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# Eureka!

## NUCLEAR FUSION

**TIME TO ENGINEER FUSION ENERGY**

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- GRAPHENE SPEAKERS
- SURFACE PREPARATION
- NASA MANNED ROCKET TESTS

# ONE. STOP. SHOP!

## Best in Class: Helping You Innovate!

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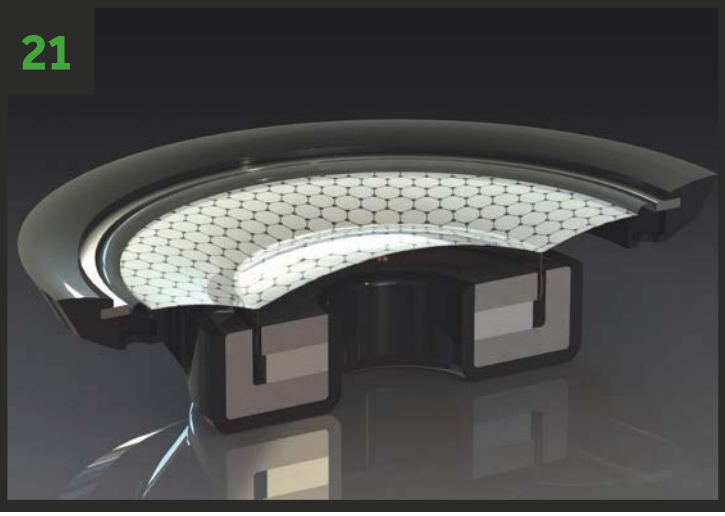

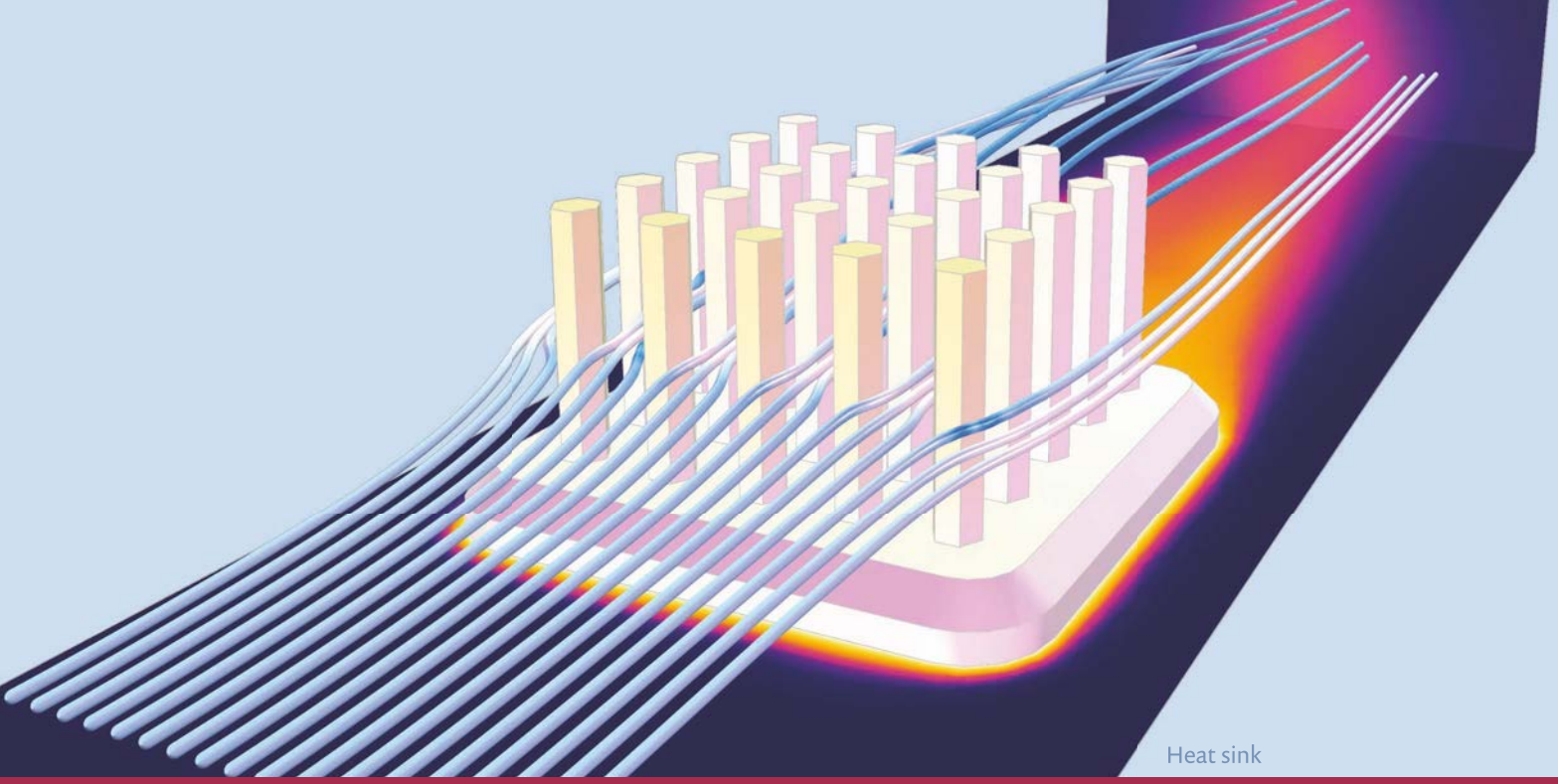

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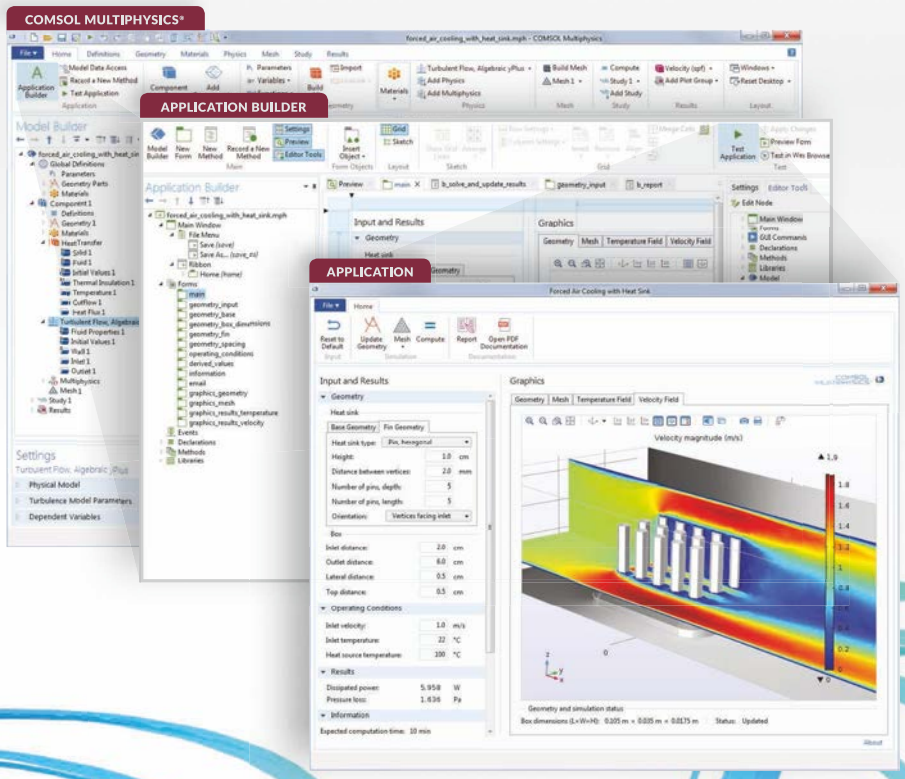


COMSOL

# GO WITH THE FLOW

**IN JANUARY A** review by former UK energy minister Charles Hendry broadly supported the idea of electricity generation using a tidal lagoon in Swansea, a scheme we covered in *Eureka!* last February.

It will cost in the region of £1.3bn and generate 320MW, which compares to the cost of building Hinkley Point C at £18bn with its generation capacity of 3200MW. Or to put it another way, 10% of the capacity for 7% of the costs. Unless we decide to use overseas financing options, we would also not be tied into sky high unit costs for the electricity generated. Nor would we have to factor in the decommissioning costs – Sellafield looks like it will end up costing an astonishing £70bn!

Don't get me wrong, I am not against Hinkley, but if it makes sense from environmental, financial and energy security perspectives then surely the Swansea scheme must be worth committing to.

As with any renewable energy source, the environmental aspect should not be dismissed, and the scheme is bound to change the ecosystem. But given natures inherent adaptability, will it actually cause any damage? The 1967 scheme at Rance in northern France saw some fish species disappear (sand eels and plaice) while others returned (sea bass and cuttlefish) – so environmental credentials may vary depending on perspective.

This French facility did take 20 years to pay back costs, but is now producing electricity at less than the cost of nuclear power stations.

The only other tidal power station of any size is at Sihwa Lake in South Korea. Only coming on stream in 2012, it is too early to assess its environmental impact, but it was designed in tandem with schemes for land reclamation and to reduce agricultural pollution.

The most compelling argument in favour of the Cardiff scheme is that if it was the trailblazer for a series of other tidal energy schemes it could provide a useful baseload for the National Grid. Admittedly the nature of tides means that there are only certain times of day when the turbines are productive. However, proposed other sites range from South Wales to the North West of England, and the difference in tidal cycles in these sites is around five hours, so taken as a whole there could be a consistent and predictable amount of electricity being fed to the grid, possibly providing up to 10% of requirements.

Beyond the Swansea scheme we have reported on a number of other tidal energy projects in *Eureka!* and it feels that this is the time when British engineers could take a lead in harnessing a global, but broadly untapped, resource.

**Tim Fryer, Editor**
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Editor **TIM FRYER**
tim.fryer@markallengroup.com

Technology Editor **JUSTIN CUNNINGHAM**
justin.cunningham@markallengroup.com

Editorial Assistant **TOM AUSTIN-MORGAN**
tom.austin-morgan@markallengroup.com

Group Editor **GRAHAM PITCHER**
graham.pitcher@markallengroup.com

Art Editor **CHRIS CHARLES**
chris.charles@markallengroup.com

**ADVERTISING SALES 01322 221144**

Sales Manager **JEZ WALTERS**
jez.walters@markallengroup.com

Area Sales Manager (North) **SIMON BONELL**
simon.bonell@markallengroup.com

Sales Executive **CHRISTIAN KOSTADINOV**
christian.kostadinov@markallengroup.com

Production **HEATHER UPTON**
heather.upton@markallengroup.com

Circulation Manager **CHRIS JONES**
chris.jones@markallengroup.com

Publisher **LUKE WEBSTER**
luke.webster@markallengroup.com

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# RECORD 56-HOUR UAV FLIGHT

**VANILLA AIRCRAFT'S VA001** unmanned aircraft system has completed a non-stop, unrefuelled 56-hour flight.

The flight, planned as a 120-hour mission, was ended early due to forecasted severe icing and range restrictions. However, the airplane landed with enough fuel on board for an additional 90 hours of flying.

Taking off and landing at Las Cruces International Airport in New Mexico, the airplane carried a 9kg payload, flying at 6,500 to 7,500 feet above mean sea level.

Co-founder and chief engineer Neil Boertlein said: "The VA001 has transformational potential, providing a scalable aerial system solution without increasing personnel or operating costs."

Vanilla Aircraft is planning a role for the VA001 in commercial applications, especially in agriculture where it would provide a cost-effective option for widespread and regular low-level surveying.

# Prototyping a Mars rover

**OGLE MODELS &** Prototypes has been asked by Airbus Defence & Space to create a prototype Mars Rover, as part of Europe's plan to send a UK-assembled robotic rover to the red planet in 2021.

To keep the weight of the body and solar panels to a minimum, Ogle used fibre faced aluminium composite Cellite panels.

A CNC machine was used to create 15mm MDF jigs and a table router was used to cut out the Cellite panels from the jigs. Ogle's model makers worked to bond a threaded metal insert to enable bolts and fixings to move securely.

The completed panels were then bonded onto SLS printed extrusions which, when assembled, formed a three-dimensional skeleton with the Cellite panels spanning the flat surfaces.

Dave Bennion, marketing and sales director for Ogle, said: "Whilst an array of CNC and SLS capabilities were used on this project, it was largely completed with bench model making skills to ensure each precise component functioned fully and fitted within the specific design and weight restrictions."

# Altra completes acquisition of Stromag

**Altra Industrial Motion, a global manufacturer and marketer of electromechanical power transmission and motion control products, has announced that it has closed on the acquisition of the Stromag business from GKN. Stromag generated approximately €131million in revenue in 2015, and the acquisition is anticipated to add to Altra's earnings in 2017.**

**The acquisition cost was approximately €198m which included €14m of debt.**

**"Stromag provides Altra with complementary products, increased presence in key geographic regions and penetration into new growth end markets," said Carl Christenson, chairman and CEO of Altra. "It has a strong reputation, and its highly engineered clutches, brakes, torsional couplings and limit switches serve as excellent product extensions for Altra."**

**Stromag serves the agricultural equipment, construction, crane and hoist, marine, metal processing, renewable energy and general industrial markets.**

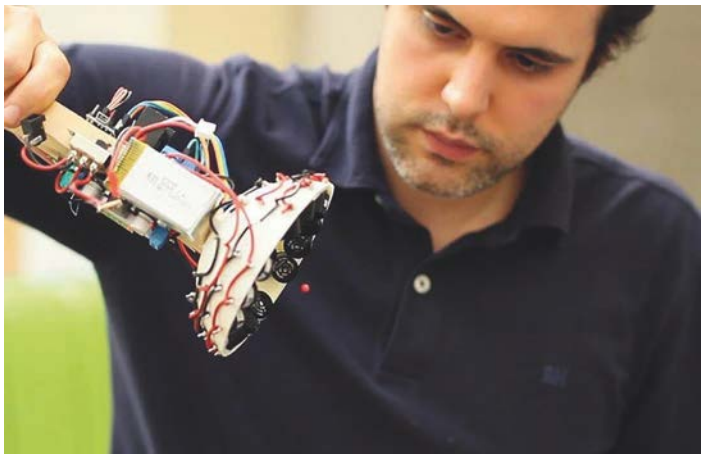
# 3D PRINTED ACOUSTIC TRACTOR BEAM

**A WORKING TRACTOR** beam has been produced using 3D printed parts and off the shelf components. The device is able to trap and pull objects using sound waves emitted from a single direction.

Sonic levitation uses sound waves to push around macroscopic objects or create patterns in resting sand and flowing water. Based on similar fundamental physics used to create optical traps for decades, these tractor beams are true to their name in that they can trap small beads and even insects.

"The most important thing is that it can attract a particle towards the source," said Asier Marzo, a researcher at the University of Bristol. "It's very easy to push particles, but what's hard is to pull them towards you. It can levitate small plastics; it can also levitate a fly and small biological samples."

The simplicity (and affordability) of the passive, static-matter approach comes from the special architecture only viable using 3D printing techniques. It is designed to shape



sound waves structurally instead of electronically, meaning as the sound passes through carefully designed elements, the waves are shaped by the internal structure of the 3D printed material.

"We can modulate a simple wave using what's called a metamaterial, which is basically a piece of matter with lots of tubes of different lengths," Marzo explained. "The sound passes through these tubes and when it exits the metamaterial, it has the correct phases to create a tractor beam."

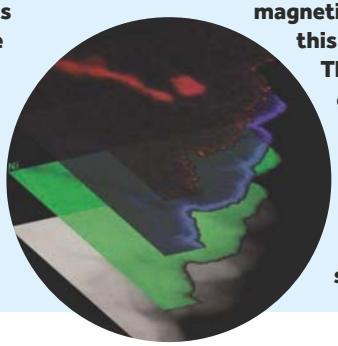
There are three designs of the device, each with trapping profiles suitable for different object sizes relative to the wavelength of the sound used. Designs and plans of how to build the tractor beam are available online, allowing anyone with access to a 3D printer to make one for around £50.

## Converting waste heat into energy

**OHIO STATE UNIVERSITY engineers have used magnetism to amplify voltage output 10 times or more on a composite of nickel and platinum that closely resembles components for future electronic devices.**

**A growing area of research called solid-state thermoelectrics aims to capture waste heat produced by electrical and mechanical devices inside specially designed materials to generate power and increase overall energy efficiency.**

**Instead of applying a thin film of platinum on top of a magnetic material as they might have done before, the researchers distributed platinum nanoparticles randomly throughout a magnetic material - in this case, nickel. The resulting composite produced enhanced voltage output due to the spin Seebeck effect. This means that for a given amount of heat, the composite material generated more electrical power than either material could on its own. Since the entire piece of composite is electrically conducting, other electrical components can draw the voltage from it with increased efficiency compared to a film.**



**While the composite is not yet part of a real-world device, the researchers expect their proof-of-principle will inspire further research that may lead to applications for common waste heat generators, including car and jet engines.**

## PRODUCTS

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

**149465**
IP67 DeviceNet I/O Module with full M8 connectivity

**149478**
Plug & play compact handling system simplifies commissioning and reduces time to market

**149509**
AKM2G servo motor range capable of 30% more performance

**149815**
5-axis articulated arms available pre-assembled

**149871**
Insulated bearings for inverter motors

**149934**
Rotation speed monitor in 6mm enclosure design now with restart inhibit

**149943**
Longwave infrared high-speed camera for R&D and science

**149473**
Stainless steel pressure sensors with digital i2C interface enable faster machine commissioning times and reduced downtime

## EVENTS

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Measurement House, Newbury

# Largest test lab for continuous-flex cables

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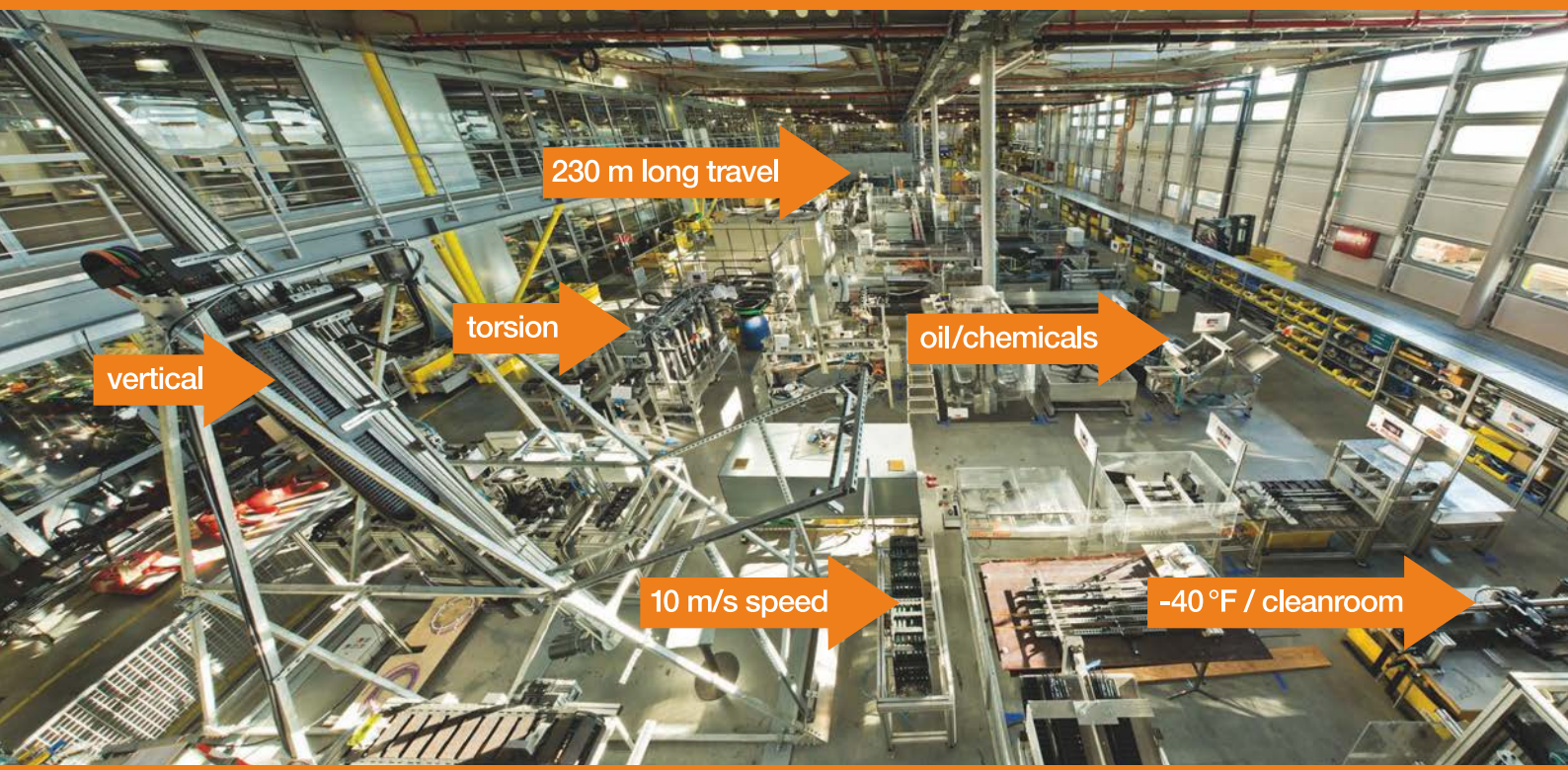


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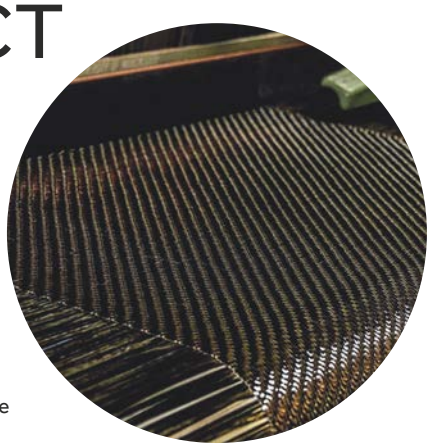
# AUTOMOTIVE LIGHTWEIGHTING PROJECT



Picture credit: Christine Twigg

**AN 18-MONTH R&D** project has begun to produce affordable lightweight carbon fibre components for the automotive industry. Backed by Innovate UK, Surface Generation will overmould long-fibre reinforced carbon composites with a short-fibre thermoplastic to produce a range of example coupons, sub-element components and demonstrator parts.

The advanced manufacturing techniques rely on its unique PtFS process, which uses active thermal management technologies incorporated in mould faces to adjust heating and cooling levels for each mould area and process stage in real-time.

It makes up part of a £2million Thermoplastic Overmoulding for Structural Composite Automotive Applications (TOSCAA) project. It is joined by a consortium of firms led by SGL Carbon Fibers and includes Jaguar Land Rover.

"The benefits of lightweight carbon fibre materials have been proven but are often uneconomic outside niche user cases," said Ben Halford, chief executive of Surface Generation. "Surface Generation's PtFS technology will extend the capability of thermoplastic overmoulding, to deliver the functional benefits of carbon composites to a new class of cost sensitive automotive components."

**SOLUTION TO LAST MONTH'S**

## Coffee Time Challenge

**SPONSORED BY MICRO-EPSILON**

**The solution to last month's challenge to come up with a portable but effective way of allowing drummers to practice anywhere comes from Kickstarter start-up Freedrum. The company say they have produced a drum kit that fits in your pocket and all you need is a smart phone, a pair of headphones, a pair of sticks and the Freedrum attachments. Freedrum is described as a virtual drum kit that uses sensors that fit over the drumsticks, and two others that slip over your feet. These pair with a phone or tablet that provide ultra-low latency drumming audio, and the user air drums until their heart is content.**

**Inside the enclosure there's a PCB with a gyroscope that detects movements and interprets them as hits on a drum. Together with the detected force and a few other magic parameters it is then translated into MIDI. The MIDI signal is sent via Bluetooth to the connected app (e.g. Garageband on an iPhone) which then plays the actual sound via headphones.**
**www.freedrum.rocks**

TECH **BRIEF**

## Industrial insect eyes

**FRAUNHOFER RESEARCHERS HAVE developed a process enabling the production of a 2mm flat camera which features 135 facets that they have called facetVISION, for use in industrial and consumer applications.**

**Like insect eyes, the Fraunhofer technology is composed of many small, uniform lenses positioned close together. Each facet receives only a small section of its surroundings. An insect's brain aggregates the many individual images of the facets to a whole picture. In the facetVISION camera, micro-lenses and aperture arrays take over these functions.**

**"With a camera thickness of only 2mm, this technology, taken from nature's model, will enable us to achieve a resolution of up to 4 megapixels," explained Andreas Brückner, project manager at the Fraunhofer Institute for Applied Optics and Precision Engineering IOF. "This is clearly a higher resolution compared to cameras in industrial applications, for example in robot technology or automobile production."**

**The cameras could also be used in cars to help with parking or in industrial robots to prevent collisions between human operators and machines. Furthermore, the researchers claim that the micro-lenses can be economically manufactured in large quantities using processes similar to those applied in the semiconductor industry.**

# Survey reveals positives and negatives of autonomous technology

**A SURVEY, CONDUCTED** by Nissan, canvassed the views of more than 6,000 people across Europe to create a report of Consumer Attitudes to Autonomous Drive Technologies. It found that more than 60% of respondents thought improved mobility would outweigh the possibility of a malfunction, of which nearly half (49%) were concerned about.

Indeed, half (51%) thought a reduction in accidents caused by human error would be a positive outcome of the new technology, followed by lower stress levels (45%) for drivers.

While one in three British residents (33%) claimed to be 'excited' about the possibility of more self-driving cars there were concerns about an overreliance on technology, with 55% saying they would be 'uncomfortable' being driven by the technology.

It also found people thought autonomous technologies will bring the most benefit to the personal mobility of the disabled (56%), the visually impaired (42%) and the elderly (30%).

"These results are pleasantly optimistic, particularly with regards to identifying the benefits to users who will rely on the technology more, such as the elderly or the impaired," Alex Smith, managing director of Nissan GB, commented. "Mass-market autonomous technologies are in their infancy, so we'd expect some hesitancies about such a revolutionary change to how we drive our cars – or indeed how our cars drive us."

*Picture credit: Brian Snelson*

# 740 AUTOMOTIVE JOBS RESCUED

**METALS TRADING FIRM,** Liberty House, has acquired metal stamping and robotic assembly specialists CovPress, securing 740 skilled jobs at the firm's plant in Coventry.

Sanjeev Gupta, executive chairman of the Liberty House Group, said: "There exists a huge opportunity for Britain's industrial supply chain to achieve dynamic growth through becoming more innovative and competitive."

Liberty already has 17 engineering businesses employing over 1,000 people across the West Midlands. It regards the CovPress acquisition as a strong strategic fit with its established and rapidly-expanding presence in the automotive supply chain.

Liberty said over 50% of parts used to assemble over one million cars in the UK is imported. The Group's strategy is to create a fully-integrated UK industrial supply chain, from raw metal production through to highly-engineered products.

# Bomb suit improvements

**Morgan Advanced Materials has completed independent testing of its Silverback 4020 Elite bomb disposal suit. The tests were conducted at an independently certified Ordnance Test Solutions facility at Faldingworth.**

**The suit uses a range of advanced polymers to enable the necessary blast protection, while allowing a wide range of mobility. The skin of the suit is made from Nomex, a flame-resistant meta-aramid material commonly used by bomb disposal experts and firefighters due to its blast and fire protection properties, and lightweight flexible construction.**

**The tests show the suit performed well against four life impacting aspects of a blast; flame immersion, high velocity fragment impact, blast pressure waves and 'tertiary' effects. Critical to survivability is reducing the impact of blast pressure waves, which alongside flames and fragments, have a devastating impact on internal organs.**

**The first blast test demonstrates the suit's survivability when kneeling against 0.567kg of C4 explosive at 0.6m. The suit provided a pressure reduction between 96.9% and 99.7%, achieving more than a 99% probability of survival.**

**Three further blast tests assess the suit's survivability when facing a 1kg C4 threat at 1m, a 2kg C4 threat at 2m, and a 10kg C4 threat at 3m. All three tests returned a survivability probability greater than 99%, with a pressure reduction between 98.1% and 98.5% for 1kg and 10kg blasts.**

**Chris Davies, technology director at Morgan Advanced Materials' Composites and Defence Business, commented: "We are delighted with the survivability performance. The suit's high performance levels have been achieved through years of blast materials research and development, combined with leading garment engineering to create a truly world class highly flexible bomb disposal suit."**

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# CNC MACHINING AND 3D PRINTING – FRIENDS OR FOES?

CNC machining and 3D printing are two technologies making a big impact in many industries. But do they compete with or complement each other? Damian Hennessey, Director of Proto Labs, examines the evidence.

In simple terms, CNC machining is 3D printing in reverse. While 3D printing creates objects by building up layers in three dimensions, CNC machining cuts into them. It's like the difference between making a sculpture out of clay (an additive process) and carving it from marble (a subtractive process).

Clearly, some items are best produced by just one of these processes. But there are many instances where they work well together. A good example of this is where a 3D-printed object is 'finished' by CNC machining, perhaps to refine the surface, or add holes, grooves or threads.

## PLAYING TO DIFFERENT STRENGTHS

3D printing is particularly good for highly specialised designs. The way it starts from nothing and adds layers means it can create an almost infinite variety of outputs, limited only by the printer's capability. Also, it's a flexible process, so you can switch quickly between jobs. And the cost per unit of a given item is always the same, regardless of quantity. So 3D printing is ideal for producing personalised, even unique, objects. No wonder it's becoming increasingly useful in many medical and dental applications, where you can use it to customise items to fit individual patients.

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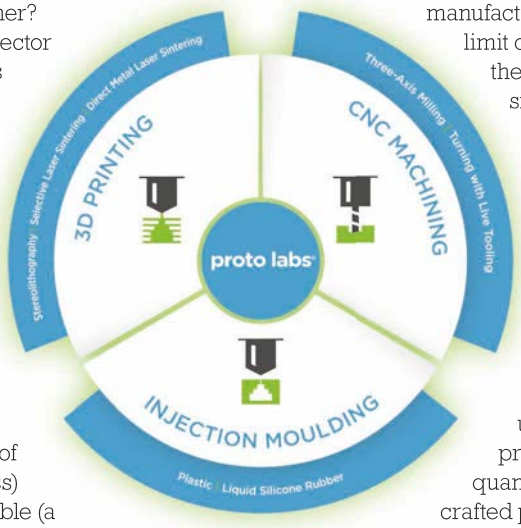



But this great strength can also be a weakness: 3D printing can be uneconomical for some large-scale manufacturing. There's also a limit on output size. While the process is perfect for small, intricate items, it currently works to a maximum size close to that of a washing machine (produced using stereolithography in certain materials).

This is where CNC machining sometimes has the upper hand. It can produce considerable quantities of precision-crafted products efficiently, in a variety of materials. Parts for commercial and industrial equipment and machinery are particularly popular applications, especially those made from high-density metals. It can also be used for smaller batches of products, but usually at a higher unit cost.

## JOINING FORCES TO MEET DESIGN CHALLENGES

So the choice between 3D printing and CNC machining can often come down to the size of the production run and size of the outputs. But when these factors are neither too large nor too small to eliminate either process, the technologies can be combined to great effect.

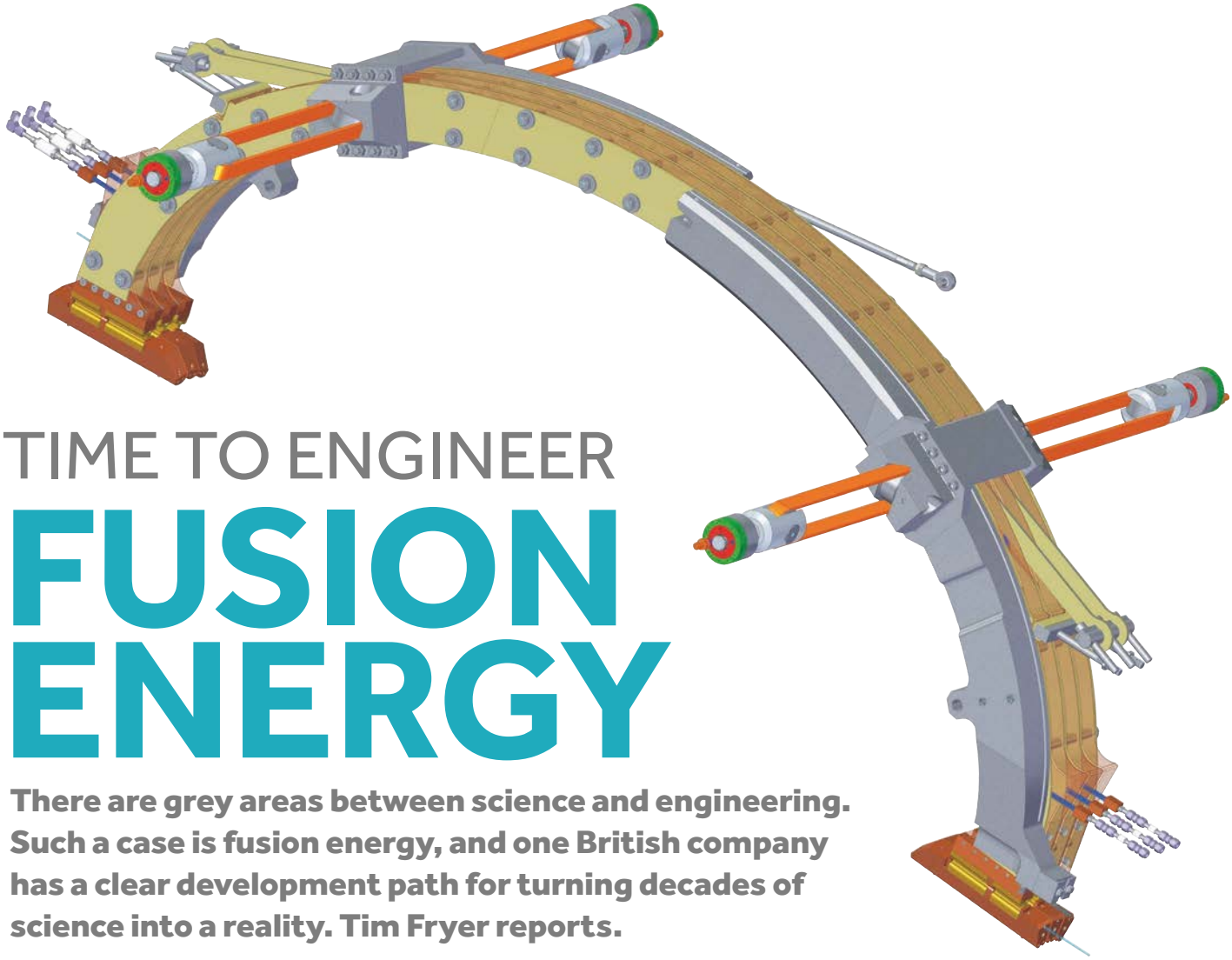
As manufacturers have to meet increasing demands from customers, so technology has to develop to keep pace. This is where combining 3D printing with CNC machining can bring major benefits.

In particular, the two technologies together can help meet the tough design challenges today's manufacturers are facing – especially the demand for lighter weight components and products, and for items with increasingly complex geometries. Here's where 3D printing, combined with CNC machining, can achieve more than any other process. The flexibility of 3D printing is enhanced by the precision of CNC machining to produce ever more intricate objects.

And because CNC machining can work as a fine-tuning add-on to 3D printing, it doesn't have to be confined to larger production runs. At Proto Labs, we have the equipment for both 3D printing and CNC machining, so we often combine technologies to produce prototypes and models, or for medium-run outputs required for performance testing. This dual approach is also ideally suited to making replacement parts for obsolete products.

The trick is to recognise the distinctive value of each technology, and apply them to design and production processes in the most appropriate way. Through the cycle of prototyping, testing and manufacturing, 3D printing and CNC machining can be used individually at different points or in combination. Working with a supplier that has both technologies under one roof means you can move more nimbly between them. The result? You make the most of both processes to meet the demands of today's fast-changing markets.

**If you have any questions regarding materials, manufacturing processes or design, please contact a Proto Labs' customer service engineer at customerservice@protolabs.co.uk or +44 (0)1952 683047 or visit protolabs.co.uk**



# TIME TO ENGINEER FUSION ENERGY

**There are grey areas between science and engineering. Such a case is fusion energy, and one British company has a clear development path for turning decades of science into a reality. Tim Fryer reports.**

Scientific investigations are the foundation of the technological world, but there comes a time when science needs to give way to engineering. Sometimes, things just need to be made.

"Take the internal combustion engine," said Dr David Kingham, chief executive of Tokamak Energy (pictured right). "When the first ones worked, people knew far less about the physics of combustion than they do now, but they knew enough to make it work. We're in that sort of position with fusion. We know enough to take it on as an engineering challenge."

Fusion is the holy grail of nuclear energy technology. With fusion, the legacy problems of radioactive waste are diminished and the fuel is cheap and widely available. It's clean, green and sustainable – the trouble is it doesn't yet work at the commercial scale.

For over half a century the Culham Laboratory, or Culham Science Centre as it is now known, has been at the core of fusion research in the UK. It was nearly 20 years ago that scientists there managed to produce 16MW from a fusion process... the downside being that it required 24MW of heat to make it work. Superficially, not much has happened since then, although the path of scientific discovery continues to be walked.

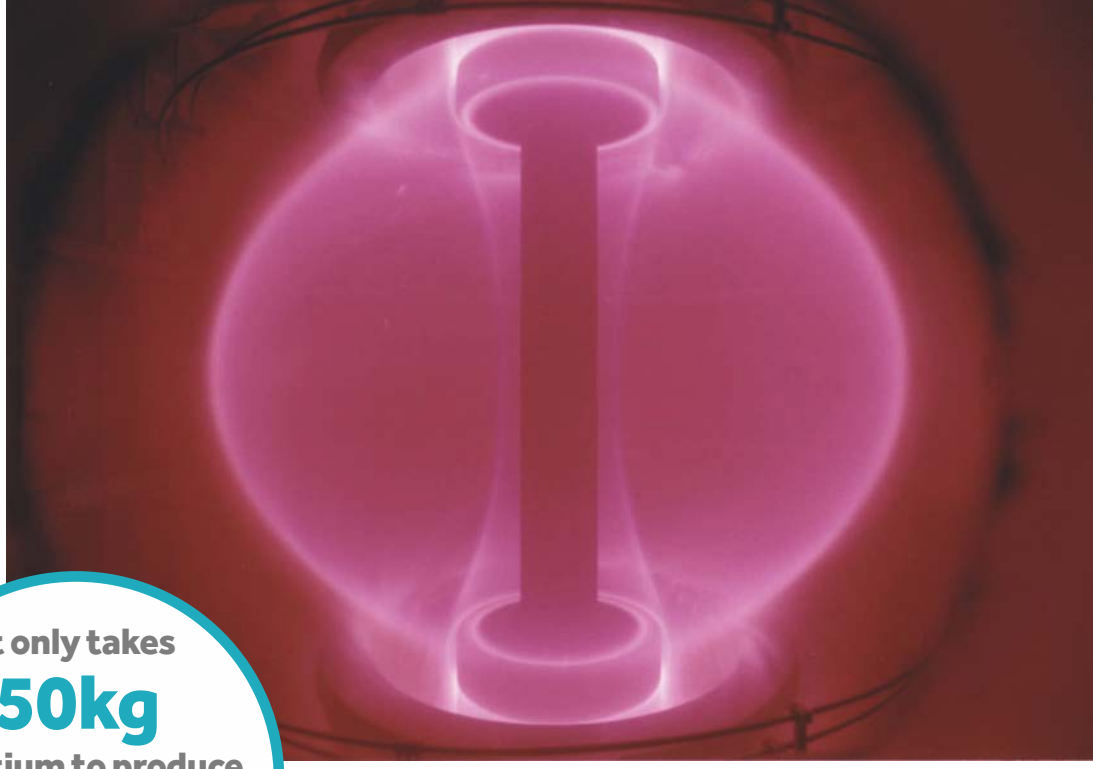
Tokamak Energy was launched six years ago with a view to change that and shake up the industry. Kingham commented: "Progress has been really slow, but that is an engineering challenge. Scientific progress has been fine. We have this feeling that the science is already understood well enough. What we need to do is build high-performance devices and get the best out of them rather than do more and more science."

Tokamak Energy believes building prototypes quickly, demonstrating performance and then moving on to the next device is the fastest route to realising commercially viable power plants. Of course 'quickly' is a relative term and since Tokamak Energy has been in existence it has produced two prototypes. Its third will be completed in the next few months.

## NUCLEAR FUSION

Fusion is what happens in the sun. Superheated hydrogen atoms collide to produce helium and a lot of energy. This combination of extreme temperature and pressure, provided by gravity in the sun, strips the outer electrons away from the positively charged hydrogen nuclei, creating a neutral but fully ionised plasma.

Attempts to develop a controlled fusion reaction revolve around forcing two hydrogen isotopes (deuterium and tritium) to collide in a similar way. However, to do so requires



phenomenal temperatures to create the superheated plasma, which contains hydrogen isotopes. The plasma, at more than 100,000,000°C, is contained by magnetic fields inside a tokamak - the name given by Russian scientists to the vacuum vessel used for fusion experiments. The phenomenal temperatures highlight why there was a net energy loss in the early Culham experiments.

Fusion reactions have proven extremely difficult to attain and, as yet, impossible to maintain. When a reaction does happen, helium and a single neutron, are produced along with a lot of energy. Four-fifths of this energy is carried out of the plasma by the neutron, which is captured outside the inner vacuum vessel of the tokamak. The energy of this particle is extracted as heat, which can then be used to produce steam for electricity generation.

These early designs were doughnut shaped but there is fresh promise seen in spherical tokamaks. This breakthrough is what led to a couple of scientists at Culham, along with Dr Kingham, to form Tokamak Energy. The idea is to combine spherical tokamaks with high-temperature superconductors to overcome the problems created by pumping millions of amps through copper magnetic coils.

Kingham said: ''The short term roadmap is to produce plasma temperatures hotter than the centre of the sun in 2017. Then we need to go hotter, to 100 million °C in 2018. We then need to get as close as we can, in 2019, to fusion energy conditions.

''The conventional view is you have to go to bigger and bigger devices, but we're saying you can keep tokamaks relatively small. You have to go to very high magnetic fields, so the engineering is very challenging, but you can get fusion in a device that's not tens of metres across, but just a few.''

**It only takes 50kg of tritium to produce 1GW of electricity for a year**

*Above: Super-heated plasma inside a tokamak*

*Top left: One of the limb assemblies of the ST40 Coil System*

*Below left: Dr David Kingham*

There is a minimum size of device that's feasible. If a device is too small then particles are more likely to hit the sides as plasma. As a consequence, temperature is constantly being lost. Equally the cost of larger devices escalates exponentially and, arguably, can become more inefficient.

''There's an advantage in keeping things as small as possible, certainly during the R&D process,'' said Kingham. ''We want to quickly tackle the engineering challenges with relatively small devices, and then scale up later if necessary. Although, we think devices just a few metres across are quite viable as 100MW power plants.''

The actual vessel is made of stainless steel, although more exotic materials would be required for production reactors in order to protect against erosion. Keeping the plasma off the vessel walls requires careful control of the magnetic field pressure and this is provided by the positioning of magnetic coils and the current passed through them. It aims to produce a gap of a few centimetres between the tokamak's wall and the superheated plasma.

In the device that is currently being built there will be up to 250 million amps in each of the 24 coils and 6 million amps down the centre column.

''The engineering challenge of doing that is substantial,'' said Kingham. ''There's twisting forces and compressive forces on the joints, and you need to get them just right. If you're trying to pass these currents through a joint between two copper limbs, you don't want too much extra resistance at those joints or you can have a real problem. You're getting towards the limits of what you can sensibly do in mechanical engineering.''

More particularly it is getting towards the limits of what can be done with copper as too much energy is wasted on resistive heating, which is why Tokamak Energy is leading research into high-temperature superconductor magnets.

''Conventional superconductors, as used in MRI, are brilliant materials but they're limited in terms of

## TOKAMAK ENERGY'S FAMILY TREE

| | |
|---|---|
| **ST25** | THE SPHERICAL TOKAMAK (ST) WITH A 25CM OUTSIDE RADIUS OF THE PLASMA |
| **ST25 HTS** | PROVED THAT HIGH TEMPERATURE SUPERCONDUCTING (HTS) MAGNETS WORKED |
| **ST40** | 40CM PLASMA RADIUS VERSION IN CONSTRUCTION, DUE FOR HIGH TEMPERATURE TESTING STARTING SPRING 2017 |
| **ST60 HTS** | 60CM VERSION WITH HTS MAGNETS, TARGETED FOR TESTING IN 2019 |
| **ST140** | 2020? |

magnetic field strength. High-temperature superconductors, particularly if you cool them down to around 20K, will deliver very high current densities in a high magnetic field.''

The particular material under trial is the yttrium barium copper oxide second-generation high-temperature superconductor.

Kingham added: ''We've actually built one of these small tokamaks with high-temperature superconducting magnets. We've managed to run the magnets for 29 hours with nice and stable magnetic fields.''

## EVOLUTION

The company has now grown to 30 employees, including five design engineers, and the increasing complexity of the third device, the ST40, has meant that 3D visualisation is important meaning a move to 3D CAD from the drawing board... literally.

Siemens Solid Edge was chosen as the design platform 18 months ago as Paul Tigwell, mechanical design consultant and another recruit from Culham, explained. ''Two of us started the same day,'' he recalled. ''The other engineer had worked with Solid Edge but knew nothing about tokamaks. I didn't know anything about Solid Edge but I knew tokamaks, so we complemented each other quite well.''

Much of Tigwell's early work was taking the original paper drawings and building them into 3D models. This process in itself highlighted the issues and clashes within the design, issues that the first prototype had to address by 'an engineer with a hammer' while assembling the device.

One of the features of Solid Edge that appeals to Tigwell is the ability to have 'alternate assemblies'. This allows the detail to be turned down, so the computer and graphics processors can update the display a lot faster.

Tigwell said: ''We've got the assembly and an overview. If I bring something new in, it affects both lines, so it's not two separate models you have to keep updated.''

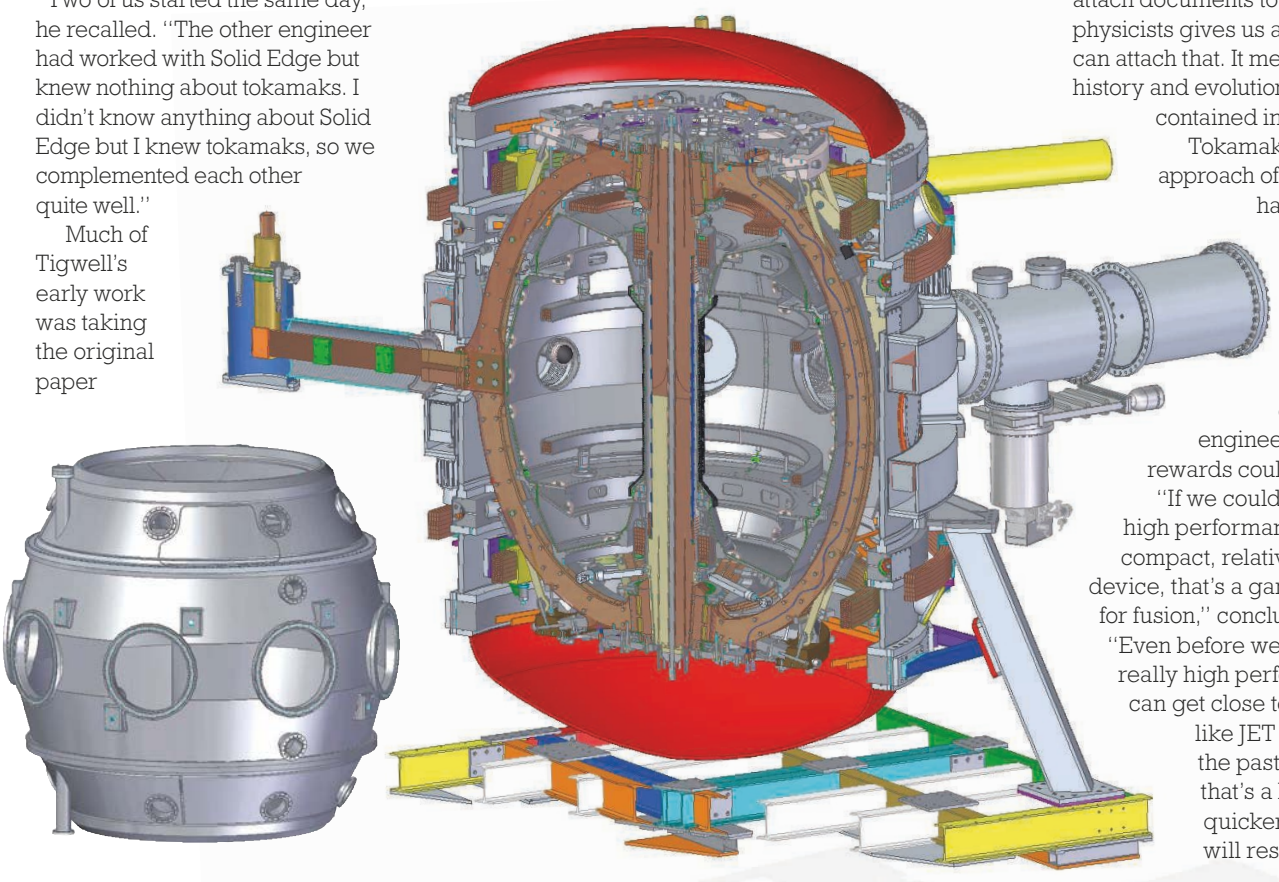
For modelling the magnetic fields the company is using multi-physics simulation software from ANSYS. There are a number of design engineers working on both the current and next generation prototype, meaning the company is also investing in Team Centre, which comes out of the same Siemens stable as Solid Edge.

''With Team Centre, you can look at the history and see when parts were changed, who changed it, and what the change was. And, we can attach documents to it, so if one of the physicists gives us a design note, we can attach that. It means we have the history and evolution of the design all contained in one area.''

Tokamak Energy's approach of getting their hands dirty, and to a certain extent trial and error, is a bold one in such a long term and high cost branch of engineering. But the rewards could be enormous.

''If we could demonstrate high performance in a relatively compact, relatively inexpensive device, that's a game changer for fusion,'' concluded Kingham ''Even before we demonstrate really high performance, if we can get close to what tokamaks like JET have done in the past, in something that's a lot cheaper and quicker, then that really will reset things.''

**Tokamak is Russian for 'Ring Shaped Doughnut'**

*Above: The ST25 undergoing tests at Tokamak Energy.*

*Below: Cut away design of the ST40.*

# Q&A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## SOLIDWORKS 2017 means more powerful rendering with Visualize Boost

### What makes SOLIDWORKS Visualize different from other CAD rendering software?

It's got super high quality rendering with an Easy-to-Use interface. The photorealistic images you can create in SOLIDWORKS Visualize are spectacular. When the software was launched last year, it received 1,500 downloads in just 24 hours and now SOLIDWORKS has upped their game with Visualize Boost and Power Boost in the 2017 release.

### What has the R&D Visualize team at SOLIDWORKS been cooking up for 2017?

The new Cut Planes feature is a great way to showcase internal working and you can now re-use more SOLIDWORKS features in animations and rendering.

### Tell me about Visualize Boost and Power Boost?

Visualize Boost lets you render output to one or more dedicated computers. This frees up your local computer resources. Power Boost is a new render mode in 'real-time' that uses a render farm to stream the raytracing to your SOLIDWORKS Visualize Viewport. The render farm could be Visualize Boost clusters or NVIDIA Quadro® VCA(s).

### What's the best graphic card to use with SOLIDWORKS Visualize?

The Nvidia Quadro series is good. Then it depends on what speed you are after and your budget.

### Does SOLIDWORKS Visualize come as standard?

If you have SOLIDWORKS Professional or SOLIDWORKS Premium on active subscription, you get one Visualize standard per SOLIDWORKS license.

### Tell me about the SOLIDWORKS Visualize webinar?

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3. Panoramic and Virtual Reality output that makes web content.

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# TESTING DEVELOPMENTS

**The automotive industry needs test facilities to keep up with their recent fast paced innovative vigour, and help them develop greener vehicles. Justin Cunningham reports.**

Diesel gate is arguably one of the biggest engineering stories of the last few years. However, the story betrays the true nature of an industry in the midst of redefining itself. Engineers have been busy battling the impossible and continue perhaps the biggest innovation drive ever seen by the sector, as it struggles to get tailpipe emissions under control. Alongside the waves of headlines following the scandal, are OEMs and suppliers that have made genuine steps forward.

It is all driven, of course, by EU regulations that demand OEMs reduce tailpipe emissions to an average 95g of $CO_2$ per km across their entire fleet of vehicles, or face pretty harsh financial penalties. Regardless, it has sparked a transition in automotive technology to lightweight chassis, ultra-efficient internal combustion engines, integrated hybrids and electric powertrains. Increasingly, smart computer controls are being used that continuously monitor engine parameters and alter engine modes to optimise efficiency. It is all adding to complexity, and bringing fresh conjecture to the question of: what makes a meaningful emission measurement?

It means those carrying out tests to develop and eventually certify vehicles are having to innovate at a similar pace to keep up. And more than that, test houses are increasingly being asked to anticipate regulation changes and technology development trends to help engineers in the design and development of vehicles.

At the coalface is Millbrook

"We are looking at new pollutants that might come in, new drive cycles, new test methodology, and also establishing new benchmarks."

PHIL STONES ▶

"This facility is something the market needs to help them develop, and it is important, strategically, for the industry as it will aid the development of tomorrow's cleaner vehicles."

◀ ALEX BURNS

Proving Ground, which has been putting cars through their paces since the 1970s. The company has recently made a 'multi-million' pound investment to modernise facilities and keep pace, part of which was the construction of a state-of-the-art 4WD climatic emissions chassis dynamometer.

''This is the biggest investment we've made, certainly this century,'' explained group president Alex Burns. ''This facility is something the market needs to help them develop, and it is important, strategically, for the industry as it will aid the development of tomorrow's cleaner vehicles.''

## REAL WORLD DATA

The dynamometer is set in a climatic cell that can recreate temperatures between -20 to +50°C. It reflects the wider range of climates vehicles are now sold and used. For example, the same vehicle is used in the blistering desert heat of Abu Dhabi and the freezing temperatures of Scandinavia. Regardless, drivers expect the same performance.

Millbrook's chief engineer - powertrain, Phil Stones, said: ''We can simulate numerous drive cycles, at numerous temperatures, on the dynamometer in repeatable conditions. That really aids and speeds up development.''

It responds to the trend of industry players demanding more cost effective, faster testing. OEMs want to build fewer prototypes, develop vehicles more quickly, and reduce both costs and time to market.

Part of the allure of this facility, Millbrook claims, is that having labs alongside its plethora of test tracks, allows data on real road conditions to be logged and instantly replicated on the dynamometer in controllable, repeatable, conditions.

''That is a huge attraction,'' said Burns. ''To do track and lab work in the same location allows much more efficient utilisation of prototypes.''

Being able to recreate the same exact conditions and drive cycles, time after time, means tests at the facility are highly repeatable.

The dynamometer is housed within a climatic chamber accurate within 1°C. Though not a wind tunnel, it 'speed tracks' airflow on to the vehicle, meaning the engine behaves as if the vehicle is travelling on a road.

This is all vital in the development of vehicles, as any change can be clearly evaluated in the data, rather than raising questions about variability in the dynamometer or the chamber itself.

## FUTURE REGULATION

Part of the development, more generally, is to keep up with – and anticipate – future trends affecting the industry. The dynamometer is perhaps its first move towards this and is capable of not just measuring carbon, but a number of other pollutants that will likely feature in air quality and emission standards going forward. These include the accurate measurement of nitric oxide, nitrogen dioxide ($NO_2$) and nitrogen oxide.

''Our latest generation of emission sampling systems can quantify both regulated and also unregulated particulates,'' said Stones. ''For example, within air quality, $NO_2$ is not actually regulated, but from an air quality and global warming point of view it is an important factor.

''We do things that are not yet legally required, but we expect could be in the future. We are looking at new pollutants that might come in, new drive cycles, new test methodology, and also establishing new benchmarks.''

There is also a great deal of thought about designing and developing vehicles to cope better with climates that induce parasitic losses, which again affect efficiency and emissions. For example, vehicles operating in hot climates might have air conditioning on all the time. So, increasing research to understand how this affects emissions is likely to feature more in the future. In addition, electric vehicle performance can fluctuate massively if the windscreen wipers and lights are on.

The aim for car developers going forward is to reduce the variance caused principally by environmental factors. However, to do so, test facilities like Millbrook must be able to accurately test and measure a variety of variables around the vehicle in highly controlled conditions.

''We have to innovate as much, and as quickly, as the rest of the automotive industry,'' concluded Burns. ''Diesel gate has changed the landscape in terms of due diligence, but going forward we expect to be used more in the design and development of vehicles, and vehicle systems, rather than to just check regulation compliance''

# PUMP UP THE VOLUME

**Graphene has long been called the 'wonder material', but has yet to find any meaningful commercial application. However, one Canadian start-up says it has found the perfect use for it. Tom Austin-Morgan investigates.**

Graphene's properties include high thermal and electrical conductivity as well as excellent mechanical properties despite being just one atom thick. However, the cost of manufacturing large quantities of graphene, and the fact that it is difficult to shape, have hampered its vast potential.

Despite the drawback, Canadian start-up ORA Sound has developed a range of speakers using the material to give distinct improvement to users. Its GrapheneQ, a graphene oxide-based composite is stiff and lightweight, but it is also easy to shape and inexpensive to manufacture. ORA claims that GrapheneQ shows sound quality comparable to high-end audio materials while being only slightly more expensive than the most basic. The name was chosen because of its low density and high stiffness which, it is claimed, allows for louder drivers with a lower Q resonance in acoustic transducers.

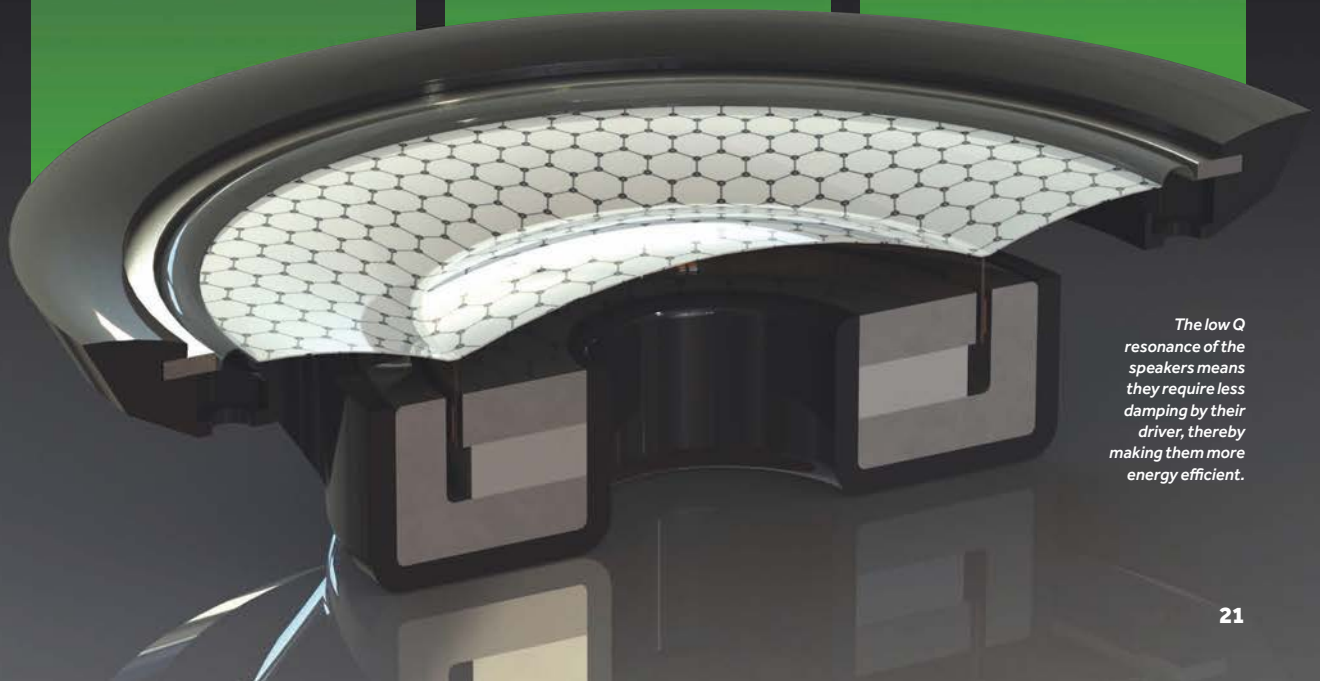
Rather than use chemical vapour deposition (CVD) to create graphene films, which is cost and labour intensive, potentially harmful to the environment and requires reaction chambers and whiterooms, ORA decided upon using graphene oxide. It also allows ORA to produce speakers at scale.

"Graphene oxide can be handled and slurried and just left to dry," explained co-founder of ORA Sound, Xavier Cauchy. "It's much easier to have a macroscopic device made out of graphene oxide material than it is with crystalline CVD graphene. And it's more environmentally sound."

The Graphene used by ORA is bought in and has proprietary additives mixed in to make it even stronger. The stronger the membrane, the better the frequency response and lower distortion. GrapheneQ has a Young's modulus of 130GPa, allowing sound waves to travel very quickly through the material producing better overall sound quality. The material has very high thermal conductivity too, which makes it less likely to be damaged from overheating – a common cause of speaker damage. The perfect material for speaker design, according to Cauchy, is one that is as stiff as possible while also being as light as possible.

"This is difficult to do with materials like Kevlar or carbon fibre. If you want to want to make these very thin, you will have problems with isotropy of the forces," Cauchy continued. "Graphene solves that problem with one single step. Graphene has strength on one axis – the planar direction – and speaker membranes are two-dimensional by design, so we have strength in just the direction we want."

Compared to other materials traditionally used to make speaker membranes, graphene



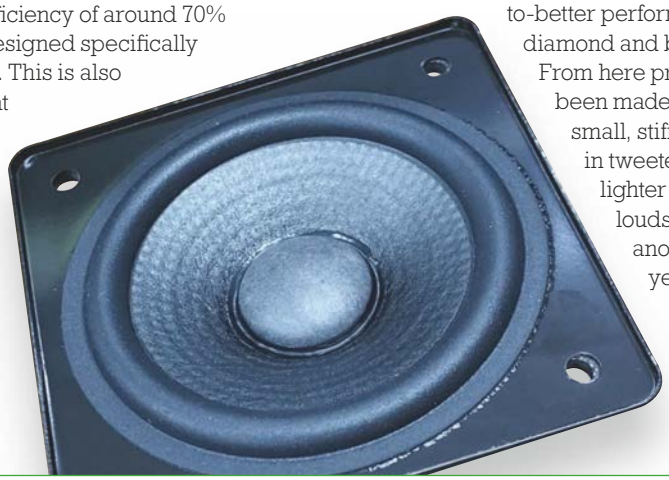
*The low Q resonance of the speakers means they require less damping by their driver, thereby making them more energy efficient.*

difficult to shape. Mylar, for instance, can be stamped and shaped straight out of a sheet of boPET (Biaxially-oriented polyethylene terephthalate). However, GrapheneQ is easier to shape than CVD graphene because of its method of production as well as the additives ORA uses. It is also claimed to display performance that matches, and even exceeds, that of materials that are used in high-end audio speakers such as beryllium and CVD diamond.

What's more, Cauchy says that because of the GrapheneQ speakers' low Q resonance they require less damping by the driver, meaning they are more energy efficient and that could help to increase the battery life of mobile devices.

"A loudspeaker typically has an efficiency of around 2%, which means that 98% of energy is lost through heat in the coil and damping," he said. "By making it twice as light, we calculated that we could get an efficiency of around 70% with a driver designed specifically for GrapheneQ. This is also considering that the speaker would break-up at the same frequency."

The alternative, for real audiophiles, is that the GrapheneQ speakers can be made at the same weight as traditional speakers, reducing efficiency but increasing strength further, which drastically increases the fidelity of the speakers to ultrasonic levels.



The ORA team used a theoretical model that calculates the bending mode frequencies of materials. From this, the team calculated the figure of merits to compare GrapheneQ to other materials. It was then tested with a frequency response measurement device to see at what frequency the sound would begin to break-up and distort.

"Break-up is where the frequency causes the membrane to vibrate in resonance and it starts to vibrate in the opposite direction than you want it to," explained Cauchy. "Effectively what you'll have is a soundwave cancellation at certain frequencies which, to the human ear, just sounds distorted and nasty."

This was where the team found that GrapheneQ showed equal-to-better performance than diamond and beryllium.

From here prototypes have been made and tested; a small, stiff version for use in tweeters; a thicker, lighter version for larger loudspeakers; and another which, as yet, is under wraps.

GrapheneQ speakers have been incorporated into headphones, which were displayed at the Consumer Electronics Show (CES) in Las Vegas last month. This was seen as the perfect way to compare the performance of GrapheneQ against materials like Mylar.

Future applications include frequency drivers in Bluetooth speakers, tweeters for high-end audio equipment where high frequencies will be explored, and micro-speakers for smartphones where improvements to sound quality and battery efficiency will be demonstrated.

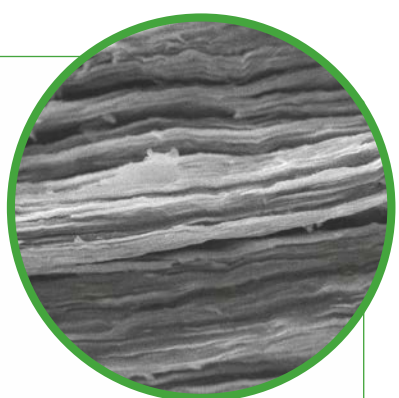
"We are continuously making it better," Cauchy exclaimed. "The beautiful thing about this material is that it's highly tuneable, you can do virtually anything with it. If we were to dream, we might also find an application for GrapheneQ anywhere where carbon fibre is used at the moment, because of its strength."

Cauchy said that ORA has been approached by major players in the audio and consumer electronics industries and after CES thoughts are turning to collaborations. To get all the advantages from GrapheneQ – and to make it the standard material for loudspeaker membranes going forward – the speaker would need a bespoke driver.

As ORA don't have the manpower to do this and phone manufacturers redesign their drivers with every model, it would seem that partnering with a manufacturer would be a sound idea.

## A BRIEF HISTORY OF THE GRAPHENE SPEAKER

- In 2011, researchers from Seoul's National University were the first to develop a transparent, lightweight speaker made from Graphene for possible use in windows and displays as well as in noise-cancelling devices.
- In 2013, University of California, Berkley scientists created the first earphone sized thin-film graphene-based speakers, measuring 5mm in diameter and 30nm thick, which were claimed to outperform the best traditional earphones.
- Most recently, in September 2016, researchers from Korea Advanced Institute of Science and Technology (KAIST) produced a thermoacoustic speaker based on graphene oxide said to be specifically aimed at the mobile audio market.



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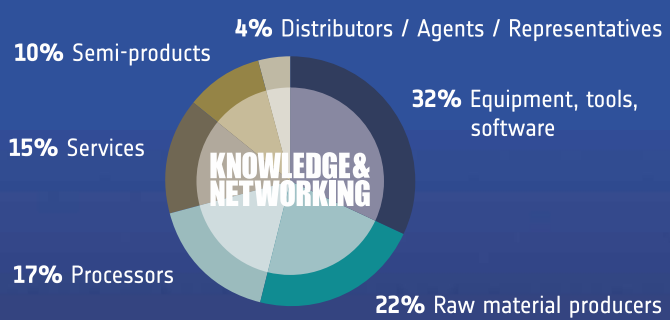


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# GET YOUR MOTOR RUNNING

**Motors are essential components in motion control applications across all industry sectors. Here, Tom Austin-Morgan gives an overview of the latest innovations in motor technology heading in to 2017.**

From powering each individual wheel on the Mars Exploration Rovers – one of which has remained active 13 years after it landed on the surface of the red planet – to the humble tattoo gun, motors need to be reliable. They also have to meet ever more stringent efficiency regulations, especially in industrial applications where every extra revolution has an effect on the bottom line.

At the smaller end of the scale, in terms of size, FAULHABER has released a compact DC-motor with high torque for applications where maximum power is required in compact spaces, such as in precision tools, optical devices or active prostheses.

The '1016…SR motor series' reaches a continuous torque of 0.92mNm at a length of 16mm and a diameter of 10mm. Its Δn/ΔM characteristic curve has an especially flat slope of 5953rpm/mNm, which is said to make it possible for soft transitions during a load change. The motor also exhibits low power consumption, high energy-efficiency, minimal vibration and low audible noise.

The DC-micromotor has a wide range of gearheads and can be combined like the other motors in the SR family. It reaches a torque of up to 300mNm with the 12/4 planetary gearhead. For high-precision positioning applications, zero backlash spur gearheads are available as a compact alternative where undesirable play can be reduced or eliminated. Optical and magnetic encoders with a resolution of up to 256 pulses per motor shaft revolution make highly precise control of the drive possible. In addition, it can be combined with numerous controllers, from the miniaturised SC 1801 speed controller up to the MC 3002 motion controller for a complete solution.


Diakont's compact DA Series actuators, available in the UK through INMOCO, have been designed for easy installation and maintenance in space-restricted applications. Its integral servo motor is designed so that it can be mounted in a number of different ways, including flange mounting, using a rear clevis pin, extended tie rods and trunnion to make mounting a single step process.

**For demanding applications where the DA units are likely to be used, long term reliable performance is vital and downtime must be kept to a minimum**

*Top: ABB's Dodge Quantis gearmotors*

*Below: FAULHABER's compact, high-torque 1016...SR DC-motor series*

In the demanding applications where the DA units are likely to be used, long term reliable performance is vital and downtime must be kept to a minimum. A patented system allows complete lubrication changes to be carried out in less than 30 minutes without removing the actuator from its machine or to disassemble it, making maintenance fast, simple and cost effective.

The DA series actuators are based on an inverted roller screw mechanism that is compact yet capable of carrying high loads. It also offers a working life many times longer than ballscrew alternatives. They were originally developed for and used in the nuclear industry and INMOCO is now finding uses for them in a variety of applications, including presses, bending machines and other machine tools, automated welding systems and


factory automation, clinching, plastic moulding machines, clamping, work holding and packaging machines.

Available in the UK through Heason Technology, Spinea's DriveSpin (DS) series compact servo actuator range has been expanded to include a variant that offers additional mounting possibilities.

The DSM series features a housing design with adaptable fixings for the direct and versatile mechanical interfacing of end effectors and other automation components without the need for adapters or support brackets. Its modular design also allows the simple assembly of self-supporting 'kinematic' modules by connecting DSM's together.

The series joins the standard and hollow-shaft variants of the DS range that provide industry leading tilting and torsional stiffness, high precision and accuracy with minimal vibration and long service life. The range's torque-to-size ratio is claimed to save space and cost in robotics, precision positioning stages, machine tools and other high performance machine applications.

Available in three frame sizes with square sections of 50, 70 and 110mm in compact lengths, the DSM series' specification includes continuous torque output from 18Nm for the 50mm model and up to 122Nm for the 110mm model – with acceleration and braking torque rated at 200% continuous torque. Output speeds in the order of 50 to 80rpm are dependent on gear ratios and bus voltages range from 24 to 560Vdc.

The 70mm model boasts torsional and tilting stiffness values of 7Nm/arc-min and 35Nm/arc-min respectively and across the range values. With superior hysteresis, excellent backlash and other significant performance related specifications, the DSM is equipped for very high performance and high load rotary positioning with long life and proven reliability even at high throughput rates.

KOLLMORGEN claims that its AKM servo motors with flexible usage options and performance are among the best on the market now it has increased the power density of the AKM2G by up to 30%.

The increased power density with an improved torque/speed ratio is the result of optimised winding technology. The AKM2G motors are said to offer improved energy efficiency, room for more performance with the same installed size as well as smoother

*Above: Spinea's DriveSpin series is available in the UK through Heason Technology*

*Below: Ross Robotics' EXTRM SC2.6 UGV is powered by maxon motor EC 45 flat BLDC motors*

## MAXON MOTORS POWER MODULAR ROBOT PLATFORMS

Ross Robotics builds unmanned ground vehicles (UGVs) that are reconfigurable to replace people in areas they shouldn't or can't work. The UGVs are primarily aimed at the nuclear industry and have attracted the attention of CERN, the European Organisation for Nuclear Research and the EDEN project at Chernobyl.

Ross Robotics originally had problems finding a motor that would work inside its modules in terms of form factor and performance.

Philip Norman, director of research and development at Ross Robotics, said: "We were looking for a compact DC motor that was easy to drive at a low speed, had high torque and was of a certain size because of the small space envelopes we had. We found maxon's standard EC 45, 70W, flat BLDC motors ideal because they are reliable and have a lot of torque. What is critical in a lightweight, man portable robot is torque not power."

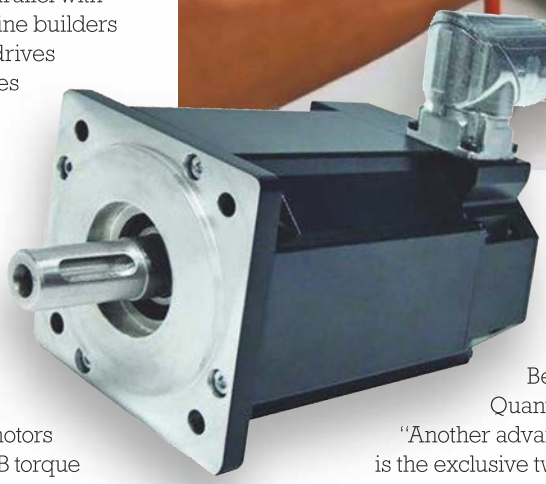
Other industries that can benefit from the UGVs include oil & gas and utilities where the robots can be used for mapping and maintaining their distribution lines. Further to this, are security forces, first responders and the emergency services.

cogging behaviour, which also improves control accuracy.

The new generation of synchronous servo motors comes in six design sizes with performance levels between 0.3 and 10kW. The AKM2G motors can be fitted with different feedback systems and are primarily provided with single-cable connection technology.

Also, because of the modular structure of the range, KOLLMORGEN says it is better able to adapt the motors to the requirements of a specific application in parallel with series production. Machine builders are thereby able to use drives that fit like bespoke drives without compromise.

At the larger, more industrial end of the scale, ABB has introduced the Dodge Quantis gearmotor, engineered to provide the highest starting torque and easiest shaft mounting of any major gearmotor. They feature IEC rated motors that have NEMA Design B torque characteristics to offer up to 50% more starting and overload torque versus competitive products.



*Top: Diakont's compact DA Series*

*Below: KOLLMORGEN's AKM2G servo motor*

"This product is unique in that both the gear reducer and the motor are designed to withstand the high torque required during cold starting with no damage to motor windings or gearing," explained Ben Hinds, Dodge Quantis product manager.

"Another advantage for customers is the exclusive twin-tapered bushings that cause no shaft damage, making it fast and easy to remove the reducer no matter how long it has been in service."

Quantis gearmotors are available in three styles; Inline (ILH), right angle helical bevel (RHB), or offset parallel (MSM). With ratings from 0.18 to 7.5kW, up to 14,000Nm output torque, and ratios up to 350:1, the Quantis gearmotor is suited for pumping, material handling, conveying and mixing applications.

From large scale industrial uses to smaller scale operations, there is a high powered, efficient motor to suit all needs. However, this is just a small selection of the products available, to see more visit the 'products' section of the Eureka! Website.

## IN LINE WITH WORLDWIDE ENERGY SAVINGS TRENDS

Industrial energy efficiency has received increasing attention in many countries due to the effect energy can have on economic competitiveness and the mitigation of greenhouse gas emissions. In line with this global concern, WEG has developed high efficiency products to offer solutions providing a quick return on investment through energy savings.

For increased reliability and economy in cooling tower applications, WEG developed the W22 Cooling Tower Direct Drive System that eliminates the gearbox of the conventional cooling tower, allowing a reduction of mechanical losses with increased operational flexibility and system efficiency.

In large manufacturing processes that require a cooling system, water is used as a heat conductor. The water transfers the heat into the environment through the cooling towers. The airflow through the tower aids heat transfer as it is forced through the water 'spray' by a large fan powered by a system consisting of an electric motor and a gearbox. The system provides torque and speed suitable to the fan operation.

WEG has developed a motor suitable to deliver torque and speed without using the gear reduction system by using permanent magnets in the rotor. This ensures high efficiency levels and high torque, even at low speed controlled by a Variable Frequency Drive. Reduction in the power required by the application is exponential with the speed of the fan, which can save significant energy over a fixed speed system.

Alex Sandro Barbosa Passos, WEG product development and application department, said: "Since the W22 Cooling Tower Direct Drive System does not require a reduction system, this eliminates contamination of the Tower's water by gear oil leaks and brings advantages to the system."

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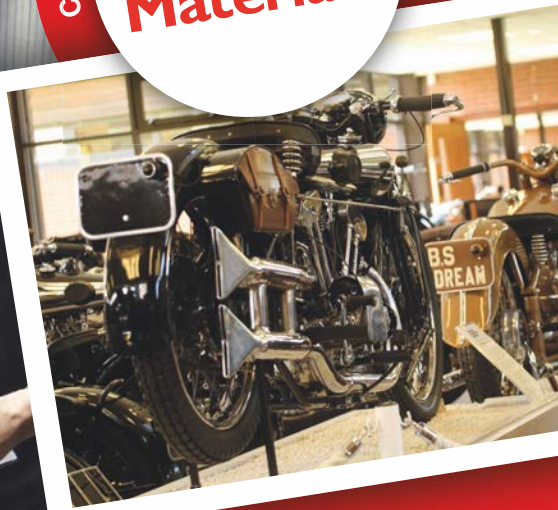

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# THE SUPERIOR SURFACE

**Increasing use of composites and multi-material assemblies means getting the surface properties right has never been more important. Justin Cunningham reports.**

The use of composites has ballooned in the last few years and the material's exponential rise shows no sign of slowing down. The lightweight but strong material is providing a viable solution for many transport industries, which are seeking to reduce emissions with minimum compromise.

However, while composites provide a solution to the overarching problem of fuel efficiency, repeatable production is notoriously difficult. The problem is that part production is labour intensive and the process is not easily automated.

Most advanced materials, like carbon fibre composites, need some form of surface treatment to ensure good adhesion with paints, lacquers and adhesives. A major worry for automotive OEMs is the delamination of coatings and paints, which results in a product having limited cosmetic value. Consumers often use the finish of the paint work as a marker for overall quality. So, if it is poor, people assume the rest of the car is engineered to the same standard.

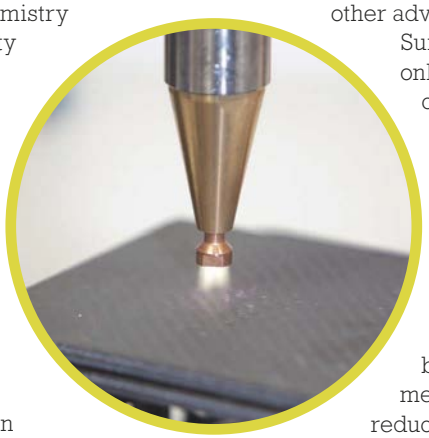
However, many surface engineering and adhesion promotion options suffer from limitations. For example, hand sanding is labour intensive, time consuming and generates dust. When deciding what's right for you, there are a number of tough trade-offs to contend with.

One UK start-up is determined to change this, however, and has been spun-out from research into the problem. Oxford Advanced Surfaces has developed a range of surface treatments to prepare advanced materials for coating and bonding, while addressing some of the shortcomings of the current available options. Based on its patented reactive chemistry platform, Onto has the ability to form a bond with most materials, making it useful as an adhesion promoter.

The attraction of Onto is particularly strong in the automotive industry. Here, the slower transition to composites and other advanced materials has meant multi-material assemblies are much more prevalent, and enabling good adhesion between many dissimilar materials is vital. It is also vital when painting, as different materials on the same assembly might react differently to coatings and paints. To have the ability to change the surface chemistry, and make the surface properties uniform, has therefore become essential in achieving a good finish.

*Above: A car's quality is often judged by its surface finish*

*Below: Plasma Surface Activation is used to alter surface properties.*



## RANGE OF APPLICATIONS

Onto is made from a water/alcohol base and unlike most adhesion promoters for plastics, it contains no aromatic hydrocarbon solvents, and is suitable for a wide range of plastics, reinforced composites and other advanced materials.

Surface preparation is not only important for applying coatings and paints, it is also fundamental to ensuring good adhesion between different materials.

Onto allows fast and easy substrate priming and improves the adhesive bond between various plastics, metals and composites. This reduces the risk of delamination at weaker interfaces, resulting in improvements to bonded assemblies and a reduction in the need for reinforcing mechanical fasteners.

Onto provides adhesion promotion uniformly across a

As multi-material assemblies become more prevalent, surface properties are vital to ensuring the adhesion of coatings and between dissimilar materials.

*Above: Failure to properly treat surfaces can cause delamination and cracking.*

coated substrate and does away with sanding, meaning no dust is generated during manufacture.In addition, Onto has a long shelf life, and its formulations can also be tailored for conventional coating techniques such as spray, dip and even brush coating.

## PLASMA TREATMENT

Surface adhesion is not just an issue with composites and the automotive industry. Those using polymers elsewhere will find that printing inks on the surface might easily rub off, gaskets won't bond and coatings won't adhere.

It is common that no matter how much cleaning or abrasion of the surface, certain materials remain difficult or often impossible to paint, coat, print or bond to without using harsh solvent based primers or high temperature flame torch treatments.

A common option used by many in industry for achieving good adhesion levels of paints, coatings, sealants and glues to traditionally 'non-stick' plastics comes from plasma treatment equipment supplier, Dyne Technology. The firm has considerable experience in achieving strong adhesion to 'non-stick' materials such as Polypropylene, Polyethylene, High-Density Polyethylene and EPDM, all of which have a low surface energy.

There are well known methods of increasing the surface energy of plastics and rubbers that include hard, environmentally damaging wet chemical treatments, high temperature flame torch treatment, high voltage corona discharge and the plasma treatment of plastics. However, Plasma Treating or Plasma Surface Activation, is a highly effective, long lasting method of achieving the same goal.

**Most advanced materials, like carbon fibre composites, need some form of surface treatment to ensure good adhesion with paints, lacquers and adhesives**

During Plasma Surface Activation, the components undergo an environmentally friendly process, which does not alter the bulk properties to the treated part and does not mark, discolour or damage the component in any way.

While many might want to overlook surface treatment, it is a vital step if the designed quality finish is to be achieved and the integrity of joints is to meet the specified standards.

## Loctite chosen for arduous, sub-zero conditions

The Prinroth Beast is built for supreme performance in the harshest of environments. Powered by a 12.5L Caterpillar C13 Acert turbo diesel engine, the vehicle is responsible for grooming mountain slopes for rejuvenated skiers the following day.

Operating in temperatures around -30°C and on slopes that can be over 45° steep, The Beast relies extensively on Henkel's Loctite engineering adhesives to secure components and keep vital hydraulic components sealed.

For sealing hoses Prinroth uses Loctite 572 to create an instant seal that cures to burst strength. Loctite 638 is also used, typically to retain ice studs and aluminium track blades. As well as being able to cope with pressures up to 550bar, the product has to remain unaffected by the freezing temperatures.

Loctite 638 provides resistance to dynamic, axial and radial loads and is one of Henkel's high strength products, capable of carrying high loads and filling all voids to prevent corrosion and fretting.

Loctite 243 is the predominant thread locking product used to prevent self-loosening and secure any threaded fasteners against vibration and shock loads. A typical application on The Beast is on M20 bolts tightened to 365Nm to secure the track-drive wheel.

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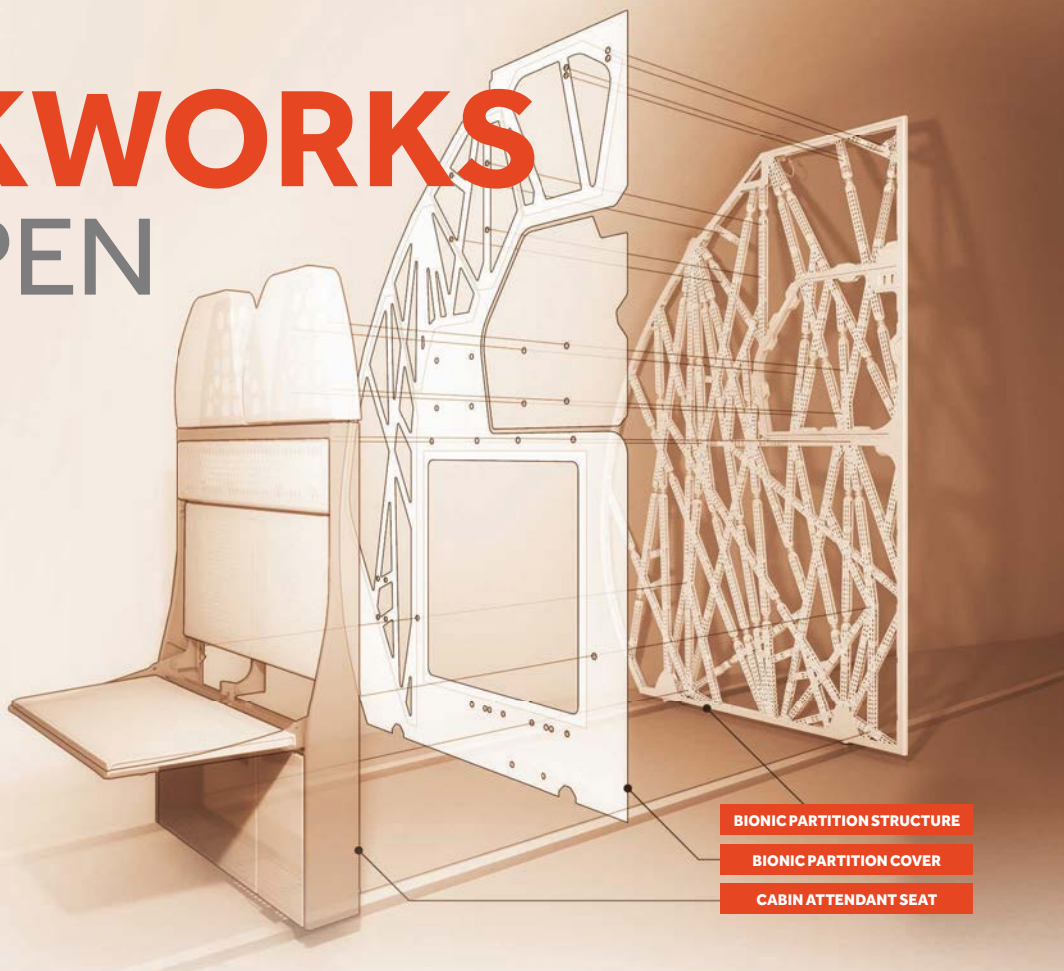
# SKUNKWORKS WITH OPEN DOORS!

**Products evolve naturally, but from time to time a bit of product revolution needs to be thrown into the mix. That is the *raison d'être* of Autodesk's OCTO, as Tim Fryer reports.**




Product development is at the core of what many Eureka! readers do, while others take a more fundamental and original look at engineering design. Lockheed Martin's legendary approach to the latter has become the stuff of legend. Its Skunk Works locks away some of its finest brains to develop top secret military solutions.

There is a parallel here with the CAD platforms that engineers do their designs on. Autodesk's Inventor and AutoCAD, being the relevant example, go through incremental updates, constantly improving the CAD environment by making the tools easier to use or more powerful. And, once in a while, completely new tools emerge, changing the design process, which is more revolution than evolution. Autodesk's route to revolution is similar to the Skunk Works in as much as it is spawned from a concentration of flexible and innovative minds at OCTO – the Office of the Chief Technology Officer. The fundamental difference is that it is completely open. Industry participation is not only welcome, it is an essential part of the process. Ongoing projects are there for all to see.

Azam Khan, director of Complex Systems Research at Autodesk, explained the philosophy. "We're surprisingly open with all of our research. In some ways we're more open than the product development teams – they're always a little secretive before a release. We [OCTO] openly partner with commercial partners and universities and students, and we try to publish all of our outcomes. We're involved with a number of different communities who are interested in the same things. But we don't have commitments to deliver specific things to the product teams, or to customers directly."

This freedom allows the OCTO team to explore completely new avenues with the intention of allowing Autodesk to provide new options and capabilities to customers in its three core markets: product design, entertainment and AEC (Architecture, Engineering and Construction). While these three are separate entities within Autodesk,

## Airbus project

OCTO worked with Airbus using generative design on the 'bionic partition project' – creating a panel that was as strong as the original but half the weight.

"We might develop something that may not be directly from an existing customer need, but we might be able to draw a picture of what the future could be, leapfrogging the current generation of tools."

AZAM KHAN

there is scope within OCTO for the cross-pollination of ideas.

A prime example is Dreamcatcher (see box), which will soon be OCTO's poster child when it is launched this spring. The package will bring generative design to the product design process, but a parallel project called Project Discover is looking at how generative design can be used by architects.

Project Discover is not ready for general release yet but it has been used for the interior design of Autodesk's new office in the MaRS Discovery District of Toronto – a location that claims to be one of the world's largest innovation hubs. Project Discover developed a new piece of software that took input from the occupants of the existing office and used an algorithm to output a design that best met the needs of all.

While Project Discover currently lacks some of the structural controls that its final version will require, Dreamcatcher is 'engineer ready'. In short, the designer outlines the purpose and parameters for a project and Dreamcatcher will calculate numerous different ways that this can be achieved using various materials and styles. This then gives the engineer a good, structurally sound starting model on which to develop final designs.

It is an example of a project that would not have resulted from ordinary product development, it took the blue skies approach of OCTO not only to develop into a workable product, but also to be able to have the vision for it in the first place.

## OCTO ORIGINS

OCTO is led by Autodesk's CTO Jeff Kowalski who set it up in 2006. There are about 120 staff split 60:40 between research and strategy. Most of the strategy group are based in San Francisco. The research team is mainly in Toronto and there are other satellite offices including one in London.

The multidisciplinary team is made up of specialists from varied domains such as mathematical optimisation, geometry, machine learning, mechanical engineering, material science, structural mechanics, user experience research, software design and development. Ideas can come from anywhere – customers, academia, Autodesk or from within OCTO itself.

''Typically a project will start with a research paper,'' said Khan. ''We do real academic research to explore what's already been done in the area and who are the experts involved in these kinds of domains. The advantage of doing that is that we can publish these research papers in the same academic journals and conferences that our research peers at universities publish. It's a way to develop relationships with these professors to find the interns that they recommend as well.''

These interns have been a valuable resource for OCTO, several having been hired following successful projects. Particularly on the research side, Khan describes the staff as a bunch of PhDs who are trained as investigators in different technologies.

''I like to think the researchers and the thought leaders at Autodesk really have the dual perspective – both the perspective of their particular domain and the deep expertise in that area,'' he said. ''But also, this ties in with deep knowledge about computer science, which could impact our products.''

Successful projects to come through OCTO include ViewCube – a navigation tool for 3D CAD; SketchBook and then SketchBook motion – animation tools that won Apple's iPad app of the year in 2016; and Meshmixer which is designed to help with 3D printing.

## Project Dreamcatcher

Claiming to be the next generation of CAD, Dreamcatcher is a generative design system that enables designers to craft a definition of their design problem through goals and constraints. This information is used to synthesise alternative design solutions that meet a set of objectives.

The Dreamcatcher system allows designers to input specific design objectives, including functional requirements, material type, manufacturing method, performance criteria, and cost restrictions. Loaded with design requirements, the system then searches a procedurally synthesised design space to evaluate a vast number of generated designs for satisfying the design requirements.

The resulting design alternatives are then presented back to the user, along with the performance data of each solution, in the context of the entire design solution space. Designers are able to evaluate the generated solutions in real time, returning at any point to the problem definition to adjust goals and constraints to generate new results that fit the refined definition of success.

Once the design space has been explored, the designer is able to output the design to fabrication tools or export the resulting geometry for use in other software tools. The picture below is of a motorcycle swing arm designed using Dreamcatcher.

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# TAMING A BEAST

**The next generation of manned spacecraft is taking a step back to more predictable technology, while applying the very latest design and development techniques. Justin Cunningham charts Nasa's progress to develop it's next iconic space launcher.**

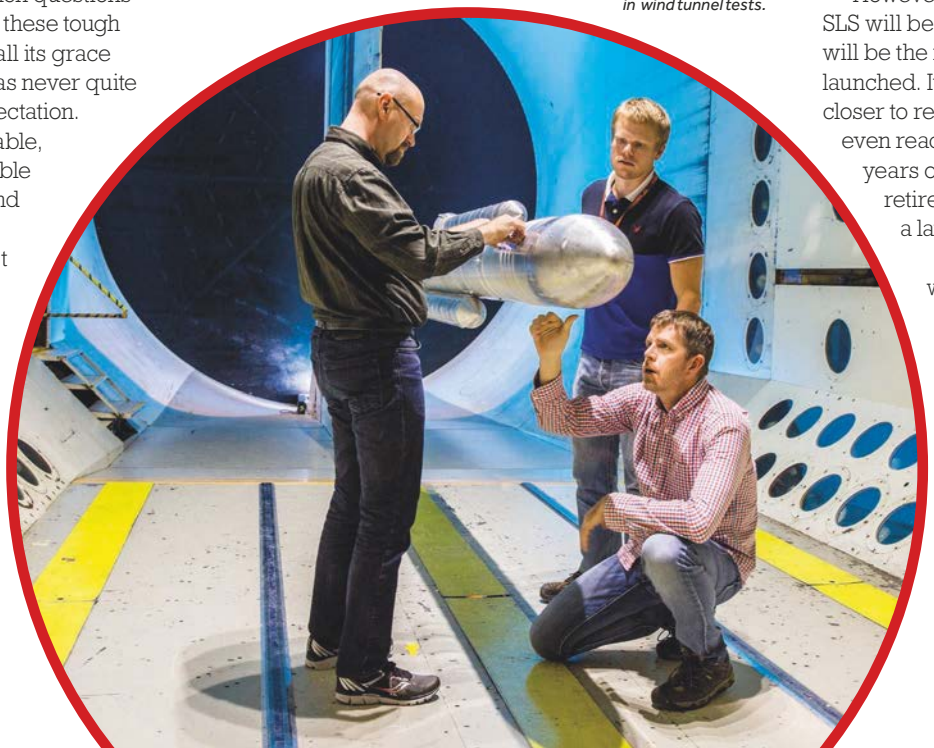
The retirement of the Space Shuttle in 2011 was the US equivalent of losing Concorde. Put simply, it left a void. A void that top engineers saw as the benchmark for technological accomplishment. Many, including myself, see the Shuttle as an engineering triumph that's unlikely to be rivalled for a generation.

Like supersonic passenger airliners, interest in manned spaceflight has fallen out of favour with government, which questions its value for money in these tough economic times. For all its grace though, the Shuttle was never quite able to live up to expectation. While broadly reuseable, it required considerable rebuild, inspection and maintenance after every flight and didn't deliver the leap forward everyone hoped.

While engineers are still fascinated by these machines, catastrophic failures and skyrocketing maintenance costs have meant those holding the purse-strings have chosen to take a few technological steps back, to more simplistic technologies that are easier to manage… hence slower airliners and the return of small crew carrying modules placed on the top of giant rockets. The next generation is going back to the rocketship and taking inspiration from the Saturn V era.

**"We'll be ready for the first flight with crew: targeted for 2021."**

**Dr John Blevins, Nasa**



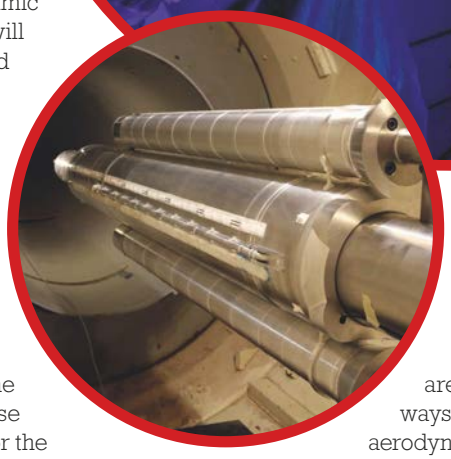
*Above: Nasa is returning to the manned capsule Below: The SLS rocket in wind tunnel tests.*

Cue the development of Nasa's Space Launch System (SLS). Of course 'simplistic' is used with a pinch of salt: we are talking rocket science after all. Space flight is notoriously difficult and just getting into orbit is a huge challenge. Breaking orbit – i.e. breaking free of the Earth's gravity to go off into space – is a mind boggling endeavour.

However, once developed, Nasa's SLS will be able to do just that and will be the most powerful rocket ever launched. It hopes to bring man a step closer to returning to the moon and even reaching Mars. So, after five years of hiatus since the Shuttles' retirement, when can we expect a launch?

"We will keep the teams working toward a more ambitious readiness date and will be ready no later than November 2018," said William Gerstenmaier, associate administrator for human explorations at Nasa.

The initial SLS configuration will be powered by twin solid rocket boosters and



four liquid-fuel cryogenic Aerojet Rocketdyne RS-25 rocket engines – the same as those previously used on the Space Shuttle.

For its first test flight, the SLS will be configured for a 70 tonne lift capacity and carry an unmanned Orion crew module beyond Low Earth Orbit (LEO). However, in its most powerful configuration, the SLS will provide a lift capability of 130 tonnes and enable missions farther into the solar system, opening up the potential for missions to asteroids, the Moon and even Mars.

The design is well beyond the initial concept phase and engineers are deep into the detail. Part of this development is extensive work into qualifying design predictions made by simulation models with test data from wind tunnels. The results will then be used to further refine the SLS design.

## WIND TUNNEL TESTING

As the launch phase is arguably the most important part of any mission, engineers need to carefully measure the forces and loads that the air induces on a launch vehicle as it accelerates through every phase of the atmosphere.

Dr John Blevins, SLS lead engineer for aerodynamics and acoustics, said: ''All the critical aerodynamic environments from acceleration through the sound barrier to booster separation at more than Mach 4 are evaluated in these tests.''

As the rocket approaches the speed of sound, shockwaves build up and move along different points of the launch vehicle. These cause buffeting, shaking, vibration and unsteady loads that can easily result in damage or even change the rocket's trajectory.

Defining the location and behaviour of these shockwaves is difficult with computational fluid dynamics alone as they continuously change angle and strength as the vehicle accelerates. To assess the impact, the aerodynamics team is developing an optical measurement method involving Unsteady Pressure Sensitive Paint.

During wind tunnel testing, special lights and cameras observe changes in the paint's fluorescence (pictured), indicating the strength of aerodynamic forces acting along different areas of the rocket.

''For a lot of aero-acoustics and buffeting work, we instrument the models with hundreds of pressure sensors,'' said Nasa engineer, Dr Patrick Shea. ''If we can start moving to more of an optical technique, such as the dynamic pressure sensitive paint, it will really allow us to make good strides forward.''

## THERMAL EFFECTS

It is not just shockwaves that design engineers must contend with. As the rocket reaches speeds of more than 17,000mph in its 8.5 minute ascending flight, the thermal effects on the outer surface become increasingly dramatic. These must be fully understood for the effective development of any launch vehicle.

The phenomenon known as aerodynamic heating is caused by friction, created between the air and the rocket's surface, as it accelerates through the atmosphere. Typically, aerodynamic heating is most significant for the SLS vehicle during the second minute of flight, when the vehicle accelerates from around Mach 1 to Mach 4.5.

Nasa uses a special type of wind tunnel to generate airflow at both supersonic and hypersonic flight conditions, recreating external temperature, pressure and velocity. The tests last just 40 milliseconds, but allow supersonic airflow between Mach 3.5-5 to be passed over the launcher's surface to assess high speed aerodynamic and thermal behaviour.

Test measurements are made in three different ways. First, pressure and aerodynamic heating are measured at nearly 200 individual sensor locations on the test model. This is combined with Schlieren imaging, an optical technique for visualising supersonic flow around objects. Finally, temperature sensitive paint is applied to critical regions of the test model to provide additional insight into the heating distribution.

The SLS rocket configuration, with boosters attached, is tested at angles of attack between 0 and 5° (at 0° the airflow is parallel to the vehicle). The boosters are removed from the model and the remaining core stage is tested again at higher angles of attack between 15-20°, an orientation observed following booster separation in nominal flight.

''Our primary objective is to gather conclusive aerodynamic heating model validation data, both before and after booster separation,'' concluded Chris Morris, aerothermodynamics team lead at Nasa's Marshall Space Flight Center. ''These tests give us a lot of insight into how well our engineering and computer models do at predicting aerodynamic heating on the vehicle. The data is very important for certifying that the thermal protection on the rocket will be sufficient to protect the rocket's structure and vital systems inside.''

## FAST FACTS

| | |
|---|---|
| HEIGHT | 111M |
| STAGES | 2 |
| PAYLOAD TO LEO | 70,000 TO 130,000KG |
| BOOSTERS | 2 |
| THRUST | 41000KN |
| ASCENT TIME | 8.5 MINS |

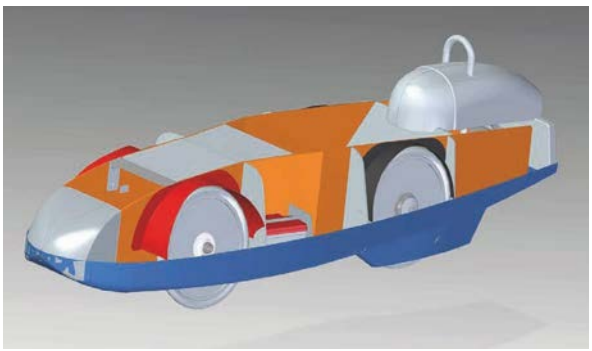
# RACING TOWARDS ENGINEERING CAREERS

**David Cullimore always wanted to be an engineer, but without the Greenpower racing scheme he may never have got there. Tim Fryer looks at the programme, how it helped David and how engineers can become involved.**

There are countless schemes in the education system that are designed to encourage students to become engineers. In fact, such STEM schemes proliferate to such an extent that, however well-intentioned they may be, they can start to trip over each other – particularly when other programmes aimed at sport, music, drama, languages etc come into the mix. When vying for the attentions of both students and educators, it's a competitive world.

What has helped Greenpower become established is the backing of Siemens, a company that is involved in so many engineering disciplines and, importantly for Greenpower, one that has its own design software. It also invests in the region of €20m a year in its educational activities, which is not of course pure altruism – Siemens needs fresh engineers as much as any other engineering company.

Mike Brown is director of academic programmes for Siemens PLM. ''Industry 4.0 is just an idea,'' he said. ''It will really hit in 10, 15, 20 years and the engineers who will make Industry 4.0 happen are in the classroom now. That is a very compelling story. If you talk to teachers and say that's the reason Siemens is involved, because we have to be, as by the time those kids graduate we want them to be able to take full advantage of Industry 4.0.



*Above: Siemens Solid Edge allows competitors to quickly design and iterate car concepts.*

''What was industry standard in the 20th century is not going to be industry standard in the 21st century, and this Industry 4.0 is going to require a whole new mind set and new technologies.''

And it is not just about attracting engineers. In an interconnected and automated future, there is also the necessity for greater understanding throughout society.

''We want to increase technological literacy at all levels of education within the student body,'' said Brown.

This is where Greenpower comes in. The Greenpower Education Trust's objective is to advance education in the subjects of sustainable engineering and technology to young people. To achieve this, it started a challenge to design, build and race electric cars and since its inception in 1999, it has expanded to cover over 500 schools and 8000 students in the UK with further participation internationally.

One of these students was David Cullimore. Cullimore has just retired from Greenpower at the ripe old age of 23, having won the championship several times and every race in the 2016 season. Cullimore's exploits led to a placement at Red Bull and postgraduate employment as a design engineer at Prodrive, working on a project to develop a rally car from the latest Aston Martin.

It is no surprise that Cullimore's fledgling career has followed such a path. He said: ''As I was growing up, I always liked making things. It seemed natural that I was going to become a design engineer. However, the UK school and university system is particularly tailored towards academic high flyers, of which I wasn't one. I failed to gain the maths and physics entry requirements to study engineering at a UK university.''

Instead Cullimore studied industrial design at Loughborough University, which provided the circuitous route to the engineering career he desired.

Greenpower played an important role in this, helping him secure his university place. ''My Greenpower

Behind **Greenpower** is a collection of heavyweight sponsors including **The Institution of Engineering and Technology** (IET), **Ford**, **Silverline**, **Unipro** and **Siemens**.


*Cullimore, above, found success building his car, left, which culminated in the Jet II, below.*

journey started at school when I was 17,'' he said. ''I was part of a team who designed, built and raced the car, but at the end of the year I still felt that there was more for me to learn in Greenpower. So in 2012 I set up Cullimore Racing as an independent team. By independent I mean that I wouldn't be associated with a school, college or corporate team, and that I would design and build a car and race with the help of my friends and family.''

His first car, Jet, designed using rough 2D sketches went on to win 24 out of its 30 races. Cullimore commented: ''I used my Greenpower experience, the knowledge that I'd gained, the practical skills, but also the initiative that I'd shown through setting up my own team, to secure a 12-month placement at Red Bull Formula 1 team. Two years before I had failed to get on an engineering course - I couldn't believe that I was now working at the highest level of motorsport.''

Part of Siemens sponsorship of Greenpower includes provision of free Solid Edge CAD for the teams. Cullimore explained how this aided progress: ''After my placement I wanted to take my Greenpower racing to the next level, so I decided to build Jet 2. The aim of Jet 2 was to design a car entirely within Solid Edge and to build it to the highest level. Much of the design is similar to my previous car with the benefit of having a 3D assembly as I was able to reduce the tolerances to improve the packaging, to reduce the frontal area and ultimately reduce the drag. Many of the components were designed in Solid Edge including the overall surface.''

Again Cullimore had phenomenal success, winning the senior championship. He believes part of this success has come from approaching engineering problems from a creative side rather than a traditional engineering methodology. But more than anything, he said it is clear that Greenpower has been instrumental in turning him into the engineer he wanted to be.

He concludes with a message to all companies or engineers who could support or mentor a Greenpower team. ''I urge you to get involved in Greenpower. It has provided me with the perfect platform for my future development, and there are many other students, like me, that would benefit from the Greenpower education programme.''

## GREENPOWER 2017 SEASON

- The official 2017 race season starts with the season opening race, which for 2017 is May 3rd; teams should register their interest with Greenpower by this date.
- Teams will already be designing/building their cars in accordance with the 2017 Rules & Regulations.
- Teams can continue to develop their car throughout the season as long as it complies with the rules and regulations.
- The 2017 Greenpower International Finals will take place at Rockingham Motor Speedway on October 7th/8th.
- Engineers/mentors can get involved at any stage. If they want to encourage a school to take part in the Greenpower Challenge then now would be a good time to start talking to the school. Many schools new to Greenpower will start by purchasing a kit car. This will enable the school to get up and running quickly and compete in the 2017 season.
- If a University wants to start Greenpower, they should be designing and building a car from scratch. If they want to compete in the 2017 season they'll need to get started ASAP!
- There is an Ambassador Pack that contains suggestions for engineers/mentors/volunteers on how they can engage with a school. Contact laura@greenpower.co.uk for more information.

**www.greenpower.co.uk**

# CHILL OUT, MAN!

Stress has become an accepted part of modern life. It means, what we have gained in efficiency thanks to modern technology, we undo by taking on more. We are busier than ever, worker longer than ever, and juggling more commitments.

For some, stress is something that is thrived on, a motivator, a call to action centred around that feeling in the pit of the stomach. But for most, it is an unpleasant sensation that only distracts us from the task in hand.

However, increasing evidence points to the fact that stress is not just unpleasant and distracting, but poses a serious health risk. Some studies say that chronic stress on a day-to-day basis is the same as smoking five cigarettes.

## THE CHALLENGE

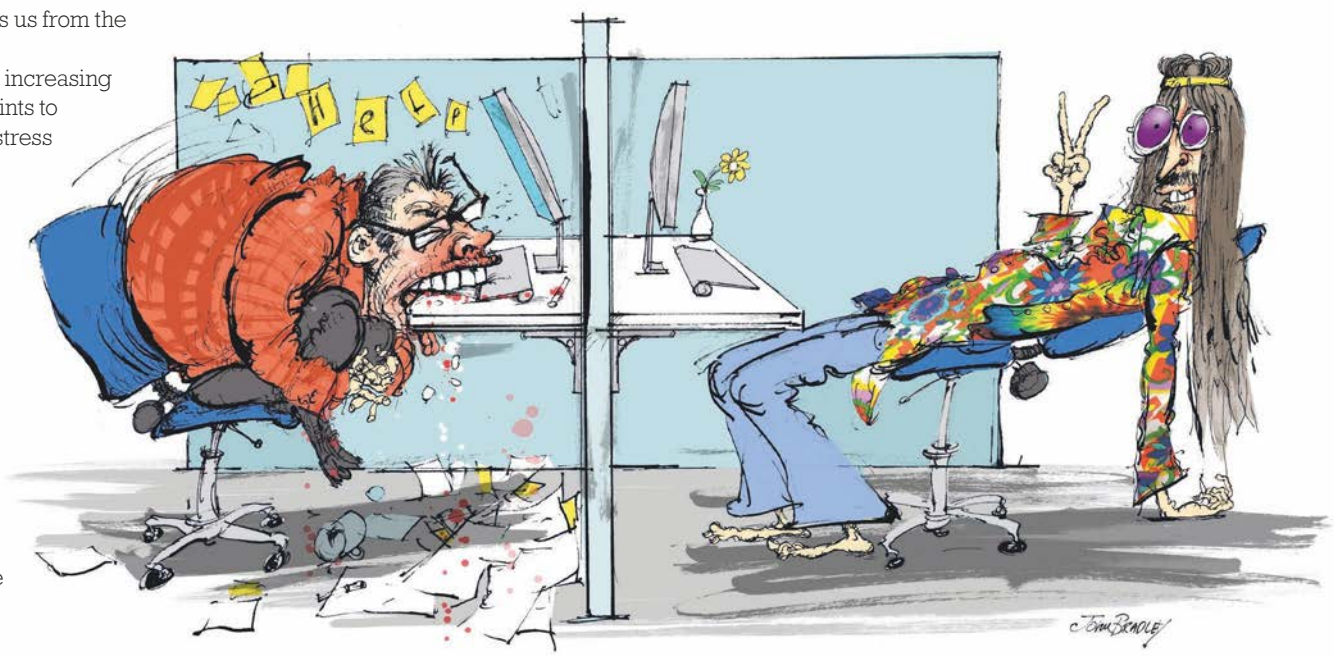
The challenge this month is to therefore come up with a way of managing and preferably doing away with stress. The solution must be a technological one, so Yoga or deep meditation is not what we are looking for, though the technology can, and should, influence our state of mind.

Stress is by its nature self-induced, despite any obvious external stimulus – cue furtive look to a lazy co-worker or uptight manager – meaning some people 'feel' more stress than others. Just ask the hippies!

The idea is not to get people to do less, quite the opposite. Stress is contagious, just as calmness is. So, any solution should try to influence your immediate state of mind by making you aware of what your body is doing.

Stress is all consuming, and it is often only in hindsight that you realise just how stressed you were. Any solution should try and alert you to the fact that you are feeling stress early, so you can take action. The solution should be about giving you subtle clues about what is happening to your body, so you can think about how to reduce it.

- We'll publish our solution in the March issue. Feel free to email your ideas to the editor (**tim.fryer@markallengroup.com**) or leave them as a comment on the Coffee Time Challenge section of the website.



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## 3D Electromagnetic Field Solver

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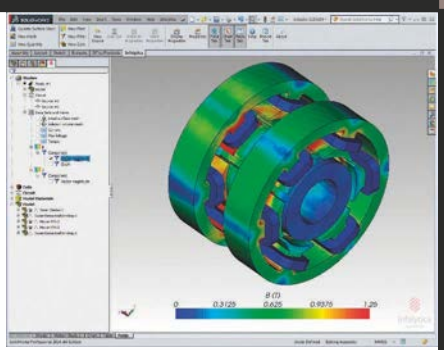
MagNet for SOLIDWORKS is the foremost 3D electromagnetic field simulator embedded in the industry leading CAD software. A combination beyond compare: just one design environment for drawing the model and analyzing the performance of any EM device such as power transformers, sensors, MRI, actuators, solenoids and much more. This is not a live link or connection of two standalone software tools, but rather a fully integrated add-in to SOLIDWORKS which runs seamlessly inside the CAD environment.

Perform electromagnetic field simulations and quickly make geometric modifications to examine their impact on the design without worrying about exporting model data and dealing with compatibility issues. The property management pages and study setup use the same look and feel of SOLIDWORKS interface, making it intuitive to existing users.

MagNet for SOLIDWORKS' solution approach is based on the highly accurate finite element method for simulating static, frequency dependent or time varying electromagnetic fields. Read more about the complete feature set.

Useful features include:
Seamlessly add electromagnetic field simulations to the SOLIDWORKS CAD environment • Current flow in coils is automatically detected for easy setup • Detach and move components when post-processing results for easier understanding of the performance • Slice and peel through field results



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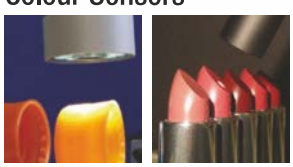

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