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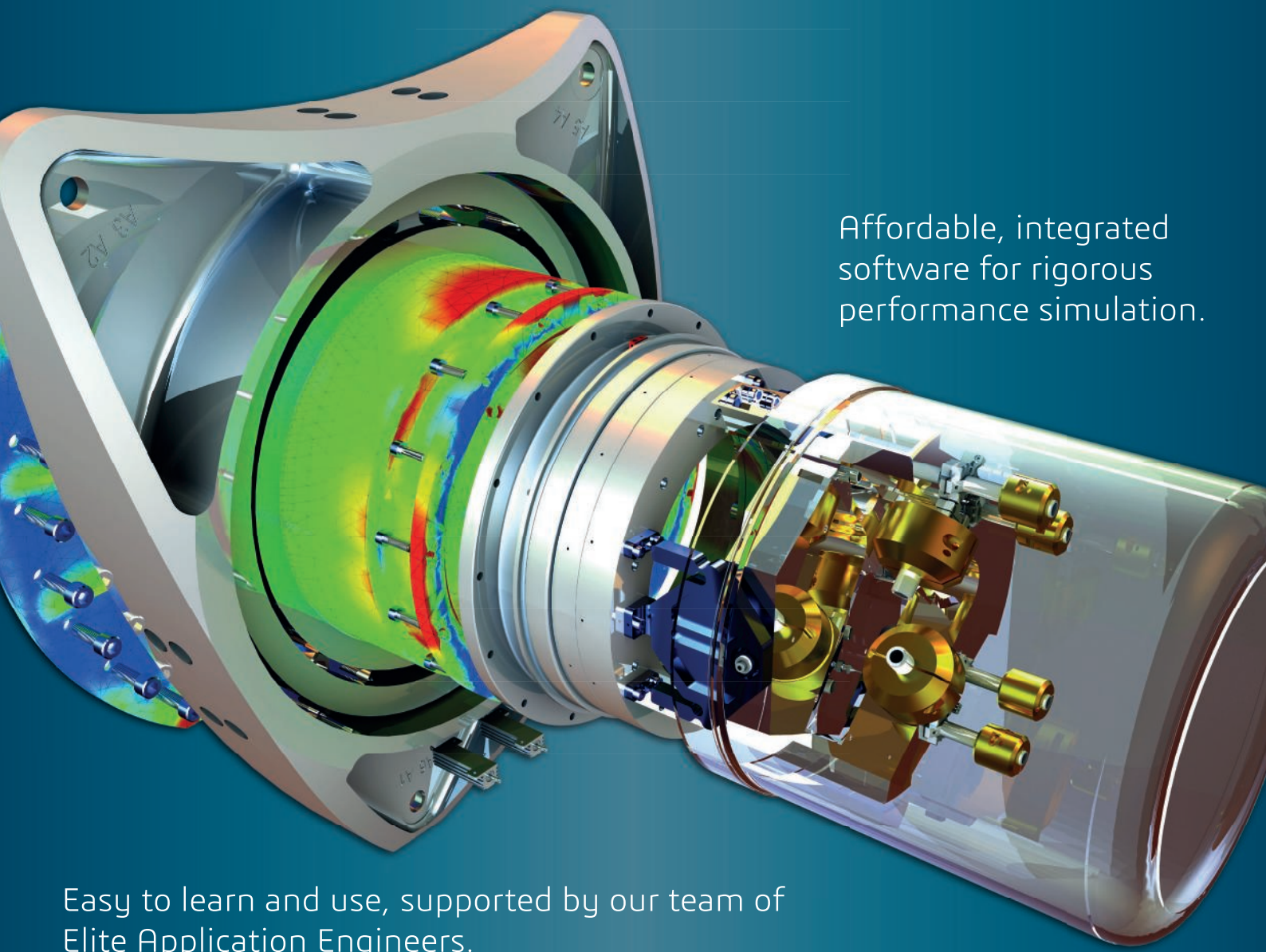

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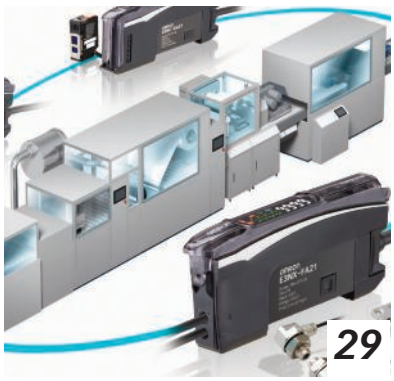

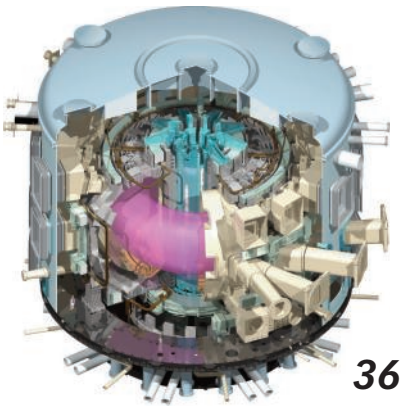

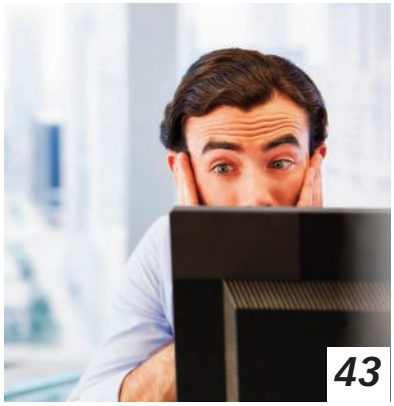

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Excellent route to market

Tim Fryer, Editor (tfryer@findlay.co.uk)

Britons invent and design and then others come in and commercialise our good work. Isn't that the popular myth?

With this in mind, it was interesting to hear the thoughts of Carlos Moedas, the EU's Commissioner for Research, Science and Innovation, in his opening address to a recent conference. The event – 'A new start for Europe: Opening up to an ERA of Innovation' – was intended to broadly embrace open science, the European Research Area (ERA) and innovation, and Moedas took the opportunity to identify the way ahead in order to overcome the challenges we face. One key challenge, he said, was that: "We are too rarely succeeding in getting research results to market. Technologies developed in Europe are, most of the time, commercialised elsewhere."

Maybe this is not such a British disease after all. Moedas went on to say that a significant reason for this poor level of technology transfer was in the funding sources and he proposed a number of initiatives – some within Horizon 2020, some aimed specifically at SMEs – that could help alleviate the problem. Meanwhile, the introduction of 'a seal of excellence' would identify companies that are fit for funding, with the intention of removing obstacles in the financing process.

It sounds good, but the problem has not always been a lack of money, the difficulty has been getting hold of it. Hopefully, the seal of excellence will be used to make the process easier to navigate.

On another matter – and a variation on the theme of 'seal of excellence' – the deadline for entering the British Engineering Excellence Awards (BEEAs) is approaching quickly. We are looking for engineers and engineering companies who can inspire through their excellence – the true beacons in British engineering.

And we know they are out there. Every year, we see a new crop that demonstrates the boundaries are constantly being pushed. Maybe for some this excellence is so commonplace that you do not realise how good you are. We would be only too pleased to be the judge of that. Entries must be in by the end of July and full details are on page 41 of this issue.

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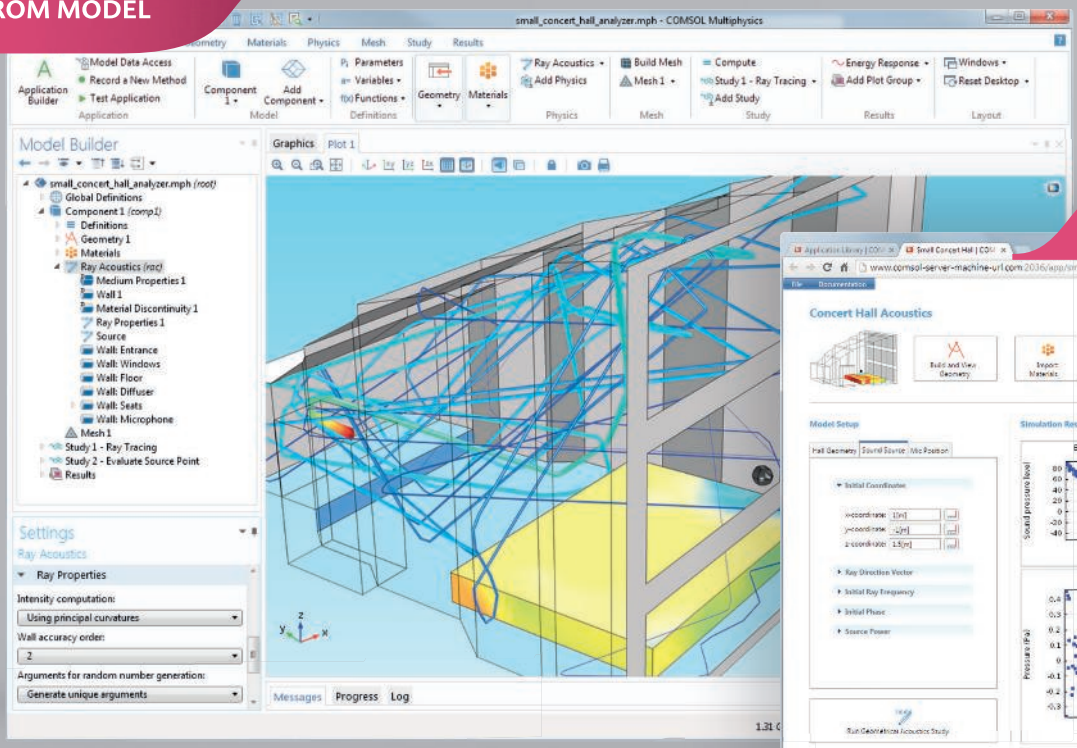

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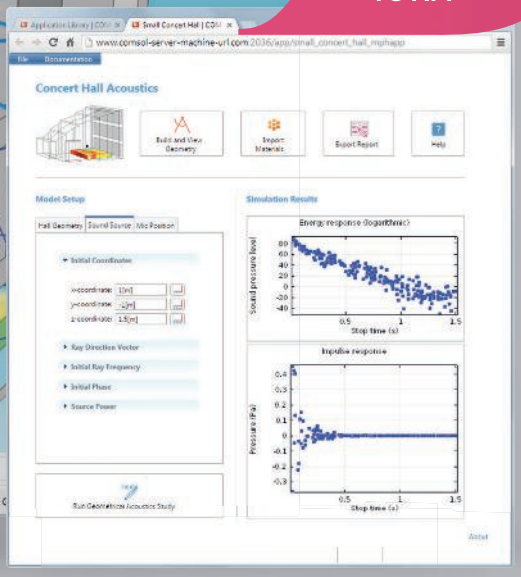

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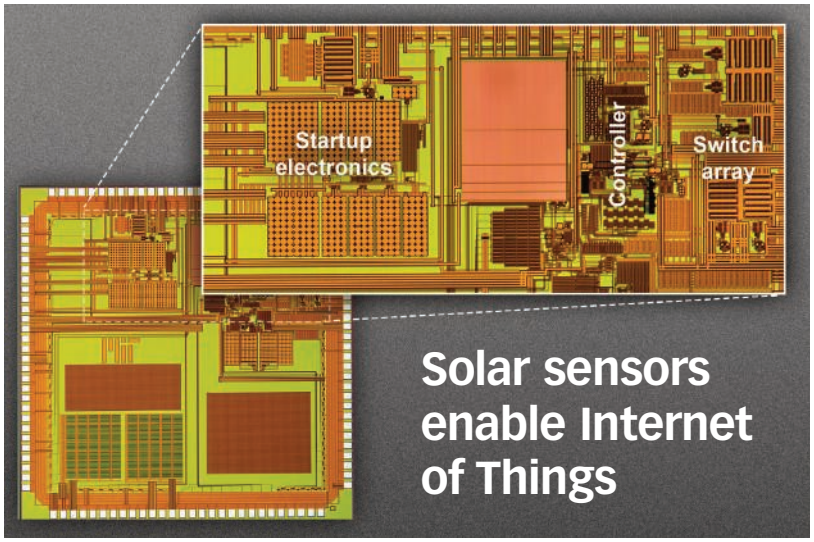
NEWS



Solar sensors enable Internet of Things

A low powered sensor has been developed by the Massachusetts Institute of Technology that offers an 80% improvement in harvesting solar energy. It is hoped the development will help enable wide spread sensor distribution and intelligent systems, a movement widely known as the Internet of Things.

The sensors use an extremely efficient power converter chip, meaning it can harvest most of the energy trickling into it, even at the extremely low power levels characteristic of very small solar cells. Previous ultra low-power converters that used the same approach had efficiencies of 40 or 50%. And where most ultra low-power predecessors either charge a battery or directly power a device, the new chip can do both.

Researcher Dina Reda El-Damak said: "We need to regulate the input to extract the maximum power, and we really want to do all these tasks with inductor sharing and see which operational mode is the best. And we want to do it without compromising the performance, at very limited input power levels — 10 nanowatts to 1 microwatt — for the Internet of Things."

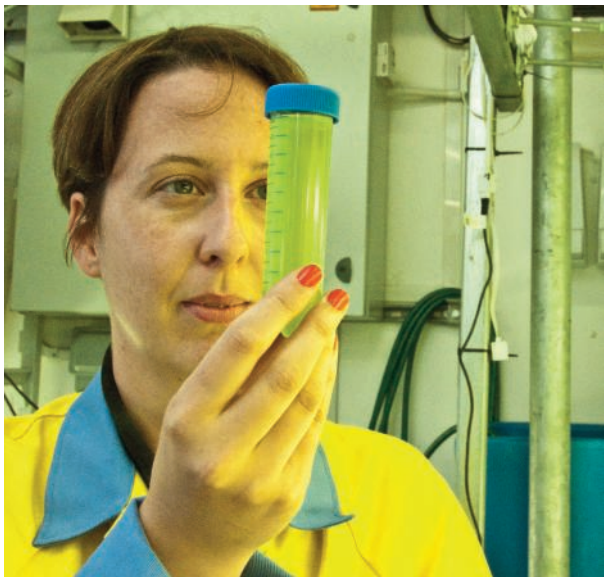
Extremely low-power sensors for broad application under the guise of The Internet of Things need to be able to run for months without battery changes, or extract energy from the environment.

Steelworks' CO_2 used to grow algae

Tata Steel is undertaking a project to see if CO_2 emissions from its Port Talbot site can be used to grow algae. The collaboration known as ACCOMPLISH (Algal Carbon Capture and BiOMass-Linked Supply cHain) is part of a wider Swansea University project, EnAlgae.

It plans to assess the capacity for natural algae to use carbon dioxide as a nutrient for growth.

Dr Alla Silkina, from Swansea University, said: "We have been able to use the Port Talbot by-product streams as an algal growth nutrient. In addition, a biomass is cultured, which can be used for energy (biomethane) production or potentially as a fish feed."



TECH BRIEF

World's highest payload 'cobot'

FANUC Robotics UK has launched a series of collaborative robots that it claimed have the highest payload on the market. It's CR-35iA has a 35kg payload, opening up applications that have previously been off limits.

Over the last couple of years, the first generation of collaborative robots or 'cobots', have been changing the way robots and humans interact and work together. In contrast to traditional robots, which cannot operate in an operator-occupied workspace without safety fencing, these cage-free robots can work side by side with humans on shared or separate tasks.

To date, cobots have been concentrated on the 5-15kg light duty 'universal robot' realm. However, FANUC said its new collaborative robot is headed for unchartered heavy payload territory. The TÜV certified CR-35iA can assist with higher payload handling, assembly, component feeding and workpiece loading and unloading tasks, which have historically had to be carried out manually. Key target areas include automation assembly lines, metalworking and packaging.

NEWS

Here is a selection of the latest products featured on the Eureka website. Just enter the reference code in the search box for the full story

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86593

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86589

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86586

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86540

Virgin Galactic to launch 39 satellites

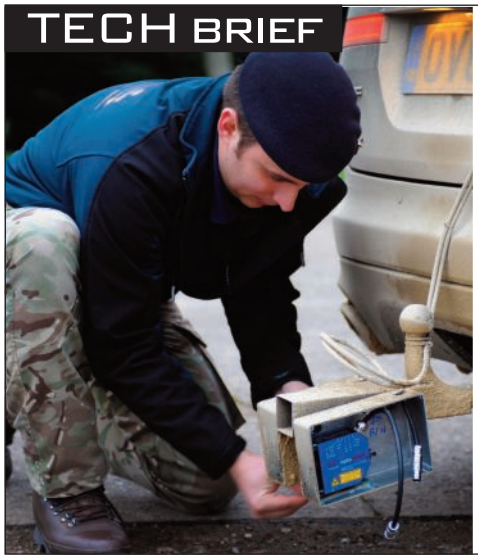
Virgin Galactic has signed a contract to perform 39 satellite launches for OneWeb, the company that wants to bring internet connectivity to every part of the globe. It makes up part of a planned 648 launches, thought to be one of the largest commercial procurements of launches in history.

Virgin Galactic has also placed an additional agreement to provide OneWeb with options for up to 100 additional launches.

The announcement coincides with declarations from OneWeb regarding $500m of new investment. The project is backed by world-class equity partners including Airbus Group, Intelsat, Qualcomm, The Coca-Cola Company and the Virgin Group. OneWeb wants to develop a global wireless communications and data system that will enable affordable broadband access anywhere in the world, including in areas currently not served by terrestrial providers.

Virgin Galactic CEO, George Whitesides, said: "The scale of this order will drive our manufacturing rates to achieve unprecedented cost reductions for small satellite launch. We are excited to support OneWeb and its partners as they harness the potential of small satellites to create new opportunities for all."

TECH BRIEF



BLOODHOUND SSC ride height test

A non-contact laser displacement sensor from Micro-Epsilon UK has been used to assess vehicle ride height during a test leading up to the World Land Speed Record Attempt next year.

The tests were carried out at the Jaguar Land Rover Gaydon Centre in Warwickshire, where two optoNCDT 1700 laser displacement sensors were mounted side-by-side to an adapted tow bar at the rear of a Jaguar XF with the laser window pointing down towards the ground.

The car was accelerated up to 50mph on off-road muddy terrain with measurements being taken and carefully monitored.

Joshua Thompson, systems engineer at BLOODHOUND, said: "Measuring the ride height is a critical measurement parameter on the BLOODHOUND Supersonic Car. We need to know the exact distance between the wheels and the ground to see how far into the ground the wheels sink during trials.

"First, we needed to test the performance of the ride height sensors under harsh, on-vehicle conditions. We also wanted to verify that our software could correctly interpret the measurement data coming from the sensors. On both counts, the tests were successful."

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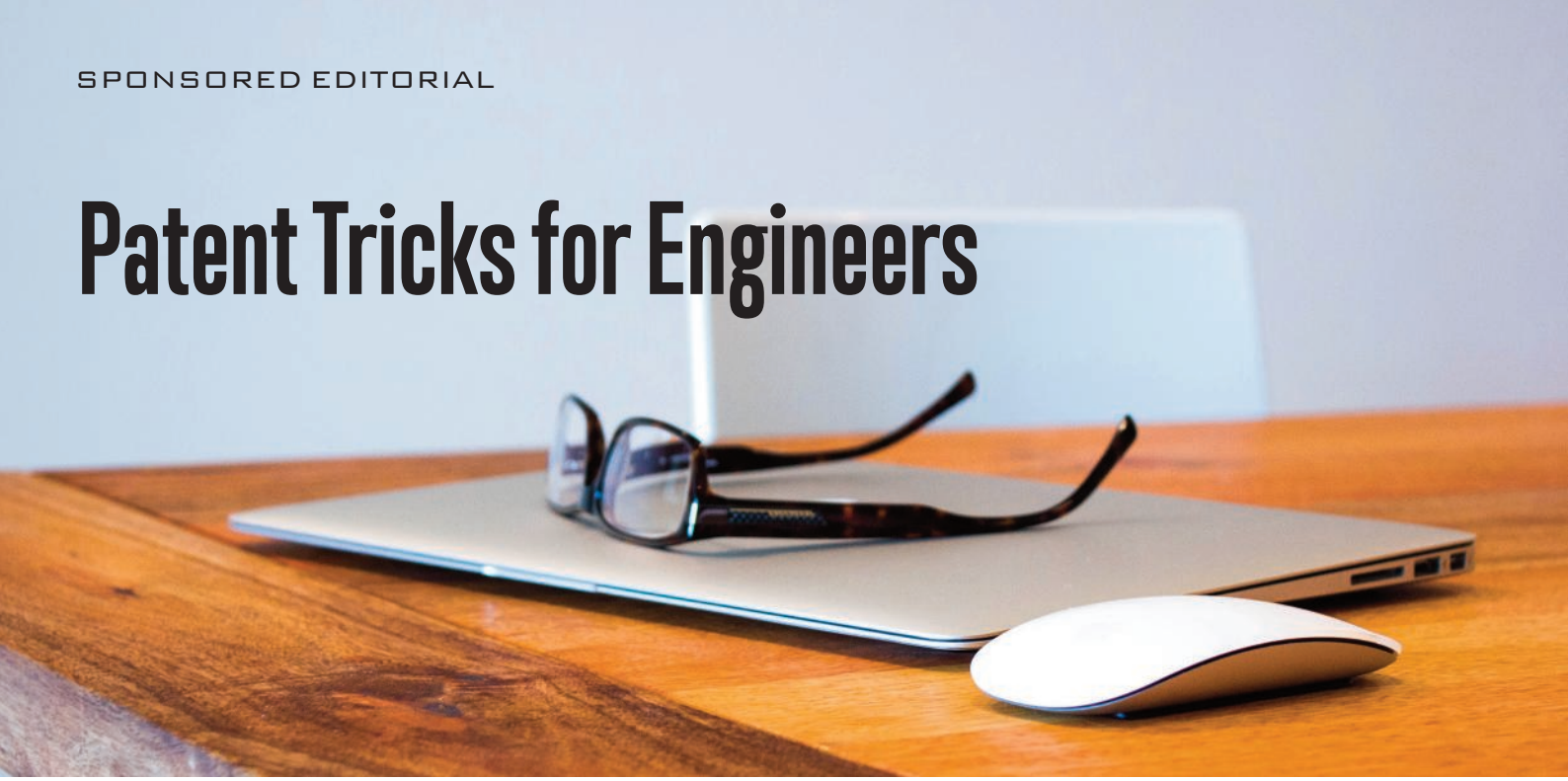
Patent Tricks for Engineers



Despite 30 years as a mechanical engineer in industry, patents remained a little mysterious. Sure, I've read hundreds - for the purposes of freedom to operate searches and patent workarounds - but I've never really made IP work for me. Yet, when recruited to lead a new group called Pure Ideas at law firm Avidity IP, I realised that I could have been much more effective in the exploitation of patent protection. This article aims to helps engineers learn how to 'flex' the patent process and articulate some useful questions to their IP partner.

1 **Getting the Timing Right**. Many people see a patent application as a route to success. It may be better to think of a patent as an obstacle to throw in the way of a competitor! The better the patent the bigger the obstacle, but you will rarely create a total roadblock with a single patent - a whole family may be necessary. Before filing a patent application weigh-up the pros and cons of the timing. Remember, 18 months after the first filing your competitors get a look at your published application.

2 **Patent Pending**. Whilst it can be useful to file a 'quick and dirty' application to derive a 'Patent Pending' number for use in your marketing (to give the illusion of an obstacle to others) it should not defer the proper patenting process. Do not expect quick and dirty applications to mature into valid patents. Use Non-Disclosure Agreements in all discussions as not doing so risks placing any improvements to the invention in the public domain – obliging you to then rely on your original patent application for protection.

3 **Refile and Top-Up**. You have a 12 month period after filing to refine the invention, gather experimental data, conduct market testing and file a 'top-up' application. That said, bear in mind that the new features and material will only be entitled to protection from the date of that top-up the application.

4 **Pending Applications Are Flexible**. I have frequently been surprised by the extent to which claims can be stretched or changed during the examination process. So don't always rush to get a granted patent, especially if you intend to negotiate with 3rd parties for licenses or cross-license opportunities. A granted patent has intrinsic value but you may miss out on a greater opportunity. This is a complex mix of commercial and IP knowhow so make sure your attorney is experienced in advising in both regards.

5 **Prior User's Rights**. Did you know that a user of an invention who has made serious and effective preparations for putting his invention into practice prior to being aware of your patent application can continue to do so regardless of your patent? Under certain conditions, this right may even be assigned to others. However, there are serious caveats to this exception and a patent attorney should be consulted if you intend to use this approach!

6 **Deliberate Disclosure**. If you are sure you will not be pursuing patent protection yourself, it may make sense to put an idea in the public domain to prevent others obtaining a patent and later presenting you an obstacle. You can publish in Scientific Journals or in Research Disclosures.

The patent process is an important part of the commercial mix and understanding this can provide a better commercial value from the process. The CIPA website provides a list of attorneys in your area and you should use this to seek out an attorney group who understand more than just how to copy down your ideas.

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NEWS

3D printed car makes big claims

A start-up Californian technology company has claimed to have produced the world's first 3D printed supercar. It goes further by calling it one of the greenest and most powerful cars in the world.

The company in question, Divergent Microfactories, has applied a variety of 3D printing processes to produce a vehicle with the overarching aim of 'dematerialising and democratising car manufacture'. The technology centres around its proprietary joining technique it calls Nodes - 3D printed aluminium joints that connect pieces of carbon fibre tubing to make up a chassis.

Divergent said its Node process dramatically reduces material and energy use with assembly reportedly taking just minutes. Kevin Czinger, founder of Divergent Microfactories, said: "Society has made great strides in its adoption of cleaner and greener cars. But, while these cars now exist, the actual manufacture of them is anything but environmentally friendly."

Divergent's goal is to enable entrepreneurial teams to set up 'micro-factories' and build their own cars at an affordable price, bringing down the cost of innovation.

The vehicle itself, called Blade, is equipped with a 700hp bi-fuel engine that can use either compressed natural gas or petrol. The vehicle goes from 0-60 in just over 2s and weighs around 640kg. Divergent Microfactories plans to sell a limited number of the high-performance vehicles that will be manufactured in its own micro-factory in Knoxville, Tennessee next year.

Funding competition for aerospace technology

Innovate UK is investing up to £10million in collaborative research, development and feasibility studies to accelerate the commercialisation of highly innovative technologies for civil aerospace.

The competition is open to participants from outside as well as inside the aerospace industry including SMEs and universities where their high-end academic knowledge and innovation expertise will bring significant benefit to projects.

The deadline for registration is 9 September 2015 and more details are on **www.innovateuk.org**

Events

For more event details go to www.eurekamagazine.co.uk

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A free interactive training event at the National Fluid Power Centre

21 – 22 October
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Ricoh Arena, Coventry
Exhibition and conference for Design Engineers

29 October
British Engineering Excellence Awards 2015
London
Showcase Award ceremony for design engineering industry

03 November
NI Days 2015
London
Annual graphical system design technical conference and exhibition

09 – 10 November
Innovate UK
London
Innovation inspired conference and exhibition

Warwick to develop intelligent vehicles

It has been announced that the National Automotive Innovation Centre (NAIC) currently being built on the grounds of the Warwick Manufacturing Group (WMG) will feature a multi-sensory virtual 'real-world' environment.

The centre, due to open in 2017, will enable intelligent vehicle systems to be developed that learn driver behaviour. The systems developed there will be optimised to enable drivers to reduce emissions and fuel consumption, assist monotonous tasks and react to potential hazards.

Experts will also research the cyber security of vehicles to ensure that increasingly computerised cars have the maximum resilience and protection against the possibility of cyber-attacks in the future.

Bristol Uni partners with Airbus

The University of Bristol has signed a partnership agreement with Airbus with regard to training, education and diversity.

The agreements aim to foster long-term collaboration in areas such as complex systems, architecture and integration; networks and content security; manufacturing and engineering; programme and project management; the development of common educational programmes and designing student competitions.

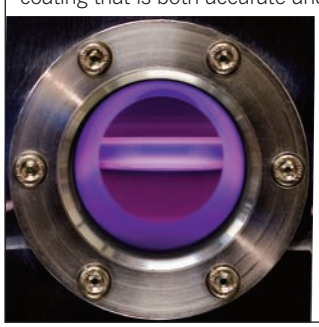
TECH BRIEF

Consortium targets smarter coatings

A smarter approach to applying advanced thin-film coatings to high value engineering products is being developed by Teer Coatings, Cobham Technical Services and The Open University. The collaborative project, which is co-funded by a £577,000 award from Innovate UK will develop tools for simulating sputter coatings, to deliver a right-first-time process.

The development project brings together experts on non-equilibrium plasma physics, computer-aided engineering software for modelling and simulating electromagnetic and related physics effects, and the design and use of the physical vapour deposition (PVD) magnetron sputtering tools to apply coatings that are important in a wide range of high value manufacturing applications.

The key aim is to develop a practical software-guided approach to thin-film coating that is both accurate and fast.



The tool will give an intelligent and automated analysis of a proposed deposition process to help users optimise the performance of a coating tool and the characteristics of a surface coating applied to workpieces. Such an approach will potentially eliminate the need for prototyping, and will be relevant to intelligent and optimised surface coatings, enabling performance advances in a many engineering sectors.

Solution to last month's Coffee Time Challenge

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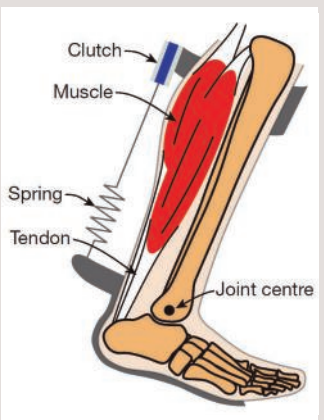
Last month we asked you to come up with a way of making walking less tiresome, either to aid the less able or to pamper the less willing. Our solution is far from being a commercially available product, but instead has been developed and used for research carried out at Carnegie Mellon University and North Carolina State University.

They have developed a lightweight elastic device that acts in parallel with the user's calf muscles, off-loading muscle force and thereby reducing the metabolic energy consumed in contractions. The device uses a mechanical clutch to hold a spring as it is stretched and relaxed by ankle movements when the foot is on the ground, helping to fulfil one function of the calf muscles and Achilles tendon.

Unlike muscles, however, the clutch sustains force passively. The exoskeleton consumes no chemical or electrical energy and delivers no net positive mechanical work, yet reduces the metabolic cost of walking by around 7% for healthy human users under natural conditions, comparable to savings with powered devices.



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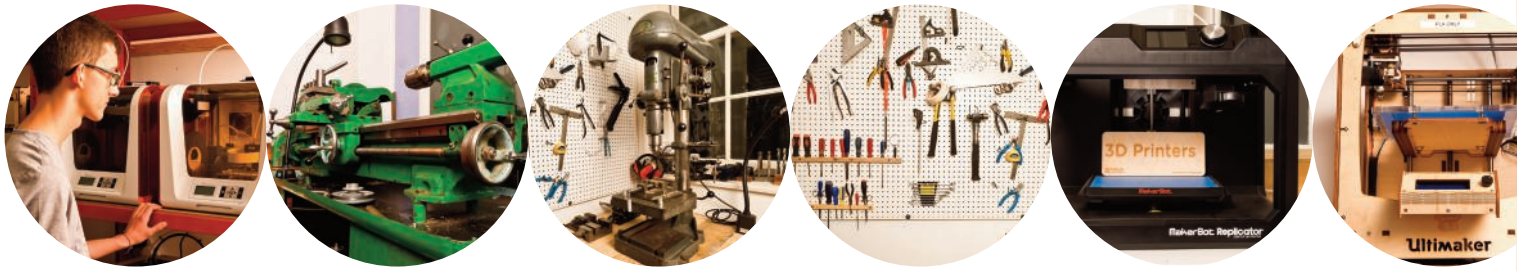


Fab Lab

Where ideas are turned into reality

Fab Labs restore faith in the creativity of people. As an organisation that can encourage, inspire and develop both people and their ideas, Fab Labs play an interesting catalytic role. But to what extent do they contribute to the engineering sector in the UK?

Tim Fryer investigates.

Fab Lab – a Fabrication Laboratory – is a fully-kitted workshop that gives users the power to turn ideas and concepts into reality. The most important aspect is that 'the user' is not necessarily an engineer, or serial inventor, or employee of a technology company. 'The user' can be anyone. Part of the Fab Labs constitution is that the labs are open to all for at least one day a week. The inner inventor in all of us therefore has a conduit through which to flow.

And all of us have an inner inventor, according to Keith Ashton, author of 'How to fly a horse' and the man who named 'The Internet of Things': "The creativity myth is a mistake born of a need to explain extraordinary outcomes with extraordinary acts and extraordinary characters, a misunderstanding of the truth that creation comes from ordinary people and ordinary work."

So even though *Eureka* readers live off their abilities in engineering design, there is still a difference between designing a routine part for someone else's project and inventing (and physically making) a product of your own. Ashton continued: "All that is necessary is to begin. Our first creative step is unlikely to be good. Imagination needs iteration."

And apart from inspiring existing engineers, could Fab Labs also be encouraging a new group of people into the engineering profession? It is a tantalising prospect and, given that the new Fab Lab London has had over 9000 people through its doors in less than a year, it is clearly more than just wishful thinking.

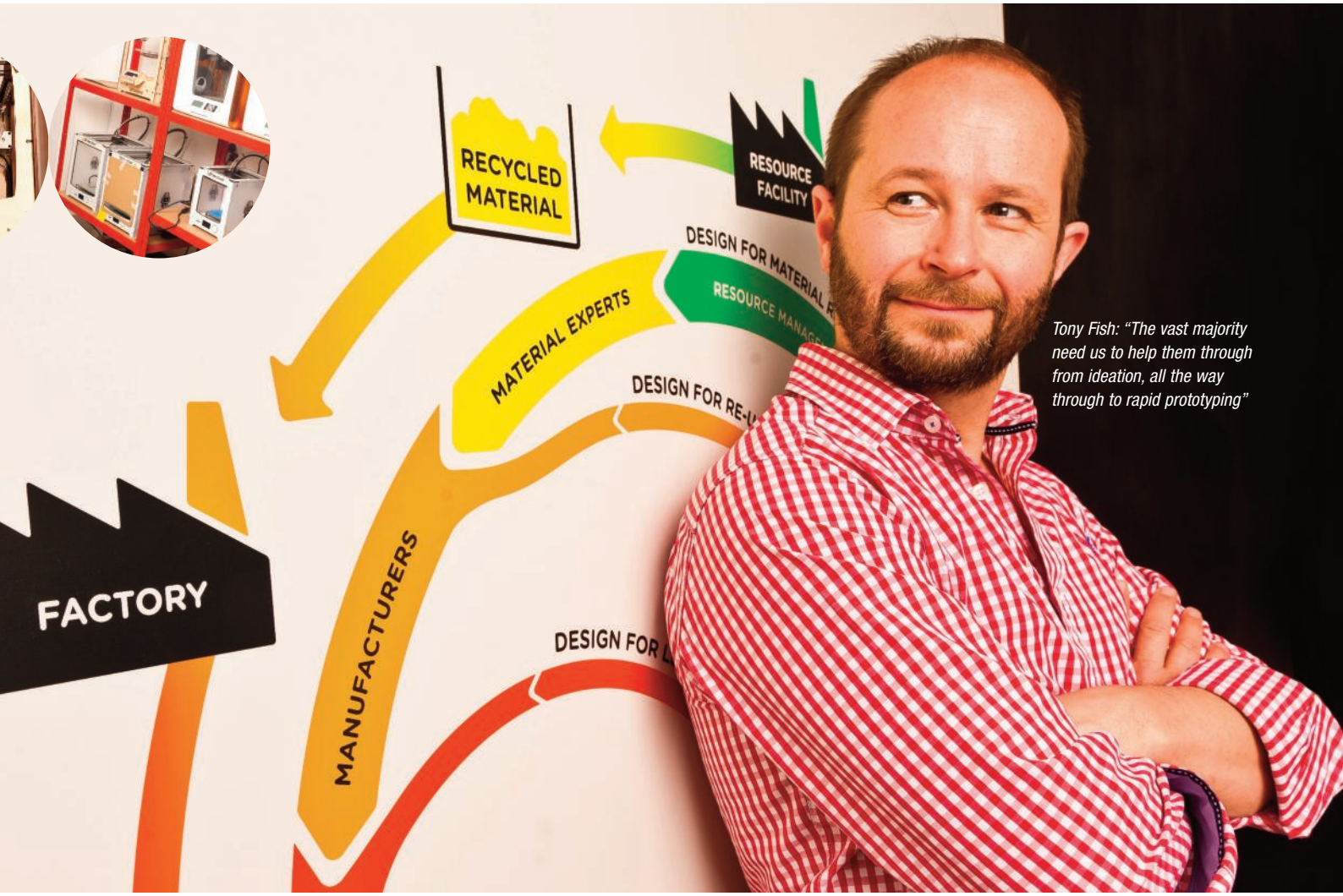
Born out of the Centre for Bits and Atoms at the Massachusetts Institute of Technology in the US, the Fab Labs programme kicked off in 2001. By January 2015 there were 432 Fab Labs globally - 88 in North America and 240 in Europe. Of these 19 are in the UK which is relatively low compared to our major European counterparts, but a British collective, Fab Lab UK, hopes to grow the number of Fab Labs in Britain to 50 by 2018.

Every Fab Lab, although part of the overall network, is a standalone unit with its own objectives to offer a unique set of facilities and skill sets. This makes the way each one is used and its target audience unique. In fact, there does seem to be trends appearing depending on which side of the Atlantic you are on.

Shelly Lassiter is President of the Fab Foundation – the umbrella organisation that facilitates and supports the growth of the international Fab Lab network. She has a global perspective and said: "For all our plans for people to have access to the tools and the knowledge for invention, what we have found is that the killer applications for this is in education, specifically science, technology, engineering and mathematics. It is an amazing catalytic environment for learning."

Lassiter gives the example of a STEM high school in East Cleveland in the US that is '90% lunch subsidised' and has a Fab Lab as part of its armoury. It has achieved a 9% graduation rate, which is far higher than would be expected in that community, and of those about three quarters have gone on to higher education.

"These are nice numbers," said Lassiter. "Now we have to tease out how Fab Lab is contributing to that specifically. It is very exciting. We have



Tony Fish: "The vast majority need us to help them through from ideation, all the way through to rapid prototyping"

Photographs: Sonja Horsman

seen that the kids are very engaged, but now we have to quantify that."

And quantifying it is not easy given the disparate nature of the Labs geographically and in their objectives. An example of this difference is in the new Fab Lab London, which started in September last year. And it is not only the miles that separate it from East Cleveland.

Fab placement

Most Fab Labs fall into two categories. One is those that are based in universities, where they have taken existing labs and added the necessary facilities to make it into a 'digital fabrication lab', and provide open access at least one day a week. The other broad category has governmental (either UK or European) backing.

And then there is what founder Tony Fish described as: "The very, very rare ones like London, where it's completely privately backed. There is no government money, we're doing it off our own bat."

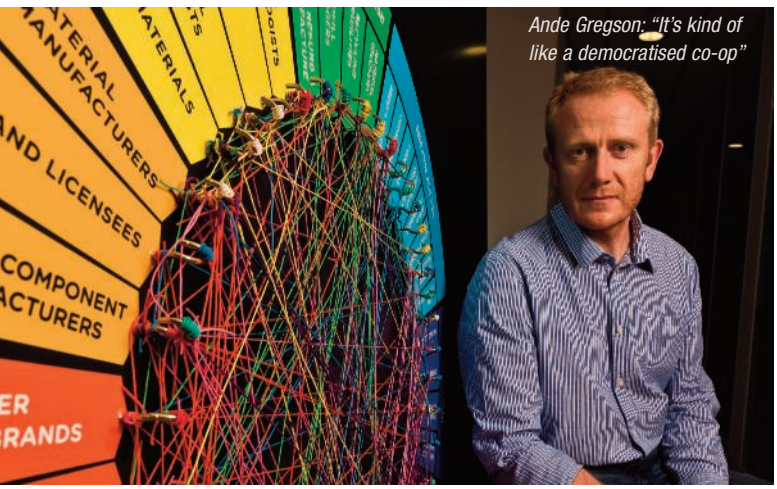
It still provides free and open access to anyone on a Friday, and has the regulation Fab Lab kit list that includes a laser cutter, 3D printer and CNC machine. The tool box includes most things that an engineers (or tradesperson) could think of.

It attracts people from ages eight to 80 investigating one–off personal projects, community and educational groups, training scenarios and companies developing their product portfolios.

Fish commented: "People immediately jump into an ideology about revenues and justifications and business plans, because that's an environment that lots of people are brought up in. We haven't got a business plan as such. The strategy is much, much simpler. Go discover amazing start-ups, help them grow and then fund them. But I'm an engineer more than a venture capitalist, we're much more focused on engineering and design than we are on providing funds."

The design focus is provided by co-founder Ande Gregson, a creative technologist, but Fab Lab does not have full time staff. "It is a community-based project. As things earn income, we distribute the income to the people who are working on that particular project, and therefore it's kind of like a democratised co-op. As long as it washes its face and manages to pay everybody, we really happy."

The pool of people, all with different skills sets, now numbers about 50 and all use the philosophy: Learn how to do something, make it and then share it.



Ande Gregson: "It's kind of like a democratised co-op"

"Learn, make, share," said Fish. "If you go round that cycle lots of times you end up with lots of different skills and can make lots of different things."

Some of the people in this pool will come from engineering companies who will release staff for an occasional volunteering day or related CSR type function. But there are companies who use the services as part of their product development strategy.

"The minority of companies who come in here know what they want to do, why they want to do it and have actually got all the skills to do it," claimed Fish. "The vast majority need us to help them through from ideation, all the way through to rapid prototyping. One of the things that they recognise, which is massively beneficial, is we do daily iterations as opposed to sending something off to China, wait for six weeks, something comes back, not right, every three months you're basically one iteration forward. We're doing daily iterations."

Moreover, designers who are slaves to their workstations may benefit from having hands-on experience during prototyping. "Therein lies a fascinating dilemma," said Fish. "Lots of people who do drawings or models have never actually seen what a product looks like when it's made. They do make a huge number of assumptions, and when they actually see it and what the problems are, they can iterate. Too often the two have been disconnected. Some designs can't actually be manufactured because the designer has never seen the process."

Equally, designers typically want their products to look aesthetically perfect, whereas engineers want prototypes to be functional, particularly when this includes electronics. It can mean that further versions have implications for the layout of the board or of the product around it.

Using the Fab Labs daily iterative process could resolve problems early and not, for example, result in having to re-layout the PCB, which is a far more time-consuming process.

There is electronics expertise within the skills pool, so electronics development can be based around any number of platforms or development environments including Raspberry Pi and Arduino.

Mechanical design can be done on SolidWorks as the company supplies a free copy to all Fab Labs globally. However, those who prefer tinkering in Tinkercad, Rhino, SketchUp and other 3D tools have the facility to do so.

Beyond SolidWorks other companies including Ultimaker, Trotec printer, MakerBot, Roland, RS Components, Intel and Cisco, are all supporters in a variety of different ways.

For engineers of all varieties?

The sort of person Fab Labs attracts varies considerably. Some may be working for a company who have to solve a problem but don't have access to the right tools. Some may not want their company to know they are working there, and some small businesses literally outsource their entire product design process up to prototype.

Fish said: "So you gain these vast arrays of crossovers. We tend to focus on what the individuals are and the skill demands, rather than saying, 'we've got this number of companies working with us'.

"The thing washes its face completely. Partly because we have corporates who want to do ideation days, we've got companies who want to pay us to build stuff, we've got an event space and we've got members who come in to use the machines. Every single week is different and every month has been different."

And perhaps what makes Fab Lab London's clientele slightly different from those elsewhere in the country, is that it has a very particular purpose – to discover really early high-growth potential, product-based companies, and then back them.

"It might take us a year to find the right one," admitted Fish. "It could take us five years to find the right five. I might expect to see one a year.

"Success will be looking back in 10 years time, when those companies have grown and been successful and we can say, 'yes, we were there helping seed it and fund it'."

Much to Fish's surprised there are already two companies, neither of which can be disclosed yet, that fit the bill. For one, Fab Lab London went through the whole prototyping process, and for the other it helped solve a problem, concerning a difficult part, on an existing prototype.

"It is stunning what they have built," claimed Fish. "I could see 100 million people a year using their product."

Fab Labs around the UK

BEC Fab Lab, Cumbria
www.becfablab.org
Fab Lab Airedale, Keighley
www.fablabairedale.org
Fab Lab Cardiff
fablabcardiff.com
Fab Lab Ellesmere Port
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Fab Lab Plymouth
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Sky's the limit

As the new CEO of GKN Aerospace settles in, we ask what is likely to change under his tenure and if he can sustain the impressive growth seen in recent years. Justin Cunningham reports.

GKN Aerospace has been an ongoing UK engineering and manufacturing success story for more than a decade. Under the leadership of Marcus Bryson it triumphed through a period where many technology companies fell by the wayside. So as new CEO Kevin Cummings gets comfortable, is it more of the same or does he plan to mix things up? Well, it certainly seems to be all change at the company with numerous, and notable, shifts in senior management. So, how does the new team compare?

"Well, obviously the leadership team just got a lot smarter," he quipped at the pre-Paris Air Show press conference last month. With a broad grin and a 'just kidding' type retraction, Cummings explained how he really sees the changes made to its top flight management team.

"I would say that there are natural cycles, though we can't look back and say anything other than, 'what an excellent job'. But the world changes and you want to refresh and have an interjection of new ideas.

"We have become a much larger global company in the last 10 years, and to some degree we are immature in some of our approaches. Fresh ideas are good, but we also honour the people who were in these slots and will continue to listen to them."

GKN Aerospace is indeed in a different place to when Bryson took over in 2007. It now represents 30% of the group's revenue, and its business reach and international order book are on an entirely different, world-class, scale. The numbers speak for themselves. In 2006 sales were in the region of £600million. Last year they had almost quadrupled to £2.2billion.

Cummings has clearly set out his agenda and defines the priorities for the business under two separate headlines. The first is delivering the tremendous backlog of purchased items that need to be produced and delivered. "The number one priority is execution on our current programmes and delivering current business," he said. "The second priority is developing growth."

For a company that already operates in seven countries, across 33 sites and employs more than 12,000 people, you have to ask, how much more of a foothold does it need, and can it get?

"We still do not believe we are everywhere we need to be," said Cummings. "Specifically, we are going to focus on moving into Asia. That is an absolute goal of ours."

And perhaps this is where Cummings wants to have greater success than his predecessor. Last year a joint venture with the Shanghai Aircraft Manufacturing Company fell through after two years of discussions. At the time, it was Bryson who conceded that mistakes in the implementation of its strategy in China were responsible. But Cummings is not put off by the prospect and is dogmatic in his view of rapidly conquering Asia.

"We will go into Asia in a big way," he said. "We still do not have the presence we need in Asia and over the next few years we will remedy that situation… [and become] a completely global company, so the Asia question is complete, and the sun does not set on what we do."

And here lies the other backbone in GKN's growth strategy: the application of cutting edge technology – much of it proprietary and materials based – but all responding to the demands of the aerospace industry, such as running engines at higher temperatures and inducing natural laminar flow across wings.

It means that although the main platforms by Airbus and Boeing have been set out for the next decade or so, GKN can continue to develop technology that can be retrofitted in much the same way as an aircraft engine upgrade, meaning that it is not locked in to the R&D programmes of OEMs.

Perhaps, however, what is interesting about Cummings' view, and is indeed notable, is the ambition and the speed at which he thinks it can all be delivered.

"You are going to see performance improvements rolling out on a pretty frequent basis because the breakthroughs are coming so much faster now," he said. "We are starting to get chunks. Instead of offering a 1% improvement, we've got a 15% improvement and we are already prototyping."

However, although GKN Aerospace has become a powerful technology and materials developer, it acknowledges just how competitive the area of applied technical research has become. So, being selective about technology development has never been a higher priority for business development and future growth.

"We have set a threshold where if you can't get costs down 20%, weight out by 20%, fuel burn down 15%, then you don't get any money," said Cummings. "We don't have unlimited resource, nobody does, so we have to make decisions all the time, and that is mostly on what we don't do."

The ambition of these targets is perhaps reflective of Cummings' position at the helm. He certainly doesn't think it's time for consolidation, and wants to continue the company's push in unprecedented growth, technical reach and global footprint. Indeed, of all of the major platforms flown at the Paris Air Show last month – from commercial, rotorcraft, military, or whatever – they were all likely to have somekind of GKN technology on board. It's impressive stuff, and for the moment sky seems to be the limit for Cummings and GKN Aerospace.

www.gkn.com/aerospace

CV

Kevin Cummings joined GKN in October 2008 as CEO and President Aerostructures - North America. And after a hand over period, in January 2015 he became sole CEO of GKN Aerospace. He joined the company from Alliant Techsystems (ATK) where he had most recently held the position of Executive Vice President and General Manager - Launch Systems. He has over 20 years of experience in the advanced weapon and space systems industry working for both ATK and Hercules Incorporated. He held leadership roles with both companies across programme management, operations, engineering, strategic planning, business development, and corporate development. He has a degree in engineering and an MBA.

Doing away with **dirty diesel**

Pollution is a problem and one of the main culprits in the urban environment is the bus. Cleaner buses are therefore important and one company has developed a hybrid solution that could clean up dirty diesels. Tim Fryer reports.

There are approximately 8700 buses operating in London and 47,000 public service buses around the UK. Buses, in fact, form the backbone of transport infrastructure networks in urban areas all over the world. However, their diesel engines are also responsible for emitting vast quantities of pollutants, such as carbon monoxide, nitrous oxide and particulate matter into the air.

While hybrid buses help to reduce emissions and cut fuel costs, currently the only way to get a hybrid bus is to buy a new one. With new hybrid buses costing at least 50% more than the diesel equivalent, this choice has not been popular. And it was this that inspired Alex Schey and Toby Schulz to develop a solution that ultimately led to Vantage Power being founded.

The pair understood that to have a significant impact on reducing bus emissions, they would need to develop a product that could be retrofitted to buses already on the road.

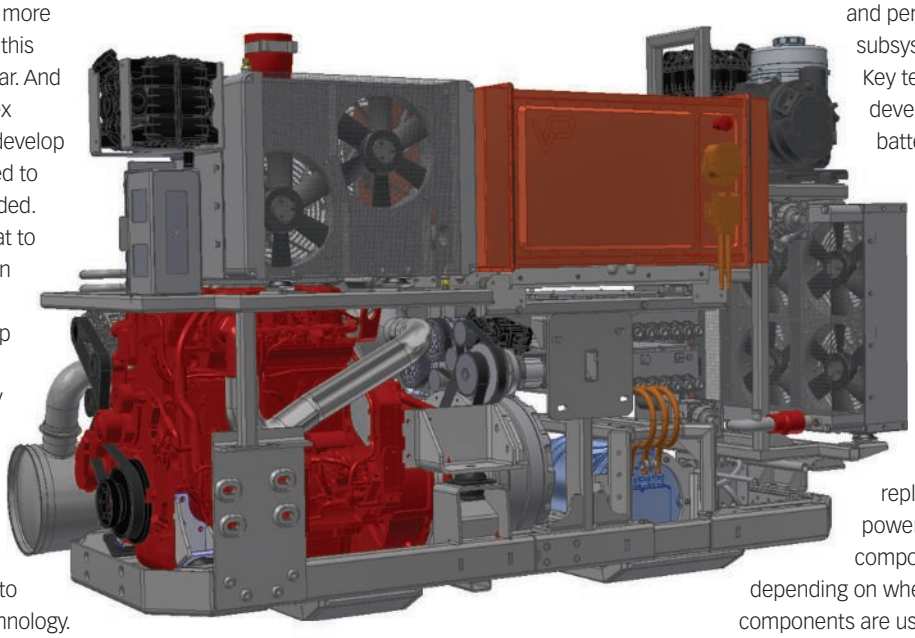
Schey and Schulz met while studying mechanical engineering at Imperial College, and both shared a keen desire to develop hybrid vehicle technology. After graduation they designed and built the world's longest range electric car and drove it from Alaska to the southernmost tip of Argentina. The success of this project inspired them to found Vantage Power and develop an energy efficient transport solution on a bigger scale.

Setting the wheels in motion

Vantage created the B320 System – a self-contained hybrid powertrain that is designed for retrofit on the most common diesel-powered double-deckers on the road. Current focus is on the two most popular bus models - the Volvo B7/B9TL and ADL E400.

The system is designed to be robust and reliable while at the same time reducing fuel consumption and emissions by over 40%. "A bus powered by our B320 system can be thought of as an electric vehicle with on-board charging capabilities," said Schey, who is CEO of Vantage Power.

The hybrid technology is based on a series architecture. This means that the engine is mechanically decoupled from the wheels, which are instead powered by an electric motor. This motor is powered by a battery pack, which in turn is charged by an electric generator. This generator is turned by the diesel engine. Schey continued: "This overall architecture is well known in the industry, but it's the design and performance of the many subsystems that make it unique. Key technologies that have been developed in-house include the battery pack, control system and cooling system. This has all been designed from the ground up."



CAD creation of Vantage Power's B320 hybrid engine: while Autodesk Inventor was used to model the hybrid engine, specialist simulation packages were used to assess the thermal performance of the cooling system

As well as being Euro 5 (and soon Euro 6) compliant, each B320-powered double-decker bus will save operators about £20,000 per year in fuel costs. Schey commented: "The cost of replacing a conventional powertrain with similar components is typically £20k-£40k depending on whether new or used components are used. Our B320 system compares very favourably with this considering that our product gives the operator a brand new warranty on the entire driveline alongside a suite of new technologies including zero-emissions geo-fencing and 24/7 live data monitoring and logging."

The solution is designed to bring hybrid technology to existing fleets of buses

Hybrid under control

Vantage used CompactRIO and LabVIEW system-design software to create an onboard embedded controller. The system constantly calculates the optimal power split between engine and battery, whilst translating driver commands to provide a smooth running vehicle, and ensuring all components are running within safe limits.

"With the seamless integration between LabVIEW and CompactRIO, the team could focus on algorithms rather than spend time on hardware-level implementation," said Vantage Power's Toby Schulz.

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The existing engine and gearbox are removed, and the B320 is installed by connecting it into the existing body electronics, hydraulics, pneumatics and chassis mounting points, but designing for retrofit has its problems.

"The biggest challenge for our application was packaging all the components of the hybrid system into a standard engine bay," said Schey. "We don't have the luxury of packaging our system around the bus as one would when building a new vehicle - we have to make do with the space we have. This influences the second challenge that relates to cooling of the engine, power electronics and battery. Unlike in cars where radiators can be positioned in line with high-speed airflow, the buses' engine bays are located at the rear of the vehicle without access to airflow. This makes cooling a particularly challenging problem given that engine bay temperatures can reach up to 90°C."

Temperature control was a limiting factor in the battery design. Each of the 1760 cells - each one slightly larger than a standard AA battery - must stay within 2°C of each other in order to promote the longevity of the pack and to reduce degradation. To do this Vantage designed a liquid cooling system to bring cool fluid to each of the cells, and to ensure that the temperature of the fluid was as uniform as possible. This is a demanding requirement, but made particularly challenging given that one side of the pack is located next to a hot engine, and the other side next to a fan drawing in cool air. Consequently, Vantage had to conduct detailed computational fluid dynamic calculations to visualise the fluid flow, and the cooling effect it would have on each cell.

"We found that one of the biggest expenses in starting up an engineering company was the CAD packages."
Alex Schey, Vantage Power

Starting up with CAD

Although founded in January 2011, the first design was complete by early 2013. Subsequently, the first prototype was ready by the end of 2013 and the first model was put to the test in early 2014. "We achieved our target fuel savings and also demonstrated technologies such as geo-fencing and cloud-based remote control and telemetry," observed Schey.

Right from the start the Autodesk Product Design Suite played an important role, as Schey explained: "When we were starting out we were very resource stretched. We found that one of the biggest expenses in starting up an engineering company was the CAD packages - up to £12,000 per person for all the required software. However, Autodesk was there to support small businesses like ours, and allowed us to purchase over £100,000 worth of professional CAD software for a few hundred pounds. This level of support is a true enabler, and gave us the resources to design our product and build our business much faster than alternative options."

Two systems have been built to date, and the manufacture of 6 to 10 pre-production units will be underway shortly now that the design is proven. Both prototypes were fully designed and FEA simulated on Autodesk's Inventor prior to any components being built or assembled.

"Simulation in such a multifaceted and diverse system is a big challenge, and typically can't be done with a single piece of software," added Schey. "Inventor is great for simulating mechanical components from a finite element point of view e.g. stress analysis, computational fluid dynamics and thermal simulation. However, for performance simulation software like MATLAB and LabVIEW needs to be used."

Vantage Power has now partnered with Ensignbus Company - the UK's largest used bus dealer. The company's 40 years of industry expertise is helping Vantage Power bring the concept of retrofitting buses with the B320 System to a global client base. The company's mission is to manufacture 1000+ units a year by 2018. Once the system has been rolled out to a range of bus operators, Vantage Power will also look to the rest of the heavy goods vehicles market.

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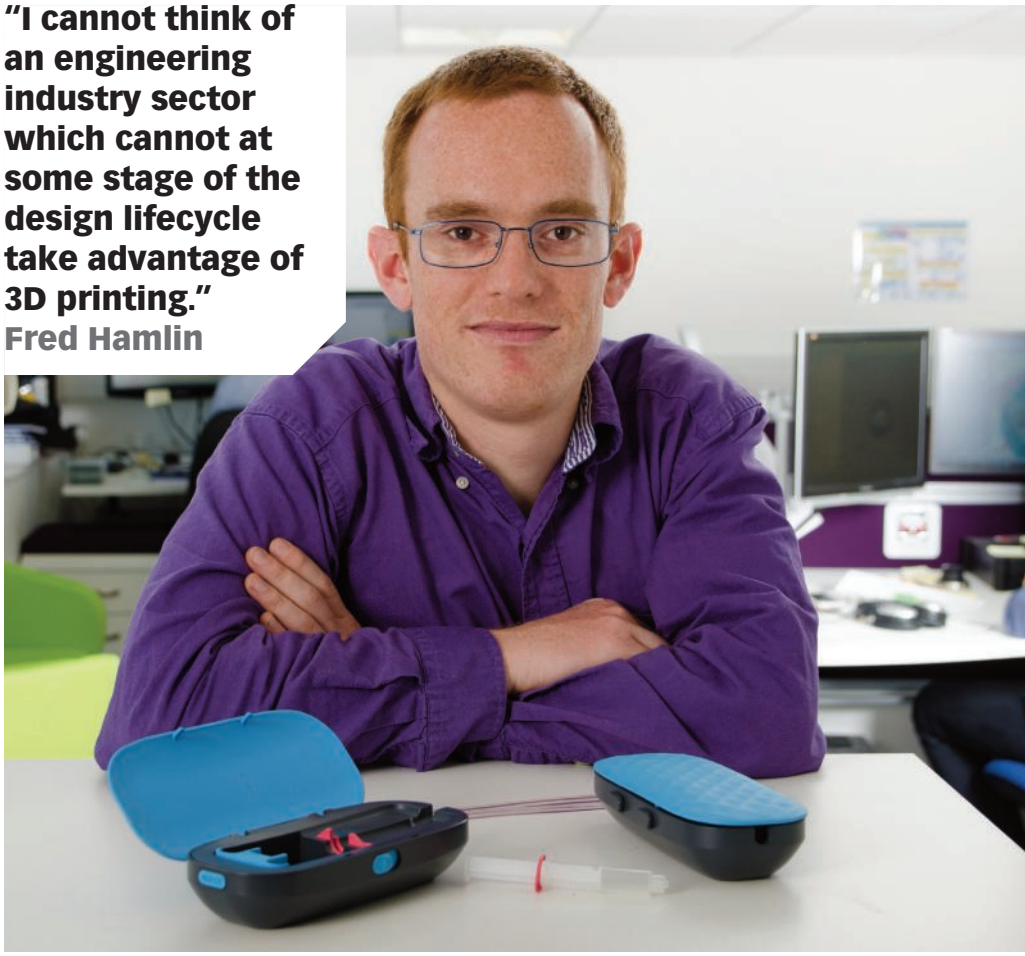

"I cannot think of an engineering industry sector which cannot at some stage of the design lifecycle take advantage of 3D printing."
Fred Hamlin

Time to bring 3D printing in-house?

The buzz around 3D printing continues unabated. So, has the sweet spot between price and capability been reached, and no self-respecting design team should now be without one? Tim Fryer finds out.

3D printing gets masses of media coverage and there is a reason for that. People see the potential.

In our recent survey of *Eureka* readers over half the respondents quoted 3D printing as the single most disruptive technology affecting our industry. But is the reality matching up to the hype – at least to the point where it should be a standard rather than a luxury appliance in a design environment? We asked a 3D printer supplier, a design consultancy and a prototyping house for their differing perspectives.

But before installing a 3D printer as a standard accessory, perhaps the first question that needs to be addressed is what do you want your 3D printer to make for you? Ross Nicholls, general manager of prototyping company Malcolm Nicholls, commented: "The answer to this question is what is most commonly misunderstood by the masses. The idea that we can print anything that you can imagine is not uncommon. Managing expectations is a very important part of project managing our work. Believe it or not, we have actually been asked if we could produce a small scale motorbike engine that actually worked, all for less than a tank full of petrol in cost!"

With respect to mass production, could 3D printing replace injection moulding? "Certainly not now," claimed Nicholls, "and not in the next few years. Will it ever? – maybe."

Assuming then that we are not looking to 3D printing for next generation manufacturing, but as the 'turn to' prototyping solution, is the quality of 3D printers now adequate?

Again that depends on the particular application. "For a lot of parts and models, the level of detail and resolution that current generation printers produce is excellent," said Fred Hamlin, a principal engineer at product design and development firm Cambridge Consultants. "However, if your part contains very small details, or relies on parts which are expected to slide past each other or tight tolerances on parts which have to fit into each other, then printed parts often are either not suitable or will have to have additional subtractive manufacturing operations performed on them afterwards. The surface finish of 3D printed parts is often quite different from the equivalent moulded part you are trying to simulate."

This is often not an issue but must be a consideration, as is the lifetime of the part. Usually the longevity of a prototype is not important but if it is then the degradation of some of the polymers used in 3D printing must be taken into account.

And, if calculating total cost of ownership, these polymers remain expensive. Nicholls commented: "SLA materials are circa £150 per kilo, still very expensive, these prices haven't changed much for years. SLS material can account for 50% of SLS component prices, again the price hasn't really changed much over the last 5-10 years. Filament for FDM (fused deposition modelling) type machines is decreasing with increasing competition."

Part of the reason for lack of movement on prices is that the market has not developed enough for economies of scale to apply, according to Peter Hansford vice president of sales at 3D printer manufacturer Blueprinter. "The big chemical companies are not directly supplying and they won't get involved until the market is big

Getting an early prototype in hand can be invaluable when trying to sell a concept - either internally or externally

enough. For them 3D printing is very small. Higher prices of materials leads to lack of use, which is counter-productive for end users. There does need to be a balance, I see the pricing coming down in most cases for the future. If you buy a printer today that costs a lot to run, you might not have the money to invest in additional technologies, so choosing the right type of 3D printer is very important."

Blueprinter now believes that 3D printers have come down in price sufficiently to become affordable for the masses and claims there are ROI calculations to prove it. Moreover, claimed Hansford, it has allowed users to benefit in unexpected ways. "It can change the way they create products," he said, "and changes the way they work. So buying the correct equipment is the key regardless of initial cost, as long as the payback is there."

The payback depends on what needs to be made and how often. A high-quality professional FDM machine, which would be suitable for handling models and industrial design, rapid exploration of form factors, would require no larger an investment than many of the software packages or IT infrastructure which most companies already own. The problem is that one 3D printer does not do everything. Companies like Cambridge Consultants require a range of materials, sizes, finishes etc.

"Every company should use all their technologies, the skill is getting best utilisation of all of them." Peter Hansford

Hamlin said: "The major hurdle is that many companies, ourselves included, require flexibility in the materials and construction technology they are able to use so that they can select the correct properties for the part. This requires a whole room full of state-of-the-art machinery rather than a single installation. This rapidly multiplies the capital expenditure and associated maintenance costs, which become prohibitive."

This is one of the reasons why bureaus/ prototyping houses remain popular. Another is that bureaus will invest in the latest technology so that its customers don't have to. They also, as Nicholls (predictably) pointed out, believe they offer the best value for money: "I firmly believe this is still true today as it has always been. We have lots of technologies to chose from to best suit the application in mind. We also have highly skilled finishers to produce the quality demanded. The market place is still full of potential service providers so competition is rife ensuring that prices are kept competitive."

"In my opinion they do offer better value for money," concurred Hamlin. "Using external services means that you are not tied to one technology or resin, and can easily pick and choose what materials you want the part to be constructed from, depending on the aesthetic, mechanical, tribological, dimensional and cost requirements of the part."

"CLIP technology is very exciting as this may well bring about a 'layerless' 3D printing method which should improve surface quality." Ross Nicholls

And while Hansford does not disagree with this, he added: "3D Printers can be bought for small amounts - sub £10K - and it's all about sharing ideas and communication. There is a huge advantage of having a printer to explore a design brief or going off piste with something a client hadn't thought of. It helps all aspects of the business - design, engineering, marketing, packaging, customer steering groups etc. Showing parts in someone's hand has a huge impact."

Perhaps that sweet spot is still a few years off. While machines are affordable for all, the ones that provide the necessary quality are typically found in the bureaus. But maybe the machines at the lower end of the market are increasingly being deployed by design teams for those 'first design in hand' scenarios.

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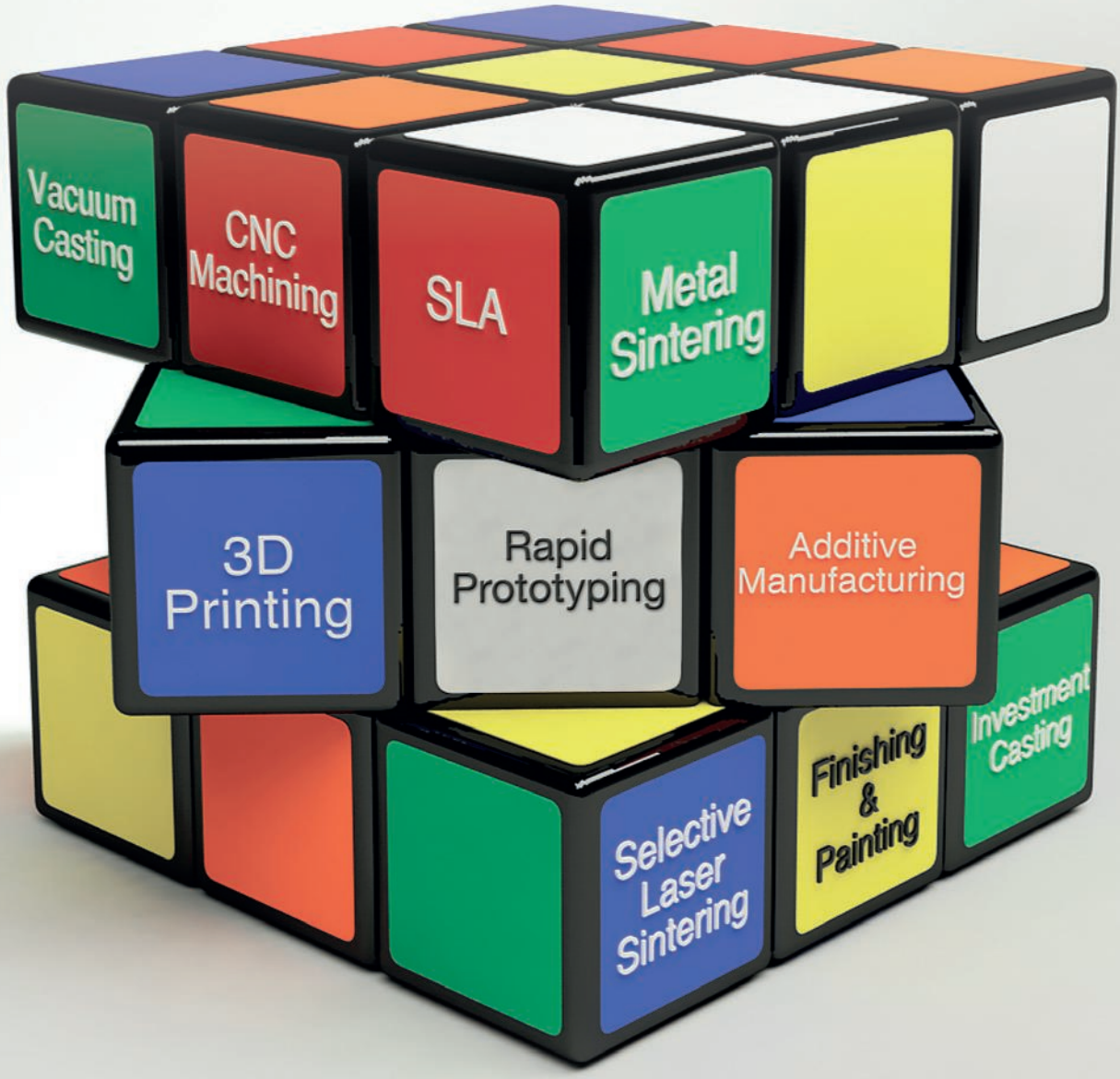

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Sensors star in industry's generation game

Whether you call it IoT or Industry 4.0, there are a few technological hurdles to jump before it becomes a reality. But there are enabling technologies – notably EtherCAT and intelligent sensors – that are already fit for purpose. Dan Rossek gives his view on how Industry 4.0 is developing.

Industry 4.0, or other equivalent terms, seem to be the buzz words of the moment, and attract an expansive amount of focus and opinion. Whilst there seems to be some commonality with regard to the conceptual meaning, what can only be described as a 'hiatus in information' seems to exist when it comes to providing a solid foundation for implementation.

In retrospect, this is unsurprising as the scope of this topic is so huge that it only really becomes manageable by drilling down into bite size chunks. Whilst a 'top down' overview of Industry 4.0 provides a conceptual insight, a 'bottom up' perspective that takes into consideration the specific systems and enabling technologies will be required to pave the way for implementation.

Introduced as a concept at the Hannover Messe in 2011 to describe and connect trends across different industries, the term Industry 4.0 has evolved to herald a new paradigm in manufacturing. Defined loosely as the 'computerisation of manufacturing', it refers to a shift towards self-organising manufacturing operations, with a greater distribution of intelligence towards individual machines and components.

Under Industry 4.0 it is hypothesised that production lines will reconfigure automatically in order to optimise productivity, reduce changeover times and accommodate wide product variations. Driven from an end-to-end array of technologies and software systems, ranging from sales, order processing, supply chain management, logistics and production management, it is clear that future production machinery and components will need to integrate dynamically and seamlessly into such higher level IT systems.

As an integral part of most production machinery, sensor systems will require a number of enabling technologies to provide the necessary functionality to realise the demands of an 'Industry 4.0 ready' machine. It is clear that the passive on/off operational functionality of standard sensors will not provide sufficient capabilities to support the required level of integration.

Integrated sensors that can communicate with higher level control systems to monitor, configure and parameterise automatically, will undoubtedly

"EtherCat is known for its flexibility to support the integration of a wide range of peripheral devices beyond sensor systems including machine vision, servo drives, inverter drives, pneumatics and safety. It provides the benefit of a single interface platform for all machine peripheral devices, simplifying the configuration and cross communication between devices on a machine."

be a prerequisite to enable dynamic changes to machine configurations, as described by the Industry 4.0 concept.

Taking the simplified example of automating a product changeover process on a machine, this could be vastly improved through the use of intelligent and integrated sensor systems. Traditionally sensors are configured individually and manually during machine changeover based on the requirements of the product being manufactured; perhaps due to a change in colour, size or any other physical difference in the product. This can be time consuming, inefficient and a source for manual errors.

Intelligent sensors

However, by deploying an Industry 4.0 concept, the process could be fully automated, being driven end-to-end from point of order and production scheduling through to machine configuration down to component level, even including sensor systems. Intelligent control systems will automatically set detection parameters and settings to allow seamless product changeovers, improving efficiency and eliminating common manual errors.

In addition, with increased levels of integration of sensor systems, the operational status and stability of sensors could be communicated back to the machine control system, via this intelligent link. By monitoring these statuses, automatic optimisation of the sensor setting could be made, improving production efficiency even further. The intelligent link could also provide fault diagnostics and preventative maintenance information, helping to reduce machine downtime and again improve production efficiency.

Unlike many elements of the Industry 4.0 concept which are based on futuristic, unrealised technologies, integrated sensor systems with an advanced intelligent link already exist today. Essentially integrated sensor solutions which incorporate a fieldbus interface are readily available, providing all the necessary functionality to realise the demands of a fully integrated production system.

EtherCAT

In reality the sensor solution becomes a secondary consideration and the fieldbus technology is the enabling factor, providing the interface to the machine control system and beyond. The fieldbus provides the bi-directional communication platform to ensure that both measurements and settings can be easily communicated between devices. This provides the ability to realise the functionality required for intelligent production systems - and the industry 4.0 concept starts becoming reality.

There are now number fieldbus solutions available for sensors, each with their own benefits and restrictions. Some fieldbus technologies were specifically designed for sensor communication, like I/O Link, developed to support the unique requirements of sensors. But there are also generic fieldbus solutions which support additional devices beyond sensor systems and provide a single machine fieldbus solution for all common machine components. EtherNet/IP, ProfiNet and EtherCat are probably the most common machine automation fieldbus technologies and are widely supported by a number of manufacturers through an open vendor agreement.

Whilst Omron supports a wide range of fieldbus technologies, our primary offering uses EtherCAT which is widely recognised as the fastest fieldbus solution currently available. EtherCat is also known for its flexibility to support the integration of a wide range of peripheral devices beyond sensor systems, including machine vision, servo drives, inverter drives, pneumatics and safety. It provides the benefit of a single interface platform for all machine peripheral devices, simplifying the configuration and cross communication of all the devices on a machine.

Integration of these devices into the fieldbus network is simple and can be configured, with no more than a few clicks of your mouse and via a single network configuration software package, providing instantaneous data exchange with the machine control platform and the peripheral devices. This completely eliminates developing complex protocols or writing custom code, and therefore provides fast and seamless integration.

Whilst the functionality of integrated sensors is very much a reality today, it is clear that the uptake of these solutions is very much in its infancy. But with the increasing demands of manufacturers and the drive towards the realisation of the Industry 4.0 concept, the expectation is that demand for these integrated sensor solutions will increase exponentially in the coming years.

"Unlike many elements of the Industry 4.0 concept which are based on futuristic, unrealised technologies, integrated sensor systems with an advanced intelligent link already exist today."

Dan Rossek,
Marketing Manager, Omron

A collaborative project between Schaeffler and KIT has produced an assisted steering system for electric vehicles

Resistance (to motion) is futile

Bearing manufacturers are increasingly able to offer their expertise when it comes to motion, and making it as efficient as possible. Justin Cunningham takes a look at some recent developments.

Bearing companies are increasingly keen to offer engineering expertise when it comes to advising customers about the smooth running – and in many cases increasing functionality – of modern bearing systems.

For some time bearing suppliers have been waving the consultancy flag, and it seems to be paying off after a raft of engineering successes, and accolades, have attributed bearing components to step change improvements. In particular, automotive OEMs have reached out to the expertise on offer.

A recent example comes from bearing company SKF, who launched an upgraded version of its third generation hub bearing unit (HBU3), designed to reduce preload and CO_2 emissions on a variety of vehicles.

For those not in the know, preload is essentially an interference fit on the actual ball bearings inside a casing. Ball bearings need some level of clearance when fitted inside a housing, meaning there is some 'give' between the different parts to allow them to freely rotate. But these internal clearances need to be tightly controlled so there is not too much axial movement, as this would cause vibration and inefficiency. Normally manufacturers induce a permanent thrust load on the bearings to secure them in place. However, that means more friction is produced on rotation.

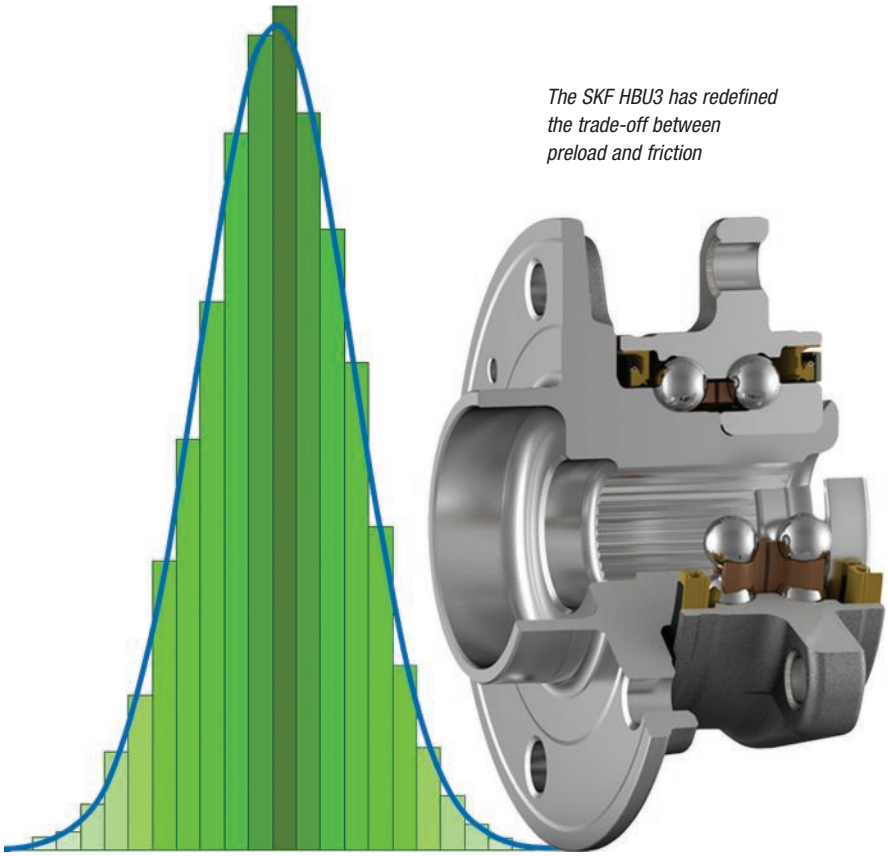
Advanced assembly processes

Getting the balance right has been a constant source of optimisation and trade off for bearing developers over the years. However, SKF has said that it has managed to reduce preload, and its associated friction by 10%, by revising the design of internal components and enhancing the manufacturing and assembly process normally applied at its factory. Though tight-lipped about the details, SKF found the new design and manufacturing technique has also improved reliability and quality of existing hub bearing units.

"The third generation hub bearing unit has been developed while working with leading automotive OEMs," said Massimiliano Leone, customer project manager for the automotive markets at SKF. "As a result, we have produced a unit that is easy to install and replace, that offers a class-leading standard of reliability, and gives both OEMs and their customers the opportunity to improve vehicle performance."

The theme of low-friction is an obvious one for bearing companies and the trend of reducing it has undoubtedly been impressive over the last few decades. Modern bearing design and manufacture has become as advanced as the projects and products they look to enable.

Part of this 'enabling' process is not just direct CO_2 savings by decreasing rolling resistance, but also the optimisation of sub-assembly systems that have bearing components at their heart. And it was this that saw bearing giant NSK develop a



The SKF HBU3 has redefined the trade-off between preload and friction

low-friction reduction gear for electric power steering (EPS) systems on vehicles.

The premise of EPS goes back to the common view that power steering is provided using hydraulic systems powered by the internal combustion engine. However, EPS saves energy here, as the motor that provides power can be turned off when the vehicle is travelling in a straight line. This results in an improvement in fuel efficiency over hydraulic power steering systems.

The move to EPS is an industry wide trend and the use of this sub-system could eventually make hydraulic power steering systems obsolete, and there are a number of reasons why. The first is the ability for it to be 'smart'. The motor providing the steering assistance can be electronically controlled to respond to a number of driver and environmental inputs, including the amount the driver turns the steering wheel (so changing lanes on a motorway to swerving), the vehicle speed and road conditions. Here, the aim is not necessarily to cut CO_2, but improve safety as well as drivability. For these reasons the application of EPS is rapidly expanding.

In addition, the system aims to reduce steering fatigue experienced by drivers by making steering smoother during straight motorway driving, as well as improving comfort when the steering wheel returns from larger turns at a junction. One key element in creating this kind of smoothness is the amount of friction in the system.

To aid this, NSK developed a low-friction grease that reduces the frictional force of the reduction gear, thereby decreasing driver effort and improving the 'feel' of the steering.

NSK leveraged its tribology technology here and optimised the formation of oil film by using a new grease that prevents any increase in viscous drag. As a result, oil film is formed in a reliable manner between the face of the gear teeth. The result is an astonishing 17% decrease of friction in the reduction gear.

However, NSK is not the only one to lean on years of tribological knowhow to create an advanced steering system. Schaeffler has also carried out a project with a similar end in mind.

During a carried out a collaborative project with the Karlsruhe Institute for Technology (KIT) in Germany. The aim of the project was to research and develop technologies for improving the energy efficiency of assisted steering systems, specifically for electric vehicles.

Like NSK the premise was to develop an electric power steering system, with the ultimate end market firmly being electric vehicles. In conventional vehicles, the internal combustion engine not only accelerates the car but also supplies power to on-board assist systems, including the power steering system. In electric vehicles, this energy comes from the battery, which reduces the vehicle's travelling range, so a workaround is an industry necessity.

The project known as 'Intelligent Assisted Steering System with Optimum Energy Efficiency for Electric Vehicles (e²-Lenk)' looks to improve the energy efficiency of steering systems by intelligently controlling the drive torque transmitted to each of the vehicle's four wheels.

Though Schaeffler is perhaps best known as a bearing and linear system supplier, it is fast being recognised within the automotive industry as transferring that knowledge and engineering expertise to produce automotive sub-systems.

Project manager Dr Marcel Mayer of Schaeffler, explained: "The assisted steering system would require fewer system components in an electric vehicle, which would mean savings in terms of weight and energy. This, in turn, would mean that an electric car would be cheaper and have a greater travelling range."

The basic idea of the e²-Lenk project is simple: the wheels of an electric car are driven individually by electric motors. If the wheels on the left side transmit more drive torque to the road than those on the right side, this will result in acceleration of the vehicle to the right without the need to turn the front wheels or consume additional energy for steering. Tracked vehicles or quadcopters steer using the same principle.

"Steering assistance can be provided while driving by means of an intelligent control system and suitable wheel suspension," said Dr Mayer. "Only steering when stationary remains a challenge with conventional designs."

As part of the project, functional demonstrators are being built, with which the concepts and components – no doubt of which bearings and low friction movement play a vital role – will be validated and optimised in tests later this year.

www.skf.com
www.nsk.com
www.schaeffler.co.uk

Nuclear materials **race is on!**

Making fusion power a practical energy source is going to require materials that survive unfathomable extremes in temperature. Justin Cunningham investigates.

The challenge to produce clean and sustainable power for future generations is an intimidating one. While fusion power offers this tantalising possibility, it is tomorrow's technology that is at least 30 years away... and it seems always will be. In all reality, however, it will be far more than that, so it's fair to say the challenge isn't just intimidating, it's downright terrifying.

Not many understand the sheer scope of the problem more than Professor Steven Cowley, chief executive of the UK Atomic Energy Authority (UKAEA), head of the Culham Centre for Fusion Energy, and respected world authority on the subject. Professor Cowley has dedicated his life to understanding fusion reactions, and explained the scale of the materials and engineering challenges to make it a practical source of electricity production at the IOM3 annual lecture, last month.

"I believe we are going to need fusion power at some point," he stated. "I can't guarantee there will be a fusion reactor in the future, but if we don't solve some materials problems I guarantee there won't be.

"We are within striking distance of demonstrating that fusion is possible, but I don't see us quite at the point of being able to show that it is economically viable. And much of the problem is in materials science and engineering."

The UK is well placed in the fusion power materials race. The Culham Centre for Fusion Energy has the world's number one fusion reactor in JET, the Joint European Torus, the only machine to have produced a 'significant' amount of fusion power in a controlled way. However, it is just a baby step down a very long road.

The next phase of this journey is the construction of ITER (The International Thermonuclear Experimental Reactor) in southern France, the first machine that's hoped to achieve a self sustaining fusion burn.

The timescale is predictably slow and delayed. Now, that's not to appear defeatist or cynical of the project, more an acknowledgement that this is a genuine trip in to the unknown where such things tend to come as standard. Fusion power, coupled with a manned mission to Mars, are arguably the greatest engineering challenges for the next several generations. Make no mistake, even in its current undeveloped state, ITER is – and certainly will be – an impressive piece of technology.

The scale of the problem becomes clear when numbers start to be added in to the equation. The

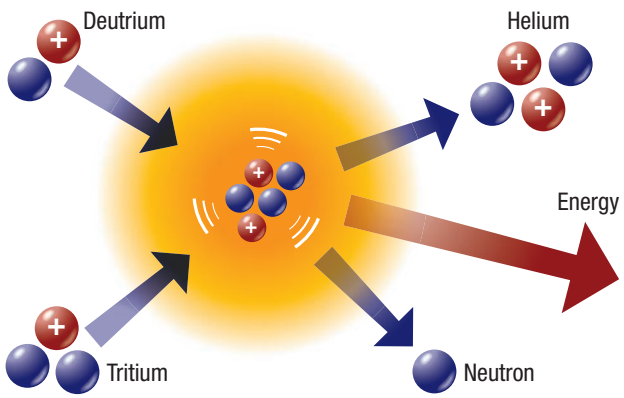
What is Fusion?

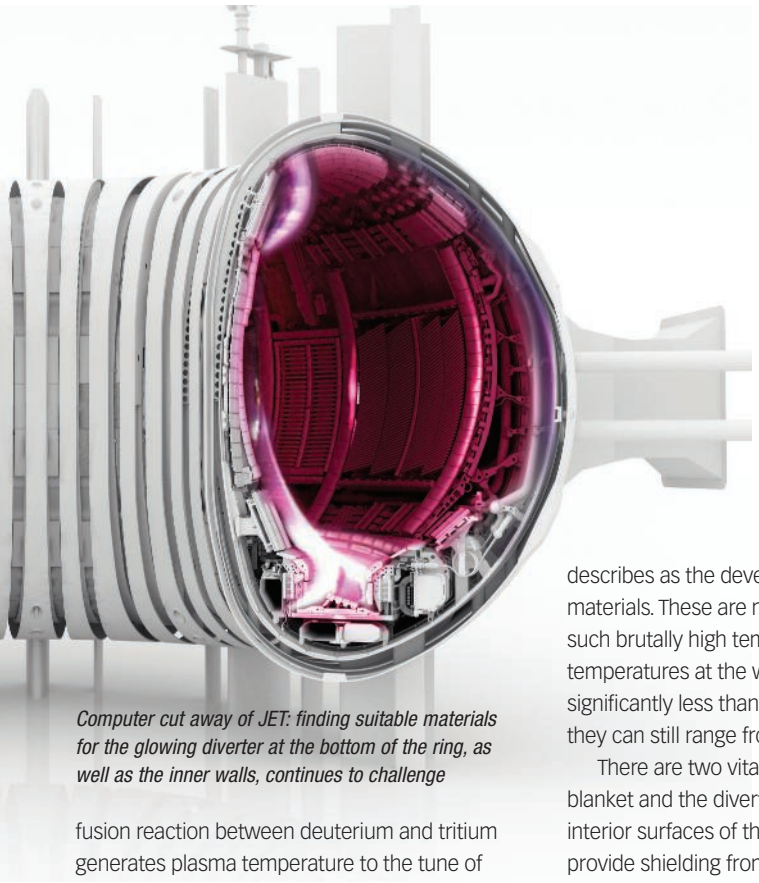
Fusion occurs naturally in the Sun and other stars. Hydrogen nuclei collide, fuse into heavier helium atoms and release a tremendous amount of energy in the process.

Scientists have identified the most efficient fusion reaction to reproduce in the laboratory here on Earth as the reaction between two hydrogen isotopes: deuterium (D), extracted from water and tritium (T), produced during the fusion reaction through contact with lithium. Like the nuclear reaction in the Sun, when deuterium and tritium nuclei fuse, they form a helium nucleus, a neutron and produce a lot of energy.

The D-T fusion reaction produces the highest energy gain at the 'lowest' temperatures. It requires nonetheless temperatures of 150,000,000°C to take place – ten times higher than the nuclear reaction occurring at the Sun's core. One way to achieve these conditions is a method called magnetic confinement, which controls the hot plasma produced by the reaction with strong magnets. The most promising device for this is the doughnut shaped 'tokamak', the Russian word for a ring-shaped magnetic chamber.

Nuclear fusion is one of the most promising options for generating large amounts of carbon-free energy in the future as the only by-product is a small amount of helium, which should not add to atmospheric pollution as it is inert.





Computer cut away of JET: finding suitable materials for the glowing diverter at the bottom of the ring, as well as the inner walls, continues to challenge

fusion reaction between deuterium and tritium generates plasma temperature to the tune of 230,000,000K that will be contained by magnetic pressure of over 100atm within the central vacuum chamber of the doughnut shaped reactor. At the centre of the reactor are superconducting magnets that need to be kept at just 4K. The two massive extremes in temperature will be just metres apart - an indication of the demands on the material properties this structure will have to cope with.

If predictions are correct, ITER will produce just over 0.5GWatt of power in a self sustained fusion burn lasting from 100s up to 2000s. Current estimates are that full fusion experiments could begin in the late 2020s.

"Any fusion power station really needs to be a maintenance system with a reactor on the side," said Professor Cowley. "So much of it will have to be replaceable. All the components will take wear and tear, and will need to be taken out of a nuclear environment remotely and either stored or disposed of."

This includes, for example, the hundreds of tonnes of super conducting magnets. The reality is it's simply not good enough to make plasma, neutrons and a fusion reaction. The whole structure needs to last at least several years of operation for practical fusion to become a reality.

"It is enormously challenging," said Professor Cowley. "Our ambition though is that the UK gets to design it. It's a big engineering job and is one of the most challenging things we will ever set out to do. We have to start thinking, what are the materials we are going to build this from? How are we going to do the engineering? We would have to do this with industry and universities and really collaborate."

While Professor Cowley conceded there are masses of materials problems, he highlighted what he sees as the two main challenges. The first is what he describes as the development of high heat flux materials. These are materials capable of surviving such brutally high temperatures. Although temperatures at the wall of the reactor are significantly less than the centre of the plasma, they can still range from 3,000 to 10,000K.

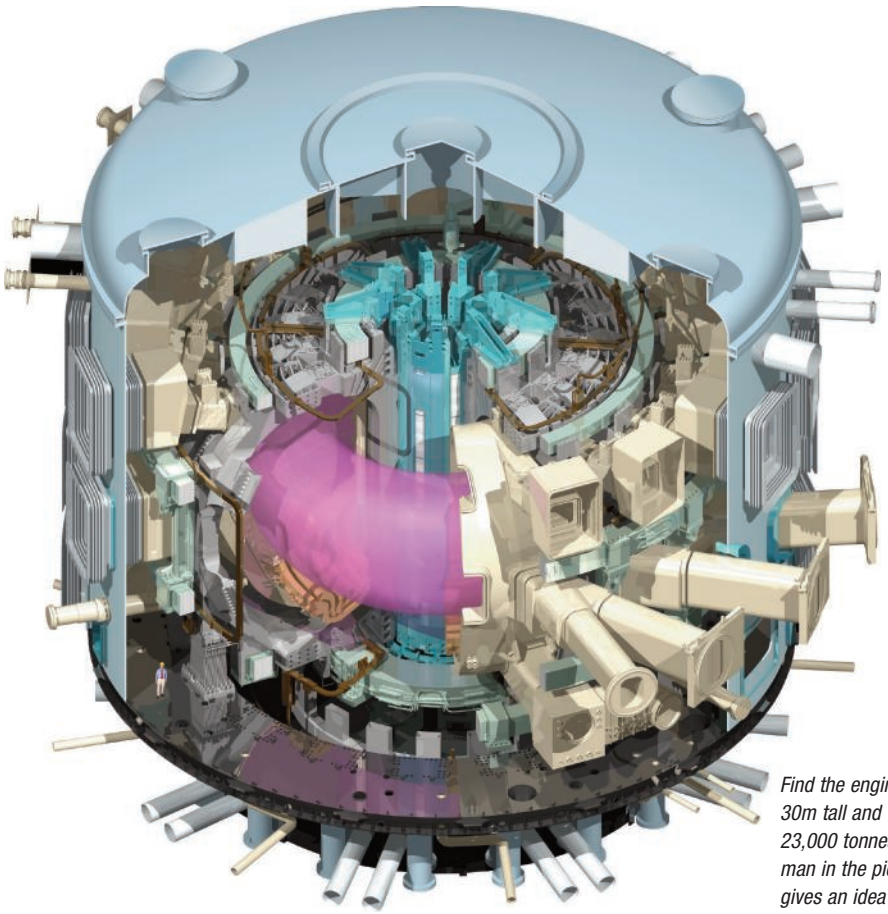
There are two vital components here: the blanket and the diverter. The blanket will cover the interior surfaces of the vacuum vessel and provide shielding from the heat and neutron fluxes produced during a fusion reaction.

The neutrons are slowed down in the blanket where their kinetic energy is transformed into heat energy and collected by coolants, possibly flowing within the walls. These channels could be produced using additive manufactured processes. For purposes of maintenance on the interior of the vacuum vessel, the blanket wall will need to be modular and will consist of 440 separate 1 x 1.5m, 4.6 tonne, individual detachable segments.

"The plasma sits in the middle of the [doughnut shaped] chamber, where heat and helium work their way to the outside due to eddies that carry them across the magnetic field," explained Professor Cowley. "These then flow in to what we are calling the diverter, which will carry waste heat and waste helium away."

And here is the other major materials challenge. ITER will put a predicted 100MW of waste power in to the diverter, which to date is designed as a very narrow channel. It needs a material capable of handling a plasma load of 50MW/m^2, and that is simply not possible with any current material.

"The first thing is to get that heat load down," said Professor Cowley. "Like any heat exchanger we want to spread the heat over the



Find the engineer: At 30m tall and weighing 23,000 tonnes, the man in the picture gives an idea of the machine's scale

biggest possible area."

By revising designs it might be possible to get the load down to about 5MW/m^2, but even this is an ambitious target for material survivability. Tungsten is proposed because of its durability, but even then it is not certain to survive.

"There are all kinds of problems," explained Professor Cowley. "The tungsten has to be above a certain temperature because of its brittleness. But, it has to be below a certain temperature because it makes what we call 'tungsten fuzz' on the plasma surface, and this cuts down on the heat transfer, so surface temperature goes up. And, we have got to restrict the erosion of the tungsten surfaces to below 1mm per full power year, as we only have a few mm between the surface and the coolant channels inside."

The other problem for the materials will be exposure to the nuclear environment, notably the neutrons. Most of the neutrons come from the middle of the plasma and journey outwards where they will hit the inner tungsten blanket wall, and degrade the materials. Neutrons from a fusion reactor have 10 times the energy compared of those produced during a fission reaction.

These neutrons produce helium inside tungsten. They strike grain boundaries inside the crystalline structure and begin to line them with helium molecules. This build up continues until the material becomes embrittled, full of defects, voids and flaws.

"After five years of running it will be not tungsten," said Professor Cowley. "It is some weird alloy of tungsten, packed with helium. So will it be strong enough? Will it hold? Will the helium embrittlement mean we'll never make walls that will last long enough?

"We have got to produce a new generation of materials – not only for fusion, but for fission as well."

Indeed, Culham has a new materials facility that will test medium irradiated materials cut into micron sized samples for strength, embrittlement, and all sorts of properties.

"We haven't solved this problem," concluded Professor Cowley. "We have just begun to get started on how we might do it."

FUSION FACTS:

Deuterium can be extracted from water and tritium is produced from lithium, which is found in the earth's crust. Fuel supplies will therefore last for millions of years.

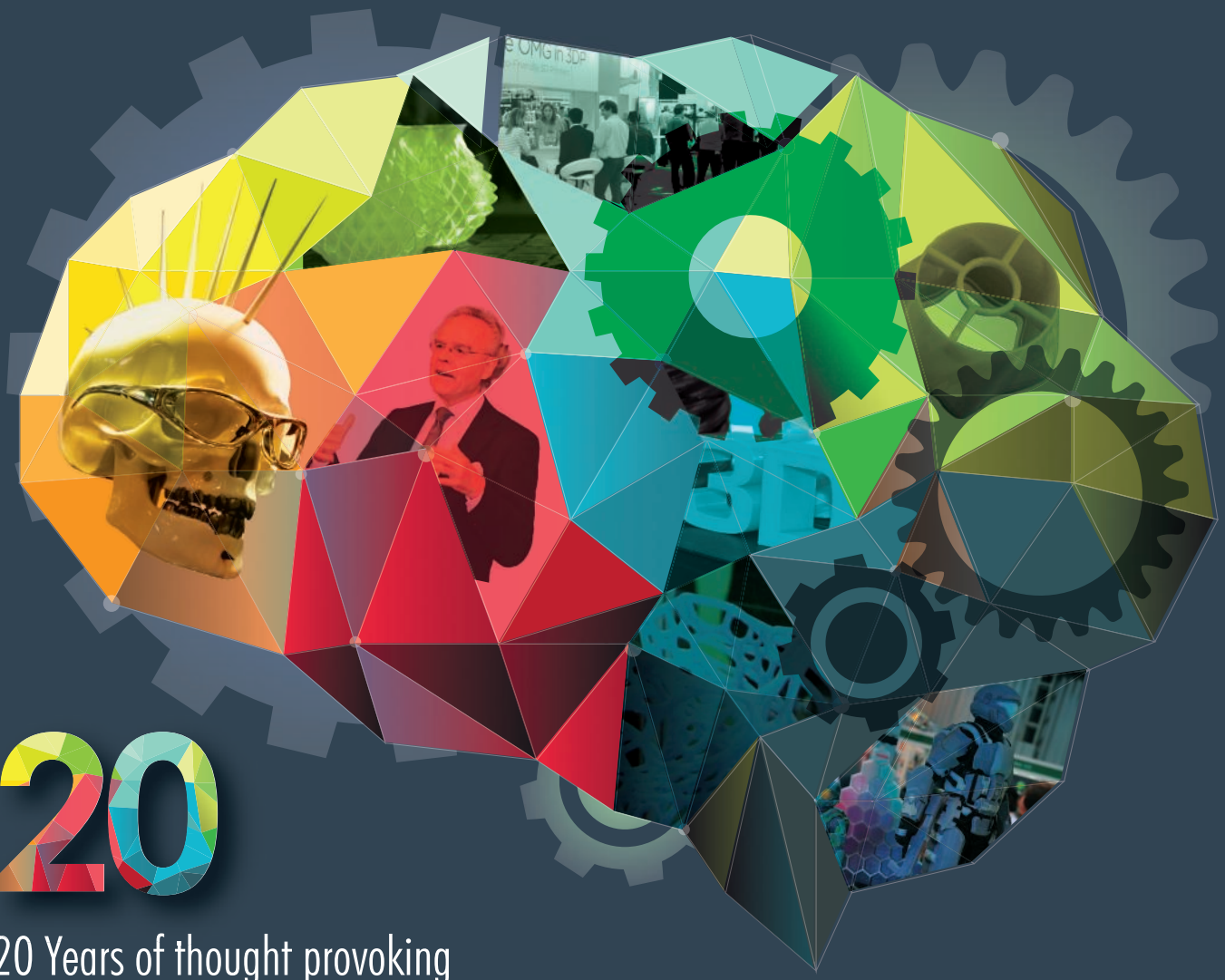
One kilogram of fusion fuel can provide the same amount of energy as 10 million kilograms of fossil fuel.

No long-lived radioactive waste. Only plant components become radioactive and these will be safe to recycle or dispose of conventionally within 100 years.

The small amounts of fuel used in fusion devices (about the weight of a postage stamp at any one time) means that a large-scale nuclear accident is not possible.

Fusion power plants should provide a baseload supply of large amounts of electricity, at costs that are estimated to be broadly similar to other energy sources.

Accelerating 3D Technologies



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Have you done it better?

The deadline for entry to the BEEAs 2015 is approaching fast – but there is still time!

Entries for the 2015 British Engineering Excellence Awards will close at the end of July 2015, and so the simplified online entry procedure still gives plenty of time to allow you to put forward industry's finest people, projects, products and companies.

Now in their seventh year, the Awards are designed to celebrate those UK companies and individuals that have demonstrated the skills, invention and dedication to succeed and compete on an international stage.

Recent winners of the Grand Prix, which is the outstanding category winner each year, includes design consultancy Romax Technology (2014) for its pioneering work in gearbox optimisation; Sebastien Cuvelier Mussalian (2013), Senior Engineering Consultant for Team Consulting for his inspiring leadership and technical capability; Parker Hannifin (2012) for the Racor Super Impactor CCV, winner of the Green Product of the Year; and ICS Electronics (2011), an outstanding small company with global reach.

A high quality panel of independent judges will select winners for each of these categories, and from these will then select a British Engineering Excellence Grand Prix winner.


Peter Poon of Romax Technology

Interestingly, and entirely coincidentally, the overall winner has come from a different category each year. These award categories cover all aspects of excellence in engineering design. For 2015, these categories are:

- **Consultancy of the Year**
- **Design Engineer of the Year**
- **Design Team of the Year**
- **Green Product of the Year**
- **Materials Application of the Year**
- **New Product of the Year (Electronic)**
- **New Product of the Year (Mechanical)**
- **Small Company of the Year**
- **Start Up of the Year**
- **Young Design Engineer of the Year**

In order to ensure that companies of all sizes can compete fairly, the judges will take into consideration such factors as team size, project budget, project design cycle time, the regulatory environment, the competitive nature of the target market, the materials and technology selected by the design team and the attention paid to environmental issues.

The Awards will be presented at a lunch event, being held at London's Hurlingham Club on 29 October – a new and glamorous venue that reflects the increasing profile of these awards in the British engineering sector.

If you believe you have what it takes to win in any of the above categories – or know of a product, company or individual that does – entry forms, detailed entry criteria and additional information on the Awards categories can be found at **www.beeas.co.uk.**

As a guide to what it takes to be a BEEAs winner, Peter Poon, co-founder of Romax Technology, said on receiving the Grand Prix Award last year: "Romax came from humble beginnings, from an engineer who had a desire to improve things. You ask 'Can you do it better?' – and you will always find a way. That is deep in my psyche and in my blood, and I subscribe to it any success I have had."

So if you think you have 'done it better', enter the BEEAs and maybe by October you will be the toast of the engineering industry.

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Have you got the **right hardware?**

Engineers tend to focus on the software environment, but is computer hardware also important? Very much so, as Tim Fryer found out.

Are all computers created equal? Is the bare minimum in terms of specifications often, 'good enough?' Or does the performance of the hardware have a direct relationship to the productivity and creativity of the engineers using it? There are four companies who dominate this area in Europe – Dell, HP, Lenovo and Fujitsu – so we asked these questions, along with tips on how to get it right. What should the engineer be specifying when looking at a new workstation.

Is hardware important?

"Hardware is fundamental," said Sean Young, worldwide product development and AEC (Architecture, Engineering and Construction) segment manager at HP. "Software is something that the users are using all day long and it's completely dependent on the hardware to do its job. So, if the hardware is not properly spec'd, the configuration will be incorrect for the user's needs and that is going to result in either a poor, or slow, experience with the software or at worst major problems with the function."

It was a problem that resulted in a new class of workstations that may look like regular PCs on the outside, but in fact are built to meet the demands of people working within the CAD environment, where the equipment will be used all day long and, with deadlines around every corner, slow performance or downtime cannot be tolerated.

AEC segment manager for Lenovo Tom Salomone explained: "When SolidWorks first started out, a lot of people put their SolidWorks on PCs and they just had too many problems. Typing would be slow. Their graphics wouldn't work right. So SolidWorks went through a certification process where they take the hardware in and test it. They make sure it works with SolidWorks and certify it.

"If you're doing CAE, any kind of analysis like computation of fluid dynamics, or FEA, then you're going to want a high end workstation, something with a lot more ports."
Tom Salomone, Lenovo

All the major ISVs (independent software vendors) now certify equipment as capable of running their software, and have these certifications in place.

Leigh Schvartz, product manager for high performance computing and workstations at Fujitsu commented: "Each of our products is certified by the CAD companies, ensuring that specific application software is supported by the vendor on our workstations. However, this still allows for plenty of customisation – as the base product model is certified in combination with a professional graphics card. Therefore, if customers want to customise their hardware with regards to CPU, HDD or memory, that is not a problem."

But does this mean that engineers, or their IT managers, can look at the 'minimum system requirements' as quoted on the software box and be confident of seamless operation if these requirements are met?

"Minimum hardware requirements can be very misleading," said Scott Hamilton, a precision strategist at Dell. "Software vendors provide these only as a minimum requirement for the software application to function, anything less

will not work properly. But these are not recommendations and certainly won't give you good performance. We partner with ISVs to test, certify and optimise professional software on Dell workstations, enabling a stable and reliable platform to create, simulate, visualise and collaborate on designs, speed up workflows and maximise productivity."

As a result of this work, Dell helps potential customers define their unique system configuration using a tool called the Precision Workstation Advisor. Equally HP has the HP Performance Advisor, while Fujitsu positions its machines as good, better and best for each of the popular software packages.

What to look for

Lenovo's Salomone said if you asked an engineer what his top three priorities should be it is: "Performance, performance, performance. First, it's processor performance. Then it's the graphics performance and then it's the disk drive and memory performance. They'd be looking to get the most performance they can for the money they have. For CAD applications the performance should be really the highest gigahertz.

"For CAE applications the performance is really about having the most cores; you get 18 cores in a processor in a P900 now, and you get two of those, so you can get 36 actual cores. Intel has a spec now, it's called Hyper Threading and you turn that on, that's equivalent to 72 cores. So that's a lot of cores and lots of threads that can be processed at a desktop level now for people to do analysis quickly."

The different ISVs also use computer resources in different ways, sometimes even when doing equivalent functions and this can have an impact on the hardware.

HP's Young added: "[software packages] all have differences, they all have different strengths. In terms of the workstation requirements, they're different across the board. It really depends; some support multiple port processors better than others, some use GPU for rendering, some use CPU, some use both. Some have different memory requirements, and more memory requirements, as they all manage data differently on the back end."

With all the help available from the hardware companies, finding the right equipment should be straightforward. Design teams can be made

● Lenovo ThinkStation 900

Top of the range at Lenovo is the ThinkStation 900. The power comes from its latest Intel Xeon processors and NVIDIA Quadro graphics cards to provide sufficient performance to run all ISV (independent software vendor) certified applications. The ThinkStation P900 is up to 73% faster than its predecessor, the ThinkStation D30.

The features revolve around flexibility, with storage maximised by allowing up to 14 drives, with redesigned single trays that support 2.5" and 3.5" hard drives. FLEX bays allow easy 'mix and match', so that only components that are needed are used. These include HDD, ultraslim ODD, 29-in-1 media card readers, and firewires. Thunderbolt 2 adds in cards allowing for faster data transfer. Functionality is increased without sacrificing slots using two innovative FLEX connectors, supporting SATA/SAS/PCIe storage and advanced RAID solutions.

There are intuitive red touch points to guide the user to quick and easy component changes – even to the motherboard and removable power supply – without a single tool. And a revolutionary tri-channel design and unique air baffle maximises airflow, keeping components cool, quiet, and strong.

www.thinkworkstations.com

▲ Fujitsu Celsius C740

Fujitsu claims to be the only global tier-one vendor offering a 1U rack workstation, which maximises data centre density benefits. The Fujitsu Celsius C740 rack workstation is flexible enough to be used as a one-to-one remote workstation, versatile enough to form the basis of a one-to-many virtualised workstation, and powerful enough to become a node in a high end rendering cluster.

Features include:

- Two PCIe x16 slots and an additional PCIe x8 slot allow for maximum flexibility to add either two single height or a double height graphic cards in combination with a Teradici card or LAN- or RAID-controller-card
- Maximum memory capacity of 256GB of DDR4 running at 2133 MHz
- NVIDIA GRID graphics supporting a virtualised graphics environment
- New Fujitsu SSD PCIe card: Choice of adding one 1x 256 GB or 1x 512 GB card directly to the board or support of a flexible expansion card with up to two modules
- Up to 18 cores of Intel Xeon processor E5-2600 v3 family
- SATA DOM (Serial ATA Disk on Module)
- Simple to administer, server-based management includes an integrated Remote Management Controller (iRMC S4) and Fujitsu ServerView Suite embedded Lifecycle Management (eLCM)

www.fujitsu.com

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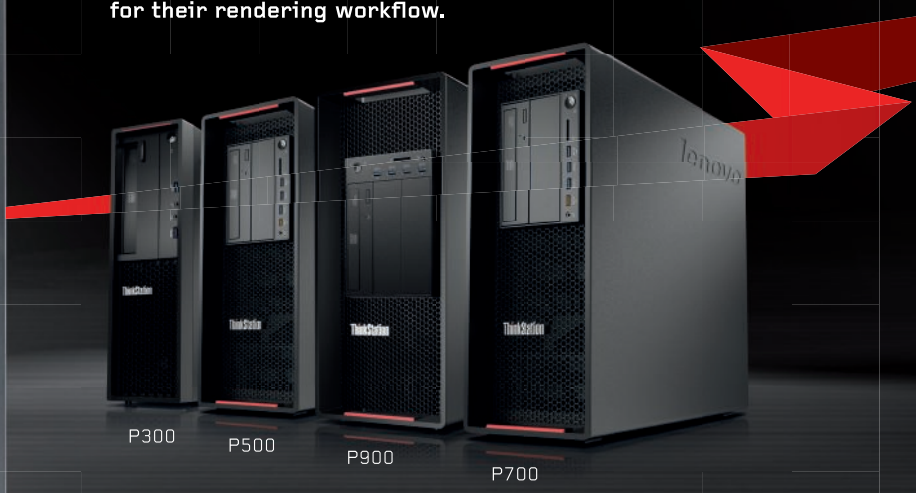

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up of a diverse range of engineers and designers, some running different applications and there will always be pressures on the IT manager to keep costs within reason. But, as Hamilton summed up, shortcuts don't pay off.

"The most common mistake Dell sees is not building a balanced system that meets all of the requirements needed for the applications and workflows," he said. "Dell's advice is to consider how the system will be used in all cases and don't sacrifice performance to save a few dollars. Remember all of the components working together provide the best performance.

"It is much more important to make the user as productive as possible as this will bring many benefits to your company like cost of labour savings, better product design, less costly physical prototyping, faster to market and avoiding costly mistakes."

Workstation, mobile or virtual?

While workstations dominate the CAD environment today, is the vision of the future designer as a free spirit, taking his craft with him on his laptop, close? Not yet according to the big four.

Fujitsu's Schvartz said: "As a company we don't believe laptops will be used for mainstream CAD work in the near future. We see the importance of having access to designs on the go for showcasing in front of customers and working on the move, but any heavy work will still need to be ported back onto the desktop."

Hamilton concurred: "Workstations are tuned and optimised to run top engineering and design applications at peak performance that boost productivity that laptops don't have the capabilities to run."

So what of centralising the processing on a server and 'virtualising' the design. While virtualising has been around for ages for general office applications, CAD software requires a GPU and, until recently, virtualised graphics has been a problem. HP's Young said: "Nvidia has created the technology called Nvidia Grid which enables the video GPU to be virtual. That really opened the possibility up for users to have the full virtualised workstation experience. We're starting to see companies embrace that and get started with it, but many haven't fully rolled it out yet."

● Dell Precision Tower 5810

The Precision Tower 5810 is claimed by Dell to deliver up to 75% better performance than previous generations for iterative design and prototyping. The power comes from Intel Xeon E5-1600 v3 series processors, NVIDIA Quadro and AMD FirePro graphics.

System memory is expandable up to 256GB using the latest DDR4 RDIMM memory technology. The Dell Precision Tower 5810 delivers up to 5.5x higher graphics performance than previous generations on SolidWorks, 3.7x on CATIA, 5.5x on CREO, 6.8x on MAYA and 3.6x on Siemens NX.

Storage options include the actively cooled PCIe SSD storage solution for fast and reliable content storage - up to 180% faster than traditional SATA SSD storage. A more traditional storage option is the 12Gb/s RAID controllers, doubling the I/O speed of the previous-generation workstation.

Different applications have different system requirements and the new Dell Precision Optimiser takes the guesswork out of customising settings by automatically adjusting Intel Hyper-Threading, number of CPU cores, graphics and power settings. Precision Optimiser automatically tunes the workstation to run specific programs at the fastest speeds possible.

www.dell.com

◆ HP Z1 G2 Workstation

The HP Z1 G2 Workstation is an all-in-one workstation with a large-screen display, which can be customised with 10-point touch technology in an edge-to-edge glass design. It features 4th generation Intel Xeon E3 processors, NVIDIA Quadro graphics, ECC memory and a wide range of ISV certifications.

The engineering behind the Z1 G2 includes a high end professional MXM Graphics cooling module, optional multiple hard drives and an adjustable custom display stand. Thunderbolt 2.0 ports allow for fast connections.

For frequently used data that is permanently held on the machine there is quick accessibility through the optional mSATA storage technology that provides fast storage and cache for OS and applications. And for designers who need, or want quality sound on their workstations there are premium audio features on the HP Z1 G2 including dual cone, front-facing speakers and DTS Studio Sound.

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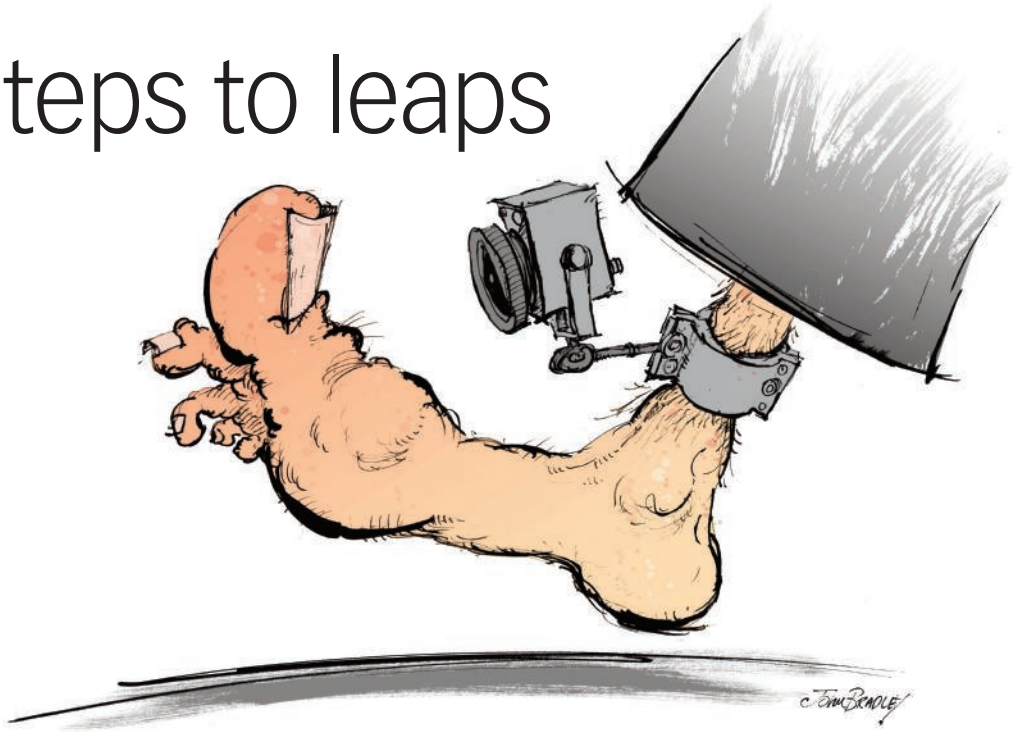

The answer to last month's Coffee Time Challenge – how create a new aid to making walking more efficient - can be found on p12 of this issue.

There is a fair amount of buzz around wearable technology at the moment. But while everyone is seemingly talking about it, few are consistently wearing it. The problem is, beyond the initial spell of gimmicky expectation, what is the real value?

Perhaps one of the most popular 'wearable techs' in recent years is the pedometer. While it is nice to know just how many steps you've done over the course of the day – and perhaps motivate you to do more – the often inaccurate and limited output is enough to turn many off after a while.

The hype, though, is not without some merit. People genuinely want to find out more about this aspect of their daily lives and the corresponding health benefits.

The challenge

The challenge this month is to therefore come up with a better method of counting your daily steps. Any device should not be limited to just counting though, but yield other pieces of useful information beyond distance, time and calories burnt. This could include cadence, stride length and stride time, the impact of the foot on a surface, feedback on gait and so on.

Armed with this information, the device should also be able to go a step further and give users specific feedback and coaching on aspects relating to certain activities, from acting as a marathon coach to analysing a golf swing. In addition, it might suggest a move to more high impact training mixed in with longer jogs, or encourage regular walkers to take on runs.

There should also be medical benefits. For example, identifying ankle angle at time of landing (known as out-toeing and in-toeing gait), gait coaching, left and right gait comparisons, as well as identifying any gait abnormalities that can be used to point to signs of spinal musculoskeletal disease. Other healthcare benefits would also be to monitor the activity and rehabilitation of patients that have undergone surgery or had a stroke.

Any device needs to be non-obtrusive and the wearer should be virtually unaware that they are being monitored. The data should be easy to access and quick to give users useful information. And above all, it must be extremely accurate! So perhaps the wrist is not the right place to monitor the foot's activities?

As always, the idea we have in mind will be published next month but if you have any entertaining or interesting solutions then feel free to leave a comment on the Coffee Time Challenge section of the website or email the editor at tfryer@findlay.co.uk

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Specialist power transmission supplier jbj Techniques Limited were recently contacted by the staff of Bloodhound SSC R&D engineering team to solve a problem on the fuel pump test rig. jbj Techniques had worked with various team members in the past and this previous experience made 'jbj' an easy choice to assist with this project.

The scope of supply was to produce a suitable drive coupling with a maximum diameter of 160mm which is capable of transmitting 550Nm @ 10,000 rpm, needed to be as short an assembly as possible and at the same time be able to accept misalignment within the drive-train.

'jbj' proposed a Sier Bath coupling from their principles RL Hydraulics in Germany who are a wholly owned subsidiary of Lovejoy Inc. in the USA. The high torque capacity of the coupling meant that, when assembled, it fitted perfectly within the existing adaptor arrangement and the crown tooth gear form on the coupling allows for relatively high misalignment without transferring loads between the shafts. 'jbj' had the blank parts in stock having a comprehensive stock of power transmission couplings of many types and designs. jbj Techniques are well known for this, being able to provide customers with essential quick turnaround to keep industrial downtime to an absolute minimum.

jbj Techniques's proposed solution required a special drive shaft, which when connected to the output flange of an automotive gearbox enabled easy assembly of the Sier Bath Unit. 3D models were then supplied and approved by the Bloodhound team and after manufacture the complete assembly was dynamically balanced to ensure that the coupling operated without generating any additional forces.

The fuel pump is the pump for the rocket, effectively it's an end suction centrifugal pump driven by a Jaguar 'F' type V8 engine. It's roll is to pump the oxidizing agent (hydrogen peroxide) into the rocket engine which contains the actual (solid) fuel (rubber). The other engine is a jet and does not require a separate pump.

The end-suction centrifugal pump is basically an impeller mounted within a volute housing, the impeller is mounted on a shaft supported on two bearings. One is mounted close behind the impeller with a pressurised double mechanical seal to prevent leakage. A bearing housing accommodates the length of the shaft and ensures a suitable gap between the bearings sufficient to support the rotating parts. This picture shows it standing on its suction inlet (picture above) flange with the outlet (discharge) pointing to the left and the coupling at the top mounted on the end of the shaft.

Rocket "fuel pump" test rig.

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