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RIGHT GEAR FOR RIO

Olympic teams turn to technology in a bid to gain a competitive advantage

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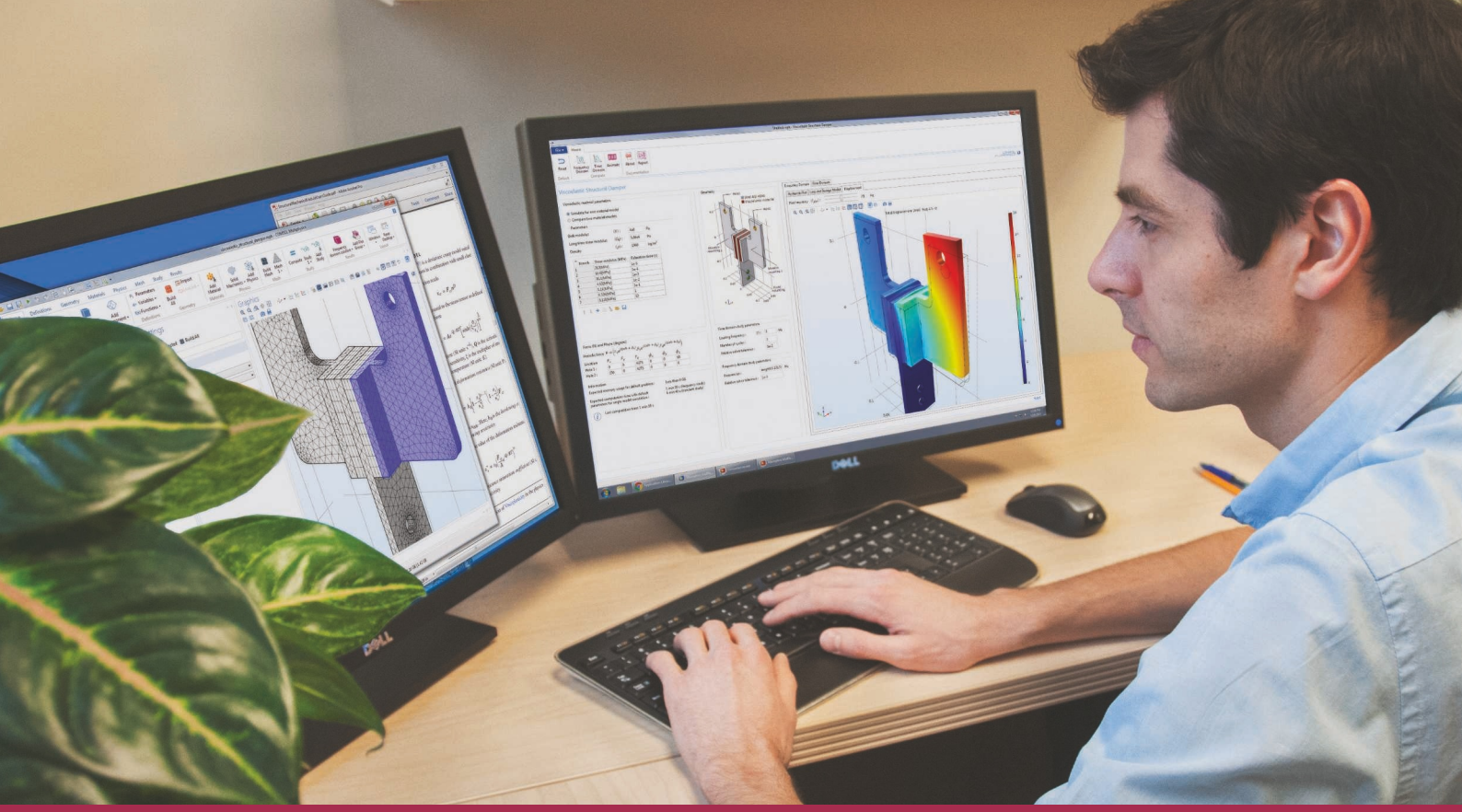

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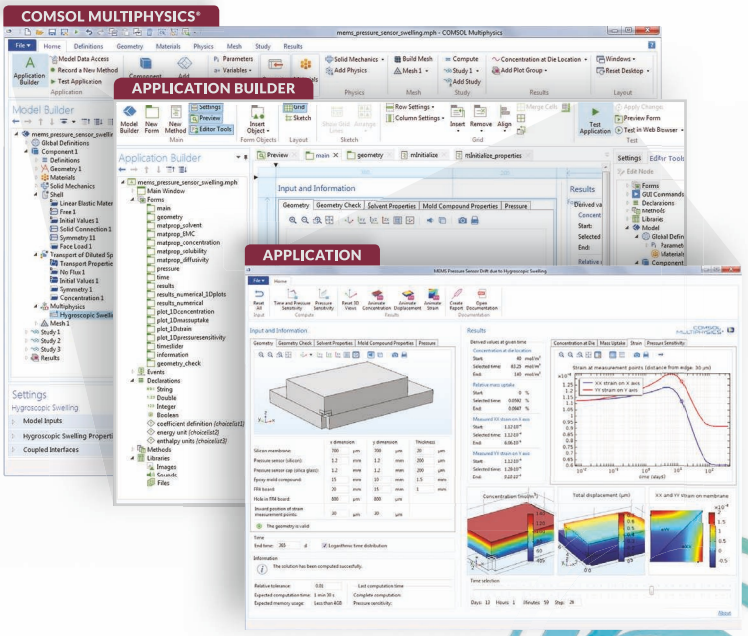

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MA BUSINESS

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Good sports

Tim Fryer, Editor (tim.fryer@markallengroup.com)

Sport is a wonderful thing. It polarises and inspires, and changes at the drop of a hat. Unfortunately, due to publishing schedules I don't know whether Andy Murray won Wimbledon (although I know he cruised through the first week) or got knocked out in the first round or who won the Silverstone Grand Prix. At the time of reading, it will only just have become known who are the football champions of Europe - for all I know that could still be Wales. Win or lose, it is a fantastic summer of sport and the tip of this huge iceberg for many will be the Olympics in Rio.

Children generally engage in sport at a much earlier age than they do vocational subjects, so could this sporting enthusiasm be channelled more effectively to inspire engineers? BAE Systems certainly think so. It has engaged in a long term tie-up with UK Sport and, as *Eureka* reports in this issue, helps British athletes in their bid for success at the Olympics.

This is not just an altruistic venture, of course. At a time when we have a well reported lack of engineers coming through the education system, it sees sport as an ideal way of influencing young minds. Nigel Whitehead, group MD for programmes and support, spoke at a joint UK Sport/BAE event last month. He said: "The whole issue of inspiring the next generation translates universally because we need the next generation of engineers to be interested in science, technology and maths. And we need them to be interested in those subjects before they start to get difficult at school so they continue studying them. We have a role in doing that. We have to keep feeding the pipeline and our relationship with UK Sport is helping us to do that."

Olympic success is undoubtedly linked to enthusiasm for sport. If it has positive consequences for engineering, then so much the better. This model could work elsewhere, in other sports, that are backed by excellence in engineering like Formula One, for example? Surely more initiatives linking the two could happen, the question really is, why aren't they?

Industry reacts to referendum result

"At a time when we have a huge shortage of engineers, limiting the number of professional engineers that could come and contribute to our economy would affect the industry and the nation's financial wellbeing."
Naomi Climer, IET president

As the dust settles on last month's referendum result, we ask leading figures in the engineering industry for their thoughts, and what effect this might have for UK PLC going forward?

The Institution of Engineering and Technology (IET) was generally downbeat in its initial reaction, calling for an urgent discussion to mitigate the impacts on the engineering sector, specifically the impact it could have on the skills base. Naomi Climer, IET president, said: "At a time when we have a huge shortage of engineers, limiting the number of professional engineers that could come and contribute to our economy would affect the industry and the nation's financial wellbeing."

Other issues identified by the IET include access to global markets and companies, a decline in funding for engineering and science research, and a weakening of the UK's influence on global engineering standards.

However, Leave supporter James Dyson responded by writing a column in the Sun newspaper, saying: "We have nothing to fear and everything to gain from the new opportunities.

"A lower Pound makes our exports cheaper and more competitive, which is why our biggest blue chip exporters have seen shares rising, not falling."

He goes on to highlight that the UK is now in a better position to react to emerging market forces, such as growth in Asia and the rest of the world.

However, his positive message has been met with a blunt practical response from industry bodies. An example comes from Dame Ann Dowling, president of the Royal Academy of Engineering, who said: "Engineering contributes at least 20% of the UK's gross added value and accounts for half our exports. It is vital that the economy is carefully managed in the wake of the Brexit vote in order to maintain our world-leading position in innovation and industrial development."

Robert Bosch's CEO, Dr Volkmar Denner, offered a view from outside the UK. He said: "The EU is a successful

project. We are disappointed by the decision to take the UK out of the world's largest single market, not only for economic reasons. The long-term economic consequences will only become apparent gradually."

The UK is Bosch's second largest European market after Germany, with sales of £2.7bn made in 2015. In total, Bosch employs some 5300 associates at 40 locations (including seven in manufacturing) in the UK. All four business sectors – Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology – have operations here.

Dr Denner said Bosch is currently examining the effects of leaving the EU on its business and has already put precautionary measures in place. For example, the company has significantly raised its hedging ratios in order to counteract a possible depreciation of the pound. "We currently do not have any plans to scale back our capital expenditure in the UK," he added. "As we are traditionally well represented in many European markets, we will likely be less affected than companies that use the UK as a base into Europe."

GE, based in the US, provided another perspective from outside the EU. Chairman and CEO Jeffrey Immelt said: "Although GE supported the UK remaining in the EU, we respect the decision of the British people and remain firmly committed to the UK and Europe. GE has 22,000 employees in the UK and 100,000 employees in Europe overall, who will continue to focus on delivering great outcomes for our customers.

"We believe in the potential to build a competitive Europe and UK through digital transformation and manufacturing."

While industry, much like the rest of the UK, comes to terms with the real fallout, the waters remain murky and at the moment, given the turbulence, the real effects on business, trade and the economy are anyone's guess.

Have you been effected by the referendum? Let us know your thoughts, concerns and outlook by leaving a comment online or by emailing tim.fryer@markallengroup.com.

NEWS

UK manufacturers don't get Industry 4.0

A report published by the Institution of Mechanical Engineers (IMechE) warns that UK manufacturers risk falling behind global competition due to their reluctance to invest and implement Industry 4.0 related technologies and processes. It warned there remains a 'gaping hole' in the education and understanding of Industry 4.0.

It said 92% of UK manufacturers did not have significant understanding of Industry 4.0 processes, despite 59% recognising the impact it will have on the sector. It also claimed 25% have no plans to invest in this area in the next two years.

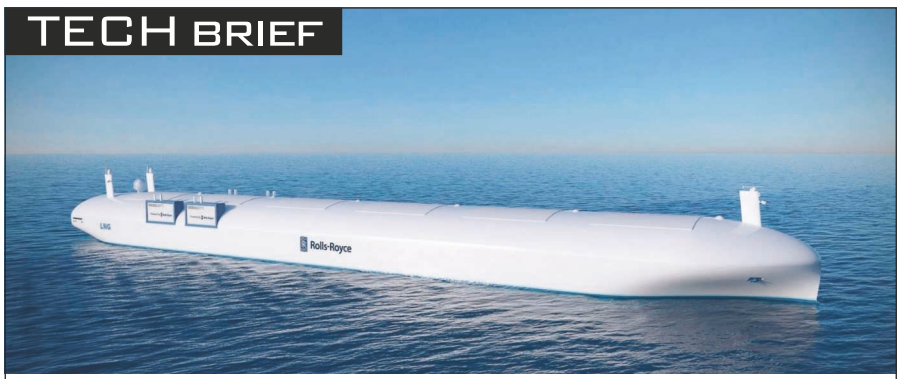
"The survey findings show that much more is needed to be done to help our manufacturers understand how technologies such as automation can add value to their businesses," said Philippa Oldham, head of manufacturing at the IMechE. "By embracing this new revolution our factories will become much more intelligent, as well as detect and even predict faults in production lines before they happen. This will not only lead to increases in efficiency and productivity, but also drive out waste."

According to the report, increased productivity, better data analysis, increased competitiveness and lower manufacturing costs are the top ways in which Industry 4.0 can benefit manufacturers. Increasing automation, data exchange and wider supply chain communications may well also offer huge opportunities. However, their implementation and cost remains a challenge.

Of those that are increasing investment levels, 16% of companies expect to spend over £500,000, while 7% plan to invest more than £5million before 2018.

The report can be downloaded for free from imeche.org

TECH BRIEF



ROLLS-ROYCE'S AUTONOMOUS SHIP

Rolls-Royce is to produce the preliminary design and specification of a planned future autonomous ship, as part of a €6.6 million project. The company has outlined its vision in a whitepaper about how it plans to make remote and autonomous shipping a reality.

"This is happening," said Oskar Levander, vice president of Innovation at Rolls-Royce Marine. "It's not if, it's when. The technologies needed to make remote and autonomous ships a reality exist."

Rolls-Royce led the Advanced Autonomous Waterborne Applications Initiative (AAWA) that explores technical challenges and legal implications. Autonomous ships would be able to do away with living quarters and systems needed to support the crew, increasing cargo capacity and potentially impeding the risk of pirates, as there would be no access to the ship or a crew to hold hostage.

"Autonomous shipping is the future of the maritime industry," said Mikael Makinen, president of Rolls-Royce Marine. "As disruptive as the smart phone, the smart ship will revolutionise the landscape of ship design and operation."

The project is testing sensor arrays in a range of operating and climatic conditions in Finland and has created a simulated autonomous ship control system that allows the behaviour of the complete communication system. The project runs until 2017, with Levander concluding: "We will see a remote controlled ship in commercial use by the end of the decade."

NEWS

Overhead lines for road haulage

A pilot scheme in Sweden is looking to tackle the problem of greener road haulage by fitting overhead electricity lines on highways. The concept borrowed from the rail industry would overcome the need to carry heavy batteries and avoid long recharging, essentially overcoming the head scratching issue of how to electrify lorries.

The project has installed overhead wiring on a 2km pilot stretch of the E16 motorway, with lorries being equipped with overhead catenary wires. The overhead wires provide 750V of direct current to the hybrid electric system in the truck through a pair of pantographs.

The pantographs can automatically deploy and attach to the wire while the vehicle is travelling at speeds of up to 90km/h, meaning that the truck can seamlessly enter and exit a roadway. The truck itself is hybrid electric, with a 360hp engine that runs on both biofuel and a 5kwh lithium battery pack that provides enough power to travel 3km.

Sweden is also testing a different type of electric road, using conductive transfer technology based on an energised rail embedded in the road surface. The rail is exposed, and special 'shoes' underneath vehicles can draw energy from it continuously. The rail is only energised when a vehicle passes over it, and 'multiple safety barriers' are in place to minimise the risk of accidents.

These roads will be undergoing testing over the next two years. The Swedish government hopes that it will learn enough about what works and what doesn't to help it make informed infrastructure decisions, with the goal of a completely fossil fuel-free vehicle fleet by 2030.

IET announces new President-elect

The Institution of Engineering and Technology (IET) has announced that Professor Jeremy Watson will become its next President, taking up the position on 1 October. Watson is Professor of Engineering Systems and Vice-Dean in the Faculty of Engineering Sciences at University College London. Previously, he was chief scientific advisor for the Department of Communities & Local Government and Arup's Global Research Director. He was awarded a CBE in the Queen's 2013 Birthday honours for services to engineering.

TECH BRIEF

Covestro's 3D printing material

Covestro is developing a complete range of filaments, powders and liquid resins for all common 3D printing methods. The polymer technology company aims to advance the use of 3D printing in industrial mass production.

The company markets products with a variety of properties like toughness and heat resistance as well as transparency and flexibility that support a number of applications.

"We want to work with leading partners in the process chain to further advance these developments," said Julien Guiu, who leads the company's global 3D printing activities. "These include formulators, 3D printer manufacturers, software companies, service providers and of course OEMs."

Covestro recently opened a laboratory for 3D printing at its headquarters in Leverkusen. The lab will be used by the company and its partners to develop material solutions and test them under practical conditions.

The company offers a choice of filaments for the fused filament fabrication (FFF) process, from flexible thermoplastic polyurethanes (TPU) to high strength polycarbonate (PC).

EVENTS

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04-05 October
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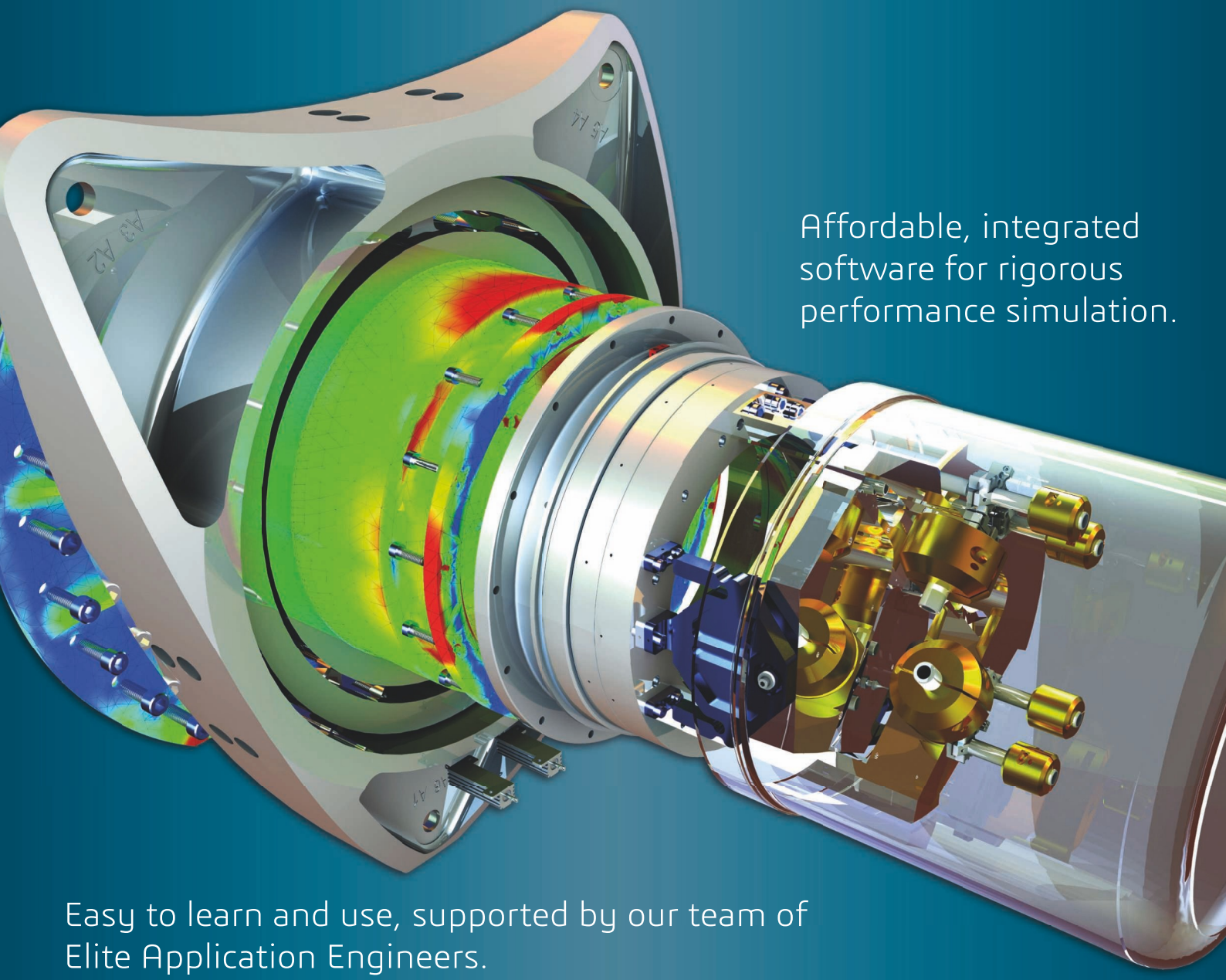

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NEWS

Formula Student smashes world record

A car competing in this year's Formula Student has smashed the Guinness World Record for electric car acceleration, going from 0 to 62mph (100kph) in 1.513s.

The car was developed and built in less than a year by a team of 30 students at ETH Zurich and Lucerne University of Applied Sciences and Arts. The team broke the record at the Dübendorf air base near Zurich. The previous record stood at 1.779s and was set last year by a team from the University of Stuttgart.

The car weighs just 168kg, with the chassis made from carbon fibre. Each wheel on the four-wheel drive car has a specially developed wheel hub motor that is capable of generating 200hp and 1700Nm of torque. A sophisticated traction control system regulates the performance of each wheel individually, allowing the car's acceleration to be optimised.

No production car can reach comparable acceleration with the Porsche 918 Spyder being the fastest at 2.2s. An F1 car is thought to achieve 0-60mph in 1.7s.

£12m facility creates 160 jobs

Oxford-based Polar Technology Management Group is opening a state-of-the-art £12m R&D facility in Eynsham.

The site will develop and manufacture high tech engineered components for market sectors including aerospace & defence, motorsport, automotive, energy and clean processing industries. These components include exhaust and high temperature ducting systems, complex manifold assemblies, heat shields and thermal protection, suspension systems, pressure vessels, torsion shafts and moulded composite parts for structural high-end applications.

"With the launch of the project we'll be recruiting 160 new employees to invent, design and manufacture sophisticated component solutions from composite materials for our customers," said Scott Roberts, chairman of Polar Technology Management. "Our techniques will produce stronger, lighter and more efficient engineering structures, which will be used in industry sectors across the globe."

Products

142747
Flowmeter for metering viscous fluids

142248
Ultra-slim permanent magnetic brake

142079
3D printer with largest volume capacity on the market

141972
Fully integrated microstep motor controller

141830
Making the most of your CATIA licenses when working with JT data

141823
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141768
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141767
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141763
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141721
Rockwell controller improves accuracy and performance of high-speed applications

Solution to last month's Coffee Time Challenge

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The solution to last month's challenge – to detect a lorry tyre blow out before catastrophic failure – comes from British firm TyrePal. It has produced a tyre pressure monitoring system (TPMS) to help OEM trailer builders and trailer fleet operators tackle the problem of tyre blowouts.

Its TeleTPMS is a remote tyre pressure monitoring system for commercial fleet vehicles comprising of a set of sensors, which can be fitted inside or outside the tyres and a dashboard-mounted module that displays the pressure of the vehicle's tyres for the driver's benefit.

An indicator operates independently of the truck to provide an immediate visual and audible alert when the sensors report rapid pressure loss, tyre overheating, under-inflation or over-inflation. The module also transmits location and tyre data via GPRS to a remote database.

Peter Tilliotson, business development manager of TyrePal, said: "Due to the weight distribution and design of HGV trailers, especially double-decker trailers, if tyres pick up slow punctures, they often go unnoticed until it is too late. When the improperly inflated tyre is forced to work, it heats up and can cause blowouts. This leads to downtime and creates potential hazards to the driver and other road users. Apart from being very unsafe, it also increases fuel usage."

The device operates on an internal battery – automatically recharged when power is available, either from the trailer supply or by connection to the trailer lights. When the trailer is not in use, the indicator goes into a sleep mode and automatically turns back on when there is any vibration.The device is also fully GPS trackable, allowing fleet managers to track their vehicles tyre pressure remotely.

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Science behind the **gold rush**

Great Britain had a phenomenally successful Olympic Games in 2012, winning 65 medals (29 golds). It was our most successful Games since London first hosted the event in 1908. But although the home support no doubt played its part, there were other reasons for this success, and engineering was one of them. Tim Fryer reports.

It is not easy to gain much competitive advantage from the equipment used in Olympic competition. The attraction of the Olympics is to see athletes winning gold for doing things faster, higher and stronger. As a consequence, and to ensure there is a level playing field for all competitors, the governing bodies of the individual sports can be very prescriptive about the equipment used. However, winning is all important so these restrictions don't stop the quest for a competitive advantage.

Most athletes would attribute success to their own hard work and dedication, but everyone – even the best - could do with that extra bit of help. Hannah Cockroft (main picture) was a double gold medallist at the 2012 Paralympics and is competing in three events in Rio this year. She is one of the many beneficiaries of the project UK Sport is running with BAE Systems that is helping British athletes succeed in Rio. "For me it has changed my positioning in the chair," she explained. "At the London Olympics my feet were down which created drag, but this chair holds them up to improve the airflow. It is a slight adaptation of the chair. It was really just having that little bit of assistance to find out what was best and if it could be improved to aid my performance.

"I can feel a difference because it is slightly more uncomfortable, but you can see a difference when it comes to timing - a difference of 0.1 second can be the difference between winning or losing."

Aerodynamics plays a big part in these speed sports. Increases in speed result in a squared increase in the drag, so such differences as silhouette, posture, helmet shape can all be critical. Although Cockroft is now reaching 20mph in training ("Hopefully a gold medal winning speed," she says) the fastest British athlete is David Weir. It was therefore him who was subjected to the wind tunnel tests at BAE Systems' site in Warton, Lancashire, a facility normally reserved for testing scale models of Typhoon fighter jets.

While positioning will be the big consequential change for the Rio Olympics, in London 2012 it was helmets – most are still being used now. Cockroft observed that further testing may result in there being a different style for the sprints from the longer distance events.

The collaboration between BAE Systems and UK Sports started with an individual project in 2007 and then formalised into an agreement that currently runs until 2017, but seems likely to be extended. Nigel Whitehead, group managing director of programmes and support, commented: "We don't know and will never know what incremental difference we made but we like to think we are part of that team and that feels fantastic. [It involves] employment of some of the most specialised engineers – aerodynamicists, hydrodynamicists, structural engineers, system engineers – some of the very best of what we do in the UK applied to a particular set of problems and challenges faced by our athletes. It's an exciting and rewarding thing to be involved in."

Already the programme has been involved with 250 athletes across 30 sports and at London 2012 contributed to teams that won 19

The Ergometer is helping the British Cycling team get valuable performance data

(Main picture) Hannah Cockroft winning gold at London 2012

medals and a further five golds at the paralympics.

For all that the focus is on the summer games in Rio, one of the best examples of British engineering coming to golden fruition was the skeleton bob in 2010. It was designed specifically for Amy Williams in terms of weight distribution so that when she went down the run, the runners were always in contact with the ice, which is tremendously efficient from an engineering point of view. Reference to such past glories reflects one of the main problems when trying to report on the programme – in order to protect any advantages that it might deliver, it needs to be kept secret.

One training device that BAE is willing to disclose is the ergometer that it developed along with the Great British Cycling team. The system measures the workrate and energy expended by cyclists, and is capable of replicating the inertial forces of a velodrome more accurately than any other testing tool. The vital data collected includes gas and blood analysis, and enables testing at high speeds to analyse the athlete's technique.

Paul Barratt, lead biomechanist at the Great Britain Cycling Team's English Institute of Sport said: "Every performance on the world stage requires elite athletes to be at their best. Highly accurate testing tools such as the cycling ergometer help to ensure athletes are performing at their most competitive. BAE Systems has created a portable and accurate system that we believe will be integral to the team's training regimes and will help us to achieve our medal winning target at the Rio Games".

As well as track events such as sprints and endurance rides, the cycling ergometer can also be used to test the performance of cyclists involved in road events. It has proven crucial for track stars including Sir Chris Hoy and Sir Bradley Wiggins.

The benefits to BAE vary from developing skill-sets to team building, along with the creative use of new technologies and introducing children to the power of engineering. Whitehead said: "The whole issue of inspiring the next generation translates universally because we need the next generation of engineers to be interested in science and technology and maths. And we need them to be interested before those subjects get difficult at school so they continue studying them, and we have a role in doing that. We have to keep feeding the pipeline and our relationship with UK Sport is helping us to do that."

Let us hope that both our Olympians and the next generation of engineers benefit.

Material matters in the pool

Swimsuit design has caused some controversy over the years. In particular, the 2009 World Championships in Rome, when world records were tumbling in almost every event, resulted in the full length polyurethane swimsuits being banned.

It was clear to the sport by then that substantial physiological and even psychological benefits lie in how elite swimmers were clad. Though the new rules minimised the potential of these benefits, it is still worth continuing to look at the engineering behind swimwear.

One of the leading suppliers is Arena and it had started a development program before the Beijing Olympics in 2008. "I think it's fair to say that the perception was that Speedo [with its LZR swimsuits] were ahead at that stage," said Andy Milton of Innovia Technology, the design agency who worked with Arena to come up with an alternative.

One of the curious aspects to the project was the design process at Innovia, which screens and develops ideas at a very early stage. Milton said: "Where we work upfront, we are often screening ideas. We need to have understanding and for all that we've used FEA for, it is often pencil and paper when understanding what works and what doesn't. It is the thing that we use a lot. Put another way, a lot of my ideas are stupid. And I come up with a lot of them, and I can often kill them using pencil and paper ballparks, just to show this is not going to work. And that's a really useful and valuable tool."

Some of these ideas that Innovia started, literally on the drawing board, now feature in the Arena's latest Powerskin ranges. These include the use of anisotropic stretch that provides flexibility in one direction and all important muscle compression in another.

Another is an 'x-pivot system', which is the format of the seams and panels in the women's suit that provides a connect between shoulder and opposite hip to make swimming more efficient.

One of the biggest changes in swimsuits is the materials they are made of and in particular the use of carbon fibre which helps with the compression. Carbon fibre is only 1% of the material, the rest is 52% nylon and 47% elastane.

But how much difference does this make? Milton concluded: "You can't do pen and paper analysis and prove this suit makes 'X' percent difference. However, we can understand the physical effects and it is certainly possible that they could make some difference. And that difference? That could be the winning margin between two swimmers."

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MOTION | POSITIONING

Broadband for everyone

Bringing fast internet connectivity to every corner of globe might sound like a pipe dream, but one project is about to attempt just that. Justin Cunningham asks OneWeb's VP of regulatory affairs how it can be done.

They say knowledge is power. And for most of us, humankinds' amassed knowledge is accessible at the touch of a button. Any question can be answered, simply by 'Googling it'.

However, it's estimated over half of world's population doesn't have broadband speed connectivity, something enjoyed by the majority of the UK's population. Despite this, slow unreliable connections are a common complaint here at home.

The problem is, with so many services reliant on a fast and stable internet connection, being online has become a preoccupation. As smart as modern phones are, without data they revert to simply being just that - a phone. And who wants that?

Indeed, the concept of the Internet of Things is fast gaining momentum, but it's an idea that will only work if issues around connectivity are solved. After all, how can your fridge get in touch to tell you to pick up some milk, if you have no reception?

It's this fundamental desire, to provide a broadband speed internet connection to every location on Earth that's seen the formation of OneWeb.

CV: **Tony Azzarelli**

Tony Azzarelli serves as OneWeb's vice president of regulatory affairs where he is responsible for worldwide market access and licensing, policy changes and spectrum activities. Prior to joining OneWeb, he was head of space and science services at Ofcom, and he also held senior regulatory positions with Inmarsat, The Boeing Company and the European Space Agency.

He has an MSc in Electronic Engineering specialising in Telecommunications and Computer Science from the Polytechnic of Turin (Italy), and is a fellow and chartered engineer at the UK Institute of Engineering and Technology (IET), and a board member at the UK Charter of the Society of Satellite Professionals International (SSPI).

"We are trying to redefine satellite manufacturing, to mass produce the satellites, reducing costs and improving the schedules."

"We want to provide affordable, broadband speed connectivity to everywhere, and everyone," said Tony Azzarelli, VP of regulatory affairs at OneWeb. "We see even connected countries underserved as the goal post is always changing. A few years ago we needed to connect with people at 2Mb/s, then 10, then 24, now 36Mb/s. The more you change it, the more people become unconnected or underserved."

OneWeb's bold mission statement stands to bring the internet to billions of people around the globe. It has already managed to forge a number of partners with impressive names that include Airbus, Virgin, Qualcomm and Intelsat. The premise is similar to the existing network of GPS satellites, but instead of providing global positioning information, OneWeb wants to provide blanket high speed internet coverage.

"This will connect people, homes, schools, hospitals and businesses," said Azzarelli. "We don't think we are going to be competitive in cities, for example, where access to broadband internet is already cheap and fast. But, in rural areas we will be cost competitive. We will provide 50Mb/s download speeds, upload speeds up to 25Mb/s, and critically low latency speeds around 50ms."

Traditionally broadband has involved digging trenches and laying fibre optic cables at an average cost of $4000 a km. However, key to this project is the deployment of a satellite network. This is the ambitious part, "OneWeb will deploy a mega-constellation of satellites by 2020," explained Azzarelli, which equates to launching 648 satellites over the next four years.

Mass produced satellites

The satellites will be around 1m^3, and are to be engineered for simplicity – using fewer parts to make manufacture easier and low mass (around 150kg) to make launches cheaper. It's an interesting approach and is the

best attempt to date to bring high volume production techniques to the space market.

"We are trying to redefine satellite manufacturing," said Azzarelli. "We are to mass produce the satellites, reducing costs and improving the schedules. Each satellite will cost less than a $1million. That's quite a disruptive feature to this market."

The factory in Toulouse has already been put in place to initially build the first production satellites. However, the huge barrier is getting them in to space. Is there this much capacity available for space access over the next four years?

"We are going to be deploying Soyuz Rockets from French Gianna, Baikonur, and another facility in Russia," said Azzarelli. "Each of those Soyuz rockets can fit as many as 32 spacecraft, which will be deployed over a period of 18 months. In addition to that is Virgin Galactic with their rocket and aeroplanes, which will be able to inject to orbit one satellite at a time. We have 59 Virgin Galactic Rockets and 21 Soyuz rockets available in the current contract, so the capacity is there."

The volume of data depends on the plan people or a premises sign up to, but this can vary from 10 to 150+ GB per month of data. One of the important features for the user is the signal will come no more than 50° to 60° from the horizontal, because of the polar orbit, meaning buildings or mountains that can normally obstruct coverage, will no longer be a barrier.

OneWeb is not without its own ground infrastructure requirement, however. The idea is principally about connecting consumer equipment to the satellite constellation, "through a series of user terminals that are installed on buildings or on moving platforms like trains, ships or aircraft," said Azzarelli. "The satellites are very simple, it is the user terminals that have worked out to be the toughest challenge. The technical challenge is on the ground rather than in space."

The user terminals use OneWeb's patent-pending technology to provide high speed connectivity to surrounding devices with no change in latency during satellite handovers. The terminals can be self-installed, are small, affordable and so efficient they can operate with optional solar panels, battery packs, and provide WiFi/LTE/3G and 2G radios for coverage directly to cell phones, tablets and laptops.

"OneWeb can address the most demanding global connectivity challenges and sudden infrastructure crises," said Azzarelli. "Those affected by hurricanes, earthquakes and refugee situations are often abruptly without infrastructure — OneWeb will bridge these gaps providing instantly deployable connectivity."

OneWeb said it will act as an extension to existing networks and not a replacement. Its system is designed to extend current networks into rural areas and create affordable connectivity for all. Internet access isn't just about becoming addicted to social media, absorbed by memes, or wasting time watching vines. It can, and has, changed commerce, healthcare and education – opportunities OneWeb is keen to offer to everyone.

As Euro 2016 comes to a close, we look at the engineering behind the tournaments footballs, and why the beautiful game had to be changed for a fracas. Justin Cunningham reports.

Engineering the beautiful

As Euro 2016 has come to an end, it is worth remembering the contribution that engineering has had to the beautiful game, and the most recent tournament. The Beau Jeu, French for beautiful game, was the official match ball in every group stage European Championship 2016 game in France, and was developed in partnership by sports manufacturer Adidas and materials' specialist, Covestro.

The ball celebrated a 30 year partnership between the two companies, and was made of a special polyurethane developed for the tournament, which promised to deliver, 'beautiful matches and beautiful goals'. The white surface was also decorated in the French national colours, blue, white and red.

The ball was unveiled by French legend Zinedine Zidane in November last year, and in the lead up to the tournament was well received by players, with Wales striker Gareth Bale reportedly telling the mainstream sports press, "I tested Beau Jeu in training with long shots, passes and running at pace. It performed brilliantly."

The ball was in development for 18 months and has borrowed heavily from the well received 2014 World Cup ball known as the Brazuca, which was generally loved by players. Beau Jeu still incorporates Brazuca's innovative and widely praised panel shape, but improvements made to surface texture offered improved grip and in-flight dynamics.

Players claimed it allowed them to more precisely control speed and movement of the ball,

BALL GAMES

The Beau Jeu featured a textured surface that was said to surpass Brazil's Brazuca World Cup ball in terms of grip. The design was also said to allow players more control over movement, and stability in flight. The Polyurethane also offered some surface improvements to the outer shell, which meant that when pitches were watered before the game, it improved the speed and travel of the ball, allowing faster passes and more frenetic play. All of which allowed teams to play enticing football... Apart from England of course.

game

and critically was more stable in flight. This meant it avoided some of the sudden, and random, directional changes witnessed in the last World Cup tournament.

The Polyurethane also offers some surface improvements to the outer shell, meaning that pitches when watered before the game and at half time improved the speed and travel of the ball, allowing faster passes and more frenetic play. All of which allowed teams to play enticing football.

TECH BRIEF

From polymer balls to plastic engines

Global high-performance polymer supplier Solvay will use its AvaSpire AV-651 CF30 polyaryletherketone (PAEK) to form three sections of the nearly all plastic Polimotor 2 internal combustion engine. Led by legendary automotive innovator Matti Holtzberg, the Polimotor 2 project aims to design and manufacture a next-generation, plastic engine for competitive racing in 2016. The Polimotor 2 project aims to develop an all-plastic, four-cylinder, double-overhead CAM engine that weighs between 63-67kg, or about 41kg less than today's standard production engine.

Matti Holtzberg, who is also president of Composite Castings, commented: "We found that this particular grade of AvaSpire PAEK delivered the targeted weight reduction with an optimal balance of toughness, dimensional stability and all the other qualities required to successfully withstand the rigours of the Polimotor 2's oil pump."

It will make up the external dry sump modular oil pump housing, with each of the three injection moulded sections weighing 0.09kg compared to 0.19kg for their aluminium counterparts. Though not the primary driver, replacing the entire metal housing with one moulded from AvaSpire PAEK delivered a total weight reduction of 0.27kg while meeting the desired performance requirements of the oil pump.

A 30% carbon fibre reinforced compound, AvaSpire AV-651 CF30 PAEK delivers higher strength, stiffness and fatigue resistance compared to base AV-651 grades, and enhanced weight reduction against glass fibre reinforced AvaSpire PAEK grades. The material's long term thermal oxidative stability approaches that of carbon fibre reinforced PEEK, but it delivers better dimensional stability and warp resistance during injection moulding.

Michigan-based Molding Concepts injection moulded the three net shape parts, which were then machined by Allegheny Performance Plastics, a Pennsylvania based processor of high performance thermoplastics. Greg Shoup, president of Allegheny Performance Plastics, said: "The excellent machinability of AvaSpire AV-651 CF30 PAEK enabled Allegheny to achieve the extremely tight tolerances necessary for the pump's gear tip clearance and sealing surfaces, while achieving very good surface finishes."

The outer shell was developed by Covestro engineers with materials and production techniques transferred from more industrial applications.

Thomas Michaelis, project manager for ball development at Covestro explained the process. He said: "The ball's outer shell consists of a total of five layers based on polyurethane raw materials from our Impranil line."

The underlying intermediate layer protects the ball against external influences and lends it an unusually high elasticity. Beneath that is a polyurethane foam with millions of microspheres that ensure its outstanding flight characteristics. A polyurethane adhesive bonds the top layers to a special polyester-cotton fabric that serves as a substrate.

The ball was also engineered to be durable and last the arduous duration of a vigorous match. However, during a match between Switzerland and France in the initial rounds, a ball burst open when it clashed between the feet of two opposing players. The coming together just outside the penalty box of Switzerland, and in the middle of the pitch, halted play as players and the referee gathered around in disbelief.

The match was eventually restarted by Switzerland, which ended in a goalless draw. However, this bizarre and unusual event was not something FIFA or fans wanted to be repeated in later rounds.

New design unveiled days after

Whether connected to the burst ball incident or not, FIFA unveiled a new ball by Adidas just days later that would be used as teams entered the knock-out stages of the Euro 2016 tournament. It was the first time multiple ball types have been used in a European Championship.

The new artwork features what Adidas call a 'more disruptive' red and black design to the clean lines of its predecessor. The ball known as 'Fracas' was said to be have been launched to reflect the excitement of the "winner-takes-all" mentality of the tournament's latter stages, though it was unclear exactly what changes to the material properties had taken place… if indeed any.

Sam Handy, vice president of design at Adidas Footballs said: "For Fracas, we wanted to be bold with our design direction and create something that incorporated the emotions felt during the latter stages of tournament football.

"Beau Jeu was all about tactical football; doing what you had to do in order to get to the knock-out stages. Fracas is a more disruptive design. It represents the noise of the crowd and the excitement around a winner-takes-all mentality on the pitch."

Simplifying 3D print simulation

For technology to be useful, it must be accessible. An example is a metal 3D printing process that, thanks to simulation, may find many more applications. Tim Fryer found out more.

Additive manufacturing covers a multitude of processes, and the notion of being able to create a 3D design, press the print button and get a perfect model from your printer is not always going to be the case. A particular example is one of the more recent variations of 3D printing – Shaped Metal Deposition (SMD).

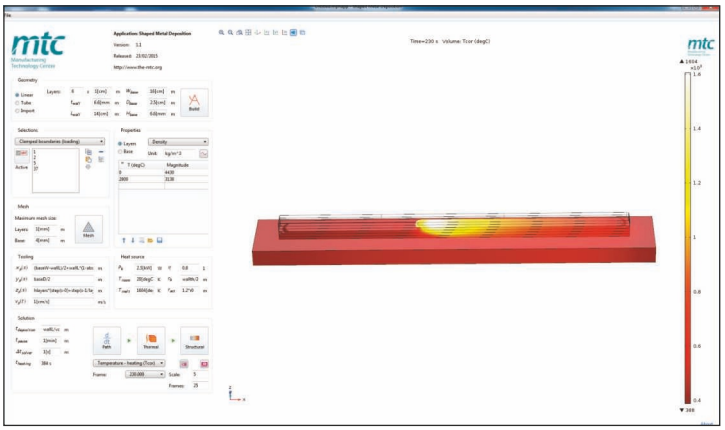
SMD is a process that requires heat. It is usual that metal changes shape when its temperature varies. Therefore, the designer of the printed part not only needs to consider the shape that is intended to be printed, but also any changes associated with temperature variations. This is not a straightforward task, and it is one that has been the focus of a project at the Manufacturing Technology Centre (MTC) in Coventry.

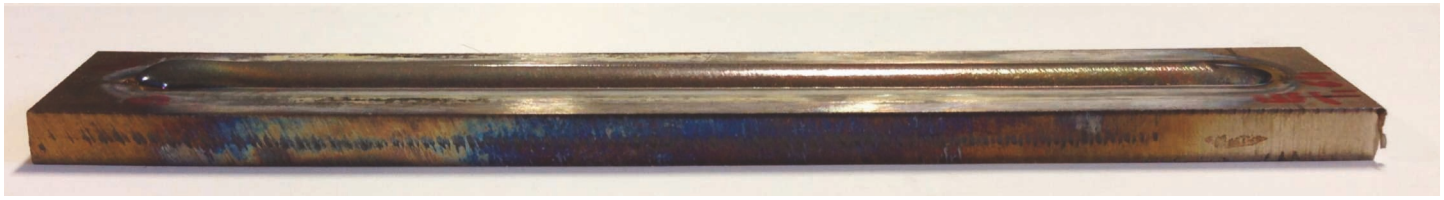
"SMD has multiple advantages over powder-based additive manufacturing technologies," said Borja Lazaro Toralles, an advanced research engineer at the MTC, with a specialism in simulation and modelling. "Among the benefits of SMD are higher deposition rates, the possibility of building new features upon preexisting components, or even the use of multiple materials on the same part."

Unlike other additive manufacturing techniques that use lasers to melt a thin layer of powder, SMD deposits a sheet of molten metal that is built up layer-by-layer on a surface. It is essentially welding a continuous piece of wire into a certain shape. It is a process that was originally developed by Rolls-Royce, but in its formative years, SMD was a process that was too difficult to control, required a lot of intervention from skilled technicians and the material properties were not well understood.

More recently organisations such as the University of Sheffield's Advanced Manufacturing Research Centre (AMRC) have progressed the technology to the point where it is commercially viable – offering savings in product lead times, reducing inventories, reducing waste (as there is little or no machining), while reducing overall cost of manufacturing by an estimated 40%.

However, SMD is still a process that can throw up problems. "One of the challenges of





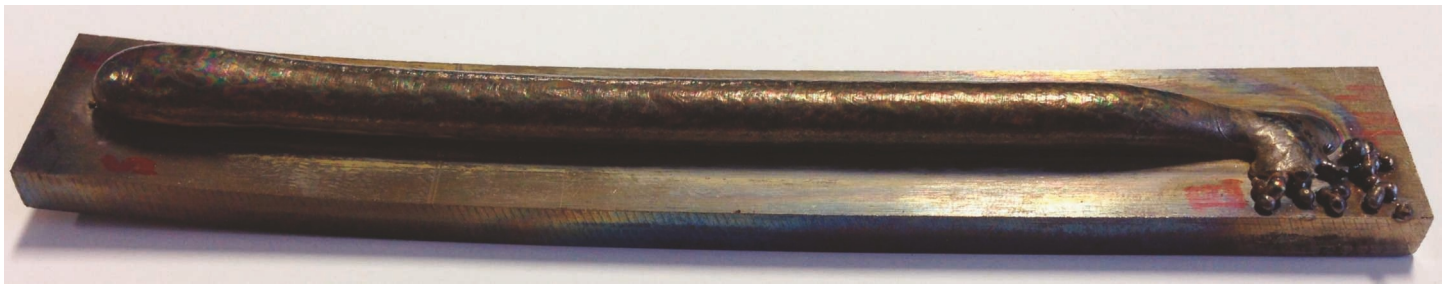


Figure 1. Top: Simulation of the SMD part. Middle: The part after just one deposited layer, with no noticeable deformation. Bottom: After six deposited layers, deformation is visible to the naked eye

this is that thermal expansion of the molten metal can deform the cladding as it cools, resulting in a final product that is different than what was anticipated," said Lazaro Toralles. "In order to predict the outcome of a proposed design, we need either to minimise the deformations or alter the design to account for them."

The start of the project looked at a simple rectangular substrate, but building a straight wall resulted in some deflection in the substrate. The objective was to provide a means to assess how to reduce that distortion without having to conduct hundreds of experiments, with all the associated material, time and cost.

"We developed this model, using simple rectangular geometry, which is representative of the process and the distortion," continued Lazaro Toralles. "We then packaged this model in a simulation app. This means engineers can go away and use more complicated geometries to reduce their number of experimental iterations."

The MTC team comprising (L-R) Adam Holloway, Borja Lazaro Toralles and Willem Denmark

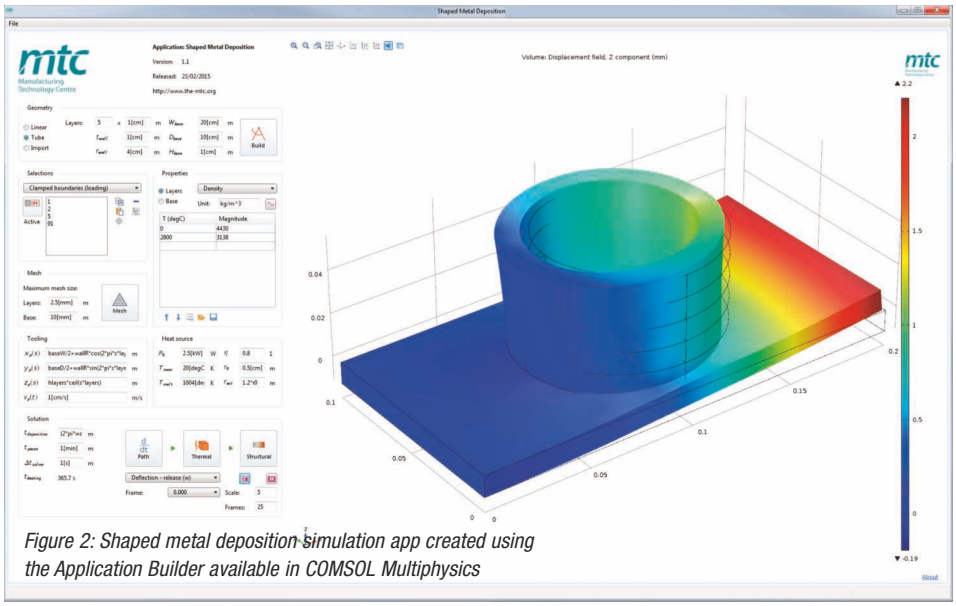


Figure 2: Shaped metal deposition simulation app created using the Application Builder available in COMSOL Multiphysics

Figure 1 shows an example of a part manufactured using SMD, where deformation occurs after six layers of deposited molten metal have been added. A model of the part, also shown in Figure 1, is used to predict the part's deflection during manufacturing, allowing the designer to update the design accordingly.

The role of the MTC is to progress its customers' technologies through the Technology Readiness Levels (TRL), typically taking projects on at TRL 3 or 4 and taking them through to TRL 6 to 7. In this case, developing the technology is one aspect of the development, the other is making it useable.

Simulating the behaviour of SMD models was created using COMSOL's Multiphysics software, but to make it useful to engineers it needed to make it accessible. Engineers want to know how their designs will turn out if produced on an SMD machine, but they are not necessarily experts in creating complex simulation models. In other words, an easy to use interface was required, and for that the simulation team turned to COMSOL's Application Builder.

Intuitive interface

The MTC leveraged the Application Builder in order to more efficiently communicate complex design ideas across multiple simulation and process departments, and to allow app users to easily explore the outcome of proposed designs (see Figure 2). Were it not for the simulation app, the testing and validation of a design would be significantly more time consuming and costly if using physical testing alone.

Simulating SMD involves solving a time-dependent model coupled with thermomechanical analysis that predicts residual thermal stresses and deformation, which arise from SMD thermal cycles.

"We built an app using the Application Builder to allow the users to predict whether the deposition process will produce parts that fall within established tolerances," said Lazaro Toralles. "If not, then the app provides a user friendly and cost efficient way to simulate multiple variations to the input until the results achieve an acceptable final deformation."

With this app, users can easily experiment with various geometries, heat sources, deposition paths, and materials without undue concern for the underlying model complexities. Two predefined parametric geometries are included in the app, and a custom geometry can also be imported.

Currently, the app is being used by members of the team at the MTC who do not have the simulation experience to independently explore different parts and projects for their customers. "Were it not for the app, our simulation experts would have to test out each project we wanted to explore, something that would have put a strain on skilled resources," claimed Lazaro Toralles. "Using the Application Builder, we can provide user-friendly app interfaces to other MTC teams.

"It democratises simulation, because it makes it available to more people who are not experts in simulation, or who have not been trained to use simulation tools. The simplified interface allows users to focus on the inputs and outputs instead of the simulation [program's complexities]."

The MTC will offer an app program for their customers in an effort to make powerful, but complex, multi-physical simulation available to more engineers. "The use of simulation apps will help us to deploy technologies at higher TRLs for their practical use in an industrial environment," Lazaro Toralles concluded. "The Application Builder provides us with a powerful development platform through which we can package complex multiphysics models and make them accessible to the wider public."

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Gaming drives **automotive design**

The automotive industry is turning to video game companies to improve the design and manufacture of vehicles. Tom Austin-Morgan attended the launch of the Digital Engineering and Test Centre where big announcements were made about the pair's future synergy.

The rise of electric and hybrid vehicles is changing the way cars are being designed, made and sold. Instead of focussing on 0-60mph as a measure of performance, miles per gallon has become the standard to which vehicle performance is measured and, looking to the not too distant future, battery life and range will be the figures to compare.

To this end, demands on designers are continuing to increase. Chassis, human machine interface (HMI) and communications design will be growth areas with an increasing trend towards connected and autonomous vehicles, a market tipped to be worth £51billion by 2030. Newer, more efficient engines also need to be manufactured for lorries and other service vehicles as these are too heavy to run on electric motors alone.

Speaking at the launch of the Digital Engineering and Test Centre (DETC) at Loughborogh University's London Campus, Jon Horsley, DETC programme director said: "We are anything but an industry of the past."

Leaders from the automotive and gaming industries convened at the launch of this joint venture between industry and academia to give an overview of the project.

"The UK automotive industry employs 800,000 people making 1.7million vehicles, 2.4million engines, and 77% of all the cars made in the UK are exported abroad," added Horsley. "It is a myth that the UK doesn't make anything anymore. The modern industry is at the cutting-edge of digital technology."

The idea behind the DETC is not just to design new products, but also explore new manufacturing processes, new ideas and new technologies from outside the automotive industry. As consumers demand a greater number of variants from manufacturers, the industry needs to respond by finding more efficient product design processes and flexible manufacturing techniques.

Solutions developed in the gaming industry are opening up a new world of opportunities for cross over with the automotive sector. Numerous breakthroughs are being made with collaborative projects between the two sectors and one of these is virtual reality.

Horsley added: "Systems are going to get more complicated, with testing and validation equally getting more complex. We need to look again at the way we test, verify and validate to see if there is a better way of doing things. The DETC is looking to bridge the gap between gaming technologies and digital engineering by utilising their software platforms and high power computing, and help them realise the business benefits of being engaged with the automotive industry."

Gaming boost

Epic Games started out in Maryland in 1991 and by 1998 had developed the first Unreal Engine (UE) used to design and run 'Unreal', a 3D first-person-shooter for PC and Mac. The subsequent four versions of UE have been used by many other companies to develop hundreds of titles over

Traditional design processes, including modelling in clay (below) are moving to ever more portable devices with more sophisticated software

the last eight years. As of March 2015, Unreal Engine 4 (UE4) – and all of its tools, features and complete C++ source code – is available for free with a royalty of 5% of gross revenue of any commercial product built using UE4 being paid to Epic rather than being leased out for millions per project. This has opened up opportunities for UE to be used in other markets.

Mark Rein, vice president of Epic, said: "We wanted people to use the Unreal Engine for more than just game design. Companies like McLaren, BMW and Tesla came to us wanting to use Unreal to create a realistic car model."

He explained that carbon fibre, for example, with its base layer of plastic or resin, carbon strands and clear top coating reflects light in different directions. This meant developing a way to recreate sub-surface scattering to make it look realistic. "Cars are something we interact with all the time, you know when it looks right and when it looks wrong," he added. "In order for our engine to reproduce the most lifelike materials that go into cars we had to create a whole materials library."

McLaren is one UK manufacturer that used UE4 to design its latest sports car, the 570S. The initial designs for its cars started off very traditionally, with designers making pencil sketches. These are then refined through computer aided surfacing to see what works and where the designers will have to compromise to bring the car to completion.

"McLaren's design studio is very small and thus has to be flexible, aiming to hit the fastest, tightest timescales," said Mark Roberts, McLaren's design operations manager. "Designs are displayed on a full-size power wall to give designers and engineers a feel for the ride height and exactly where the interior details will be located by being able to walk up to it."

The next stage in McLaren's design process is making clay models; a full-size interior and a 40% scale model of the exterior where the designs will be refined until a full-sized model can be made, typically using 2.5 tonnes of clay. This whole process takes about a year.

"Working closely with Epic, using the Unreal Engine and the HTC Vive virtual reality headset and tactile gloves, this has all changed for us in the last few months," explained Roberts. "Believability is key, if the designers believe what they see when they're sat in or walking around the virtual car, they can make confident design decisions. That comes down to the quality of the rendered image that they're seeing. The high-fidelity real-time rendering of the Unreal Engine is helping us do that."

McLaren and Epic are building powerful visualisation tools not just for the marketing of the car to customers, who are able to view the car on a device and change everything about the car, but also for the very beginning of the design process; so as soon as the sketches go from 2D to 3D the tools will help the designers to start creating in the virtual world.

"It's going to complement the process we have at the moment, it won't replace it for a long while, we still need the physical models," continued Roberts. "But it's really going to help us speed the process and it gives the designers such confidence in what they do. They can take a cast model and view it in the nearest thing as possible to the real world."

Although gaming seems a million miles away from automotive design, it is leading the way in terms of capability in design software. There are huge opportunities for collaboration between the two industries to save time and money in the design stages as well as time to market.

The collaboration between two seemingly different technology sectors is likely only to increase in coming years.

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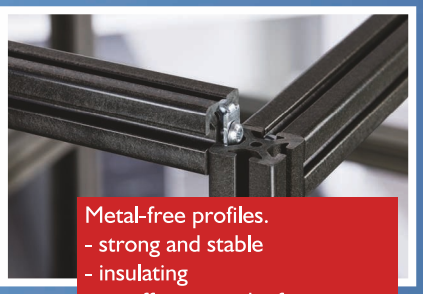

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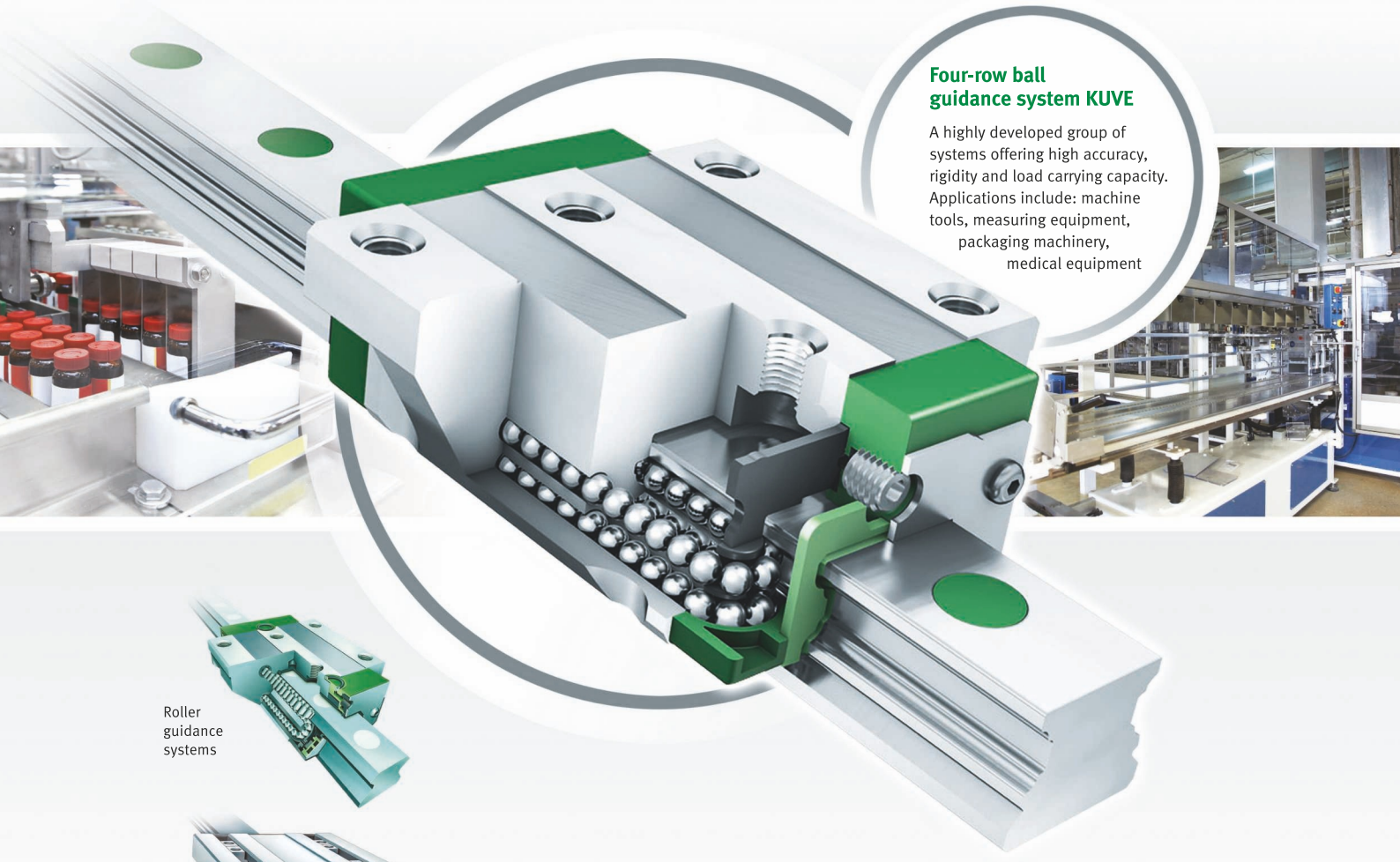

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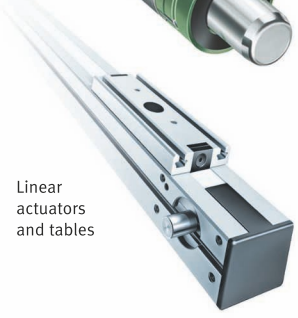

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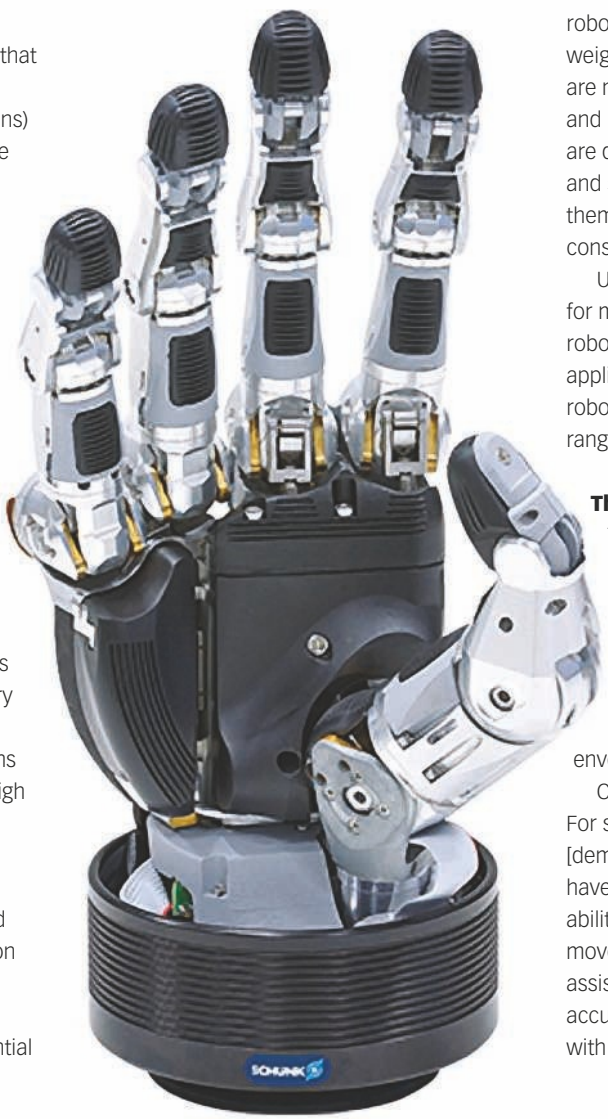
Smooth moves for **service robotics**

For robotics to progress, particularly service robots, electric actuation needs to step up to the plate. Here, *Eureka* looks at why this is and at contending technology solutions.

The efficiency and convenience of electrical actuators is driving a global trend away from hydraulic and pneumatic actuation. Innovative mobile IoT devices such as wearable bionics and service robots reinforce this trend, generating requirements for more capable electrically powered motion control that is reliably effective in unpredictable environments (such as those involving humans) and is more sustainable. Whereas most of the technologies needed by service robots are readily available as a result of mobile phone, automotive and other consumer driven developments, actuation remains the critical exception. Lack of highly capable and versatile motion control is a significant issue with potential to delay growth in the service robotics market.

Above left: Robotic applications in industrial environments are better established
Below: The Schunk five-fingered hand



Electric actuators

Today's state-of-the-art electric actuators typically consist of a planetary roller screw for linear and a harmonic drive for rotary transmission, both developed in the 1960s. The transmission converts the torque of the motor into forceful motion. Leading examples include Exlar linear and Harmonic Drive rotary actuators.

However, there are fundamental limitations with these electric actuation technologies. High efficiency is limited by friction in the transmission, particularly at low torques and only achieved over a narrow dynamic range. Thick lubricants further reduce efficiency and increase costs. Use of a separate transmission adds significant cost, weight, bulk and noise. Complex construction methods increase manufacturing cost and jamming risks. Potential to jam prevents the use of roller and ball screw actuators in important safety critical applications such as aerospace.

Typically, actuators perform specific tasks in controlled environments. They power industrial robots on production lines, where size, noise, weight, power consumption and maintenance are not critical and use cases are well specified and predictable. Constraints on how actuators are deployed are so significant that products and systems are generally designed around them – an unacceptable constraint for consumer products where appearance is key.

Unsurprisingly, there is immediate demand for more capable electric actuators for service robots, for both consumer and industrial applications. In contrast to traditional industrial robots, service robots face an unpredictable range of use cases.

The actuation challenge

To complete tasks successfully in dynamic real world environments, they need reliable motion control over a far broader dynamic range. This is an actuation challenge. The market-leading Schunk five-fingered hand uses nine motor and transmission pairs within the hand envelope to achieve baseline performance.

Consider tasks involving human interaction. For safety, a robot co-working with a [demanding and unpredictable] human must have highly controllable motion with a failsafe ability to avoid any person in its path and to move with appropriate speed and force. Robotic assistants in the home will also need smooth, accurate, relatively slow but forceful motion with back-driveability for human compatibility.

A UK technology company, WaveDrives, has recently completed a fundamental re-design of the electric actuator with the initial aim of addressing challenges in bionics. The result is an electric drive technology with tight integration of electric motor and frictionless gearing in a power dense, efficient and streamlined package.

To be acceptable to the wearer, actuation in a bionic limb must be unobtrusive (light, quiet, streamlined, fit within the limb envelope, provide realistic motion) and be reliably powerful and responsive (acceleration and speed).

Service robots must also be low maintenance and, as for all mobile devices, highly efficient over the full dynamic range is vital. Batteries are heavy and daytime recharging may be inconvenient and/or problematic. Efficiency also enables back-driveability, essential for leg free swing and a normal gait. Similar requirements arise when designing exoskeletons for supplementing, extending and recovering the human physical condition.

These characteristics are all exhibited by human muscle and it is clear that bionic devices and many service robots will need 'muscle equivalent' actuation if they are to meet consumer needs and catalyse wide-scale adoption. The EU Framework 7 project 'Viactors' (2009 - 2012) found that "actuator performance is perhaps the main limitation … on commercialisation of 'human friendly' robotics". This can be extrapolated to many mobile and safety-critical devices such as the next generation of connected, interoperable, actuated products to enable our aging population to live well and independently for longer.

Applications

Similar actuation needs are found in established markets where many of the dull, dirty and dangerous tasks identified as early targets for service robotics are currently performed by humans – supported by automated tools, which depend on electric actuation.

In aerospace there is a strong economic case for an all/near electric plane but safety considerations prevent the use of electro-mechanical actuators such as ball and planetary roller-screws for primary flight control surfaces as these can jam, blocking any fall-back system. Other logistics applications include electric cars, trains, agriculture, marine and mining.

Precise motion control is also key to many life-saving medical devices. Safety, reliability, accuracy, quiet operation and the ability to fit within constraints imposed by co-operating medical systems are pre-eminent concerns in this rapidly evolving market. In keyhole and telehaptic operations, the need for greater actuator force sensitivity (linked to back-drivability) is certainly a barrier to progress.

Can science offer solutions to bridge this gap? The limitations of existing electrical actuators, especially for bipedal walking applications, were noted in the seminal work on electromagnetic series elastic actuators (EM SEA) at MIT in the 1990s. This showed that incorporating a mechanical series elastic component aids actuator robustness, shock tolerance and force control.

However, MIT was less successful with a muscle-equivalent electro-mechanical actuator - using EM-SEA's, which clearly resulted in inefficient operation outside resonant frequencies. More recent research from MIT's Biomimetic Robotic Lab has recognised EM-SEA's may only be relevant to low-bandwidth applications, highlighting that the increase in actuator complexity detracts from practical applicability. A current focus of scientific attention is electro-hydraulic actuation, with increasing sophistication enabled by advances in 3D printing. Although inefficient, these hydraulic actuators deliver high dynamic performance and power density.

A UK technology company, WaveDrives, has recently completed a fundamental re-design of the electric actuator with the initial aim of addressing challenges in bionics. The result is an electric drive technology with tight integration of electric motor and frictionless gearing in a power dense, efficient and streamlined package. The WaveDrives electric cylinder has one moving part, is virtually silent in operation and requires no lubrication due its contact-less transmission. A low part count and simple construction make it robust and dust-tolerant. Possibly most significant for the growth of service robotics, this technology exhibits high efficiency and back-driveability at low speeds and high gearing ratios - breaking electro-mechanical actuator limitations to deliver the performance of human muscle, with greater efficiency. Initially constructed as a linear actuator with a size and power appropriate for a human thigh, other sizes and rotary formats are in development.

WaveDrive efficiency, reliability and high force at low speeds is attracting interest from new product and technology development programmes. Its potential to match electro-hydraulic systems' high dynamic performance and power density will soon be tested. Whether this device can disrupt the market is yet to be seen but the race to offer more efficient, highly capable and reliable electric motion control for service robots and other actuated devices and systems is well underway.

Information provided by Jill Burnett, Craig Fletcher & Dr Graham Whiteley of WaveDrives Ltd.

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Not so plain bearings

There is not much to think about when designing in a plain bearing – or is there? Tim Fryer found out that bearing technology is moving on and opening up new possibilities.

Such is the nature of the plain bearing – a piece of material to wrap around a shaft – that engineers can become familiar and reuse a particular part.

"You have a commodity element where people are used to using these types of bearings and they know where to use them," said Paul Mitchell, MD of Bowman International. "It's when you have someone who's maybe not used to using it or the application is something they're not designed for, that's when they need to ask about the right material or bearing style. There are many more options to go for in plain bearings than there are for rolling elements. It's more important that you get the right one for the right application."

The problems come when the same bearing is being relied on when the applications start to become more demanding – the loads get bigger or the speeds get faster.

Mitchell observed: "There's a limit to that bearing. You use it in an application that works, and then another one. But then you start to push the boundaries and you can get problems."

Problems in the bearing represent problems in the system. It is quite often the most important part of a system in as much as it is the part that keeps everything running.

"As we are developing materials or developing people's knowledge of applications, they can be the better option [compared to roller bearing] as well as maybe a more cost-effective option," added Mitchell. The guiding principle for an engineer is that the bearing is the wear element – the shaft must be made of a harder material than the bearing. It is therefore important that before the bearing is specified the shaft material and its properties are known. Having a bearing material made of the hardest available material is going to be counterproductive if it results in the shaft being damaged.

Testing the latest bearing materials

The main parameter when specifying plain bearings is the pressure velocity ratio (PVR), the relationship between load and speed, which can give an indication of the wear that is likely. It does not tell the whole story however, as Mitchell explained: "There are all sorts of lifetime calculations which, because you've got a shaft that hasn't been rated by ourselves and might be of different materials, is running against the bearing and there's a huge variable," he said. "So it's educating customers to use the right shaft, it's as important as the bearing to get the shaft material right. After that we primarily look at the load and speed, the type of load – is it an intermittent load, is it a continuous load, is there a shock load? There's all sorts of factors within the load and with speed as well."

Other factors that come into consideration are the coefficient of friction and the lubrication in the system.

It is clear from the above that no single bearing

There are many plain bearing options - the trick is picking the right one rather than the usual one

technology is going to be suitable for all applications. In fact, despite the company's claims that its latest BowMet bearings are 'the biggest advance in plain bearings in over 70 years', Mitchell admits it is not the best solution for every application.

However, it is significantly harder than ordinary bronze bearings and can accommodate four or five times the loading. The ToughMet material that these bearings are made from is a spinodal bronze, a structure that allows a very high nickel content of 15%. Most bearings have a PV of between 1.5 and 3, bronze is about 2. ToughMet is at 9.6.

"It is very useful in high-load, low-speed applications," claimed Mitchell. "For example in construction, mining, marine, on crane systems, on diggers, on conveyance systems. There's lots of applications in these of high stress applications because it's harder, it's very resistant to ingress of materials. You can imagine if you've got sand or coal dust getting into the system, it's going to be very abrasive and destroy the bearing in no time. So if you've got a material that's significantly harder, more resistant, but still has the bearing properties that a bronze-based material gives you, then it has to be an advantage. And it's proven to be."

There are other options that broaden the capabilities of the bearing. As an example Bowman's Oilite range that has oil impregnated into the structure of the surface to act as a 'lubrication for life'.

Mitchell added: "We have other bearings where you have PTFE coatings, acetyl linings, bronze coatings – all manner of different bearing materials which can be all the way through the thickness of the bearing or lining.

"But we tend to look at the base materials as much as anything. If we can improve those base materials, it puts less reliance on other lubrication or surface treatment innovations because they tend to be only adding very small percentages and they tend to be even more application-specific as well."

Such have been the recent developments in plain bearings, Mitchell said that they have increasing applications in place of the more sophisticated roller bearing.

"That's a market for looking at when using plain bearings can improve the design and improve the way that it can functions," he concluded. "On top of that there's always developments in, say, packing composites and things like that. There's people coming up with new materials and then there's supplementing all of those with new technologies like additive manufacture and laser printing, and we're looking at those as well within our designs."

Braking on the **double**

In the world of haulage there is a never ending quest for fuel efficient, lower cost and more reliable operation. Tom Austin-Morgan reports on a secondary braking system that addresses these issues.

Hilko Schmitt, Jacob Vehicle Systems' (JVS) business development manager, Europe, said: "Since the 1970s there has been an average reduction in fuel consumption of 30% while the average speed of trucks has increased by 30%."

Modern trucks are heavier and faster, but have smaller engines with lower rpms, better aerodynamics and reduced rolling resistance due to better tyre quality and improved lubricants. So how do you stop the service brakes from overheating or fading?

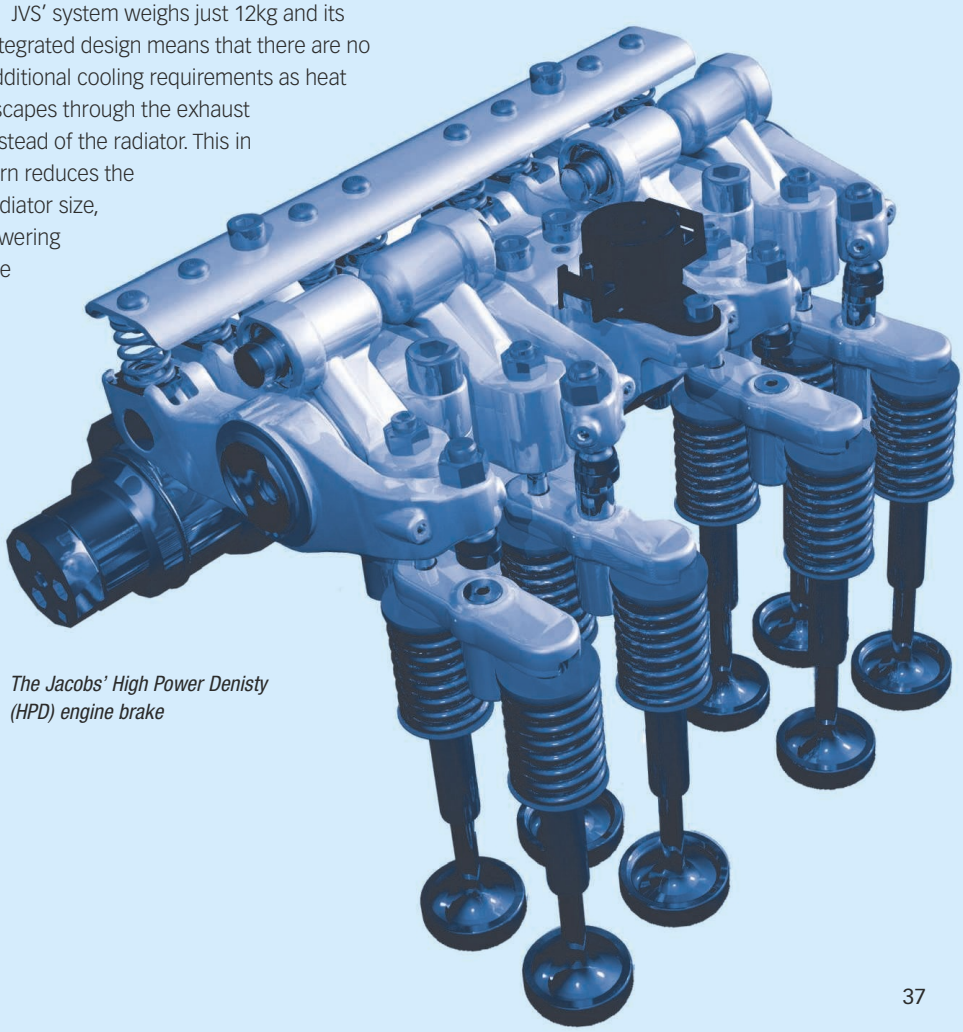
The latest version of JVS' compression release engine brake technology, the High Power Density (HPD) Engine Brake for heavy goods vehicles (HGVs), is a secondary braking system that controls the power output of the engine to allow smoother, more controlled slowing of the vehicle. The system can be activated both by the driver, via a lever on the steering column, or the vehicle's ECU and interfaces with other key systems within the vehicle, including the electronic stability program, adaptive cruise control, road speed limiter, ABS and transmission related functions.

As well as helping increase efficiency over comparable technology, such as driveline retarders, by delivering controlled slowing after the driver's foot comes off the accelerator, the HPD system also helps to control the speed of the vehicle at low speeds, when going downhill for example.

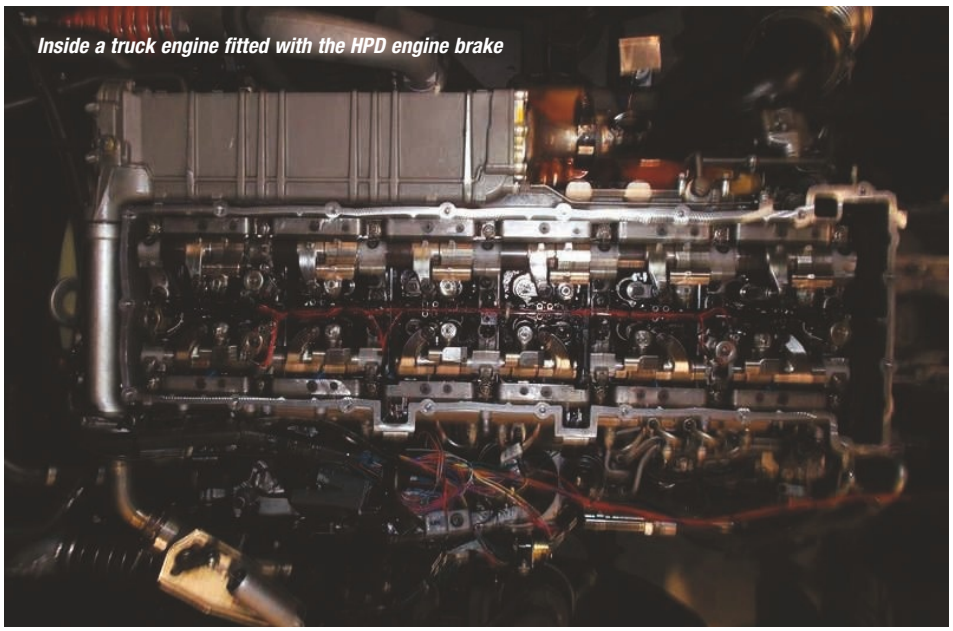
There is significant market potential for JVS' HPD Engine Brake in Europe, where Jacobs' compression release engine braking has already been adopted by Daimler, Renault, DAF, Deutz and Volvo. The majority of European trucks still use hydraulic driveline retarders, which are dependent on vehicle speed for effectiveness, and typically weigh 175kg.

JVS' system weighs just 12kg and its integrated design means that there are no additional cooling requirements as heat escapes through the exhaust instead of the radiator. This in turn reduces the radiator size, lowering the overall weight of the truck, which reduces drag and, ultimately, fuel consumption.

Sergio Sgarbi, president JVS, commented: "The Jacobs HPD Engine Brake can cope with lower speeds, eliminating the need for a driveline retarder and becoming the primary



The Jacobs' High Power Denisty (HPD) engine brake



Inside a truck engine fitted with the HPD engine brake

choice in secondary braking."

As Jacobs' HPD Engine Brake uses standard components that are neither heavy or expensive, it also offers a cost advantage. JVS says that total cost of ownership will be €3500, a fraction of the price of hydraulic retarder devices, and it delivers an average return on investment in six months compared to two-and-a-half years for hydraulic retarder devices. However, the company could not provide an exact pricing level as that would depend on the individual customers' engine and the level of integration required.

The HPD Engine Brake achieves the same retarding performance at 1200rpm as previous-generation engine brakes did at 2100rpm. That translates to a 100% increase in engine braking power at cruise speeds. This also means improved slowing times and reduced stopping distances: a heavily-loaded truck can be slowed from 56 to 43mph in 30% less time and distance with reduced brake wear.

The system is claimed to provide one and a half times the braking performance of traditional compression release braking over the engine's entire operating range and more than two times the braking performance at lower rpm. It consists of two dedicated rocker arms and two collapsible bridges per cylinder, which enables a second braking event during each engine cycle.

"The air enters the engine via the turbocharger compressor to the intake manifold. The air entry into the cylinder is timed by the intake valves," explained Tom Howell, director of New Technology at Jacobs Vehicle Systems. "The kinetic energy of the vehicle turns the crankshaft via the transmission which forces the piston up in the cylinder compressing the air that has been trapped by the intake valves.

"When the piston reaches the top of the stroke, the exhaust valves are opened which allows the hot compressed gas to be released into the exhaust manifold. Some of the energy in the gas is used to drive the turbine of the turbocharger, while the remaining energy is expelled as hot gas through the vehicle exhaust. By making the engine into a two stroke retarding machine, it not only doubles the number of retarding compression events, but also enables the turbocharger to provide higher pressure intake air which increases the amount of compression for each piston stroke, particularly at low engine speeds."

To achieve this innovative method of getting twice the amount of pressure into the system, the design process is heavily driven by simulation. The design team used GT Power for engine performance simulation, PTC's Creo for CAD, Ansys for FEA as well as a number of custom programs.

Howell explained: "One big challenge is packaging, because there are multiple components packed in with a lot of pressure in the system. We have to make sure all the components are strong enough to take those stresses and that the level of wear is acceptable, what an acceptable level of contact stress on the camshaft can be, and how good the lubrication is. As this is relatively difficult to gauge we'd move on to a test rig, fatigue rig, hydraulic rig and after all these stages we'd be ready to test a full engine."

Final test

At this stage, the next test is durability; the engines are run non-stop, switching between accelerating and braking every 30s for 25 hours for initial testing on new technologies, 300 hours for production designs. The results of these tests will then be verified by the OEM purchasing the system. Finally, fleet tests will be carried out where the system is installed into actual trucks.

There is growing interest in driverless technology, and HGVs are no exception to this with trials of lorry 'platooning' due to take place on stretches of the M6 in 2017, according to The Chancellor of the Exchequer, George Osbourne's Budget in March 2016. Could the HPD braking system be used in this application? Howell said that the company isn't looking to implement it into driverless lorries at the moment, however, he added: "There is certainly a benefit for OEMs by doing this. It would better regulate the cruising speed of platooning trucks. Though each system would have to be set up differently to combat the effects of reduced air resistance with successive trucks in the platoon."

Looking to the future JVS wants to optimise the system further to provide a consistent retarding torque across the entire rpm range. The HPD Engine Braking system should be available in 2017.

Rupture relief in small systems

Rupture disks have been a good way for providing overpressure safety, until systems started getting too small. *Eureka* looks at a potential solution to the problem.

For more than 85 years, the rupture disk has served as an effective passive safety mechanism to protect against overpressure or potentially damaging vacuum conditions in tanks and other enclosed vessels. However, as these pressure relief devices become increasingly miniaturised to sizes as small as 1/8in to meet the demands of a new generation of smaller, lighter applications, the industry is running squarely into design and raw material challenges that often require re-engineering the product itself.

Fortunately, leading manufacturers have embraced this challenge with novel structures and design elements that have led to a new category of miniaturised options from 1/8in to 1in at all ranges of pressure - low (15-1000 psi), medium (350-16,000 psi) and high (1,500-70,000 psi).

The beneficiaries are expected to be equipment manufacturers and design engineers currently developing the next generation of aircraft safety systems, fire suppression systems, lithium batteries and battery packs, cryogenic systems, bioreactors, refrigeration systems, chemical systems, and hydraulics.

When it comes to pressure relief devices, the two most common are safety valves (reclosing) and rupture disks, also known as bursting discs (non-reclosing). Rupture disks are designed to fail within milliseconds when a predetermined differential pressure, either positive or vacuum, is achieved. The device has a one-time-use membrane usually made out of various metals, but also exotic alloys and graphite.

In many applications the superior leak tightness and flow characteristics of a rupture disk are preferred over safety valves, which are known to leak. In fact, it is a common industry practice to install a rupture disk on the inlet side of a safety valve to economically protect against corrosion and provide the required leak tightness.

In traditional applications, rupture disk sizes ranged from 1- 6in, with sizes up to 60in for the largest piping configurations. To install the product, the rupture disk is placed in a holding device, called a safety head, and installed between flanged pipe ends.

However, as equipment manufacturers strive to make their products smaller and lighter, the rupture disk industry has been challenged to deliver options well under 1in diameter.

Miniature reverse buckling rupture disk

Due to a delicate balancing act between the shrinking diameters, a complicated choice between two rupture disk design philosophies, the limitations of the specific raw materials utilised for the membrane, and the variations required to meet the requirements for low, mid and high burst pressures have forced rupture disk manufacturers to the drawing board.

The first major decision when selecting a rupture disk of any size is the choice between forward-acting and reverse buckling technologies.

In the traditional forward-acting design, the loads are applied to the concave side of the disk. The thickness of the raw material employed and the diameter of the fitting in which it is mounted determine performance.

However, with this approach the rupture disk is prone to metal fatigue caused by aggressive cycling and operating conditions that can limit its operational life. Traditional rupture disk technology is additionally limited to applications having an operating to burst pressure ratio of 75% or less to avoid fatigue leading to unwanted activation.

Exacerbating the issue, forward-acting miniaturised disks with low set pressures require the use of tissue paper thin raw material that is fragile and prone to leakage when assembled.

This has caused a somewhat negative view of this type of disk even though it is still utilised in many static pressure applications and suffices for certain high pressure applications.

In a reverse buckling design, on the other hand, the dome is inverted toward the source of the load. Burst pressure is accurately controlled by a combination of material properties and the shape of the domed structure. By loading the reverse buckling disk in compression it is able to resist operating pressures up to 100% of minimum burst pressure even under pressure cycling or pulsating conditions. The result is greater longevity, accuracy and reliability over time.

However, miniaturisation of reverse buckling technology presents its own unique challenges, according to Geof Brazier, managing director at BS&B Safety Systems' Custom Engineered Products Division. He said: "As burst diameters decrease it becomes increasingly difficult to design a reverse buckling dome that will reliably collapse through such small orifice sizes.

"In many ways it can be like trying to fit a camel through the eye of a needle."

To resolve this issue, BS&B has created novel structures that control the reversal of the rupture disk to always collapse in a predictable manner.

This includes, for example, a hybrid shape that combines reverse buckling and forward bulging characteristics that are pre-collapsed. In this type of design, a line of weakness is typically placed into the rupture disk structure to define a specific opening flow area when the reverse type disk activates. Small nominal size rupture disks can also be very sensitive to the detailed characteristics of the orifice through which they burst, causing normal variations in holder support machined part dimensions to have an unwanted impact on burst pressure accuracy.

"With small size pressure relief devices, the influence of every feature of both the rupture disk and its holder is amplified," explained Brazier.

For miniaturised products 1/4in and up certified for high burst pressures up to 70,000 psi, BS&B manufactures the rupture disk and holder from a single piece of material, eliminating the usual connection between a rupture disk membrane and its support fitting. The rupture disk is intrinsically leak-tight by virtue of its unitary construction.

The devices are typically threaded, but are also available in configurations for welding, soldering, or crimping based on the application conditions and leak tightness requirements.

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An artist's impression of engineering

Do you look at the details or the big picture? Probably both, but what can you learn from artists about training your brain to be more creative in its thinking and reasoning? Justin Cunningham finds out.

Innovation is something every engineer is tasked with, but what exactly is it? Many would put it down as some kind of change to a design or process that adds more value than cost. But isn't innovation about solving problems better today than you did yesterday?

Broadly speaking, there are two overarching methods to solving problems. Some are more analytical and look for steady improvement, while others are more creative and try to find more revolutionary step change ideas. Everyone is different, of course, and usually these approaches are moulded together in different ratios that are unique to the individual and problem in hand.

First though, let's delve a little deeper into the mind. The brain is split in to a right and left side. The right side is emotional, imaginative and tends to look at problems as one big picture. The left side of the brain, by contrast, is analytical, logical, and is all about breaking problems down by looking at the details.

Now, many prospective engineers indulge the left side of the brain in their formative years by learning about maths and science, and perhaps the process of making things in lessons like design and technology. But these individuals are not usually met with advice like, 'you should do some creative subjects, like art, if you want to be an engineer'. So should they?

Many engineers have had to cultivate and nurture a creative problem solving skill once reasonably established in a career. So what is it to, 'think outside the box' and what makes great innovators?

Artist or engineer

Artist turned robotics engineer Phillip Norman is perhaps as well known for his magazine and newspaper caricatures as he is for his modular robotics platform. As a trained painter and sculptor he recalls seeing engineers at university as geeky anoraks. His initial view falls in line with the general perception that engineering is less about creativity, and more about applying logic, science and maths.

"I've changed that view," he said. "I've met a lot of brilliant engineers and they are all hugely creative people. Great engineering projects are every bit as creative as anything an artist might create."

Creating unbalance between the right and left side of brain is something we all do on a daily basis, often without ever really knowing it. This can be in the shower, talking a walk, exercising or listening to music. Archimedes' apparently achieved his breakthrough by taking a bath.

"To lead a balanced well-adjusted life we need the left and right sides of the brain to constantly communicate and live in equilibrium," said Norman. "But actually, a bit of disequilibrium between the two can be a useful thing. It allows the creative side more freedom to do just that, create."

It is the classic technique of taking a step away from a problem, and distracting yourself in an activity that let's

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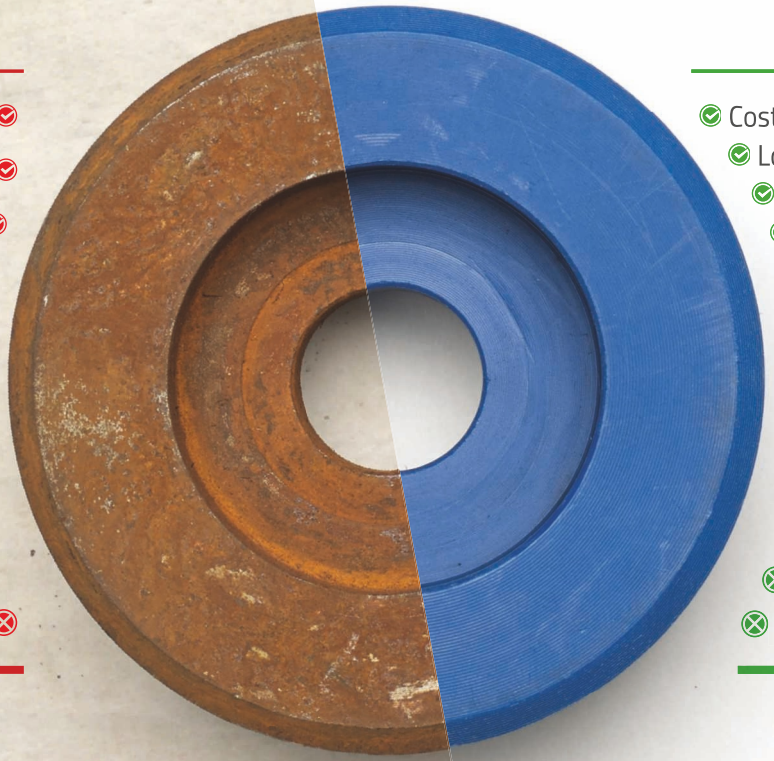

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your creative mind wonder. These seeming epiphany moments occur when the proverbial cognitive pressure is released, and the calculating left hand side of the brain takes a break and allows the right to inject some big picture thinking. It can be on a subconscious level, but taking a walk with the problem in mind is never a bad idea when you come up against a design brick wall.

Staying creative

There are a number of other techniques that help in the creative process, either as an individual or in a team setting. The first is that nothing should be off limits, or laughed at. Don't constrain yourself to things that are necessarily logical. Be open minded if colleagues suggest things that seem off the wall. Even if these are to be dismissed, they can set a path towards a more creative and abstract solution that is a preferred outcome.

Software giant Autodesk regularly does work with artists for exactly this reason. Maurice Conti, director of applied research at Autodesk, said: "We do a lot of work with artists as they approach problems in a completely different way to engineers. Artists tend to be driven by creativity, not logic, so the way they use equipment and approach design is different, and that can produce really interesting results that we can feed back to engineers, as it can be a better way of doing things that we would never have thought of."

The power of positivity is also something that helps incubate creativity. If you are happy at work it's more likely you will bring better ideas to the table. So, have fun with what you do, and with those you work with.

The pressure and competitive nature of business is a reality when approaching a design and engineering challenge, but it can be a hindrance especially if it harbours a negative working environment. This can lead to pessimistic project goals, a preoccupation to criticise or defend suggestions, which robs the right side of its creative power. Feeling comfortable in a team, being positive and having fun has a number of benefits – better design is one of them.

Another cliché is that a good team is more than the sum of its parts. It is cliché because it is true. Surround yourself with

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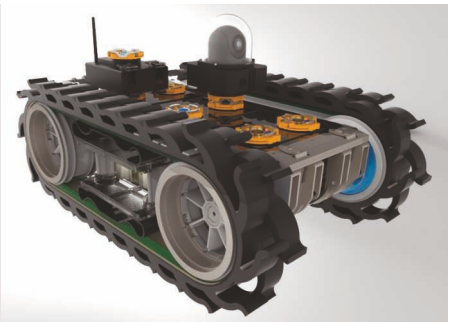

Instead of producing robots with single task in mind, where tools and sensors are permanently installed, artist turned engineer Philip Norman decided to bring about a flexible, robust and cost effective modular robotic platform.

The development of its modular platform allows robots to be easily re-configured to carry out a wide range of instruments for different applications. It also allows hardware upgrades to be easily attached via a plug and play connection, so only the module needs to be purchased rather than the entire robot.

Philip Norman is the originator of the Robosynthesis modular robotic platform and had his Eureka moment when, "I started looking at my children's construction toys and wondering why so many parts were needed to create not that many constructions," he said.

The robots have been deployed in the tunnels of the Large Hadron Collider at CERN in Geneva.

brilliant people that love what they do, are positive and passionate. Being around people that can tap into their right hand side of the brain easily can help you learn to better reframe problems, and make adjustments around how you approach problems.

A similar point to above, is to allow skills to intermingle and cross-pollinate. Having a 'not my department' philosophy acts as a roadblock, where as a more open collaborative approach has shown to be hugely valuable. Understanding different parts of a product or process can give a peripheral design vision to engineers, that improves how the product comes together as a whole.

Art meets engineering

Like engineers, artists have their tricks and shortcuts to make life easier, and give the final piece as big an impact as possible. So what are some of Philip Norman's turn-to techniques?

"I think carefully about composition in industrial design," he said. "Ask yourself, what is felicitous in terms of proportions. Every design, like a work of art, needs to have integrity and clarity in what it is communicating."

This is a key point, as being creative is not all about going off on a tangent unchecked. After all, you work for a business that needs to make money. So a good way of managing the two is to give creative thoughts a platform on which to build.

"For me, a reliable structure was the Golden Mean," he explained. "When I was working on the modular system of the robot, it is scaled on the Golden Mean. I started looking at the spiral and how it evolves through squares and creates proportions and sizes that are 61.8% apart. So when I built the modular parts, there is a 61.8% difference in proportion.

"These kinds of number relations such as perfect numbers, Fibonacci and the Golden mean, are design principles I hold in my head when I'm working. It provides a proven foundation rather than conjecture. What is liberating is that then the right hand side of the brain can go off with a great deal of confidence."

Creative and content

Today, engineering is a creative industry, and this is a trend only set to increase as much of the technical burden is being removed, allowing the solution and design to be the priority, and not the calculations. Both are vital, of course, but the pendulum is definitely swinging towards giving more thought to the abstract to produce innovation.

So are engineers driven by the right or left side of the brain, and does this need to change?

"It is a very clichéd categorisation that has gone now," said Norman. "I don't think about being an artist or engineer. One thing I would say is that engineers are some of the most creative people I've ever met, but also the most well rounded. They tend to be stable people and are much less volatile and emotional than many artists. They seem to have stability in the left and right hand side of their brains. They also tend to be fulfilled people that live interesting and content lives."

The creative checklist

Take regular steps away from a problem, particularly if you get stuck.

Distract yourself with activities like going for a walk.

Be open minded and supportive. Even if colleagues suggest things that seem off the wall, these can set a path towards more creative and abstract solutions.

Surround yourself with brilliant people that love what they do, are positive and passionate.

Try to reframe problems and look at them from a different perspective.

Collaborate! Having a 'not my department' philosophy acts a design roadblock.

Understanding different technical needs gives a peripheral design vision that helps products come together as a whole.

Keep your creative side in check by providing a platform on which to build.

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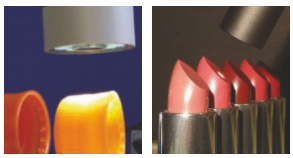

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A rather modern problem

We're a bit self-obsessed aren't we? No, not the hard working – and good looking – team here at *Eureka*. We're talking about modern society's constant need to take photos and videos to record that special moment… or just moment, as the case may be.

But it's not all narcissism. The ability to show family and friends your point of view during an exciting episode of your life is a powerful medium. To re-experience a sky dive, a walk through an ancient temple, or maybe running with the bulls, is something that can be looked back on with joy and excitement for years, and even generations, to come

The problem is, quite often the video may suffer from camera shake, especially when you are on the move. It makes videos hard to watch in the best case, and impossible to watch in the worst. The disappointment of watching an experience back, only to realise it is unwatchable can be a heart sinking experience.

The challenge

The challenge this month is therefore to come up with a way of making filming video more stable. For this exercise, we'll use a GoPro camera that has become somewhat the standard action camera.

Let's assume such activity ranges from skiing downhill to running on the beach with the family. Both situations would likely induce a fair amount of vibration and shake the camera, so your job is to make sure that is minimised.

The smooth moving shots that we see in the movies are the ideal here, but unless you are thinking about shock absorbing roller blades as a solution, then there might have to be some compromise. Really, what you need to produce is some method of cushioning movement.

The aim is to provide stabilisation in 3-axes to compensate for unwanted movement, arm shake and vibration. Any sort of device should either be hand held or able to be mounted to something like a helmet or bike. Lastly, the device should be practical and not overly extravagant, so a body mounted rig, with weights and air suspension might not be the ideal solution in this case.

As usual we have an idea in mind. However, have a think about how you would tackle the problem and let us know your ideas by emailing tim.fryer@markallengroup.com or leave a comment on the Coffee Time Challenge section of the website.

Last month's Coffee Time Challenge was to prevent lorries having high speed tyre blow-outs. You will find our solution on p10.

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