPC (High-Performance Computing) cluster at Cambridge is an impressive piece of kit – and just what the newly-born team needed. "In 2006, this used to be the biggest academic system in the country and the 20th biggest in the world," says Paul Calleja, the university's Head of HPC.

"It was even faster than the HPCx National Supercomputer in Edinburgh. It's normally used for lots of work in biology, chemistry and astronomy – there are astronomers here using the machine to analyze data they get from satellites and people doing jet engine simulations. It's even being used by a team that link into the work going on at CERN with sub-atomic particles."

The machine was more than up to the complex equations the F1 team needed for the CFD work on their 2010 car.

"Also, with the deadlines they were working to, it wouldn't have been possible for Dell or anyone else to supply them with a big enough machine in time," says Paul. "So the idea was that we'd supply them with time on our system initially, and then they'd eventually migrate over to their machine."

Bill Peters, Caterham F1's Head of IT, remembers the Cambridge period well.

"As soon as we'd sorted out our trackside IT environment, we kicked off work with the supercomputer around the same time as we started getting the factory up and running," he says. "You have to build a physical environment to house a supercomputer, and it's a very complex system. At the same time, the company was recruiting CFD engineers to help get the cars ready for the first race of the season, so they needed tools to use. That's why we made use of the HPC facility at Cambridge University."

It meant that during the winter of 2009, the team were in Cambridge constantly as they worked frantically around the clock to get the car ready. "They were here for about six months in the end," laughs Paul. "We actually ended up renting them some office space in Cambridge for a while because they were here so often!"

Paul and his colleagues at Cambridge even ended up helping Caterham F1 with the design of their HPC. "They've got a lot of experience with using Dell supercomputers, so they were very much involved with giving us advice about our equipment," reasons Bill. It meant that Paul needed to dip his toe into the world of F1 and CFD to find out what the team wanted.

"To help them with the design and implementation of their system, we had to understand what kind of calculations they wanted to perform, how they wanted to do them and what sort of turnaround they wanted," says Paul. "We worked with them and Dell to advise them, and I think they ended up with a great machine." A great machine it is, but modest in size compared to the one at the university. The Cambridge HPC's 3,584 cores dwarf the 1,488 in the Caterham one, giving it roughly five times the power. It's currently getting an upgrade that will give it around 9,600 cores and return it to the top 50 of the world's top 500 supercomputers.

It was a tough period for Caterham F1, but thanks to Dell and the team at Cambridge, they must have broken a record for making an F1 car from start to finish in the modern era. "I've had about 15 years experience in this industry, so I knew the suppliers that were out there when we were starting up," says Bill. "With Dell, we started talking to them in November and we'd signed up with them the following month. I've had experience with them before so I knew their support and reliability was great, but they moved heaven and earth for us."

The sight of Heikki Kovalainen and Jarno Trulli lining up on the grid in Bahrain 2010 was an incredible feat of organization, tenacity and hard work. But don't underestimate the importance of the blue room in getting them there.

"I've had experience with Dell before so I knew their support and reliability was great, but they moved heaven and earth for us."

From day one, Dell has worked with Caterham, formerly called Team Lotus, to find IT solutions

An F1 car can't even run without being fired up by a laptop, so the role of a Senior IT Support Engineer is vital. This is a diary of Antony's typical race weekend

When you turn on your TV on a Sunday to watch an F1 race, an incredible amount of work has been going on behind the scenes to get those 24 cars on the grid – and few jobs in the sport are more vital than that of Antony Smith.

He is Caterham's 'Senior IT Support Engineer,' or, as we like to call it, 'The bloke who gets the team's entire IT infrastructure in the pitlane up and running so that the cars can run' (although admittedly that would be slightly lengthy for a business card). His job is literally this: set up the entire network and computers for 60-odd people – and very quickly.

"It is a stressful job," says Antony. "Everything hinges on me in the early part of the week in the setting up of the equipment, and then I suppose everything hinges on me for the rest of the week in a way as well because we can't send the cars out if the computers aren't working properly. One of the reasons there's so much pressure is because you can never say no! You can't turn round to someone and say, 'Sorry, I can't get the network going' – it's always got to work, simple as that.

"The other thing is the hours – you're easily working 16-18 hour days quite a few days in a row at a race, and that's very tiring. But even during the two-week summer break that F1 has there's stuff to do – there's no holiday in IT, you know! Plus you'll walk past someone and they'll want their machine fixing – you can never escape! But it's a great job."

In Antony's own words, this is what he gets up to throughout a race weekend while you're watching the action unfold at home...

Antony gets the team's pitwall IT up and running well ahead of the race

"Imagine building an office in a different location 20 times a year – that's essentially what my job at the race is"

FRIDAY

"For a European race our trucks would normally set off from the factory on a Sunday, although what makes the race at Silverstone a bit different is that our three race trucks are all at Kemble Airfield in the south-west of England, due to us doing straightline testing in the days before the race. If it's a race somewhere like Italy or Germany I'll usually get to the country early on the Monday afternoon and head to the track – straight from the plane in a lot of cases! The urgent thing I need to do is get to the garage to start laying the cabling to get the power and network in.

When I get to a circuit, the first thing I do is start unloading the trucks with the truckies. As well as the three race trucks there are three support trucks, and all the IT equipment is in there somewhere; I can't access it until everything's been unloaded.

So before I do anything computer related I'm usually helping to build the garage, sort the paneling and generally helping out. Because we're not the biggest-budget team on the grid – and all teams are limited on how many people they can take to a race – Caterham F1 has a culture of 'mucking in'.

My job really kicks in once the trucks have been unloaded and I can get on with setting up the IT. I'm the only person who does this. When people ask me what it involves I say, 'Imagine building an office in a different location about 20 times a year' – that's essentially what my job at the race is.

The tricky thing is that all circuits are different, and even if you go back to the same one you went to last year someone will probably have trashed what you put in, or you'll be in a different garage altogether. So I always have to start from scratch.

We have our own electricians who put in the 63amp 3-phase power feeds which are mainly for the tires, but we also have to have solid power for the racks and the entire garage. I have to make sure this power isn't flaky in any way, because the power can be really up and down at some circuits and that can impact on how everything runs.

By Tuesday lunchtime I'll usually have all the servers up and running, which is very useful because ours are condensed into just three machines. Not only is this handy for me but when you have to pay $100 per kilo to transport things, it's pretty handy for the team's budget too.

By Wednesday a lot of the team are starting to get to the track and everyone has to be to the circuit by 8am on the Thursday, so the entire IT operation has to be running smoothly by then.

It's quite a lot of pressure, I suppose, and it's even more intense when there's a back-to-back race [races on consecutive weekends]. The cars need to be rebuilt between each race because they are set up differently for each circuit, and to do that the engineers and mechanics need build sheets to tell them what specification they'll be building the cars to. To get these build sheets, they need the network. Everyone relies on communications – in F1 you can't even turn the car on without a computer."

As soon as the team's IT equipment is unloaded from the trucks, Anthony has sole responsibility for setting it all up – or "building the office"

SATURDAY

"The strange thing about my job trackside is that by the time Saturday comes around, the main part of my work has been done because the entire IT infrastructure is up and running. Quite unlike most other people in Caterham, Saturday and Sunday should be my quietest days – in theory at least. I have to say that setting all this up does get easier as we go through the season: for the first few races it can be a bit frantic, but if I haven't got things working smoothly by the time the Canadian Grand Prix rolls around in June, I'm in big trouble!

One of the main things I have to do throughout the weekend is make sure the data gets back to the team at the factory in England without any problems. We have acceleration software to help with this; we're sending a phenomenal amount of data across the world and there'll only be a time delay of 40-400 milliseconds.

Of course there can also be issues, but they're usually pretty simple things like running out of disk space on machines. People are also under a lot of pressure, and sometimes issues that you might solve quite easily with a machine are not as simple to deal with when you're trying to analyze mountains of tire data. There are 60 users who want quite a lot of my time, and it's my job to help them and make sure everything's running correctly for them.

Elsewhere I'll generally be making sure everything is working at its best, that there are no bottlenecks anywhere in the system, that nothing unnecessary is clogging up the bandwidth and that every piece of equipment has the right amount of power it should have. I say it's my quietest period, but ultimately you're still talking about 80 PCs just to run two racing cars, so there's still a lot to do..."

Antony is responsible for getting the IT infrastructure up and running before the drivers can get onto the track

By the time the race starts much of Antony's work is complete, but he can't switch off just yet

"The few hours after the race are still incredibly vital for the engineers, so the IT infrastructure has to work just as flawlessly"

SUNDAY

"Usually Saturday passes without too much incident, and Sunday is the same – the vital part of my role has been performed earlier in the week. Unfortunately I can't just switch off the network as soon as the checkered flag falls though, because lots of people in the team still need to use it.

The few hours after the race are still incredibly vital for the engineers, so the IT infrastructure has to work just as flawlessly long after the winning teams have finished celebrating on the podium. Race engineers might not be analyzing live data at this stage, but they still have to compile reports and send them to various people.

Another task that needs doing is that all parts on the car have to be 'lifed' – we have to know how many miles each part has done because they all have a certain lifespan, and after a certain mileage they will either have to be reconditioned or discarded.

On top of this, data still has to be sent back to the factory in the UK for further analysis and we also have to wait to receive official track data from the FIA and FOM, who run the sport. All this means that I won't switch off the network until around four hours after the race – and even then people are still saying, 'Don't turn it off – I still need it!'

One of the other things that delays us packing everything up and getting out of the circuit is that immediately after the race, the cars go to a place called Parc Fermé. This is an official area run by the FIA where the cars are inspected thoroughly to make sure they are the correct weight and dimensions, to ensure that everyone has adhered to the rules. So we don't even see the cars until at least two-and-a-half hours after the race.

I've tried to optimize things so that people can work on the network as long as possible and I'll give some people a WiFi connection so they can still be online once the network has been switched off. A European race will be finished by about 3pm, and if things go smoothly we'll get out of the circuit by 10pm.

The thing about my job is that it doesn't really stop. I mean, the races take up a whole weekend but we fly out to get there quite a bit beforehand – for somewhere like Australia I'll fly out on the Saturday before. You'd think that the off-season would be very quiet for someone like me, but it's the only time we get to do anything to the equipment. While a lot of people might be winding down a couple of weeks before Christmas, we're making plans to improve all our equipment for the 2012 season because it has to be up and running by the end of January."

A WEEK IN THE LIFE OF ANTONY SMITH

The manic working life of a trackside IT guru during a Formula 1 race

Monday

"If it's a flyaway like Australia, we've got to set up everything from scratch – cables, tables, chairs, the lot. Then it's setting the network up and getting the WiFi working so everyone can access their emails without me having to get a load of cabling out!"

Tuesday

"Normally this is for cabling the entire garage, including all the connections to the cars. It's basically sorting out anyone who needs a wired connection."

Wednesday

"Time to get the engineers' office sorted, because they need a very high performance network. We have this office in a single box to make it easier, so we can just wheel it in and throw the cables in. We'll also get the marketing team up and running."

Thursday

"I'll get the pitwall up and tested, and all of our TV feeds too because there are an awful lot of those. We get the feed from the circuit, put it onto our network and then feed it out to whoever needs it."

Friday, Saturday and Sunday

"This is practice, qualifying and the race. Obviously I've got to be on hand if there are any issues – then it's just a case of packing it all up and going home..."

The Dell Half-Rack.
It looks like a fridge freezer from Darth Vader's Death Star, and indeed the force is strong within it. But this black box is not from the set of a sci-fi blockbuster; it is the brains behind Caterham's entire trackside operation.

Caterham's rack is roughly half the size of the ones that other teams take to races, especially those at the front of the grid

HOW THIS BOX REVOLUTIONIZED F1 RACE WEEKENDS

Without this black box, Caterham's F1 cars wouldn't even get assembled, let alone race. F1 Racing peers inside the mind-boggling world of Dell's 'Half-Rack'

So what does this piece of kit do and why is it so important? First of all, it powers the team's entire trackside operation for the duration of a race weekend.

"It contains our servers – where all our computer power is – so all the trackside laptops have their network provided by it," says Bill Peters, Caterham's Head of IT.

And, vitally, the half-rack collates and processes all telemetry to enable the engineers to improve car and driver performance and optimize race strategy. "The other major element within it is its storage capability," adds Bill. "We capture a huge amount of data from both practice sessions, qualifying and the race itself, and all of it has to be stored trackside. We also transfer it back to the factory in the UK from wherever the race is." This innocuous-looking cabinet is basically an entire mini IT infrastructure that's simply a smaller version of the team's set-up back at the factory.

Small footprints

Taking about a week to build when the team was first assembled ahead of the 2010 season, one of its benefits is its size and reduced weight. "Our rack is roughly half the size of the ones that some of the other teams take to races, especially towards the front of the grid," estimates Bill, "but I think some other teams have seen how compact our rack is and are in the process of reducing their footprint as well. Sending trackside equipment round the world is a huge expense for F1 teams – probably far more significant than people imagine."

Senior IT Support Engineer Antony Smith agrees. "It has condensed our trackside operation down massively; anything we can do to take up less space, less weight, less heat, it all helps us because we're really really tight on space during a race weekend. In terms of the weight, I think it costs the team in the region of $100 per kilo to ship equipment round the world for F1. These servers are pretty hefty and the UPSs that power them are even heavier, so you can imagine that having a rack of servers that's half the size makes a big difference to us."

It makes the complex task of having to serve 60 people and run two racing cars surprisingly straightforward

As for the equipment itself, it makes the complex task of having to serve 60 people and run two racing cars surprisingly straightforward. "The half-rack runs what's called a 'virtual environment', with 20 virtual servers, each doing specific tasks," says Bill. "Engineers access these from trackside and the factory. Rather than having a physical server for every single application that you need to run, we have some larger servers which run virtual machines, inside which these applications are run. It gives us the ability to shrink the amount of kit we take away with us and better manage that environment."

The half-rack has battery back-ups at its base to ensure it can be kept running in the event of any power issues, quite a common occurrence in F1 as it depends on the infrastructure of the country hosting the race. "At the moment we're even looking into ways of having external battery back-ups and shipping those by sea freight to all the races, which means we can avoid those heavy air freight costs," adds Bill.

An easy start

Fortunately for such a complicated and impressive piece of equipment, it's quite easy to set up – and that's good news for Caterham's Senior IT Support Engineer Antony Smith, who has to get it working at every race. "It's very easy to get →

started," he says, "because at a track we get provided with our WAN (wide area network) connection back to the UK and that's the same every race – it's just one cable. It takes longer to unpack the half-rack from the truck than it does to get everything up and running. On a flyaway, I can have the servers up and running by Monday lunchtime if everything goes well – and that's if I get there on a Monday morning. But by that time we'll have people coming in wanting to use it, so it's got to be that quick."

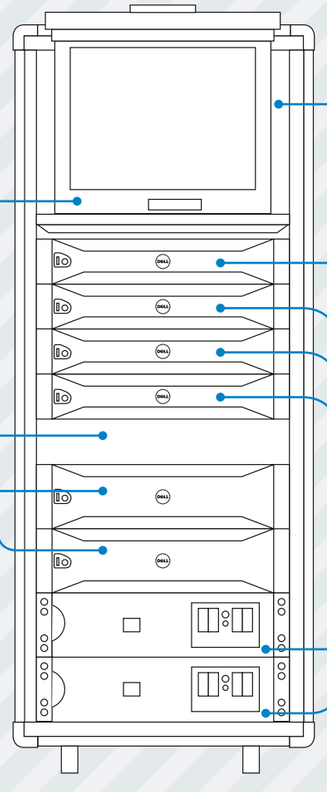
Given the nature of F1 and its relentless march forwards, nothing stays the same for long – and it's the same with a team like Caterham's Dell IT equipment. "We did a lot of tinkering with the half-rack after last season had finished," admits Antony. "We spent a lot of the off-season expanding what it can do, changing the storage so it has more capacity, increasing the memory to allow us to run more virtual machines – just tweaking it and making it better. It has been working brilliantly for the past two seasons, but all IT equipment needs updating.

"For example, on the half-rack we've been doubling up its capacity, going to newer higher-tech parts that will be smaller and generate less heat – basically just tightening everything up and improving things for the people who use it.

The team's rack is constantly updated, improving its capacity and performance at race weekends

ANATOMY OF A HALF-RACK

It's slightly more complicated than your average computer



Two Dell PowerConnect switches, which are the core of the network – all routing is done on these

A keyboard and screen – "because we always need to be able to get at it and operate it," says Antony

A Dell PowerEdge™ R710 rack server, a normal server that acts as the machine's back-up

Three Dell PowerEdge™ R710 rack servers act as 'physical' hosts, with about 20 virtual hosts running off those under VMware. "That saves us from having 20 separate machines, which would be enormous," says Bill

Two Dell Force10 switches for the SAN

Two Dell EqualLogic SANS for storage – one of them has solid state discs and the other has conventional spinning discs. The solid state gives the half-rack its speed, and hosts all of the virtual machines, while the spinning discs give all the capacity. "It's the best of both worlds for performance and storage," says Antony

Two APC UPSs (Uninterruptible Power Supplies) give power resilience and prevent blackouts, sags or surges

The half-rack gets caked in 'nasty stuff' on its travels, so Caterham have to pack a vacuum cleaner

Increasing the size of the virtual machines, giving them more memory and reallocating more processors to them has been important; if you're a data engineer at the track you'll now have more power in your machine to process the data live. This is vital for next year because our cars will be running KERS and this could potentially double our data. At the moment we generate 20GB of data in a race weekend, which all has to go back to the UK from wherever we are. And it's not only a question of that doubling – there'll be more complex simulation models on the data, which will put a lot more strain on the virtual environment."

Sensitive side

Such an important and sensitive piece of kit needs some serious looking after, especially given that it's constantly being lugged around the globe and pushed in and out of trucks. That's why it's got a specially made outside case, built out of aircraft-spec aluminum honeycomb; inside, it has suspended anti-vibration mounts to stop it getting knocked around.

At the moment we generate 20GB of data in a race weekend, and that could potentially double next year

The one thing Bill, Antony or Dell can't stop? The half-rack getting absolutely filthy. "You've got to remember that it's not kept in a nice server room – it's out in the real world at a racetrack so it gets caked in dust and sand and all sorts of nasty stuff," laughs Antony. "That means it needs cleaning – I have to take it apart and get the vacuum cleaner to it. It takes a whole day to do, because everything's got to come out. The servers have to be removed, the hard drives have to be cleaned and the fans have to be taken apart and cleaned because there's a lot of air going through them and they pick up a lot of dirt that ultimately stops them from cooling everything."

Small, money-saving and capable of allowing 60 engineers, managers and strategists to work non-stop, and two F1 cars to race at full tilt, for an entire Grand Prix weekend. Pretty impressive for something that's just five feet tall.

The power behind the passion

Want to go racing? You'll need some seriously impressive computing kit...

AT THE FACTORY **THE HPC SUPERCOMPUTER CONSISTS OF:**

186 DELL POWEREDGE SERVERS

1,488 INTEL XEON CORES

CAPABLE OF:
10,000,000,000 CALCULATIONS IN SEVENTEEN HOURS

WHICH RESULTS IN:
200 PICTURES
EIGHT VIDEOS

SIXTY Dell Precision high-powered desktops

60 Dell Optiplex standard desktops

100Tb STORAGE
ENOUGH TO KEEP **SIX MONTHS** WORTH OF CFD WORK ON IT

400x FASTER
than your PC at home

The team generates **20 GIGABYTES** of data over a race weekend

TRACKSIDE **THE IT SETUP**

THE HALF-RACK:
TWENTY DELL POWEREDGE VIRTUAL SERVERS
10 Dell PowerConnect switches
HALF THE SIZE OF OTHER TEAMS' RACKS

100 HUNDRED **DELL LATITUDE LAPTOPS**

10Tb Trackside storage using Dell EqualLogic

20 HIGH-POWERED DELL PRECISION LAPTOPS

INSIDE AN **F1 TEAM**

250
Caterham F1 Team employees, which includes ten IT staff

1km
The length of cabling that Caterham lays to connect its IT equipment at races

1
The team's IT kit for Grands Prix can all fit into just one truck

70-100
NUMBER OF IT **'MAN-HOURS'** REQUIRED PER GRAND PRIX

AT THE FACTORY **OTHER COMPUTING**

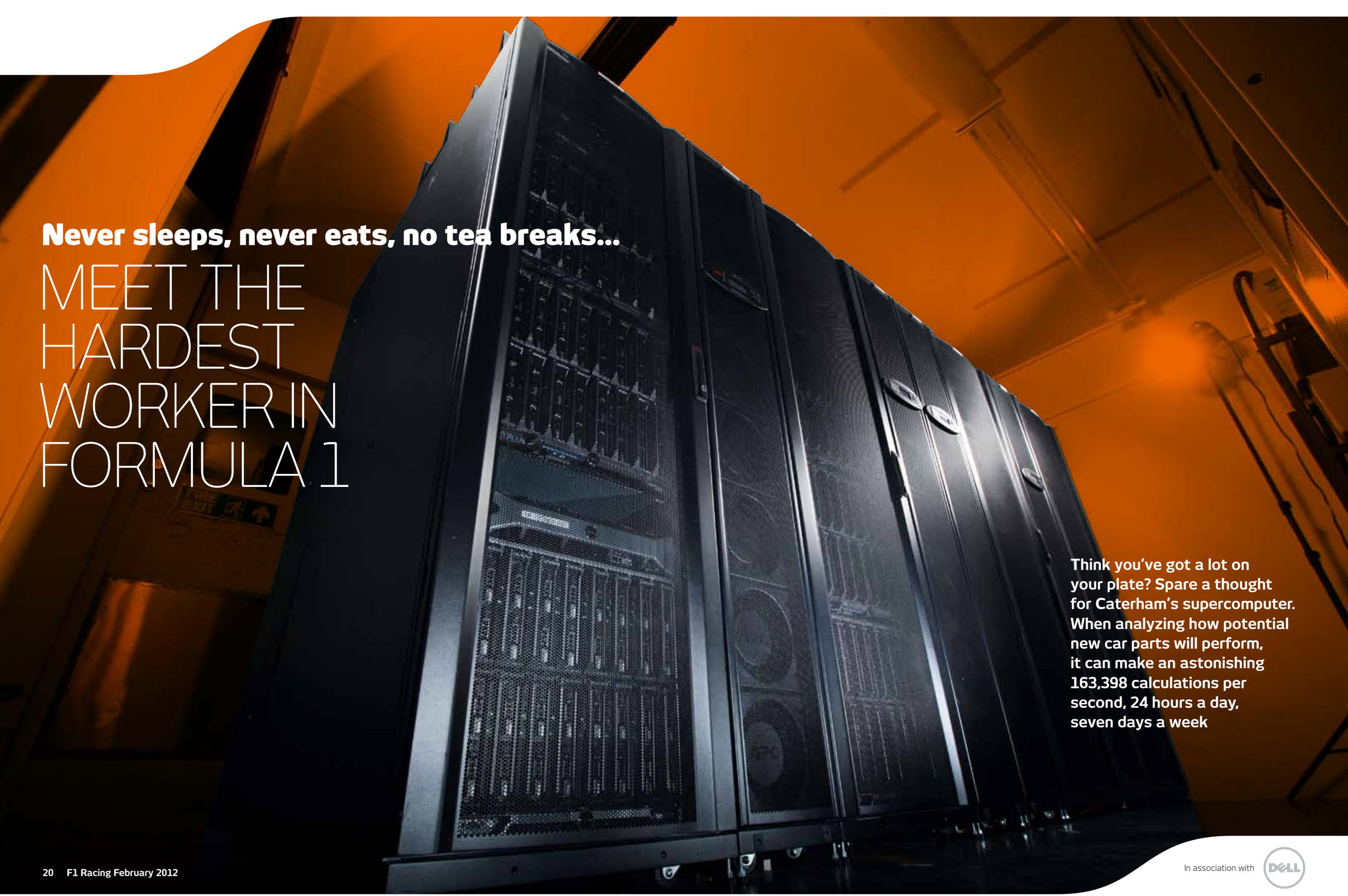
65 Dell PowerEdge servers
45 Virtual servers
20 Physical servers

TWENTY
Dell PowerConnect switches

30TERABYTES
Storage using Dell EqualLogic

Never sleeps, never eats, no tea breaks...

MEET THE HARDEST WORKER IN FORMULA 1



Think you've got a lot on your plate? Spare a thought for Caterham's supercomputer. When analyzing how potential new car parts will perform, it can make an astonishing 163,398 calculations per second, 24 hours a day, seven days a week

Caterham F1's High Performance Computer helps the team's designers to analyze new car parts

186
separate machines have been joined together to make one big one, with each one having 24 GB of RAM

Thanks to this technology, Caterham can dismiss any ideas that aren't going to make their cars go faster

Despite making an almighty racket when operating at full tilt, the HPC still manages to concentrate on millions of equations

What is Caterham's supercomputer?

The supercomputer – or HPC (High Performance Computing) to give it its technical name – is comprised of 186 Dell servers, with each server having eight cores – that's 1,488 Intel CPUs (Central Processing Units).

"The core is effectively your mathematics processor – a calculator, in other words," says Caterham's Geoff Dunk, whose job it is to look after the HPC environment. "Each core does a portion of the maths; we join those cores together to be able to calculate larger problems in a shorter space of time. We use Intel Xeon cores, which you could actually go out and buy if you wanted to – you'd certainly have a very quick machine if you did. Not only are these incredibly good, but the software that we run works very well with them."

That is essentially all the machine consists of in terms of its number crunching capabilities, although on top of that there are three large servers that do what they call the 'visualization work' in F1. "These servers take the data from the other 186 servers and produce the results in the form of pictures, videos and graphs," says Geoff. "This helps our engineers see what they're looking for, because millions and millions of numbers mean nothing to anybody."

What is it used for?

The HPC cluster's role as a gigantic number cruncher has only one purpose in F1: to help out with Computational Fluid Dynamics, or CFD as it is known. It's a technology that creates a completely accurate replica of the car to provide the team with detailed analysis of how potential new parts will perform aerodynamically. There's only one way to do this: perform several billion partial differential equations. That's where the supercomputer comes in.

The team might feed it a hundred slightly different versions of the same part, such as a front wing endplate, with the aim of finding out which one is best. Over the following 17 hours, the HPC cluster will do over ten billion calculations, eventually whittling them down to around 800 million pieces of data. Rather than just present these on a spreadsheet, the final two hours of the process is called 'Post Pro', which condenses all the information into around eight videos, 200 pictures and some graphs. The CFD engineers can then see which endplate performed best, and the part can be physically made in order to be tested further.

The main benefit of using the Dell supercomputer is saving time. In the 'old days' of F1, before technology like this existed, teams would have to hand-make all the parts to be tested – incredibly time-consuming, much more expensive and nowhere near as comprehensive.

Nowadays a team like Caterham can instantly dismiss ideas that aren't going to make their car go any faster round the track, all it takes is 17 hours in their Dell HPC cluster.

How was it made?

Supercomputers are entirely bespoke machines made to the individual

Dell technology plays a vital role in making Caterham's F1 cars as fast as they can be

specifications of the customer, and are used in everything from stock markets to weather prediction. This one took about two months to build before it was installed at the team's factory in April 2010 – with a further two months required to tune it to get it running at its optimum performance.

"You have to spend a lot of time tuning a supercomputer," admits Geoff. "That's due to the fact that you need to keep the machine as free as possible for memory and disk space so that it can be as fast as possible for what we need it for – crunching numbers. Your PC at home will probably get slower and slower the older it gets, because you'll be downloading applications and storing bits and pieces on it. But because everything on the HPC is set in stone, it doesn't get any slower," explains Geoff.

In 2011, an F1 team is capable of performing approximately 100x more work on a supercomputer than it would have been able to do ten years ago

"The other great thing about our HPC is that when we started talking to Dell about what we needed it to be able to do, we didn't go for some sort of incredibly cutting edge set-up – this is standard, tried and tested Dell kit that a lot of businesses around the world use. If you start pushing the boundaries with computer equipment it can become unreliable, and that's not going to work for us when we've got so much of our development going through this machine all the time. That decision has really benefited the team and ultimately allowed our cars to be as fast as they can be out on track, which is what matters in this game."

What if it breaks down?

Next to the supercomputer is a slightly odd sight: sixty 24-volt batteries which look identical to the ones you might put in your road car but slightly more robust. The reason for this is simple: if there's a power cut, the HPC won't immediately stop working.

"If this happens, these 60 batteries won't keep the supercomputer going on indefinitely," explains Geoff. "They only power it for a total of 12 minutes, but that buys me enough time to shut the machine down properly. HPCs don't like being turned on and off, but if you have to do it, you need to make sure it is done correctly."

How often is it running?

No piece of equipment in Formula 1 works harder than the supercomputer: it's on 24 hours a day, 365 days a year. "It usually has a maximum of six 17-hour 'jobs' running through it at any one time, meaning every single one of the 186 servers is being used," explains Geoff. "You tend to find that end of play on a Friday is a very busy time for it, because we'll load it up to do a variety of jobs over the weekend. Because of the amount of fans the HPC needs to keep it cool, you need earplugs if you spend any length of time in the room – and a coat, because it can get pretty cold."

The only time of the year the supercomputer isn't in use is during F1's enforced two-week shutdown in August, where teams are not allowed to do any work relating to the car in a bid to cut the cost of competing in the sport.

What maintenance does it need?

"I have to do daily visual checks on the HPC to ensure it is functioning properly," says Geoff. "Basically, blue lights are good and orange lights are bad. We do occasionally get them and we do sometimes get hardware failures; it's very rare, but you have to remember that these things are running flat-out all the time. It's on for 365 days of the year.

Even though it's not doing anything car-related during the two-week shutdown in August, I take this time as an opportunity to do some maintenance checks on it, do a few updates, things like that. It's hard to do all these updates at any other time of the year because it is always in use, although I can take a few servers off at any time to do maintenance if I need to."

Will it be replaced?

"We're now two years in with this supercomputer, so we need to start looking at an updated tech refresh version of it soon," admits Geoff. "We could put this one onto something else in the factory to make way for a new one. The replacement would just be made from the latest current hardware; I'd imagine that would be in place sometime next year, because three years is the maximum for a piece of IT equipment in F1 before you want to update it.

"The thing about technology is that it moves on, so a machine that has a slightly smaller footprint would probably give us the same power and a machine that's bigger would give us more power. The thing about this machine is that we can't make it any faster now. I'd say our aim for the next supercomputer we get from Dell would be to do a 17-hour CFD job in around ten hours," says Geoff.

"Getting information about new parts on the same day rather than the following morning could make a massive difference to us, because F1 is all about saving time – both on and off the track."

F1 is about constant improvement, which is why the supercomputer runs 365 days of the year

The team can analyse virtual parts rather than having to physically make models at their factory

It usually has a maximum of six 17-hour 'jobs' running through it at any one time, meaning every single one of the 186 servers is being used

Mr I.T.

As Head of IT for Caterham F1, **Bill Peters** has to make sure everyone from car designers to aero boffins have the tools for the job. But that's easy compared to getting the team up and running from scratch in just 22 weeks...

Pity the fool? Bill Peters faced a tough job to set up systems in record time

It's September 2009, and the Lotus Racing team has just had its entry into the 2010 Formula 1 World Championship accepted. Brilliant. All they are missing is a pair of drivers, two cars and a team of people to make them.

Team members demand fast, reliable IT during the race weekend

They were also without any IT equipment or, for that matter, an IT team. Getting a company's IT infrastructure up and running usually takes at least a year – especially for something as bespoke and complex as that required in Formula 1. Team Lotus had 22 weeks until the five red lights went out in Bahrain.

Bill Peters joined the team now called Caterham F1 as Head of IT in October 2009 and was, as he recalls, only the eighth person in the entire company to be brought on board. His immediate task? Get the team up and running to be able to design parts and function during a race weekend.

Not easy…

So Bill, it's the end of 2009 and there are under three months to go until the first race of the season. What was the first thing you did to get the team up to speed IT-wise?

Well, normally there would be a process for building an infrastructure in a business like an F1 team: you'd get the factory infrastructure in place first, then the trackside up and running followed by the various other systems layer upon layer.

What we had to do was put that whole process in reverse and get the trackside stuff done first, because we had to be able to perform at testing and at the first race of the season in Bahrain come March; if there were certain things not working at the factory by that time then we thought we could just work around it. So we sorted the trackside systems out and made sure we had the bare essentials at the factory to be able to communicate with the team while they were at a circuit. After that we started focusing on the supercomputer, or HPC, environment.

How long would it normally take to set up the IT for an F1 team from start to finish?

We really boiled everything down to about eight significant IT projects: factory infrastructure, trackside infrastructure, supercomputing, ERP systems for manufacturing things like purchasing and finance, CAD, data acquisition systems and so on. Now, any one of those would normally take at least six months from start to finish to get something up and running; the manufacturing system usually takes at least a year to get in place. What we achieved in getting the team to a point where everything worked by March was truly incredible. When I joined the team I was the eighth person to join; by the time March came around we were pretty much up to full strength as far as the race team was concerned, even though we were still building the factory!

It took a few late nights to get the team's IT systems up and running

In the early stages I didn't even have a full IT department, so we were very reliant on Dell to help us. We had about ten of their consultants based here at Hingham up until March and we had some all-nighters working with them, there's no doubt about that!

How long after Dell came on board was it that you had what you'd call a proper working IT infrastructure?

In terms of the numbers of people we needed for that first year, with fully functioning trackside, factory and HPC facilities, we were more or less up to strength by about May 2010. Not bad, really.

What are the main challenges of being Head of IT for an F1 team?

It's probably not dissimilar to being Head of IT for a major corporation or a small manufacturing business. The main thing you need is to have visibility across the business, because IT touches every part of it these days. You need to have a good grasp of the problems and issues each department faces, so you can provide the tools for people to be able to do their jobs.

For me, that means understanding how people like aerodynamicists and designers work. It's a pretty complicated job but it's a great one too. I mean, I love racing and I love IT – bringing those two together is a bit of a dream job really.

So presumably different departments need their computers to do vastly different things?

Yes, but it's more the applications that different people need to be able to use. The actual hardware, the tin underneath if you like, most of our staff don't tend to mind too much about that – they just want the tools to be able to do the job in hand. By far the biggest power users in the whole of Caterham F1 are the CFD guys who use the HPC; they also have incredibly powerful desktops because they're doing work that requires a lot of graphics capabilities and a lot of pre- and post-processing work. We have to make sure that we've got big performance for these people, because the CFD department is working 24/7.

At the other end of the spectrum you've got something like the marketing department. They need lightweight laptops that don't require that much power but need to be able to communicate anywhere because marketing are very mobile users. Then you've got the race team which is a mixture of the two: mobile users who need a lot of power. They have incredibly powerful laptops. In between all this there's a whole spectrum of people with a different set of needs; finance users, for example, have pretty standard computing needs.

How does the relationship between Caterham and Dell work on a day-to-day level?

It's an ongoing relationship, really. While we got everything up and running for that first season and it did the job, there weren't huge amounts of resilience built in and not a lot of process available. In between then and now we've spent a lot of time putting resilience into our systems to make sure we've got disaster recovery and things like that. But F1 is a business where things are constantly evolving and being improved, and that includes the IT side of things.

A plan comes together: Peters has established trackside, factory and HPC facilities

We have to be constantly looking to the future to make sure we can support the latest and greatest applications that our engineering and design guys want to use.

What if something goes wrong with one of the machines or even the supercomputer? That's not really the sort of thing you can take to PC World to fix, is it?

Not really! Right from the outset we've had this thing called Dell ProSupport, which provides us with support 24 hours a day, seven days a week, 365 days a year – so anywhere in the world, whatever time of day, we can get help. We've used it too – it could be during a race weekend and 3 or 4am at our factory in the UK and we can have Dell people available to us.

It also includes them bringing hardware replacements to us within four hours, wherever we are in the world. Coupled with that and because of the partnership we have with them, we have a fast-track into the product groups at Dell, because normally the sort of problems we might encounter are not the sort of things that their first-line support might be able to help us with.

Finally, how often do you have to replace computers in F1?

We're still using most of the same stuff the team started with. We'll replace a lot of kit for this coming season because we have to minimize risk and balance the possibility of things going wrong, but I would quite happily run all of our race team kit for another season.

That's quite a testament to how good it is.

HARD CASE

Formula 1 is a harsh environment for a delicate piece of equipment like a portable computer – but this innocuous-looking PC can take anything Caterham throw at it

The Precision mobile workstation is tough enough for life on the Formula 1 grid

The Dell Precision M4600 is the world's most powerful 15.6" mobile workstation

Knocked about on planes, accidentally bashed around in the garage, inadvertently dropped on the floor – not to mention being expected to work when about 800bhp of F1 car is fired up two meters away from it. These are just some of the things expected of a laptop during a race weekend in the Caterham garage, as well as working perfectly and processing enormous amounts of data in order to help the team make the car go faster. As you can imagine, not just any ordinary laptop will do. Then again, a Dell Precision M4600 isn't just any old laptop.

Although it looks like the sort of thing a lot of people might use at work or at home, this piece of kit is seriously advanced – as it needs to be to be able to cope with the demands that people like F1 race engineers place on it. One of the first things it's got to be able to do is work in a variety of different climates. "You've got to remember that these laptops are subjected to incredibly harsh environments a lot of the time," says Caterham Head of IT Bill Peters. "There are extremely cold temperatures, extremely hot temperatures in places like Malaysia, extremely dusty places in desert locations in the Middle East – our computing equipment has to be able to function flawlessly in all of them."

What allows the Dell Precision to be able to withstand all these and more is the bullet-proof build quality, as Bill explains: "The difference between this laptop and a standard one you might have lying around at home is that the build quality and resilience on these tends to be stronger. They have better power supplies and more robust casings, for example, both of which you definitely need working trackside in F1. They also have Intel Extreme Edition processors for sheer processing power – in fact, everything across the board at Caterham has Intel processors in them.

This piece of kit is seriously advanced – as it needs to be to be able to cope with the demands that people like F1 race engineers place on it

"One of the key things about the M4600 is that it has solid state hard drives. Basically, a typical home-use computer will have spinning discs, so they're actually mechanical – imagine a whole stack of CDs going round and round. Solid state hard drives have no moving parts in them. There's lots of reasons for that, but some of the benefits are that it makes the equipment lighter in weight and less likely to be physically damaged."

It's also helped solve an issue which had F1's computer boffins scratching their heads a few years ago. "We spent a long time in the sport a few years ago trying to work out why laptops would crash as soon as the car fired up!" says Antony Smith, Caterham's Senior IT Support Engineer. "Basically, as soon as you start an F1 car near a normal laptop the hard disk can't cope, so the machine blue-screens." It doesn't mean there's anything wrong with that computer, simply a case of the vibration of the F1 car making the spinning discs crash.

"We have to take the environment of the F1 garage into account with all the IT equipment we need over a race weekend, and you have to remember that when an F1 car is fired up it's an incredibly loud thing which vibrates an awful lot," says Bill. "Antony's right – a few years ago in F1 you'd see people using laptops that literally gave up the ghost as soon as the car was started. But you have to remember that you have to plug a laptop into an F1 car to start it up, so the computer has to be pretty well protected. You also have to remember that the Dell kit like the M4600 that we use trackside is just their standard, high performance equipment, and so far it's stood up to everything we've thrown at it. And believe me, over a race weekend quite a lot gets thrown at it."

It certainly does, as Antony explains: "An F1 car has a few hundred sensors on it to record every conceivable piece of data you could imagine to feed back to the engineers about how it's performing. Now, one run of data from a practice session or the race is probably about one-and-a-half gigabytes, which is data that all needs to be loaded into RAM and accessed quickly. There's a huge demand on the Intel processors and the memory of these systems. Not only that, but they've got to have an awesome screen on them; engineers look at all the data graphically, and the more you can fit on screen at once the more chance they've got of seeing what they need to be able to see."

Given that IT as an industry is constantly evolving, even a Dell Precision laptop has a shelf life. "Typically we'd expect to refresh our trackside equipment once every two years," admits Bill, "This stuff is doing a lot of mileage and getting knocked around a fair bit – that's just the nature of Formula 1 what with hauling equipment all over the world nearly 20 times a year. Generally speaking, the attrition rate on an F1 race team's IT kit is quite high," adds Bill.

"Having said that – and I'm not just saying this – our mobile workstations are still going strong. The team has been using these since that first race of the 2010 season, and we've had very few reliability issues with any of the kit, to be honest."

Antony agrees. "We've had these laptops since the start and they're really fast, but we're getting some new ones for next year which will be able to do even more. They are pretty chunky but they're incredible – you're talking a complete workstation PC in a laptop, with incredible amounts of processing power.

"They're as fast as any PC you could have. For us, to get that amount of power in a portable box is brilliant."

Powerful processors are vital given the amount of data being handled

CONDITIONS IT CAN WITHSTAND

The Dell Precision is designed to withstand extreme temperatures, dust and vibration

6°C

Winter testing in Spain can get very chilly, while temperatures in Abu Dhabi can exceed 40°C during a race weekend

200,00km

Distance traveled between races during an F1 season

140

Decibels of an F1 car firing up, which also creates vibration

The race in Bahrain can be very windy, blowing in huge amounts of dust and sand

77%

Average humidity expected during the Malaysian Grand Prix race weekend

THE CLOUD: F1's FUTURE?

In a sport where gaining tenths of a second is vital, teams are looking to advances in IT to give them the edge – and save money

Formula One may be a test of a driver's ability, man and machine in harmony under extreme circumstances, but all those daring overtaking moves, fast qualifying laps and breathtaking straight-line speeds would not be possible without computers. Ever since the days when championship-winning cars were created in oily garages no larger than Caterham's HPC room at Hingham, such as the shed in which Ken Tyrrell built his first car four decades ago, Formula 1 has been reliant on them.

Like any other industry, IT is constantly evolving and progressing, and more advanced IT systems mean better and faster racing cars. According to Bill Peters, Caterham's Head of IT, one of the biggest potential changes on the horizon is the rise in the use of Cloud technology, where data and information is stored and accessed on remote servers, rather than on physical machines owned by F1 teams themselves.

"Within the IT industry, you hear a lot of talk about the Cloud and this is something we're investigating with Dell at the moment," he says. "It means that instead of having lots of local applications and huge amounts of investment in infrastructure and storage at the factory, you have your things hosted by a third party and many of your applications hosted as a service. Something like Google Mail, for example, is essentially a Cloud-based service. There's definitely a trend of businesses moving towards this route," Peters concludes.

"This means we could essentially have resources we can turn on and off and help us to scale things much more easily; it would allow us to focus more on the application side of things which is where the real value is for an F1 team – because the main thing in this job is helping the engineers get more performance out of the car. So if we could focus our attention on looking after the applications that do that rather than worrying about whether the back-ups have been done or whether a particular server is performing as well as it should be, it would be a better use of our resources."

One of the other benefits could ultimately be a reduction in the amount of IT equipment Caterham takes to a race; an interesting avenue given that the team already powers its trackside operations with one of the most compact racks of servers in the F1 paddock.

"Ultimately using the Cloud would mean having less physical equipment, so it would be very much a phased thing for an operation like an F1 team," reasons Bill. "You would be using someone else's equipment and have your applications hosted remotely, with users connecting into that remotely. Now obviously all that depends on having a very good communications infrastructure, but if you think about it, if we had everything hosted in the Cloud, managed by Dell, and it was accessible all over the world, we could feasibly get to the stage where we don't have to take much kit to a race. It could reduce Caterham's overheads massively.

"It may not happen within the next couple of years, but I can see it happening eventually. You'd probably always need a certain residual capability back at base so that you could carry on if you lost your communications for a period of time, but it's certainly a very interesting thought."

"We could feasibly get to the stage where we don't have to take much IT kit to a race. It could reduce Caterham's overheads massively."

But in a sport as secretive as Formula One, are there any potential drawbacks of handing sensitive data to a third party? Bill Peters doesn't think so.

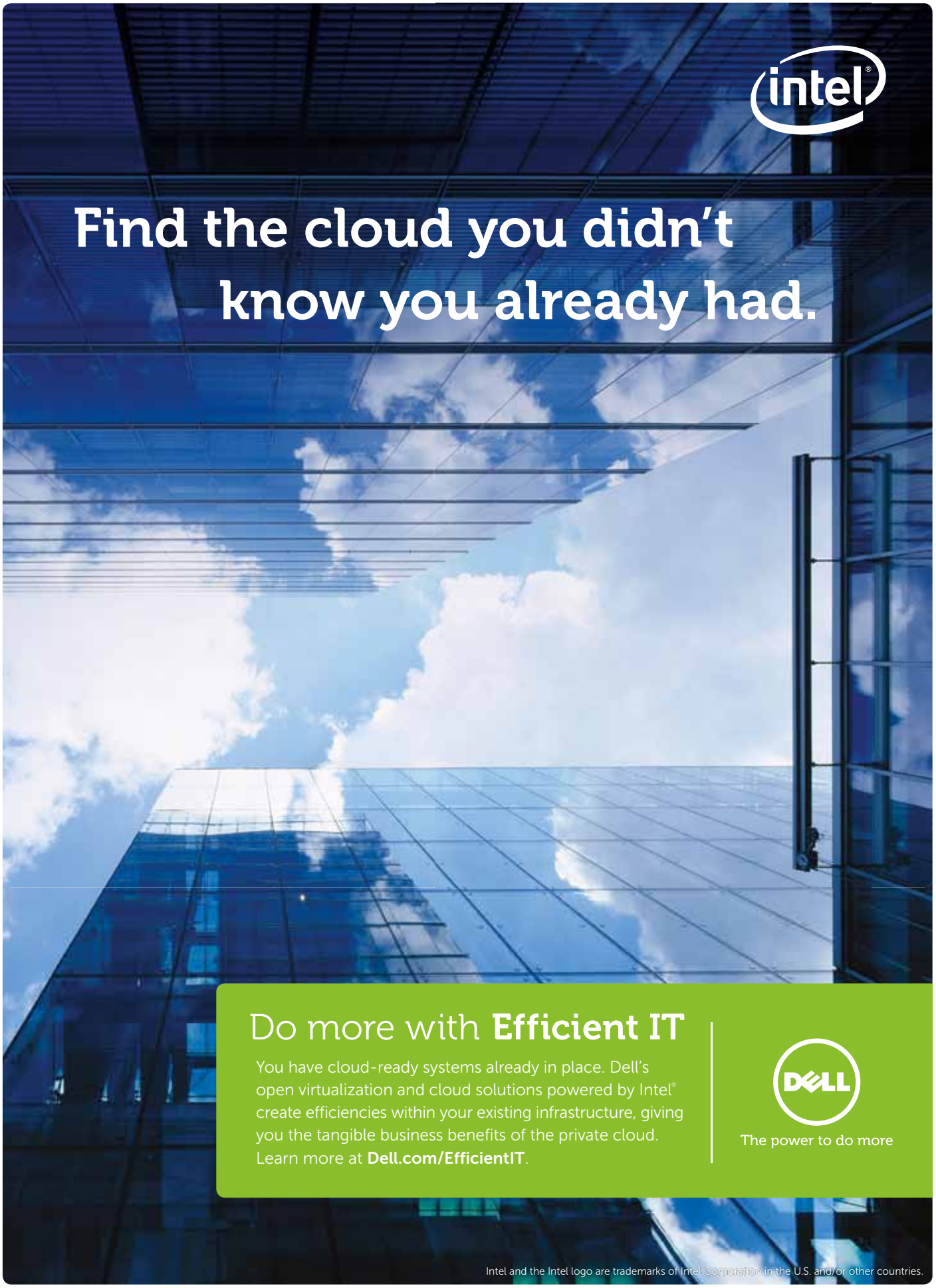
"We would embrace this! We already have a complete back-up email system in the Cloud. If our email system goes down in the factory, we can failover to the Cloud and people can still get email and the trackside operation can still continue to work through that connectivity," he says.

"The way I can see it happening is that initially you use it for remote access and support as a form of back-up.

"But also you could use it for extra storage demands – we have huge amounts of data, for example, so if we ever ran out of storage we could use some of the extra capacity on the Cloud, or archive things there to give us more storage in the factory. At the end of the day, all we're trying to do is make our systems as bulletproof and available as possible. In a sport like Formula One, where a third of Caterham F1 staff can be traveling at any one time, that's a huge benefit."

Antony Smith, the team's Senior IT Support Engineer, agrees. "The progress I've seen in F1 IT in the last ten years has been incredible, in terms of the links and the WAN (wide area network) connections that we use," he says. "The Cloud is incredible; the slight issue in F1 is that we never know what our WAN connection is going to be like at a racetrack. If we had everything in the Cloud and we lost our connection it would be tricky. The thing with F1 is that when you're at a race you can't control something like a digger ripping through a pipe into the circuit, which is what happened in India last year.

"But there's no doubt about it: the Cloud is a fantastic idea for reducing costs and equipment."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