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THE MAGAZINE FOR ENGINEERING DESIGN

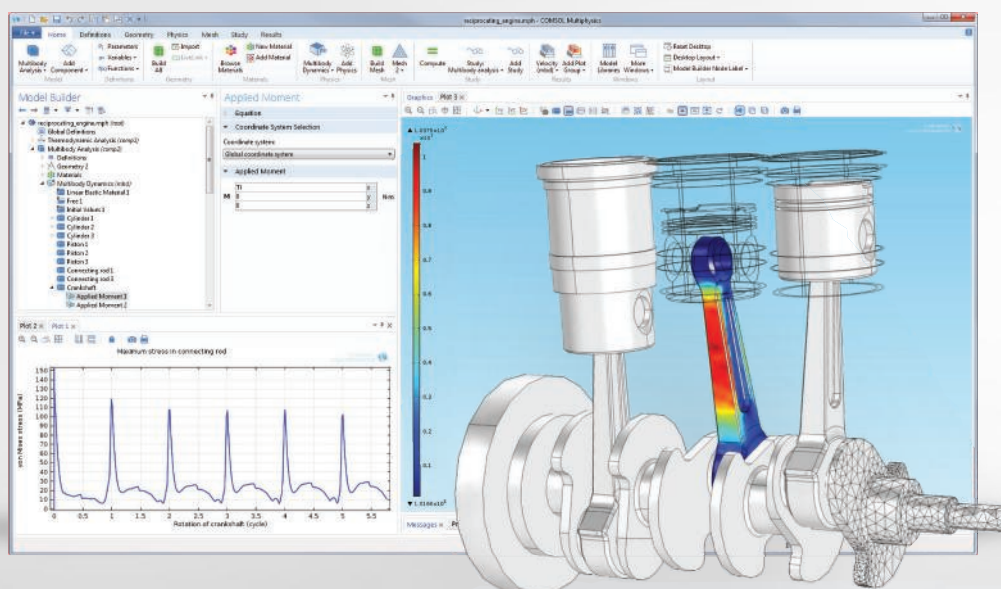
In this issue: Rapid Prototyping • Sensors, Test & Measurement • Power Transmission • Materials

## Building foundations

Getting to grips with offshore wind turbines



**MULTIBODY DYNAMICS:** Model of a three-cylinder reciprocating engine used for the design of structural components.



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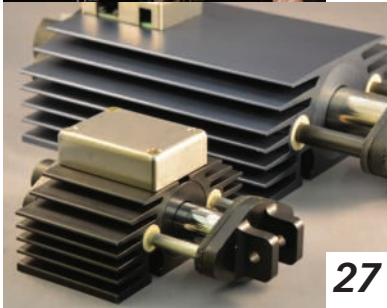




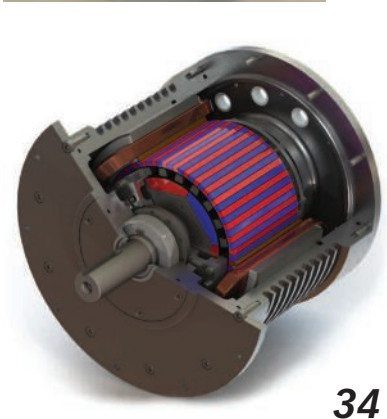
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A double winner at this year's BEEAs, Sebastien Cuvelier Mussalian is a man whose work is nothing if not highly impressive. Paul Fanning reports on his engineering achievements.

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A new additive manufacturing process allows users to use standard, off-the-shelf granular plastics. Paul Fanning takes a look at this potentially 'game-changing' new technology and assesses its potential impact.

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A new British technology could prove revolutionary enough to render pneumatics comparatively too expensive to run economically, the inventor claims. Paul Fanning takes a look.

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This month's challenge is to develop a running shoe that prevents injury.

# Save the date!



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# Printing's Progress



Paul Fanning, Editor (pfanning@findlay.co.uk)

The Gartner Hype Cycle, which gets a mention elsewhere in this issue (see page 39), is a very useful benchmark from which to assess the progress of a technology.

In a nutshell, the Gartner Hype Cycle places technology in one of five categories: Technology Trigger; Peak of Inflated Expectations; Trough of Disillusionment; Slope of Enlightenment; and Plateau of Productivity.

Taking this as one's guide, it's fair to say that 3D printing has in one form or another been balanced precariously on the Peak of Inflated Expectations for some time now. Given which, it would seem overdue for a slide into the Trough of Disillusionment, as people realise that the claims that have been made for this technology have either been inflated or will take a lot longer to become reality than they had been led to believe.

And the fact is that few technologies have been more comprehensively hyped and overblown than 3D printing. Very few mainstream media articles about it have not been accompanied by outlandish claims about its 'likely' effects on manufacturing in particular and the world in general.

From being told about 3D printed food, organs or guns to reading about the ability we will all soon apparently have to download CAD files and print out whatever we want, there are disappointments coming to anyone who does not take these claims with more than a pinch of salt.

The problem is that these excessive expectations are constantly encouraged, with every new development hailed as the great breakthrough. The problem is that, with every great breakthrough that somehow fails to have the huge effect we are told to expect, there is a danger that faith in the technology as a whole can erode.

None of this is meant to decry the real potential of 3D printing. It is a fascinating technology that is taking genuinely important leaps that are already changing industry. Indeed, in some industries (the manufacture of dental implants springs to mind) it has already had a revolutionary effect. However, for the most part, the process is more one of evolution than revolution.

So, while a trip to the 'Trough of Disillusionment' may be on the cards for 3D printing, it is to be hoped that it will not be a long one and that the 'Plateau of Productivity' will not be far behind.

**Editor**  
Paul Fanning  
pfanning@findlay.co.uk

**Deputy Editor**  
Justin Cunningham  
jcunningham@findlay.co.uk

**Web Editor**  
Laura Hopperton  
lhopperton@findlay.co.uk

**Group Editor**  
Graham Pitcher  
gpitcher@findlay.co.uk

**Art Editor**  
Martin Cherry

**Technical Illustrator**  
Phil Holmes

**Advertising Sales**  
01322 221144

**Sales Director**  
Luke Webster  
lwebster@findlay.co.uk

**Deputy Sales Manager**  
Simon Bonell  
sbonell@findlay.co.uk

**Account Manager**  
James Slade  
jslade@findlay.co.uk

**Sales Executive**  
Matt Santer  
msanter@findlay.co.uk

**Production Manager**  
Heather Upton  
hupton@findlay.co.uk

**Circulation Manager**  
Chris Jones  
cjones@findlay.co.uk

**Publisher**  
Ed Tranter  
etranter@findlay.co.uk

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## 3D printed parts flown in military jet

A Tornado fighter jet fitted with 3D printed parts has been flown for the first time.

Defence giant BAE Systems announced yesterday that the jet had completed its first test flight in Warton, Lancashire, late last month.

The parts include protective covers for cockpit radios and guards for power take-off shafts.

The process is expected to cut the RAF's maintenance and service bill by more than £1.2million over the next four years.

Mike Murray, head of airframe integration at BAE, said: "You are suddenly not fixed in terms of where you have to manufacture these things. You can manufacture the products at whatever base you want, providing you can get a machine there, which means you can also start to support other platforms such as ships and aircraft carriers.

"And if it's feasible to get machines out



on the front line, it also gives improved capability where we wouldn't traditionally have any manufacturing support."

The news comes on the heels of a recent study, carried out by European aerospace giant EADS and laser-sintering system manufacturer EOS that concluded that the cost of some aircraft parts could be substantially reduced if additive

manufacturing methods were used instead of more traditional processes.

The study concluded that material consumption can be reduced by 75% and CO2 emissions by 40%, despite the fact that the EOS technology uses significantly more energy during manufacture. Both these factors contribute to an overall cost reduction.

## EEF confirms positive manufacturing outlook

Manufacturers will experience more ups than downs in 2014, with projected manufacturing expansion of 2.7% placing the UK top of EU growth league, according to the EEF.

It has reported steady growth gains, but also greater economic uncertainty in a major survey of senior executives conducted with Aldermore Bank.

The EEF said: "The survey of 200 senior executives paints a more positive outlook than the muted picture of 12 months ago, with growth expected in all markets and across all sectors and sizes of companies. The relentless pursuit of growth opportunities in new markets, sectors and technologies looks set to be more focused for firms in 2014, but they are far from certain that risks to growth won't return this year."

EEF chief executive Terry Scuoler said: "Manufacturers are telling us they expect to make a greater contribution to growth, investment and jobs this year.

Innovation, energy and diversifying into new supply chain remain key opportunities but the UK and the Euro-zone are also looking better.

"However, global uncertainty and rising energy costs pose significant risks and, the

challenge for industry and government this year will be to get industry's investment plans over the line."

The survey reveals that actions to improve productivity, greater supply chain collaboration, strong communication with employees and increased overseas marketing efforts will top the list of strategies for manufacturers in the year ahead.

Almost three-quarters (70%) of companies expect the UK economy to improve in the next year, with 62% expecting manufacturing prospects to improve. This is mirrored in the outlook for the global economy where 57% of companies expect an improvement. However, the perception of global risk is highlighted by the fact just 3% of companies expect this improvement to be significant.

Two thirds of companies expect their domestic sales to increase and 55% expect their exports to increase. The extent of the importance of emerging markets is underlined by the fact increased demand from these areas has returned with two fifths of companies viewing this as the best source of growth. Companies in the transport sectors were most positive about emerging market demand reflecting the prospects for goods such as luxury vehicles and civil aircraft.

However, the impact of the prolonged downturn on manufacturers is also highlighted. Three quarters believe 'economic uncertainty is the new norm'. Specific risks include rising input costs. The EEF said: "This reflects the impact of rising energy costs in particular, although pay pressures, a factor not seen for many years, were also identified as a risk by a quarter of companies."

**"Manufacturers are telling us they expect to make a greater contribution to growth, investment and jobs this year.**  
EEF chief executive Terry Scuoler





# Ford unveils new, solar-powered concept car

The C-Max Solar Energi Concept car is designed to deliver the best of a plug-in hybrid without depending on the electric grid for fuel.

The vehicle relies on a solar panel roof to draw power from a special solar concentrator lens similar to a magnifying glass. Ford says it could reduce the annual greenhouse emissions a typical owner would produce by four metric tons.

"The Ford C-MAX Solar Energi Concept shines a new light on electric transportation and renewable energy," said Mike Tinskey, Ford global director of vehicle electrification and infrastructure.

The car, which will be shown at the 2014 International CES in Las Vegas, was developed as part of collaboration between Ford, Georgia Tech and SunPower.

Tasked with maximising the amount of

sunlight the car can absorb, the team from Georgia Tech developed an off-vehicle solar concentrator that uses a special Fresnel lens to direct sunlight to the solar cells while boosting the impact of the sunlight by a factor of eight.

Similar in concept to a magnifying glass, the patent pending system tracks the sun as it moves from east to west, drawing enough power from the sun through the concentrator each day to equal a four hour battery charge (8KW).

With a full charge, Ford expects the car to have a range of up to 620 miles, including up to 21 electric-only miles. The plan is to include a charging socket so that can drivers can still get power from the grid if needed.

Ford says further tests are in the works to determine if the C-Max Solar Energi is actually feasible as a production car.



## Engineering Design Show wins PPA award

The Engineering Design Show has won the 'Event of the Year' category at the prestigious PPA Independent Publisher Awards. The judges described the Show as the 'stand-out winner', despite a particularly high calibre of entries. "This event has achieved incredible success from a standing start, smashing all of the targets set," the judges said. "The event resulted in a great number of new clients for the brand, added value for existing readers, and created a sustainable event for the foreseeable future."

On receiving the award, Findlay Media's executive director Ed Tranter, commented: "Winning this award is a perfect end to a great year for the exhibition. "The Engineering Design Show has been a truly great team effort across every department of Findlay Media Limited and a significant contributor to the company's success this year so it is really fantastic news."

The 2014 Engineering Design Show takes place at the Ricoh Arena, Coventry between 22 and 23 October. For more information, or to book a stand, visit [www.engineeringdesignshow.co.uk](http://www.engineeringdesignshow.co.uk)

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## Smart wheel turns any bike into a hybrid

Created by a small team from MIT, the Copenhagen Wheel is a smart, responsive solution that transforms existing bicycles into hybrid electric bikes with regeneration and real-time sensing capabilities.

The self-contained unit, which snaps easily onto the back of any ordinary bicycle, contains a motor, batteries and an internal gear system – helping cyclists overcome hilly terrains and long distances.

It also includes environmental and location sensors that provide data for cycling-related mobile applications. Cyclists can then use this data to plan healthier bike routes, achieve their exercise goals or connect with other riders - all via a specially developed smartphone app.

The wheel is ridden like a normal bicycle – users pedal and the motor phases in and out automatically. However, what sets it apart from other solutions is the fact that it learns about the rider and intuitively recognises how hard he or she is pedalling to determine how much support they may need.

What's more, the wheel features a rechargeable lithium ion battery



that can be easily swapped in and out, and an intelligent locking system that locks the bike when the rider walks away and unlocks it upon return.

The team behind the Copenhagen Wheel is now trying to turn it into a commercial reality, and plans to start selling it next year for around \$600 (approx £367).



## Desktop 3D printer is 'world's fastest'

Desktop 3D printers have come a long way in recent years, but for the most part they're still painfully slow and unable to print very large objects.

Looking to solve both of these problems is Florida-based start up tangible engineering USA.

The company's patent pending Solidator 3D printer offers a large build volume, ultra high resolution and high printing speed – all for less than \$5000.

The device works by using stereolithography and projector DLP technology to turn liquid plastic (similar to nail polish) into a solid 3D object with just visible light.

The company claims it can print 1.5bn Voxels in 5.5 hours on an 11.8L build volume (280 x 210 x 200) – at around a third of the time it takes conventional stereolithography printers.

The team behind Solidator has launched a Kickstarter campaign to take it from prototype to production.

## Google's Schaft robot wins Darpa rescue challenge

A robot developed by a Japanese start-up recently acquired by Google is the winner of a two-day competition hosted by the Pentagon's research unit Darpa.

Team Schaft's machine carried out all eight rescue-themed tasks to outscore its rivals by a wide margin. Three of the other 15 teams that took part failed to secure any points at the event near Miami, Florida.

Schaft and seven of the other top-scorers can now apply for more Darpa funds to compete in 2014's finals.

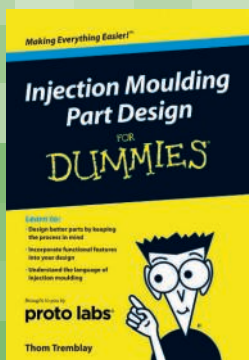
Darpa said it had been inspired to organise the challenge after it became clear robots were only capable of playing a very limited role in efforts to contain 2011's Fukushima nuclear reactor meltdown in Japan.





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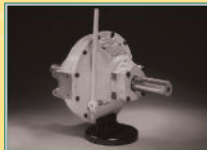
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## Clear encapsulating compound available

Henkel not only offers Macromelt hot melt low-pressure moulding technology for protecting delicate electronic components, but also a choice of encapsulating compounds for tough specifications relating to temperature resistance.

For this reason, Loctite silicones are already popular for sealing lighting products against moisture, solvents and environmental conditions. And with the addition of Loctite SI 5700 to the range another important benefit is now available for such applications.

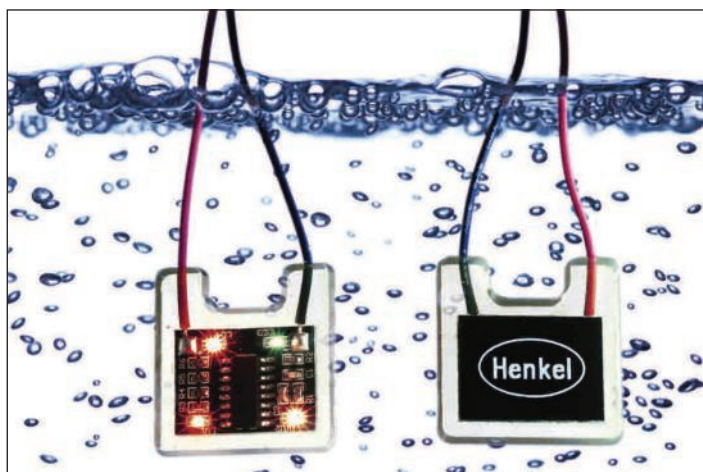
Unlike other products that can yellow with exposure to UV light and elevated temperatures, the new Loctite SI 5700 retains its colourless clarity. This encapsulating compound has been developed specifically for

tasks such as sealing energy efficient LED arrays, advertising signs or lighting façades.

This is a transparent, two compound silicone that offers good adhesion on a wide range of substrates such as metal, glass and plastics. The moulding produced with this material is bubble-free, providing OEMs with the competitive advantage of products that look good throughout their service life.

Loctite SI 5700 joins the wide range of potting and encapsulating compounds from Henkel based on epoxy, hot melt, silicone and urethane technologies. Desired viscosity, operating temperature, chemical resistance, thermal conductivity and flame retardance determine which product is most suited to the task.

[www.loctite.co.uk](http://www.loctite.co.uk)



## Anti-corrosion coating prevents rust

A modular corrosion protection solution for hub bearing unit that makes the disassembly process easier, prolongs service life and improves vehicle appearance.

SKF announces that it has developed an innovative solution for protecting the wheel bearing against corrosion. The anti-corrosion coating for hub bearing unit makes the disassembly of the bearing from the knuckle and rim easier. It improves the aesthetics of the bearing during vehicle life and stops rusty surfaces coming into contact with the seal.

The anti-corrosion coating feature has been designed to withstand over 400 hours of salt-spray test (DIN EN ISO 9227 NSS) without jeopardizing the geometrical tolerances of the hub bearing unit.

This anti-corrosion coating can be applied to all flanged hub bearings units of second and third generation and features scalable layer thickness according to customer requirements; low thickness tolerance; maximum working temperature above 200°C; UV paint.

The anti-corrosion hub bearing unit offer benefits to customers including: strong resistance against corrosion; better bearing appearance during vehicle life; easier disassembly operations in workshop; and lower risk of corroding the bearing seals with rust.

[www.skf.com](http://www.skf.com)

## Compact, multi-slide, single-axis linear units

New additions to the IEF Werner range of linear modules from R. A. Rodriguez simplify design, save space and shorten assembly time. Its new linear units with spindle or toothed belt drives can now run two slides independently and, when equipped with linear motor drives, even more.

Two variants of its Module 160/15 provide these advantages. Module 160/15G has twin toothed belts driven by two motors. So,

instead of adopting the traditional solution of two linear units assembled side by side, the system designer can now select a single, compact unit to do the job. And of course no adjustment is necessary to achieve synchronicity.

The space saving potential with this option is significant allowing a more compact overall system to be created. The linear axis is also equipped with integral collision protection so safe operation is assured.

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## Detector prevents Road tunnel Fires

The new Hot Spot Detector system from SICK can prevent catastrophic vehicle fires in highway tunnels and help avoid loss of life, freight and vehicles as well as the immense cost of closure and reconstruction.

Based on the Sick LMS511 laser sensor with the TIC 102 profiling system and integrated with thermal imaging cameras, the Sick Hot Spot Detector detects potentially dangerous situations in free-flow traffic so a suspect vehicle can be diverted before entering the tunnel.

"Some of the most calamitous disasters have happened on major highways, where a vehicle fire has trapped people in a tunnel, subject to heat and poisonous smoke, with great difficulty in escaping," comments Gary Young, Sick (UK) traffic management segment manager.

"The new system proved its potential within a week of the first installation in Austria in May 2013, where an overheating brake on a truck was picked up at the Karawanks Tunnel. On inspection, the truck also had two other cracked discs and was prevented from entering."

Developed by Sick's Swiss subsidiary ECTN AG, the new Hot Spot Detector is able to detect potentially dangerous overheating on chassis or cargo in virtually any type of vehicle, from buses and low loaders to high sided trucks and tankers.

[www.sick.co.uk](http://www.sick.co.uk)

## Tapered roller bearings cut torque

Precision bearing manufacturer Schaeffler has extended its range of high performance, premium quality, X-life tapered roller bearings.

The new X-life FAG tapered roller bearings are now available in sizes up to 635mm outside diameter (OD). This means that Schaeffler can now offer customers the widest range of high performance tapered roller bearings on the market today.

FAG tapered roller bearings in X-life quality can achieve a reduction in frictional torque of up to 50% compared to conventional tapered roller bearings. The dynamic load rating (load carrying capacity) of the X-life bearing has increased by 20%, with a resulting minimum 70% improvement in the basic nominal operating life of the bearing.

As well as improving the performance and energy efficiency of the bearing, X-life tapered roller bearings also provide additional benefits in terms of a reduced design envelope, weight and friction. Design engineers can now potentially replace a standard tapered roller bearing with a smaller X-life version, therefore downsizing the system and related components. Alternatively, a standard tapered roller bearing can be replaced with an equivalent sized X-life tapered roller bearing, which will provide improved performance and energy efficiencies.

X-life tapered roller bearings also contribute significantly towards reducing operating, servicing and maintenance costs, particularly with regard to



the Total Cost of Ownership (TCO).

The new X-life tapered roller bearings are not only more economical, but also result in lower bearing operating temperatures, which in turn, places significantly less strain on the lubricant. This enables maintenance intervals to be extended and results in the bearing operating at reduced noise levels.

[www.schaeffler.co.uk](http://www.schaeffler.co.uk)

## Linear actuators enter screw jack territory

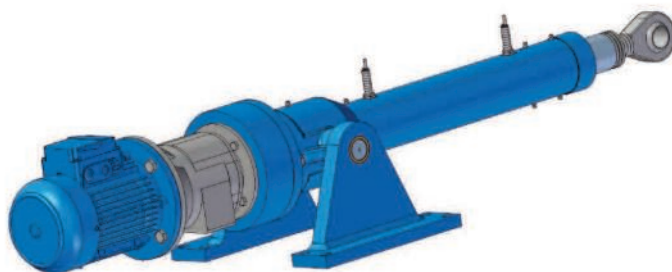
The Servomech range of linear actuators sold in the UK by Techdrives has been extended with powerful new models for forces up to 350kN (35 tonnes). These are well into the performance realm of screw jacks so design engineers have

the choice from the two technologies. Actuators are likely to be preferred for pivoting mountings, for dirty environments as there is no exposed screw thread, and where built in stroke limit switches are needed. Also linear actuators have ball screw

versions readily available that suit high duty cycles, and generally linear speeds can be higher.

The ATL/BSA range of linear actuators has been extended with two new models with rated forces of 200kN and 350kN. Linear speeds range from 9 to 140mm/s and typical motors are AC 7.5kW and 15kW. Limit switches are fitted as standard. Also new is the model ILA linear actuator with six sizes rated from 15 to 200kN. Normally linear actuators have an integrated worm gearbox driving the screw, but ILA is configured without gearing.

[www.techdrives.co.uk](http://www.techdrives.co.uk)

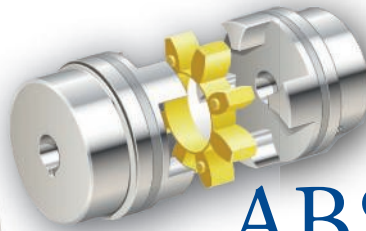




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### Solution to last month's Coffee Time Challenge

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The solution to December's Coffee Time Challenge of how to design an airline seat that can recline and adjust without inconveniencing other passengers comes from – leading global design and innovation company Seymourpowell in the form of Morph, a concept economy seat for airline travel that has been inspired by difference, new materials and flexibility.

Morph uses smart architecture to adjust both the width of the seat, and individually control seat pan height and seat pan depth to suit varying sizes of passenger. This creates a scalable value offer for airlines, allowing them to arrange the economy cabin by people's willingness and ability to pay for space, blurring the boundaries between the classes.



The concept seat works by replacing traditional foam pads with a fabric that is stretched across the width of three seats, around a frame and over formers. One piece of fabric is used for the seat back and one is used for the seat base. The fabric is clamped down by the armrests and the upper dividers to form three individual hammock seats.

By moving the formers and pushing them through the fabric, users can control the recline and a large range of ergonomic adjustments, morphing the fabric to provide a tailored fit and greater comfort.



As the recline happens within the soft furnishings, the solid seat back does not move. The semantics of the architecture and visual cues indicate that the back of the seat belongs to the passenger facing it. Passengers can extend the width of their armrests over their own lap, increasing that feeling of independence and control over their own space.

As just one sheet of fabric is used across three seats, the dividers can be moved laterally and then clamped down in a different position and so adjusting the width of each individual seat. Families travelling together can tailor their seats according to size, for example a Mum and Dad with an infant could pre-book a large, medium and a small space.





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# Keeping it **steady**

**H**arnessing wind power is a controversial issue, both in terms of the politics and the practicality. In November last year Prime Minister David Cameron declared that the UK was a world leader in wind energy. Only days later, however, energy giant RWE pulled out of its planned wind farm developments in the Bristol and Devon Channel. The 240-turbine Atlantic Array project would have been capable of producing 1,200 MW of electricity, but the company shelved the plan because of technological challenges and market conditions.

Just a few weeks later, changes to the Government's energy policy were announced. Although there is to be no change in overall spending, more financial backing is to be given to offshore wind power at the expense of solar power and onshore wind power generation. The aim is to give energy companies and private investors some stability in the market and show that Government is prepared to provide financial incentive and support to large offshore wind projects.

Politics aside, the technical challenges surrounding offshore wind are numerous. The open ocean is a challenging environment and the coastline seabed makes the installation of turbine foundations a difficult task. This is particularly the case given the size of many offshore wind turbines, which can have a tower height and even blade diameter in excess of 100m.

## **Building foundations**

There are many different methods of installing suitable foundations to mount and attach wind turbine towers with the depth of water and size of the turbine key factors for consideration. Methods for setting up suitable foundations in deeper waters are still being developed, with the possibility of floating platforms being explored.

Most existing methods of building a solid foundation deal with water depths of less than 80m. From around 40m upwards, preferred methods include gravity base structures, tripod piled type structures, and more conventional steel jacket structures like those commonly used in the oil and gas industry.

These methods have the advantage of having more than one anchor point to the seabed, making levelling more straightforward by allowing adjustment

**With the offshore wind power sector set to triple in size over the next two decades, building the foundations is a challenging task. So how is industry overcoming the technical challenges involved? Justin Cunningham finds out.**

after installation. However, when a single column monopile is used – standard for sea depths up to 40m – the columns must remain vertical as they are being driven into the seabed with a hydraulic hammer. Any deviation will make the overall structure lean. And when you multiply this by the size of the towers, the effect is not only noticeable, it can render the entire structure unsafe and useless. There is then no option but to remove these monopiles and redrive them at great expense.

This was the challenge posed to marine design and engineering expert, Houlder. The company was contracted to provide a turnkey solution for MPI Offshore, and lead the design, fabrication, installation and commissioning of a suitable method of holding

700-tonne steel monopile foundations in place as they are hammered into the seabed.

The solution came in the form of massive hydraulic gripper arms that hold in place the 75m long and 7m diameter piles as they are driven 20m into the seabed. The concept is much the same as using one's hand to hold a nail straight while hammering it in. However, this is on a massive scale, with six giant hydraulic cylinders positioning two clamping claws, each weighing 70 tonnes. These hang over the stern of a purpose built 'jack-up' vessel called MPI Discovery.

MPI Discovery can carry up to four monopiles at any one time.

Once in position, the jack-up vessel extends its legs down to the seabed to lift its entire hull out of the water. At this point a monopile is lifted up by an onboard crane and lowered in to the water. It is then hammered down in to the seabed using a massive hydraulic ram over the period of a few hours.

Keeping the piles vertical in the presence of currents and waves is a serious challenge for Houlder and pinpoint accuracy was needed to control the giant mechanical device. Three pairs of hydraulic cylinders actuate each gripper arm, with one cylinder raising and lowering the arms from a stowed vertical position, while the other two provide motion on the x and y axes.

"The gripper arms are an ingenious method of keeping 700-tonne piles vertical by providing a horizontal restraint against environmental forces," says Paul Shaw,







The 'jack-up' vessel (main) uses a hydraulic hammer to stamp the monopile (far left) 20m in to the seabed, until it is just above the surface (left).

marine equipment director at Houlder. "This will significantly improve the efficiency of wind farm installations and overall productivity."

Providing the motion control aspect for the project was the job of Glasgow-based Industrial Systems and Control (ISC). The

company has a history of control design, particularly for offshore systems such as wind turbines.

The team was set a very tight time constraint of just four months to go from initial specification to finalising and delivering the control system, as well as developing effective testing algorithms known as an emulator to see how the control functions of the grippers would perform and react given certain inputs.

Dr Andy Clegg, managing director of ISC, says: "One of the key features of this device is that, even though these mechanisms are very slow, they are also very powerful. So, we actually had to include quite a lot of quite careful kinematic constraints to prevent the arms from having the possibility of crushing the pylon or causing them to buckle."

ISC developed the control system using a National Instruments NI CompactRIO reconfigurable control and monitoring system with NI LabView software. The NI CompactRIO uses open embedded architecture. Despite its small size it is both powerful enough to be a standalone systems and rugged enough to be used in the offshore environment. Indeed, the CompactRIO controller is approved by Det Norske Veritas (DNV) for safety and meets all the necessary rules for marine operations.

The control system was configured to perform real-time data acquisition and is able to monitor and position all six hydraulic cylinders to control the precise movement of the gripper arms. ISC could even individually or synchronously steer the arms to adjust for the vertical inclination of the piles.

The use of LabView allowed





Numerous I/O modules interface with sensors, actuators and the operator (above) to control each hydraulic cylinder precisely (below). Photographs: Chapman Brown Photography

ISC both the computational power required along with the low level control and kinematic calculations necessary for the application. In addition, its proven reliability both in the software and control electronics was crucial given the safety-critical nature of the application.

ISC was able to perform factory commissioning and testing using the available parts of the real system, while simulating pieces that were actually not physically present. This allowed it to then analyse and optimise the performance of the individual cylinder control loops, as well as the overall x-y motion of the gripper arms themselves.

"This allowed us to fully test the operational software in the office," says Dr Clegg. "We can test it based on both normal operations and we can also inject fault scenarios to make sure the full functionality of the software works."

"This was really critical as these boats are almost on a continuous charter and they have got very expensive day rates. That was why the amount of time we had to commission the software, implement it and get it working was so tight. Even if we had a one day delay, it would be very costly. That is why building the emulator, which is almost as big as the software application itself, was so important, as it would allow us to avoid any problems during the actual implementation."

The interface and control of the arms by an operator is achieved using a chest pack that has a joystick controller to move the individual grippers as needed, depending on what is being attempted.

Operational logic, monitoring and fault actions are all executed on the CompactRIO and accessed through a touch panel computer (TPC) with the joystick and a set of control buttons all integrated into the operator's chest pack. The TPC is used to provide the operator interface and was also built using LabVIEW.

However, behind the chest pack is an enormous number of electronic connections from the gripper arm to the CompactRIO, many of which are monitoring and safety systems.

The CompactRIO embedded controller is equipped with numerous Input/Output (I/O) modules to interface with the sensors, actuators and the operator chest pack. The structure of the software included the main real-time (RT) application, an FPGA program including a watchdog, with the HMI software running on the TPC, and the PC-based emulator used during development.

The system was tested in August last year, with the first pile being loaded onto MPI Discovery from Vlissingen in Holland. The vessel then set sail for the Humber Gateway wind farm, 8km off the coast of Grimsby, where it was to be fully tested by installing monopiles in the sea. Due to the expensive charter rates for the MPI Discovery there was no time for a test run and commissioning would be done based on the performance on the first set of foundation installations. The Humber Gateway has 18m deep waters and thus acted as an ideal test case for the evaluation of the gripper arms and the control system.

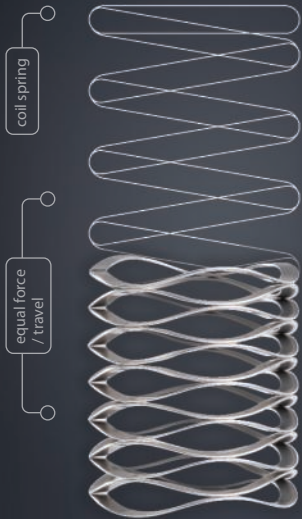
Dr Clegg says: "Considering this was the very first monopile to be installed, and this is the first time the software had been used in anger, it was a tense time for us as it would prove whether the system was really working or not."

Happily, the system worked without a hitch and it was able to move the piles as required and hold them perfectly in place, as the hydraulic hammer stamped them 20m in to the ground until the top of the monopile was just a few metres from the water's surface.

Since the first installation in August, the MPI Discovery has been working continuously and has completed more than 20 monopile foundation installations, which are now ready for a turbine tower to be installed. However, with the array needing a total of 77 turbines installed by 2015, there is still plenty of work to do.

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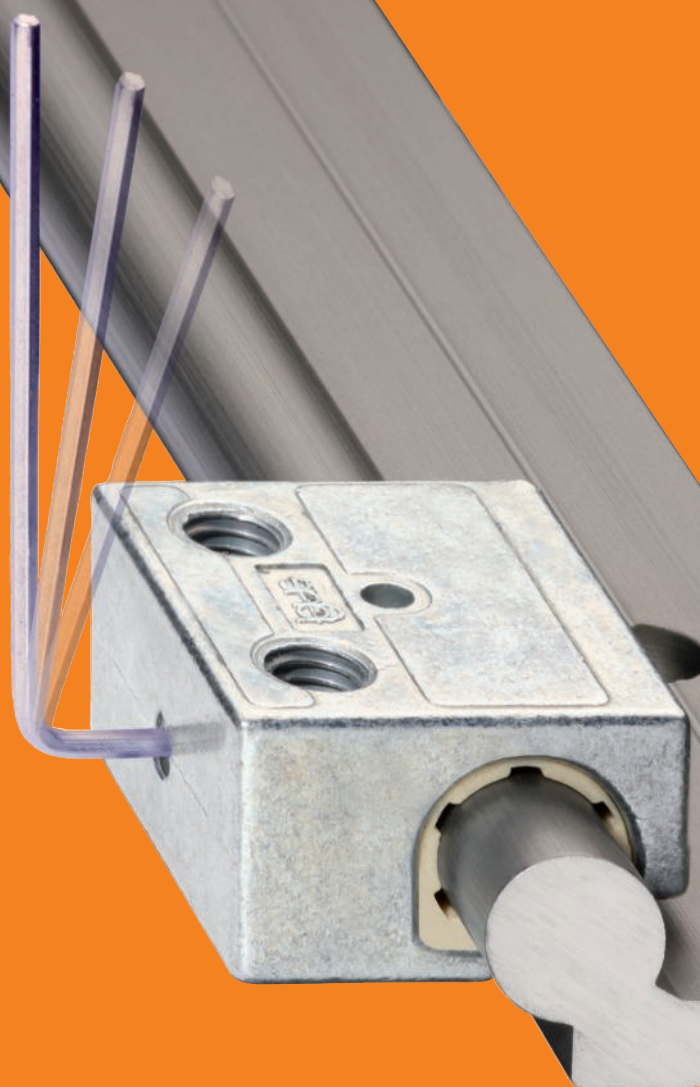


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# British Engineering Excellence Awards 2013



# A Team Player

A double winner at this year's BEEAs, Sebastien Cuvelier Mussalian is a man whose work is nothing if not impressive. Paul Fanning reports.

**A**wards and accolades may not always be the best way to judge an individual's merits, but sometimes people receive so many that it becomes impossible to ignore. Sebastien Cuvelier Mussalian and Team Consulting (for which he has worked as a senior engineering consultant for the last five years) are cases in point.

At 2013's British Engineering Excellence Awards, Mussalian won both Design Engineer of the Year (the only unanimous winner in this category the BEEAs has ever had) and the Grand Prix. This was in large part for his work as lead engineer on the OrganOx perfusion system, which keeps donor human livers 'alive' before being transplanted – a project that had already won Team Consulting 'Consultancy of the Year' at the previous year's BEEAs.

Add to these a clutch of other awards received by the team for this highly innovative and life-saving project and it becomes clear we are dealing with something very special indeed.

So what has made Mussalian stand out to this extent? His nominator for the BEEAs put it thus: "For more than five years at Team Consulting, Sebastien has built an international reputation for the design, development and industrialisation of innovative, robust and capable medical devices. He is an accomplished engineer and system architect, providing the technical drive of high value product development projects in the highly regulated medical device industry. He has experience in all stages of the product development lifecycle, working with start ups as well as large organisations."

As well as being lead engineer for the OrganOx perfusion system, Mussalian has also been:

- System architect for a closed loop Class III safety critical system which continually monitors the subject's physiological parameters and reaction to the drug intervention during clinical trials.
- Project lead for the concept development of an innovative, low-cost lab-on-a-chip bio sensor that detects serious or life threatening intravenous drug errors before they harm patients.
- Electrical engineer for the development of an in vivo intracellular injection needle system for the injection of a Hepatitis C DNA vaccine into muscle tissue, and
- Software lead for the development of a medical smartphone app measuring the respiratory rate of patient with sleep apnoea.

Referring to these different roles, he says: "The beauty of working in the medical device industry is the feeling of making a difference in the life of people through good design, rigorous engineering and creative thinking. Designing safety-critical medical systems, outside the obvious

regulatory challenges, is a mind-set of its own. I cannot sleep at night until I know that our devices perform at 100% of their specifications."

Originally from France, Cuvelier Mussalian has spent five years at Team, having previously acquired a degree in this country. During his time with Team Consulting, he has successfully managed projects and held technical lead roles in the development of complex medical systems. Sébastien's "Joie de vivre" comes from helping clients taking a concept or an idea, and turning it into a creative robust device that is ready for market.

Budgetary considerations do play a role, of course. Mussalian says: "Don't forget most clients come with a fixed budget and that will sometimes influence the architecture. Sometimes, there's no point in including an embedded GUI, so simplify the system and make it cheaper to manufacture."

*"We took a complex problem that hadn't been solved and applied scientific, medical and engineering knowledge to create a simple solution"*

Mussalian sums up the challenge of Organox. "We took a complex problem that hadn't been solved and applied scientific, medical and engineering knowledge to create a simple solution – it works from just three buttons. But there's a lot of processing going on behind the scenes."

A strong project and technical leader, he challenges and encourages his peers and team members to improve themselves. He has developed or updated a number of design approaches and

processes within Team Consulting, including a 'leaner' method of equivalence testing for the US FDA 510(k) process.

Cuvelier Mussalian has also worked on a variety of community projects with schoolchildren and young engineers; not only to inspire them to become engineers and scientists, but also to give them the skills to think through challenges. Alongside his participation in the 'Engineers Without Borders' programme, Cuvelier Mussalian has also taken part in a Science Week at a local primary school, where he led a Year 5/6 class in solving the challenge of cleaning a litre of 'dirty' water; something he said was, "probably the hardest I've ever had to work".

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- Typical problems that robots can be used to overcome**
- Product quality issues
  - Fast switchover between different products/handling duties

# Why wait to automate?

**With UK SMEs in certain sectors seemingly still reluctant to invest in robotic automation technology which could see them compete on a more equal footing with their European and Far Eastern counterparts, Eureka in association with ABB Robotics recently surveyed over 220 British SME manufacturers to try and get to the bottom of their concerns. The results make interesting reading**

Just one of the interesting statistics to come out of Eureka's recent survey of 221 UK manufacturing companies shows that 59% review their automation needs 'as and when necessary' which suggests that many will wait to automate until they get an order. This risks incurring additional delays through time spent specifying, installing and commissioning and learning to use the technology and may also hinder the best choice of automation technology for the application. Evidence shows that companies that continually invest in automation can achieve significant advantages over competitors.

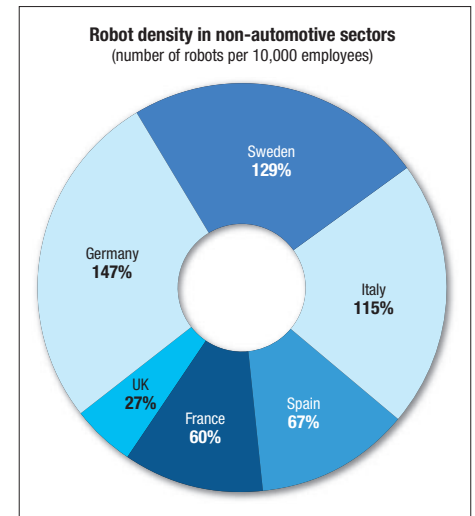
It's often said that there is safety in numbers, especially when it comes to justifying resistance against embracing new technologies. This would especially seem to be the case when it comes to the take-up of robotic automation in the UK, as Mike Wilson, chairman of the British Automation and Robot Association (BARA) notes in a recent blog post. He comments that on the face of it, the growth of robots in the UK seems healthy enough. In 2012, demand for industrial robots increased by 82%, compared with 68% the year before. Strip out the figures for automotive, however, and the figures present a strikingly different picture, revealing how much work still needs to be done in winning over manufacturers outside of the resurgent UK automotive industry.

Even despite the role that robots have played in assisting this resurgence, acceptance of robotic technology remains especially patchy amongst the UK's 65,000 small to medium sized (SME) manufacturing companies. Lack of awareness remains a big problem. "I don't know



anyone else like me who has used a robot", is one of the common reasons given as a justification against investing in robots. While robots have a proven track record in automotive applications, handling an estimated 80% of all production tasks, automotive companies, with their global ownership, are seen as being too big and too different for SMEs to identify with.

Yet there is proof out there to show that UK SMEs are already using robots to their advantage. Characteristix in Cornwall, for example, achieved new levels of competitiveness after automating its process with a plastic injection moulding cell, which includes a six-axis robot. The improvements brought by the cell have helped the company to fight off



competition from overseas and attract top customers for its custom moulded plastic novelty products including BBC Worldwide, Disney and Warner Bros.

Witter Towbars in Deeside, North Wales, has achieved a 20% improvement in production efficiency, together with reduced welding cycle times and improved product quality, after installing 10 new robotic welding cells.

For the Youngman Group, the decision to install two fully-automated robotic welding cells has enabled it to compete rigorously against imports from lower cost countries. There has also been a dramatic increase in flexible production, enabling the business to meet even the most challenging production demands.

These and other examples like them, go to show that automation is not just for the big companies, but can deliver valuable business benefits for smaller companies too.

## Robots increase jobs

There is understandably some concern about job security in the manufacturing sector as the aftermath of the global economic crisis continues to be felt. So it's little wonder that the growing presence of robots in manufacturing makes many people anxious about being displaced by automated systems. The good news is that robots are actually extremely good at creating and protecting jobs, as revealed by a recent study.

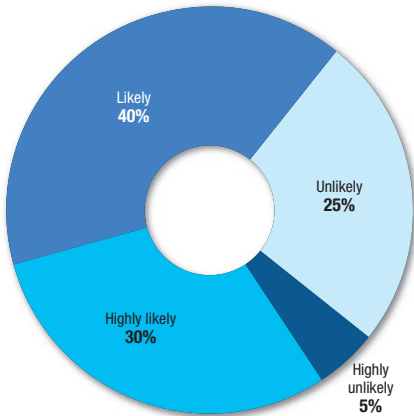
The report from London market research company Metra Martech on behalf of the International Federation of Robotics (IFR) found that robots will help create more than two million jobs over the next eight years. While it

- Ability to quickly turnaround fast/short notice orders
- Skills shortages

**Example of survey responses received include the following:**

- Bespoke manufacturing is better suited to people than robots
- I do not believe it is currently economical to use robots for small volume manufacture
- Nature of work does not suit robotics
- Our company only does small batch work – currently one-offs
- The current tasks are too variable to justify investment in robotics
- Volume not sufficient and/or repetitive enough to warrant a robot
- We produce low volume bespoke equipment

**How likely are you to invest in robots in the next 18 months?**



acknowledges that certain jobs will be reduced it stresses that many more jobs are set to be created thanks to the boost in productivity and competitiveness that robotics deliver in manufacturing enterprises.

By the end of 2011, robots had directly created between four and six million jobs in world manufacturing, which is equivalent to about three to five jobs for each robot in use. And once factories can compete more effectively in the global market, the communities around them also benefit, so the robots had a knock-on effect on indirect jobs of between eight and 10 million.

Better still, the IFR report says that these jobs are likely to be generally better paid than those that the robots displace. In other words, the use of robotics effectively helps companies to level the playing field in markets with very different wage structures. This is great news for people in places like the USA and Europe, where we're

already seeing evidence of a gradual 'reshoring' of manufacturing jobs.

In short, the addition of robots to the workforce can be the shot in the arm that manufacturing businesses need to compete in the global market, safeguarding jobs and providing benefits for both workers and employers.

### Investment strategies

The survey shows a mix of real and perceived problems when it comes to investment in robotic automation. Major factors cited include: Cost, both purchase and cost of operation; insufficient in-house technical know-how; lack of experience in robotic technology; access to funding; and that they are deemed to be unsuitable for low volume batch and bespoke products.

Unfortunately UK manufacturers have a notoriously short-term view on investment, with expectations of payback typically within two years. This compares with three to five years in countries such as Germany. The survey shows that 48% of companies have spent the same on automation technology in the past five years. This compares to 40% that have increased their investment between 20 to 50%. Strategies therefore appear to be more 'wait and see' than 'where could we be?'.

The survey shows strong propensity amongst existing robot users to make new and repeat investments. Of the survey respondents, 75% of those companies already using robots said they were likely or highly likely to make another investment within the next 18 months.

Although robots are only one element of automation they provide a measurable indication of levels of automation, and one that is reported internationally. The IFR reports (World Robotics 2010) that Germany has an installed base of 144,100 industrial robots, Italy 62,200, France

34,100 and Spain 28,800 whereas the UK records only 13,900.

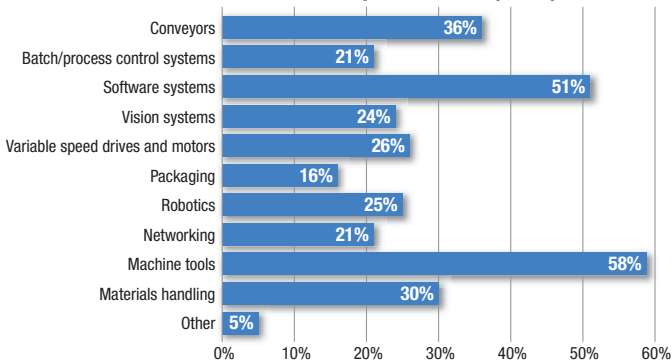
This demonstrates the remarkable lack of robot utilisation in UK manufacturing when compared with competing European countries. The UK also compares unfavourably to other international competitors, such as the USA at 74 and Japan at 235 robots per 10,000 employees. These figures provide proof, as if it were necessary, that UK manufacturing has been much slower to adopt robots and automation than our competitors. To be successful in the global market this needs to change and change soon.

### Survey conclusions

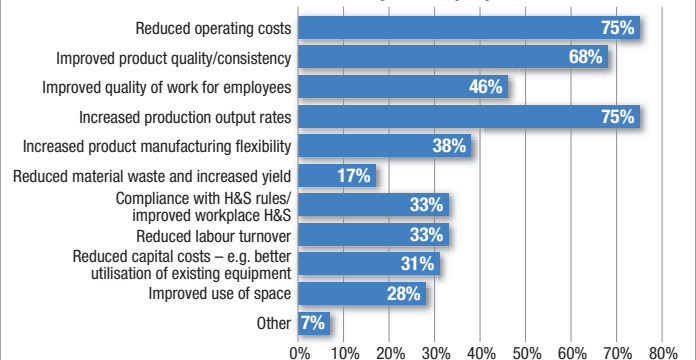
The majority of robots in use are six to 12 years old, so the users are getting good use out of them for a long time and it indicates that they are a good long-term investment. Also, 38% of users have a new robot, so it appears that once a company decides to invest and sees the benefits it will continue to invest in the future. This is backed up by the fact that 70% of existing users plan to invest in new robots in the next 18 months.

- Only 41% buy direct from a manufacturer, so it is important for robot manufacturers to have good relationships with systems integrators and machine builders.
- Of the companies surveyed, 75% state that robots have led to reduced operating costs.
- Over half (51%) of companies not currently using robots would consider using them. Those who would not consider them believe have no use, e.g. they undertake a great deal of small batch work.
- The survey results suggest that the potential for robot investment in the UK to increase is quite significant. Basically 70% of existing users are looking to buy new robots and 51% of non-users would consider one.

**What automation investments have you made in the past 5 years?**



**What have been the main benefits to your company of the robots?**





# Plastic's fantastic for AM process

**A new additive manufacturing process allows users to use standard, off-the-shelf granular plastics. Paul Fanning takes a look at this potential 'game-changer'.**

Barely a week (sometimes barely a day) seems to go by without news of a new additive manufacturing machine, process or material reaching *Eureka's* inbox. Naturally, this is sometimes the cause of a certain amount of cynicism about the claims made in these announcements, particularly when it becomes apparent that the machine or process in question is actually a work in progress.

However, one machine that does seem genuinely to have moved things forward and is far from a work in progress is the Arburg Freeformer, which was given its world premiere at the K 2013 Show in Düsseldorf. This success continued at the Euromold Show, where the Freeformer also impressed trade visitors from the mould construction, design and product development sectors.

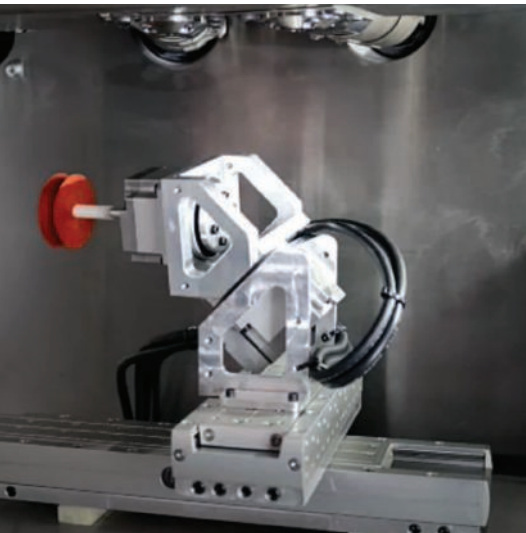
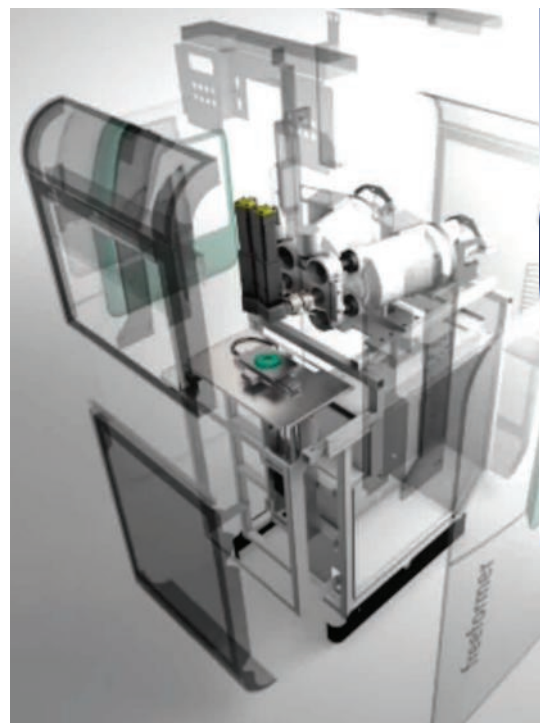
Unlike conventional additive manufacturing techniques, with Arburg Plastic Freeforming (AKF) standard granulates are melted as they are in the injection moulding process. The process makes use of 3D CAD files, that are read in directly by the Freeformer. After start-up, everything else takes place automatically. A nozzle closure with piezo technology builds up the desired component layer by layer from miniscule plastic droplets without using support structures. During this process, the

item under construction is moved by a component carrier with three or five axes. The discharge unit with nozzle remains stationary, while the component carrier moves.

As one of the world's leading manufacturers of injection moulding machines, Arburg enjoys a well-established reputation as a reliable partner in the plastics processing industry. "The Freeformer and the Arburg Plastic Freeforming (AKF) technology have expanded our product portfolio and mark our entry into additive manufacturing, which will benefit the entire industry," says Arburg's Herbert Kraibühler.

The potential of the Freeformer and of Arburg Plastics Freeforming (AKF) was demonstrated at the recent Euromold Show, with two exhibits which produced different one- and two-component parts from standard material. The demonstration was supplemented by the exhibition of wide-ranging components produced using the new technology. "Our exhibits were extremely well received by the public. Visitors were impressed with the look and feel of the surface quality of the components, most of them assessing it as exceeding expectations," says Dr Oliver Kessler, Arburg's department manager for plastic freeforming.

Because the Arburg Plastic Freeforming (AKF) process uses standard granulates, rather than special resins, powders, strips or other pre-fabricated materials, this means that a wide selection of materials and colours are available.



The material costs are accordingly low. These low costs and the fact that the user is not restricted to expensive proprietary materials whose supply is controlled by the machine manufacturer is potentially the most game-changing aspect of the Freeformer.

Material preparation in the Freeformer is very similar to that for injection moulding. The machine is filled with plastic granulate and a heated plasticising cylinder ensures an optimally prepared plastic melt. The parts are produced from tiny droplets of plastic, which are produced by the fixed discharge unit featuring a nozzle and

a patented piezoelectric nozzle closure. This enables fast opening and closing movements to produce the plastic droplets under pressure

With the movement of the three- or five-axis component carrier the desired part is being built-up layer-by-layer from droplets. With the optional five-axis execution a wide range of undercuts without support structures can be realised. This means that even complex 3D geometries can be produced waste-free with minimal material consumption, achieving highly cost-effective results.

However, the Freeformer can do even more. The version with two discharge units can also be used to process two components. In this manner, movable hard-soft combinations, for example, or parts with a special appearance or texture can be produced, in which both components are firmly joined and the parts can be used functionally.

Arburg has consistently followed the same approach with the Freeformer as with its injection moulding machines, developing complex technology in-house and making it simple to use. The parameters required for the construction of the parts are automatically generated by the Freeformer control system with a gesture-controlled multi-touchscreen. This receives the 3D CAD data for the components to be manufactured in the form of .STL files, processes it automatically through slicing, after which production can start. No special programming, processing knowledge or extensive training is required.

One aspect that proved extremely popular among developers and design offices in particular were the plug-and-play features of the Freeformer. The parts are produced completely

free from dust and emissions. The machine is therefore suitable for virtually any application environment, whether in production, the office, the design department or a clean medical technology environment. No extraction or filtering equipment is required.

The Freeformers are mobile and universally usable, thanks to their compact dimensions and immediate production readiness. The machines are simply connected to the power supply and production can begin straight away.

In addition to questions relating to technical features and availability, questions have also been asked in relation to the production of parts and the plans for other Freeformer sizes.

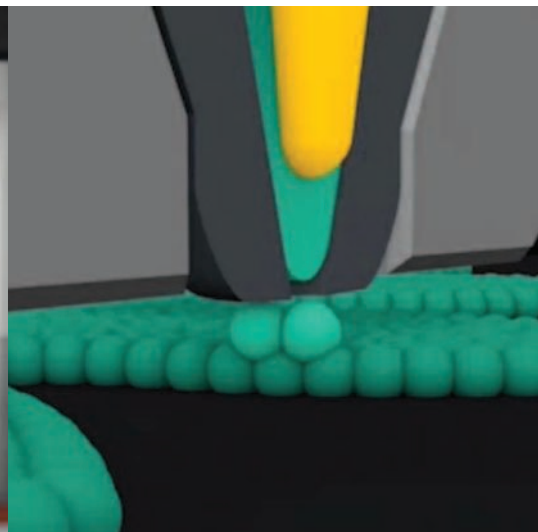
Herbert Kraibühler answers these by placing the Freeformer in the context of the company's overarching philosophy of production efficiency: "The Freeformer is the ideal addition to our range for the cost-effective production of plastic parts. The central question for our customers in the future will be: 'How many parts do you plan to produce, how quickly and in what quality?' Injection moulding will always be the right solution for the production of high-volume runs in top quality. One of the benefits of the Freeformer is that it operates without a mould on the basis of 3D CAD files. It is possible to change products in just a few minutes, producing one-off parts or small-volume batches as required."

Another key breakthrough here is the ability to process more than one material at a time through the use of multiple 'discharge units', giving rise to parts that integrate hard and soft polymer elements or multiple colours.

**[www.arburg.com](http://www.arburg.com)**



*The Arburg Freeformer produces the component without support structures, layer by layer from miniscule droplets, made from standard granulates. The discharge unit with nozzle remains stationary, while the component carrier moves.*







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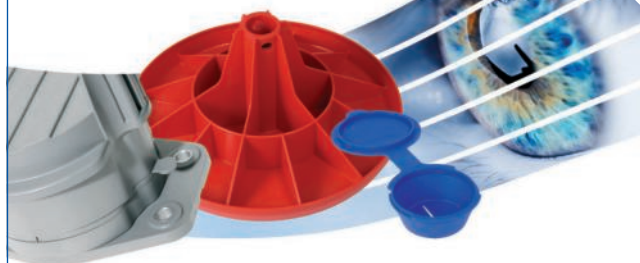
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# Linear piston gives electric option

**A new technology could prove revolutionary and render pneumatics too expensive to run.**

**Paul Fanning talks to the inventor.**

Compressed air is a fact of life in many industrial scenarios, but it has its downsides. It requires compressors (which consume large amounts of energy), it generates noise and it is also not the most precise technology available.

With these objections in mind, Southend-based Direct Thrust Designs has developed ElectroPistons. These are a new alternative to air pistons claimed by the company to be 'The world's first linear electric piston'.

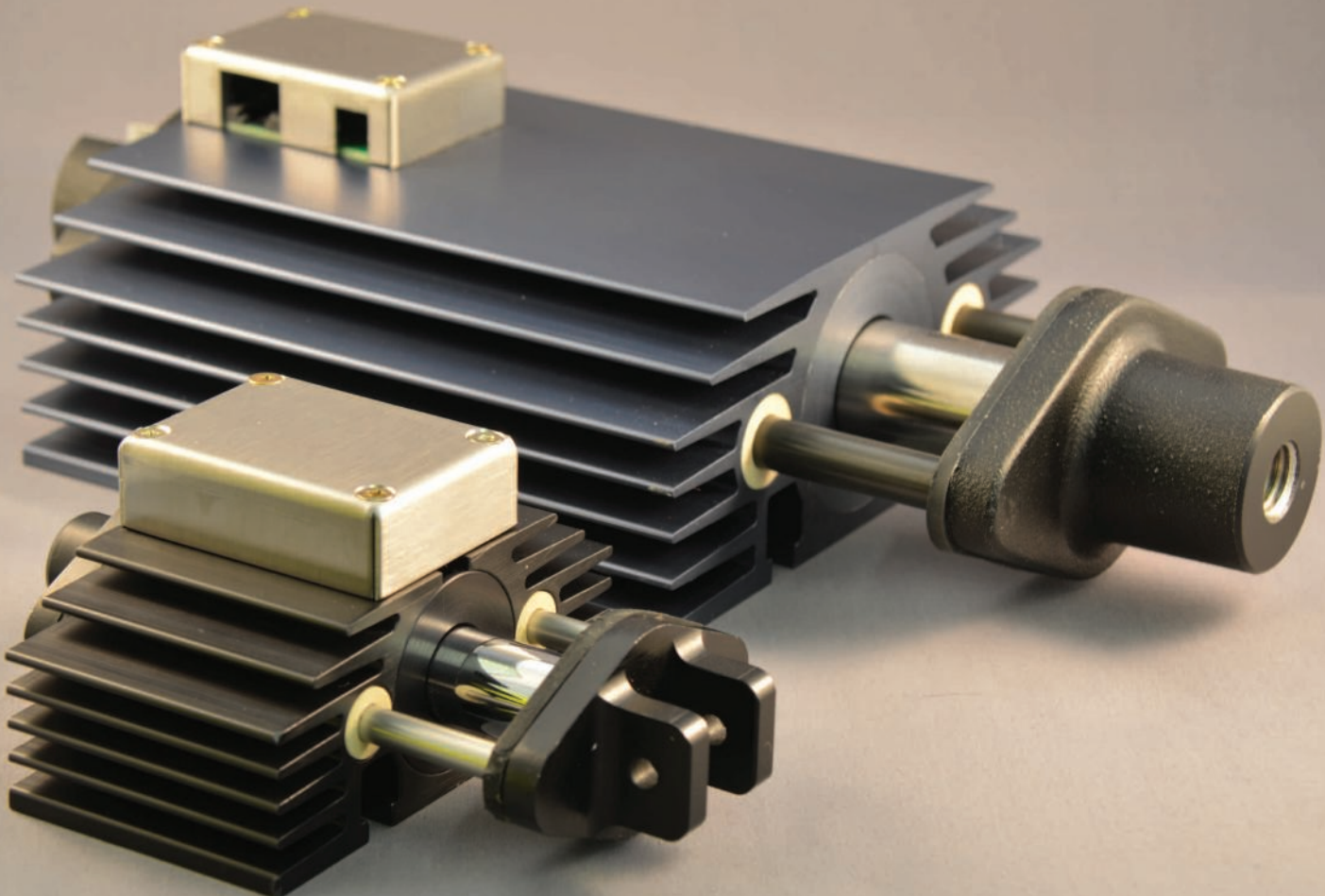
The inventor is Hugh-Peter Kelly, whose track record includes the development of the tubular linear motor back in the late 1980s. And, as with this invention, the ElectroPiston – rather than using compressed air to provide the motive force – instead provides a combination of powerful magnetics and DC electrical power.

Kelly describes the potential applications for this technology as being: "Any application where there's something that goes back and forth and where the user would prefer to use

electricity rather than compressed air." He is keen to point out, however, that it is not a solenoid, a linear actuator or a linear electric motor but instead a, "controlled in-out motion, which does not require complicated, expensive control circuits".

The advantages inherent to this technology include the fact that it is many times more efficient than pneumatics, offers no power drop off or time lag with multiple rams and has a very quick setup, high reliability and is virtually silent.

*The ElectroPiston can eliminate pneumatic systems with cleaner and more energy efficient all electric DC point to point linear actuators*





However, the real selling point of this solution lie in the cost savings it can offer. These are fairly spectacular, although this is hardly surprising when one considers the sheer quantity of equipment eliminated by this development (compressors, air preparation, filtration, control valves, etc) as well as the electricity required to run them.

In fact (based on figures given by a pneumatics supplier, Kelly admits), the five-year total of running this system is £1705.75 (capital cost £907.40, annual running cost £159.67), as opposed to £7422.50 for a four-cylinder compressor system. As Kelly puts it: "We think that this has the potential to render old-fashioned pneumatics simply too expensive to run."

## ElectroPiston's advantages over air pistons

- ➔ They eliminate the need for an air compressor or many air compressors (if using multiple cylinders), and all the associated components which go with them.
- ➔ They have an instant dynamic response, no waiting for air pressure to build up, or unequal response where several pistons are used.
- ➔ Force is unaffected by the direction of travel.
- ➔ Virtually silent. No noise pollution.
- ➔ Cost effective, both initial capital cost and annual running cost.
- ➔ Minimal maintenance, no statutory inspections.

The pistons provide smooth continuous force over their entire stroke, exactly the same as pneumatic pistons, but without all the complications and expense associated with compressed air supplies. Using a novel and patented technology to obtain their linear and smooth powered movement, the forces they are capable of providing are many times that of conventional solenoids, making them useful for countless industrial applications.

The ranges of ElectroPistons available from Direct Thrust Designs cover push/pull forces from a 1N up to 141N for the single block range and up to 282N for the double block range. It is important to select the correct specification unit for the intended job and duty cycle, especially when operating at the top end of performance.

The product has only one moving assembly, and is therefore low-maintenance. Maintenance is confined to the checking of and occasional

cleaning of the guidance rod surfaces and the unit itself. The moving part of the ElectroPiston (known as the "thrust rod") contains application specific permanent magnets. The stationary part (known as the "thrust block") contains especially configured electrical coils.

When the coils are energised, a magnetic field is created which interacts with the powerful fields produced by the thrust rod. This causes linear movement of the rod to either end of its movement, the direction of travel simply depending upon the direction of the current flow.

The force of the movement is similar to air systems, the greater the supplied current (akin to air pressure) the greater the push/pull thrust available. The force is equal in both directions.

The pistons are built to withstand heavy industrial use, and can be installed to provide repetitive push / pull movements for virtually any type of machinery. Proprietary igus linear bearings are used to guide the bearing shafts on all three ranges. These have been selected as suitable for continuous, arduous industrial applications.

Unlike air pistons, there are no air seals or valves to wear with age or use. Correctly used, the life of the magnetic components

themselves is theoretically infinite. ElectroPistons are equipped with a rugged bearing system and each size of ElectroPiston in this range has been proof tested in free running (in line) direct push/pull mode to over 100,000,000 cycles. This is equivalent to one stroke per second over a 16 hour shift, five days per week for seven years.

ElectroPistons have an extremely rapid response and can move end to end in a fraction of a second, so potentially speeding up automation operations. With low inertia loads, they are capable, depending on the unit size, of speeds from 6 to 18 or more full cycles per second. With the benefit of the velocity control option, they are also able to move at slower speeds, so making possible various speed/stroke combinations such as 'slow in, fast out'.

The operation of the ElectroPistons is virtually silent, the only associated sound being

contact of the end plates with the body at the extremes of stroke. All the hissing and escaping air noises associated with conventional air pistons are avoided, so transforming the noise pollution suffered by air systems and the users operating them.

Unlike pneumatic products, the force exerted by ElectroPistons in either direction of travel is the same, as opposed to that of the bi-directional air pistons in which the surface area of the piston reduces force in one direction of travel compared to the other.

This system is also inherently clean. The pollutants associated with compressed air driven systems are absent, and for many applications they can operate without any external lubrication. For this reason they are an ideal choice for automation systems operating in hygienic environments, such as food processing, sensitive electronics or medical equipment.

ElectroPistons instantly respond to the electrical power supplied to them. There is no mechanical lag, or need for pressure build up, regardless of the number of pistons installed in a particular system.

With compressed air systems, a continually running compressor uses considerable electrical power. ElectroPistons only use electrical power when energised. A recent report by the UK based Carbon Trust states that on average only 20% of the electrical energy used by a compressed air system is expended in moving the air piston. With ElectroPistons, it is 100%.

Another surprising facet of the ElectroPiston is revealed when Kelly places a 27kg weight on top of one, which it proceeds to lift easily. "That is just for people who think that linear actuators are weak," he smiles. That said, he does make clear that ElectroPistons are not suitable for providing very large forces.

However, Kelly remains aware that it is going to be a challenge to shift people from the pneumatic systems they have been using for decades. He says: "The only way to really persuade people of the worth of this system is if they buy it and run trials. Obviously, the technological, environmental and – most importantly – cost arguments are very strong, but only by using them and seeing that they work will people ultimately be convinced.

**[www.directthrust.co.uk](http://www.directthrust.co.uk)**

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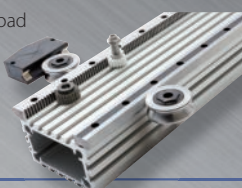
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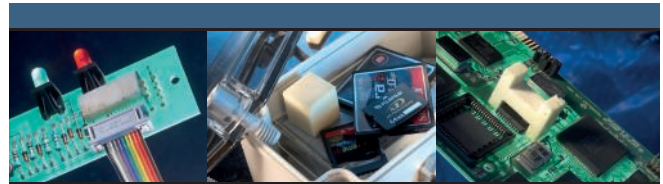
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# Thermal imaging gets the picture

A leading manufacturer of fibre lasers is using a thermal imaging camera in its quality control system on a variety of its products.



SPI Lasers has been using Micro-Epsilon's thermoIMAGER TIM400 camera on a routine basis for both product development and manufacturing. The company's product range includes a wide variety of fibre laser products, including lasers for welding, cutting, marking, engraving, and for micro machining.

Vincenzo Scarnera, senior research and development engineer at SPI Lasers UK says: "We found our previous thermal imaging cameras were very difficult to interface with our code. Data logging for R&D purposes and for test programmes was proving very challenging and time consuming, so we decided to look for an alternative solution. A colleague at SPI Lasers pointed me in the direction of Micro-Epsilon.

"As well as being a very affordable, compact thermal imaging camera with high resolution, we selected it because we were particularly impressed with its software integration capabilities. I can write my C#.Net code in an easier way and integrate the TIM400 camera with my new and old setups. The camera is so versatile that I can interface it to almost any R&D or NPI application where I need to log the temperature profiles of diverse laser components. I've also been impressed with the camera's reliability."

Scarnera says that the TIM400 is able to log the temperature profile of laser components and output the data to other software programs.

"The camera fully supports the Microsoft .Net framework for programming, including VB.net, C++.net and C#.net," explains Scarnera. "The delegate/event paradigm is fully implemented by the Dynamic-link Library provided and it is extensively documented by Micro-Epsilon, allowing me to write event-driven programs."

As well as enabling easy integration with R&D and test lab software, the TIM400 can also integrate with existing plant automation and

control systems. The fully featured software TIMConnect provides quick and easy set up together with a range of software tools and a developer kit. The TIM400 is supplied with an integral process interface for input and output of analogue and digital signals such as alarms or temperature values. Open connectivity drivers are also provided for software integration via Dynamic-link Library, ComPort and LabVIEW.

The thermoIMAGER TIM400 is also able to capture and store thermal video and images with extremely high optical resolution (382 x 288 pixels) at a full frame rate of 80Hz. The camera is also equipped with a detector that provides excellent thermal sensitivity of 80mK.

One of the smallest USB cameras in its class, the TIM400 weighs 320g with dimensions of

46mm x 56mm x 88mm. The camera comes pre-calibrated with temperature ranges from -20°C to 900°C, with an option to extend this up to 1,500°C.

David Jones, sales engineer at Micro-Epsilon UK says: "The TIM400 camera is very versatile and opens up a multitude of possibilities for thermal analysis and hotspot detection of components in R&D and test lab environments. Compared to conventional infrared cameras, the TIM400 offers more than four times the number of pixels, which means infrared images are significantly clearer and sharper. In addition, very small objects with surface areas down to just 0.8 square millimetres can be detected reliably. A frame rate of 80Hz also allows infrared images to be captured in real time."

[www.micro-epsilon.co.uk](http://www.micro-epsilon.co.uk)



*The compact thermoIMAGER gives high resolution real-time infrared measurements and is easily configured.*



## Pressure sensors on demand

Turck Banner introduces a new pressure sensor, the PS500. It allows users to individually configure pressure sensor for the application from three electronic variants. With two switching outputs, a switching and voltage output, or a switching and current output – it allows 12 different relative pressure ranges up to 600 bar and 12 different process connection threads enabling the creation of 432 possible variants.

In order to offer users optimum flexibility, Turck Banner has also given the devices a modular design to enable final assembly in the shortest possible time.

Each device of the PS500 series can be made ready for shipment from its central warehouse within 48 hours from receipt of an order, even if it is not already pre-assembled in the component warehouse.

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the central warehouse are completed by the next working day.

[www.turckbanner.com](http://www.turckbanner.com)

## Low-cost Herga potentiometer

Switching and sensing solutions leader Herga Technology has added a low cost all-electronic foot potentiometer that provides a variable voltage output proportional to the position of the pedal.

Aimed at applications across medical equipment, domestic appliance, office and industrial machinery, the robust 6210-VO features a solid state optical sensor for wear free operation with extremely long and reliable life of more than 1 million operations. The unit is designed for use on manually operated equipment with control input ratings from 4.5 to 12 VDC at 10 mA,



enabling precise adjustment for functions such as motor speed or torque for lifting, mixing, dispensing, cutting and sealing – and all areas where a low cost means of providing manually controlled variable functions is required for maximum productivity.

The 6210-VO meets EN 60950 low voltage directive standards and has EN 60529 IPX2 protection rating. A durable thermoplastic pedal housing includes a spring return mechanism that provides a high level of operational comfort. The compact unit measures just 105 x 140 x 40 (w x d x h) and the scope of supply - even for low quantity applications - includes fully customised colours and logos as well as choice of connection method to customers' requirements.

Herga Technology, a part of the Variohm Holdings Group, manufactures a comprehensive range electrically and pneumatically actuated foot and hand switching controls in standard or custom designs that meet a wide range of international approvals including IEC/UL 60601. [www.herga.com](http://www.herga.com)

## Variohm chosen for off-road wheelchair

Variohm EuroSensor's ELPM linear position sensor is being put to full use by the innovative all-terrain electric wheelchair designer and manufacturer Molten Rock. The compact IP67 rated sensor, selected for its motorsports proven durability, provides steering position feedback as part of the servo control system for the joystick operated version the ruggedised and reliable Molten Rock Boma7 off-road wheelchair.

With a distinctive and ergonomic design that allows users easy access and straightforward operation, the electrically powered Boma7 range enables simple outdoor activities such as walking a dog or visiting a local park but is equally at home for use in more challenging landscapes. Harsh weather environments and steep gradients with mud, rain and ice mean that the chassis, suspension and especially the steering mechanism are subjected to high levels of shock and vibration.

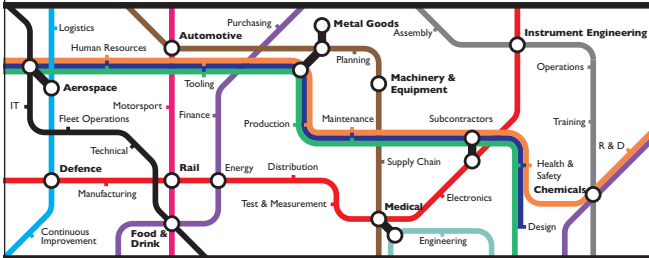
Molten Rock's designers chose Variohm's ELPM linear position sensor to match the high demands of the steering system specification, which includes a robust Linak linear actuator and a Dynamic Controls joystick control system. The ELPM's pedigree as a compact solution for motorsports position measurement for ride height, suspension and steering angle measurement helped the company decide on putting the slimline miniature sensor through its paces with impressive results.

Molten Rock company director Chris Swift explains: "We've been producing the joystick version of the Boma7 since 2010 and from development through to full field use the sensor has been thoroughly tested on the wheelchair and has performed very well."

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# Magnet gear trains to drive efficiency

**The use of magnetism within power transmission systems could help make hybrid vehicles more efficient in the future.**

**Justin Cunningham finds out how.**

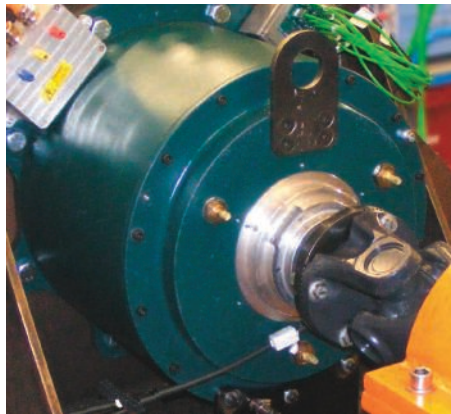
Hybridisation is being given increasing priority by the automotive industry as it strives to reduce emissions and ramp up the efficiency of vehicles. However, this has put the many challenges of effective hybridisation firmly in the hands of engineers. Many concepts for hybrid drive transmissions have been proposed and while many seem elegant on paper, the devil is in the detail and practical implementation is rarely straightforward.

The advantages and disadvantages of hybrid cars are by no means as simple as some would have you believe. While tailpipe emissions might be better, increased electrification of the overall powertrain relies on largely lithium batteries that are not the easiest components to dispose of or recycle at the end of life. In addition, while automotive engineers strive to lightweight, hybridisation adds weight as it essentially requires two different powertrains.

The integration of an internal combustion engine with electric motor/generators also throws up some interesting mechanical issues in terms of gearing and power transmission. The ability to switch and split power between the two easily and smoothly, without too much energy loss and weight penalty is no small feat.

Probably the best known hybrid car, the Toyota Prius, overcame this issue by developing its Hybrid Synergy Drive. At its heart, this is essentially a single planetary differential gear set that removes the need for a more traditional stepped gearbox and transmission components.

Aptly named, Toyota's Power Split Device (PSD) is a continuously variable transmission (CVT) but with a fixed gear ratio between the

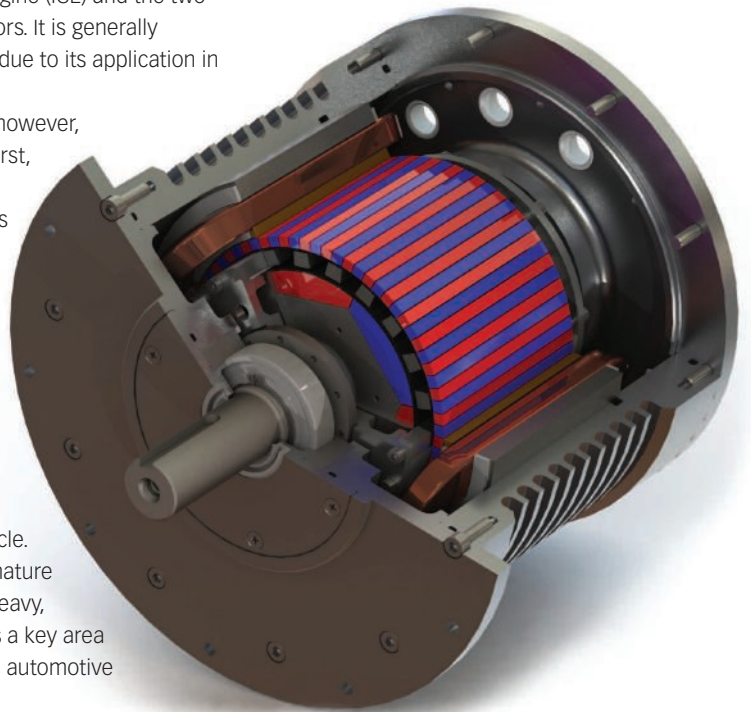


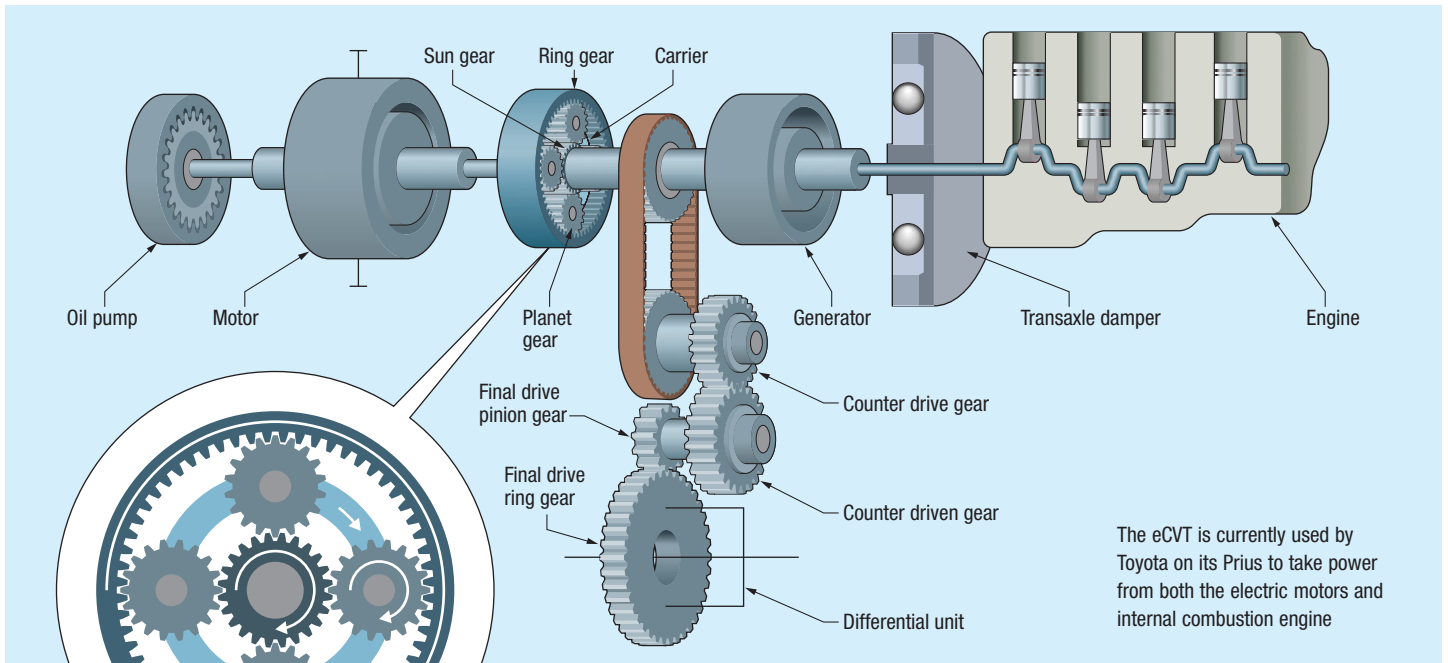
internal combustion engine (ICE) and the two electric motor/generators. It is generally referred to as an eCVT due to its application in hybrid vehicles.

As with all hybrids, however, there are drawbacks. First, it is complex. The number of moving parts in the design is far from ideal, with each requiring a bearing. This results in some associated loss of energy as well as a need for lubrication and maintenance. Also the eCVT is expensive, adding cost to the vehicle. And finally, due to the nature of its application, it is heavy, adding weight, which is a key area of reduction for today's automotive design engineers.

The frustration of taking significant steps to reduce weight, only to be counteracted with the increasing introduction of hybrid technology is, however, being addressed, in part, by one Sheffield-based spin-out technology company.

Magnomatics was established in 2006 to commercialise magnetic transmission systems. To date, it has been able to successfully demonstrate and prove the technology for a number of applications and has recently been invited to join The Proving Factory, a collaborative project set up by the automotive industry to industrialise key innovative technologies.





Key to this development is the Magsplit, designed to improve hybrid powertrains in performance, weight and cost. The Magsplit essentially fulfils the same functions as the eCVT of the Prius but has been shown to improve hybrid systems' fuel efficiency by 3% to 5%, as well as reducing complexity and weight.

"The principle of a magnetic gear is to use an array of magnets to create a flux field at the centre of a rotating cylinder," says David Latimer, business development manager from Magnomatics, speaking at this year's Advanced Engineering Show. "We then insert steel pole pieces in to the flux field to give a preferred flux path leaving airgaps between them to act as a flux inhibitor. This modulates the flux field, creating a harmonic that rotates faster and in the opposite direction to the rotating cylinder. We then place another magnet array within the

first cylinder to lock on to the harmonic and give a high speed output."

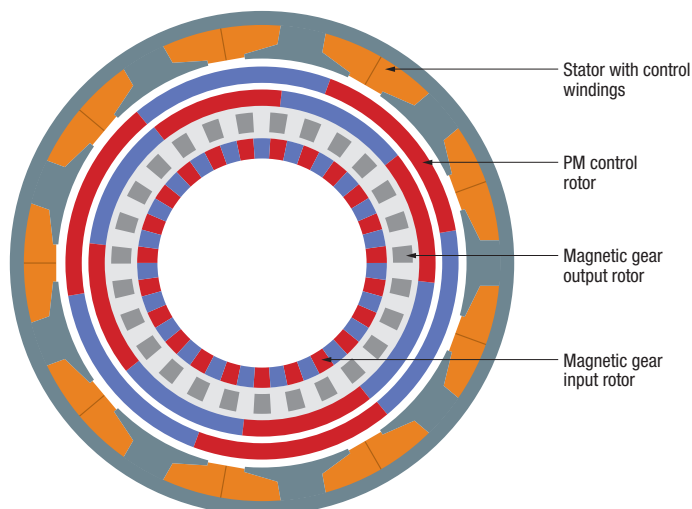
The principle of the gearbox is analogous to an epicyclical gearbox with the inner array of magnets acting as the sun gear, the steel pole pieces as the planet carrier, and the outer array of magnets behaving like the ring gear.

"But there are differences," says Latimer. "One of the interesting things with a planetary gear is you always have to have a high speed shaft on the inside as the sun gear is the smallest gear, and therefore has to be the fastest. As we are dealing with magnetic poles, we can actually move that high speed shaft to the outside."

This allows Magnomatics to do a number of things. By using three rotors that are all free to rotate, it can use the inner array of magnets and the steel pole pieces as the primary input and output shafts, with the outside acting as the control mechanism. Then, by moving the control rotor in the same direction it can add RPM to both shafts, change the gear ratio or rotate the control rotor backward fast enough to actually stop the output rotor, equivalent to declutching or being in neutral.

Magnomatics already has its first gear in operation driving a pump within an oil well. However the company is firmly setting its sights on the volume markets of mid-range automotive producers. Hybrid vehicles are likely

Magnomatics is developing power transmissions for hybrid vehicles that use magnets to transmit power.







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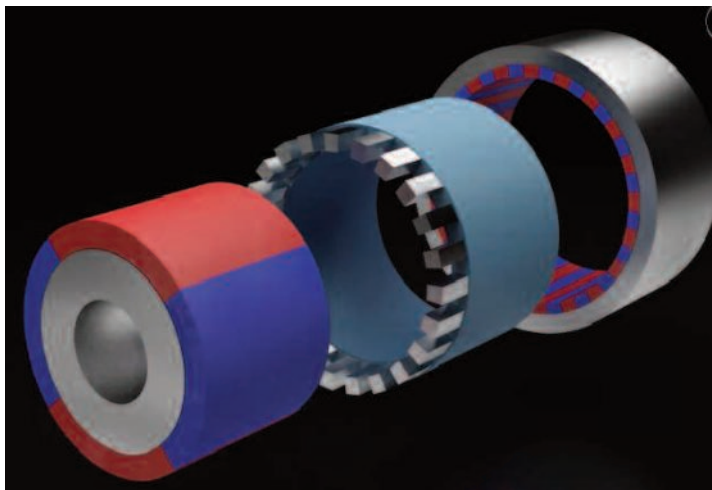
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**“Typically Magsplit can replace three items compared to an eCVT; the motor/generator, the planetary gearbox or power split device, and also they can remove the flywheel and even the torsional damper in some cases”**

**David Latimer - Magnomatics**



to increase significantly over the next five years and its Magsplit could improve the existing eCVT systems currently being used on cars like the Prius and Ford Fusion.

“Typically Magsplit can replace three items compared to an eCVT; the motor/generator, the planetary gearbox or power split device, and also they can remove the flywheel and even the torsional damper in some cases,” says Latimer. “Also there is no contact, so no wear. And that means it is very efficient. We have measured efficiencies more than 99.5%.”

Further development of the technology has led to the development of its latest iteration, the Magsplit 2. While this has all the same functionality as Magsplit 1, it uses fewer magnets and fewer parts. The design of the Magsplit 2 allows the transmission to be overloaded much more frequently, making it ideal for drive cycles that experience frequent peaks.

“In Magsplit 1 the losses are mainly speed dependent, whereas in Magsplit 2 they are mainly torque dependent and the choice of which to use really depends on the drive cycle,” says Latimer. “So, for a car where you need a lot of peak torques and powers Magsplit 2 is best. For a truck based power train Magsplit 1 is the optimum.”

Magnomatics claim that the Magsplit transmission results in better fuel economy compared to hybrid cars based on an eCVT power split device. The Magsplits are also lubricant-free, offer a shorter package length and can replace several components with a single one.

The Magsplit transmissions are scalable, with studies, and interest, from motorbike to very large truck manufacturers. Studies have even shown applicability to quarry trucks. In addition both Ford and Volvo have expressed interest in developing the transmission for future hybrid vehicles, with trials and evaluation currently taking place.

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# Making hydrogen cost effective

**While many would like to see a transition to hydrogen-powered fuel cells to provide clean energy, the cost of the platinum catalyst make the technology uneconomical. So how close are we to finding an alternative? Justin Cunningham finds out.**

Just a few years ago, the future was hydrogen and fuel cells. The hype around the technology was at fever pitch and it seemed tantalisingly close to commercialisation, with clean, hydrogen-fuelled vehicles with water for emissions soon to become a reality for all.

Perhaps another example of Gartner's Hype Cycle, the technology has not quite been able to keep pace with expectation and progress has seemed to slow. Today, many engineers from major European automotive OEMs will tell you that, while interested in the technology and aiding its development, they expect there to be no serious crossover in power train, at least to hydrogen fuel cells, until 2025 at the earliest.

Although many of the world's largest automakers, including Hyundai, Honda and Toyota have announced plans to launch fuel cell vehicles by 2015, like many of today's electric cars they are likely to be prohibitively expensive. There may well be thousands on the road before 2025, but it is unlikely there will be millions.

There are many significant technological hurdles to overcome and barriers to entry include power density, reliability and storage. In addition, the surrounding infrastructure necessary for a hydrogen-fuelled economy is currently in limbo dominated by a chicken and egg situation of what will come first, vehicles or filling stations. Much like the current trend towards hybridisation and electric cars, don't expect any sudden moves away from the internal combustion engine just yet.

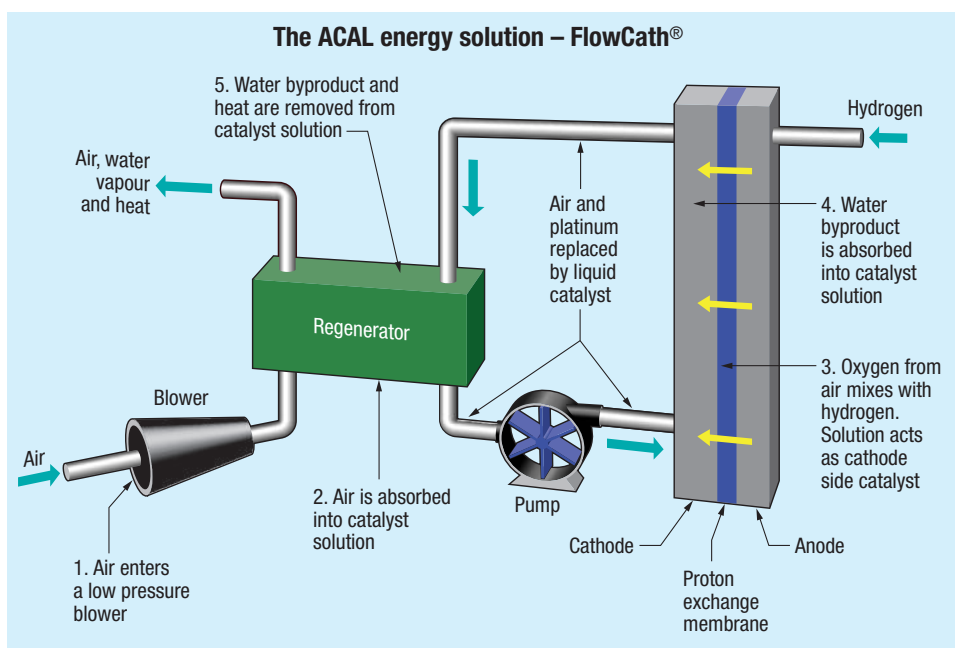
However, despite the roll-out of the technology being slower than many would have preferred, engineers in general like the technology and see it as a viable future technology that is undoubtedly going to become increasingly significant.

Current fuel cell technology has one inherent drawback, however, that really does need to be addressed before it can make its mark; the catalyst. Currently, platinum is widely used, with an average fuel cell car needing 30g of the precious metal to function adequately. With the average price of platinum around \$50 a gram, the raw material alone incurs a significant cost. Many current fuel cell developments are based around trying to reduce, and even replace platinum catalysts altogether with some kind of low-cost ubiquitous material.

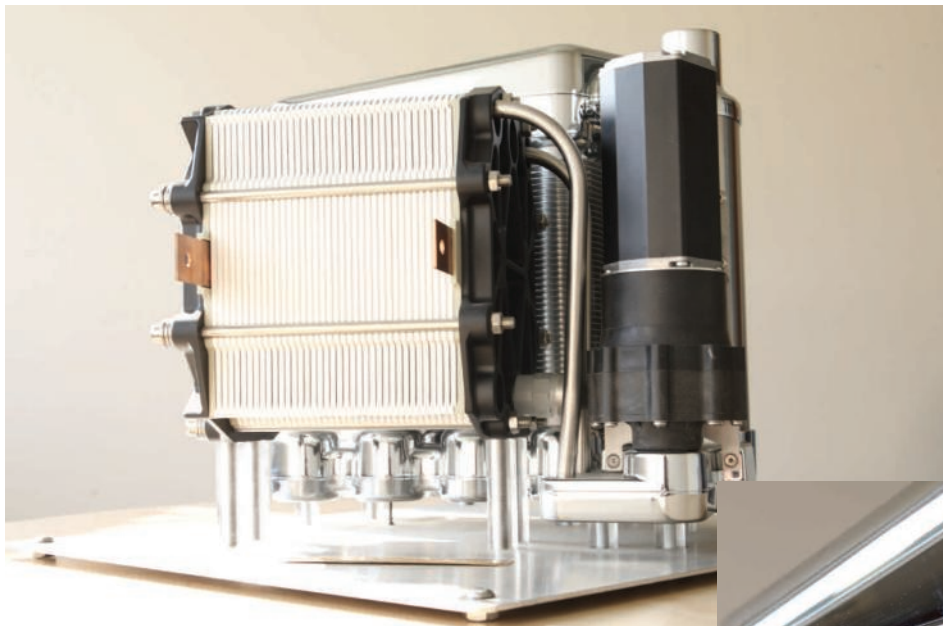
Last year the US National Institute of Standards and Technology said it had developed a reliable method of applying atom-thin layers of platinum that would be cheap and easy to implement. The process would allow the precise deposition of

layers of platinum to be applied to a substrate to reduce, by an order of magnitude, the amount of material necessary for the catalyst and so to the associated cost. The process involves using platinum dissolved in a solution, which can then be deposited on a gold surface in single-atom layers by alternately applying positive and negative voltages. It is clever stuff, but the science is complex and will not be easily industrialised.

Another exciting development, however, is happening here in the UK and comes from Cheshire start-up, ACAL Energy. The company is working on what could be a revolutionary liquid catalyst for a proton exchange membrane (PEM) fuel cell, which could reduce the required platinum by 80% or more. The technique is offering some real potential as the liquid catalyst







technology known as FlowCath replaces over three-quarters of the necessary platinum with a low cost liquid catalyst.

FlowCath is a method of replacing the fixed platinum catalysts on the cathode with a liquid regenerating catalyst system. The liquid is continuously pumped through the fuel cell stack into an external regenerator and then back to the stack. The technology reduces platinum content by up to 80% and actually helps to simplify the overall fuel cell system. As a consequence the technology not only radically reduces cost, it also improves durability and robustness.

"In the 19th century, coal was the fuel and the steam engine was the engine of choice," says Dr Andrew Creech, chief technology officer at ACAL Energy. "In the 20th century it was hydrocarbons and the internal combustion engine, and moving in to the 21st century we will give up hydrocarbons for hydrogen. The fuel can be made with renewable energy and the engine of choice will be the fuel cell.

"Our system can get rid of much of the platinum needed in a fuel cell and we now have working fuel cells. We're targeting the automotive industry and already have a lot of interest from major OEMs."

The use of a liquid catalyst dramatically improves a PEM fuel cell's durability and at the same time reduces the cost of a system. The liquid acts as both a coolant and catalyst for the cells, ensuring that they last longer by removing

*The FlowCath fuel cells employ a method of replacing the fixed platinum catalysts on the cathode with a liquid regenerating catalyst system*



most of the known decay mechanisms.

Importantly, ACAL Energy's technology significantly reduces the total cost and weight of a fuel cell and enables a competitive fuel cell drivetrain with a power output of 100kW approximately equivalent to a 2-litre diesel engine.

By using a liquid catalyst an ordinary transition metal can be used in the system instead which can be orders of magnitude cheaper than platinum. It is fundamentally stable, which also helps durability, and by having a liquid present it prevents the fuel cell membrane from expanding and contracting as it swells with liquid and then dries. This, in a normal fuel cell, creates an undesirable mechanical stress that leads to wear, fatigue and even eventual failure.

"All these factors help our system to be much more reliable," says Dr Creech.

Over the last 16 months, ACAL Energy has put its proprietary catalyst and fuel cell system through an automotive industry standard stress test protocol. This simulates a 40-minute car

journey with a start and stop at the end of each cycle. The cycle is repeated 24 hours a day, seven days a week, and mimics vehicle journey's with frequent stops and starts as well as occasional motorway cruising. This particular test was used to accelerate the aging of components and stress on the fuel cell systems.

"We have recently reached the 10,000 hour runtime on a third party automotive industry durability test," says Dr Creech. "We passed it without any signs of degradation, which is a significant milestone to pass."

The 10,000 hours mark is equivalent to 300,000 driven miles and it makes the hydrogen

fuel cell comparable to the best current lightweight diesel engines under such test conditions.

The technology is around the Technology Readiness Level 4 (TRL4) mark and ACAL is now in the process of entering some Joint Development Agreements (JDAs) with automotive OEMs and Tier 1 companies to integrate the technology and show long term viability. The fuel cell is also being engineered for cost effectiveness to enable higher volume manufacture.

"The car companies and fuel cell industry has already designed many of the parts and components we need," says Dr Creech. "So we are in the process of adapting our designs to incorporate parts that are already [available off the shelf]. But, we can only take the engineering so far. We want to take it to a point where we can do a functional specification and then let automotive companies take it forward from there."

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# No pain, no gain?

**With the New Year upon us, how can technology help people run without injury?**

For those of us who are currently trying to remedy some of Christmas' worst excesses, there are a number of options available. Abstinence from rich food, drink and all those other good things is one option, of course, but probably the most effective solution is to undertake exercise. And for many people, that means running.

It is no coincidence at this time of year that the pavements positively teem with large numbers of people in running gear that looks suspiciously new and whose red faces, laboured breath and even more laboured progress suggests that they are fulfilling a New Year's resolution to shed unwanted pounds.

The problem is, however, that running places considerable strain on the human frame. The shock put through the joints is considerable: a fact that often only becomes apparent too late. These strains are of naturally made even worse if the runner is carrying excess weight (which, of course, they usually are at this time of year).

And, of course, the amateur runner is usually not equipped to combat these problems. They do not have expert trainers telling them how to improve their running style in such a way as to maintain health and usually also lack enough knowledge to provide themselves with the right equipment – and the single most important type of equipment in this context is the running shoe. So what should they do?

## The Challenge

The challenge, this month then, is to devise a type of running shoe that genuinely helps to prevent injury. Of course, most runners usually assume that this is simply achieved by the largest possible quantity of shock absorbing and cushioning material. This is not necessarily the case, of course, because however much padding one's shoes may contain, if they are

putting your feet in the wrong position, the knock-on effects on a runner's joints will still be just as damaging.

Plus, of course, if you actually provided enough cushioning to negate the impact of running, the shoe itself would likely become unwieldy, heavy and probably impossibly high, which would present its own dangers.

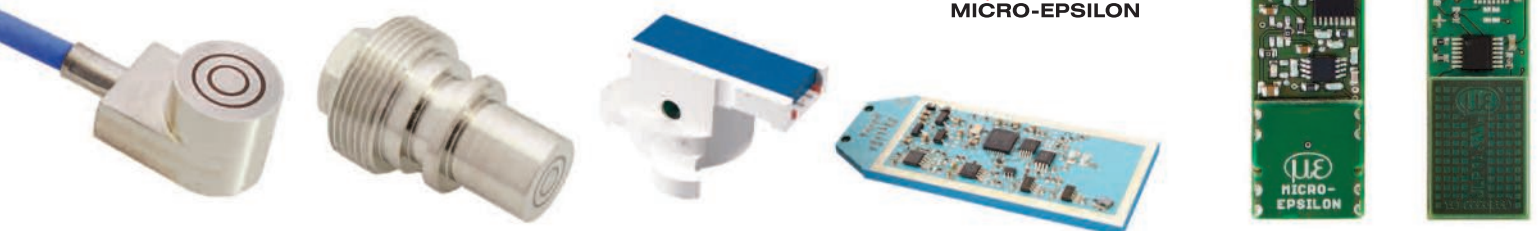
As ever, we have a solution in mind that employs some relatively sophisticated technology to aid the runner. However, this may not be the best answer and *Eureka's* readers may be able to devise something lower-tech that can make 'runner's knee' a thing of the past.



The answer to last month's Coffee Time Challenge of how to fix the problems associated with airliner reclining seats can be found in our Technology Briefs section on page 14.

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