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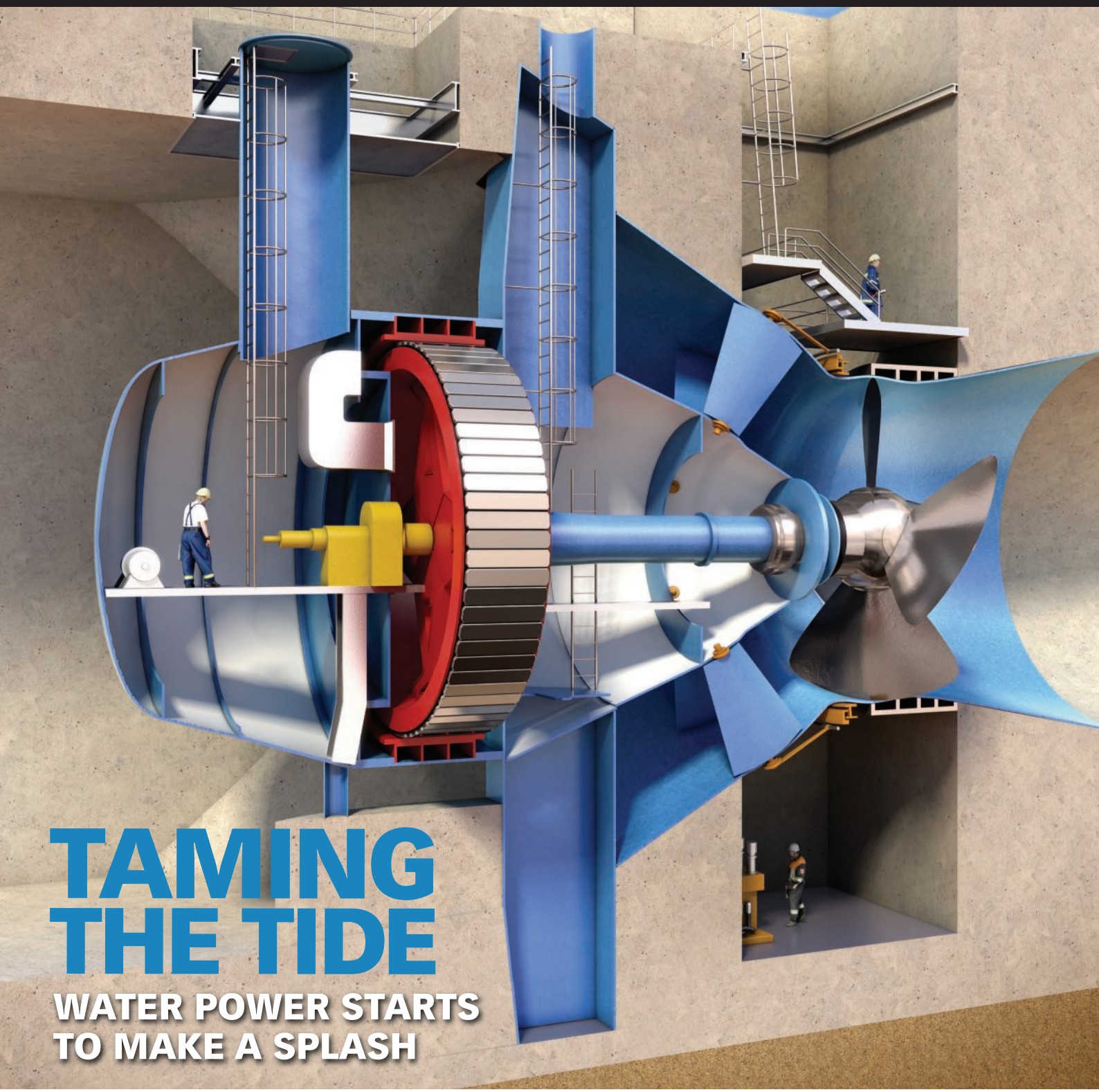
THE MAGAZINE FOR ENGINEERING DESIGN

In this issue: Design Twin • Clean technologies • Fastener properties • Autonomous vehicles



TAMING THE TIDE

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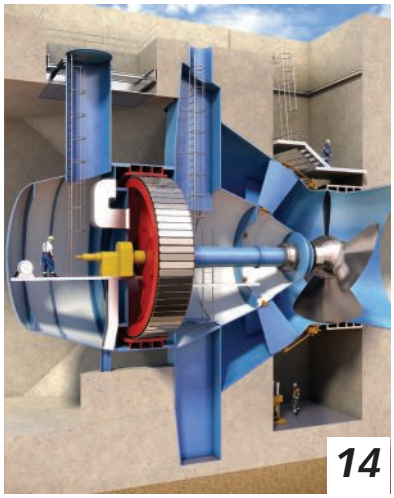

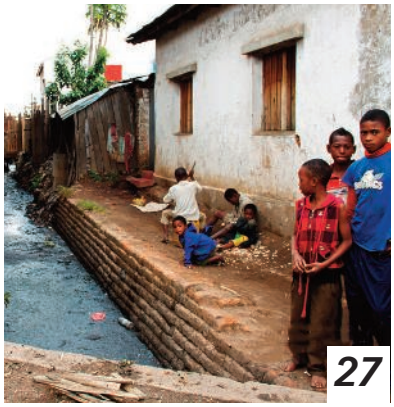

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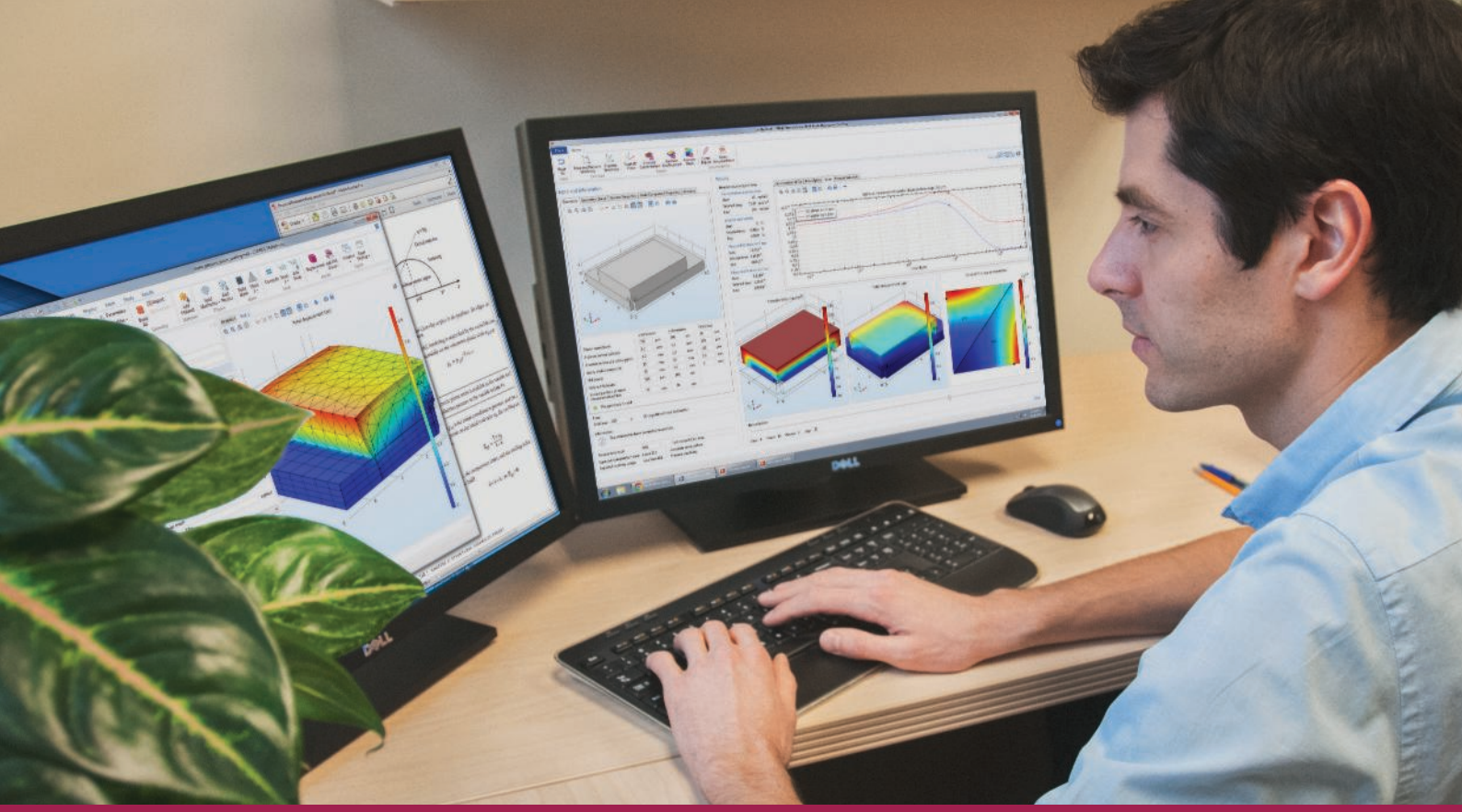

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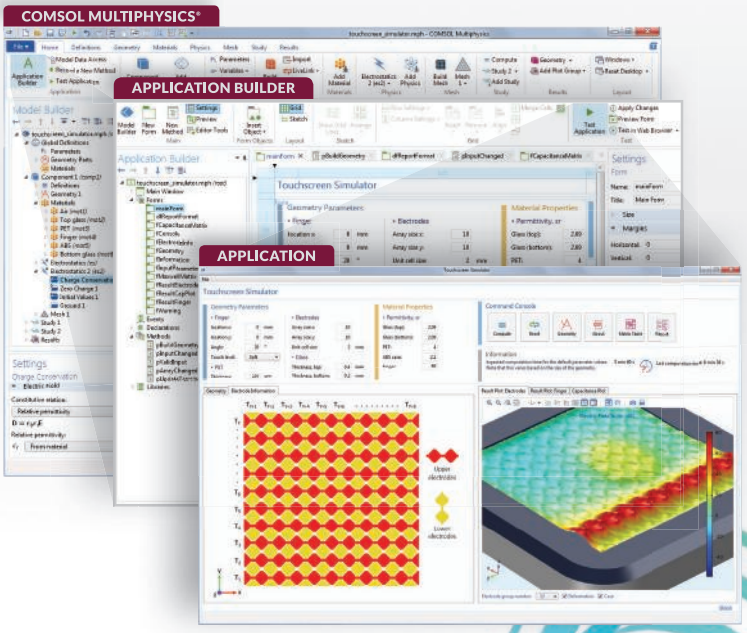

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Engineering without compromise

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

In terms of manufacturing 2016 did not get off to a great start with news of further devastation to the steel industry. This may be caused by short term factors – comparatively high UK energy costs and dumping of cheap Chinese steel – but despite Redcar being in mothballs, much of the capacity lost will not be recovered when market positions change. While this understandably hit the headlines, what might have gone unnoticed were the positive results from the car industry in 2015, which showed that 1.6 million cars were made in the UK last year – a ten year high. Mini, Toyota and Vauxhall were all up and the star of the show was again Jaguar Land Rover, who now make nearly half a million cars a year. Beyond manufacturing, what also often slips under the radar in the UK is the strength of engineering in specific high value or advance technology sectors.

Our Vision 2020 supplement (if you didn't receive a copy in the post it is available for download on the website), surveyed a number of leading companies who identified sectors where the UK is leading the field. Such sectors include automotive, aerospace, rail, medical, robotics, even oil & gas despite the plummeting oil prices – all areas where the quality of the engineering is non-negotiable. There remains the concern that a healthy engineering sector needs to feed a healthy manufacturing industry and, despite the success of the car industry, the other sectors are not high volume. It would take a lot of companies making satellites to replace what has been lost in steel, shipbuilding et al. However, the jobs that are being created are in sectors that are high-value, growing and, importantly from the perspective of attracting new recruits, they are interesting as well. So while Tim Peake has captured the imagination of the British science and technology sector from the International Space Station, there is plenty going on down on home soil to be optimistic about as well.

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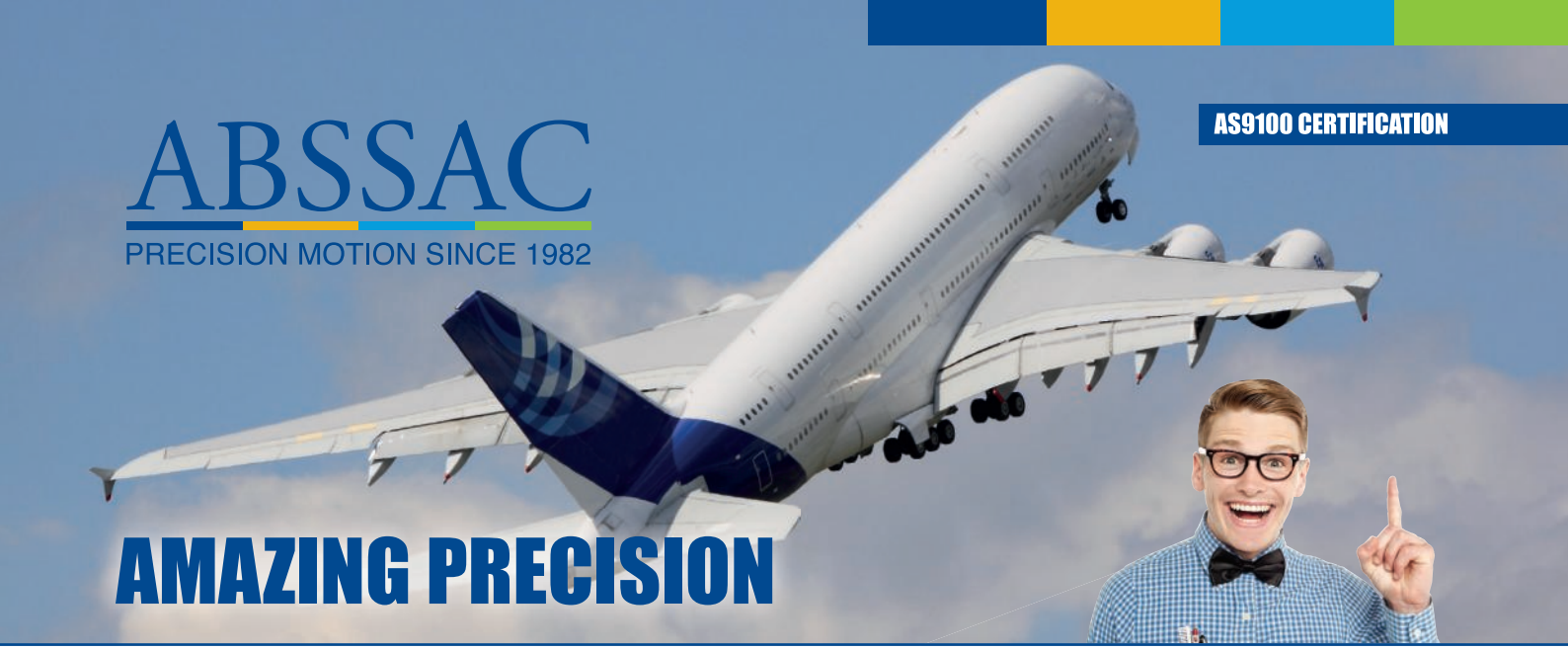
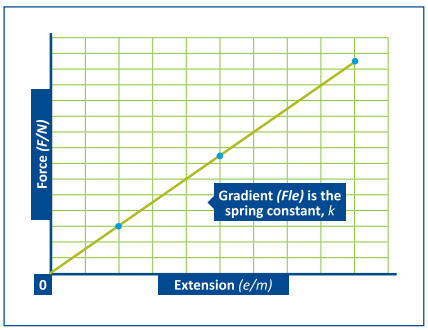


AMAZING PRECISION

Compression spring machined from a solid piece of material.

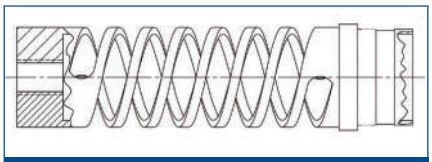
Integrate end attachments into the one piece machined spring

In classical physics, a spring is seen as a device that stores potential energy, specifically elastic potential energy. Back in the 17th century the British physicist Robert Hooke developed what was to become known as *Hooke's law of elasticity.* This states that the extension of an elastic rod (its distended length minus its relaxed length) is linearly proportional to its tension, the force used to stretch it. Similarly, the contraction (negative extension) is proportional to the compression (negative tension).



This accuracy of spring rate is more or less impossible to achieve with a wound spring but is readily available in the machined spring format.

All spring forms adhere to this law, however it is the linear accuracy of the relationship between the compression or extension to the force applied, that separates the traditional wire wound spring from the machined spring. As the name suggests, the product is machined from a single piece of bar stock material rather than coiling wire. Due to the geometry of the machined coil, the spring rate is extremely linear in compression and extension. In fact spring rate tolerance can be as good as +/- 1% if required.



The spring is machined from bar stock material

So why use machined springs?

Two main advantages are immediately apparent. Machined springs can provide very precise, linear deflection rates because virtually all-residual stresses are eliminated. Secondly, the machined spring also enables the designer to incorporate the way in which the spring attaches into the single piece design, often incorporating parts of the spring assembly into the single part construction.

Why are machined springs so unique?

Quite simply, it is possible to have one, two, three of more spring coil elements in the single piece spring construction. Multi-start springs

Double and triple start springs are available

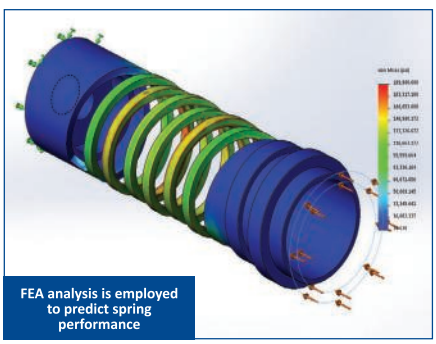
deliver outstanding performance advantages, since the independent helixes are in the same cylindrical plane, which provides totally enhanced spring performance. In fact, the machined multiple start spring coil configurations takes the performance and reliability to levels simply not achievable by the traditional wound spring format.

So why use machined Compression or Extension springs?

A single start spring provides a reaction force plus a moment. On multiple start springs, virtually all internal moments are resolved within the spring itself, which translates into excellent compression or extension parallelism.

The machined spring product has proven itself in medical, aerospace, semiconductor and motor-sport industries to name a few. Wherever a wound spring is not able to meet your performance criteria or a new spring design requires accuracy and repeatability, the machined spring is the ideal partner.

The next time you require a spring in a critical or high duty cycle environment, the machined spring from Abssac Limited may be the answer to your design problems.



FEA analysis is employed to predict spring performance

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NEWS

Ship quiet enough to hunt submarines

The Royal Navy is working with BAE Systems and GE Marine on the Type 26 Global Combat Ship, designed to undertake a variety of maritime missions ranging from complex combat operations to counter piracy as well as humanitarian and disaster relief.

BAE Systems has recently announced that the first three ships will use advanced electric propulsion motors and drive systems developed by GE Marine. GE has deployed a team of noise and vibration specialists using special 3D modelling software to map the acoustic dynamics of the ship's electric motors. The team claim to have designed an electric propulsion system that is quiet but also powerful. It is said the system will allow the ship to hunt submarines more effectively without being detected.

The ships will use the electric motors for patrolling and cruising at lower speeds. They will draw electricity from diesel generators, but the ships will also have a gas turbine for sprinting at high speeds.

Lady Judge chairs ACE

Lady Barbara Judge, - has been appointed by the Association for Consultancy and Engineering (ACE) as Chairman of its Advisory Board. ACE represents the interests of professional consultancies and engineering companies operating in the social and economic infrastructure sector.

Lady Judge said: "This is a crucial time for the industry with much-needed investment a key priority for ACE to influence at national, devolved, regional and local levels. ACE has recognised the business imperative to embed a diverse and inclusive culture for positive sustainable change within its member firms, and I am committed to moving this important agenda forward."

NEWS

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

Free 3D models **112491**

World's largest plastic energy chain **112921**

High sensitivity gas leak detection **112629**

'Plug and test' smartphone-based tools **112279**

Energy chain retraction system **112636**

Ultrasonic flowmeter **112632**

ZEMIC strain gauges **112719**

Leak free turbine pumps **112486**

Digital rate and total flowmeter **112495**

Antibacterial material for medical **112723**

Bringing a concept to reality

Faraday Future has adopted Dassault Systèmes 3DEXPERIENCE platform.

The electric-car company is said to have deployed the 'Target Zero Defect' and 'Smart Safe & Connected' industry solution experiences for the development and delivery of the FFZERO1 fully electric vehicle and connected automotive experience concept unveiled during CES 2016 in Las Vegas.

The emerging next-generation connected cars require manufacturers to integrate traditional automotive design disciplines with Internet-connectivity, alternative power-sources, and autonomous driving technologies.

PTC acquires Kepware

PTC has completed its acquisition of Kepware, which enhances PTC's portfolio of Internet of Things technology, and accelerates the company's entry into the factory setting and Industrial IoT. Kepware's KEPServerEX communications platform will become a strategic component of the PTC ThingWorx IoT technology platform. The integration will allow organisations to gain enterprise-wide insight and to proactively optimise mission-critical processes enabling them to improve operational performance, quality, and time to market.

Business will drive AR and wearable tech

A report from Beecham Research, suggests that business applications will drive growth in augmented reality (AR) and wearable devices over the next five years, contrary to much of the hype surrounding the consumer market.

The report points to healthcare, manufacturing, logistics and retail as some of the most dynamic markets, where AR offers a new way for people to interact with information hands-free, to provide a greater depth of control and access to knowledge.

The report also highlights recent acquisitions that reflect a growing level of market activity and consolidation. This includes PTC's purchase of Vuforia at the end of last year for $65million to support its next generation of technology solutions for manufacturers and follows acquisitions of IoT companies ThingWorx and Axeda. Other acquisitions in 2015 included Apple's purchase of Metaio, borne out of a project at Volkswagen and Facebook's purchase of AR company Surreal Vision.

"It is clear that the overall status of the enterprise market for AR and wearable technology is at a tipping point, moving from trials and testbed projects to real commercial deployments," said Matthew Duke-Woolley, market analyst at Beecham Research.

The report looks at some of the emerging business applications of AR and wearable technology, such as head up displays in manufacturing systems to support complex production processes, collaborative product design and prototyping; and remote assistance of specialist distant engineers and technicians.

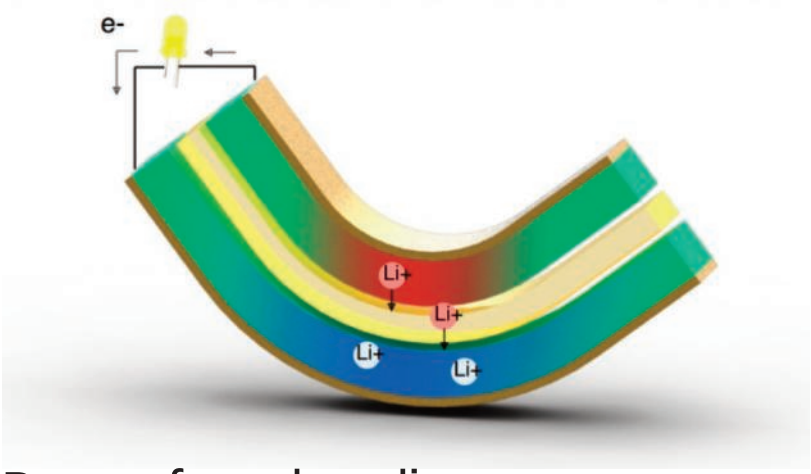
3D printing using rust

A team of engineers from Northwestern University has created a way to print 3D metallic objects quickly using rust and metal powders.

While current methods rely on large metal powder beds and expensive lasers or electron beams, the Northwestern team's technique is claimed to use liquid inks and common furnaces, said to result in a cheaper, faster, and more uniform process. The team also demonstrated that its method works for a variety of metals, metal mixtures, alloys, and metal oxides and compounds.

"Most advanced manufacturing methods being used for metallic printing are limited as far as which metals and alloys can be printed and what types of architecture can be created," said Ramille Shah, assistant professor at Northwestern's McCormick School of Engineering. "Our method expands the architectures and metals we're able to print, which really opens the door for a lot of different applications."

By creating a liquid ink made of metal or mixed metal powders, solvents, and an elastomer binder, Prof Shah was able to print densely packed powder structures using a syringe-extrusion process at room temperature. Despite starting with a liquid ink, the extruded material instantaneously solidifies and fuses with previously extruded material, enabling large objects to be created and immediately handled. Then, with collaborator David Dunand, Professor of Materials Science and Engineering, the team fused the powders by heating the structures in a simple furnace.



Power from bending

Researchers from MIT have developed a method of harvesting energy from a range of natural motions and activities, including walking. For many applications such as biomedical, mechanical, or environmental monitoring devices, harnessing the energy of small motions could provide a small but virtually unlimited power supply.

Most previously designed devices for harnessing small motions have been based on the triboelectric effect or piezoelectrics. The researchers say these work well for high-frequency sources of motion such as those produced by the vibrations of machinery. But for typical human-scale motions such as walking or exercising, such systems have limits.

This system uses technology similar to that in lithium ion batteries; theoretically, it could be produced inexpensively at large scale. In addition, these devices would be inherently flexible, making them more compatible with wearable technology and less likely to break under mechanical stress.

While piezoelectric materials are based on a purely physical process, the new system is electrochemical. It uses two thin sheets of lithium alloys as electrodes, separated by a layer of porous polymer soaked with liquid electrolyte that is efficient at transporting lithium ions between the metal plates. But unlike a rechargeable battery, which takes in electricity, stores it, and then releases it; this system takes in mechanical energy and puts out electricity.

When bent, the layered composite produces a pressure difference that squeezes lithium ions through the polymer. It also produces a counteracting voltage and an electrical current in the external circuit between the two electrodes, which can then be used directly to power other devices.

Solution to last month's Coffee Time Challenge

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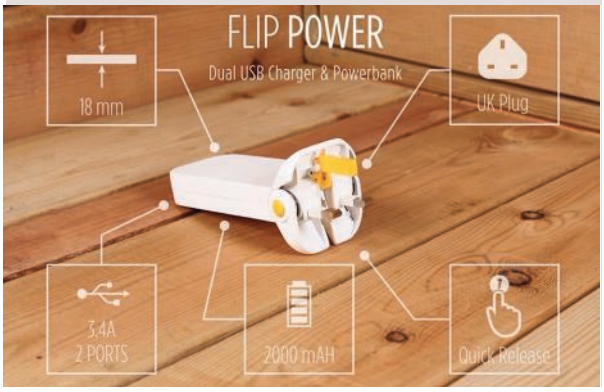
The solution to last month's Coffee Time Challenge – to redesign the humble 3-pronged British plug, comes from Hong Kong based Oneadaptr, which has recently launched a Kickstarter campaign to get its 'Flip' foldable plug launched onto the market.

While there have been some foldable plugs before, Flip is the thinnest yet at just one third of the size. Flip has set out to optimise the trade off between size, ease of use and features using USB ports and power bank for today's high-tech mobile devices.

The folding design allows the thin enclosure to be realised, while also hiding the pins away when not in use, stopping them scratching screens of tablets as they are stored in a bag. The devices can also come with an optional external battery, so when plugged in can charge both the internal battery and any connected device concurrently, as well as being able to provide charge even when not plugged in at the mains.

The company said: "If we make Flip too thin, concerns arise regarding both the sturdiness and the ability to add new functions. We found 18mm to be the right balance between thickness and features."



UK 3rd in innovation impact

According to an analysis by the Information Technology and Innovation Foundation (ITIF), only two other nations do more than the UK in supporting global innovation on a per capita basis. The findings come as part of a report assessing 56 countries that make up close to 90% of the world's economy.

While previous research has ranked countries based on innovation capabilities or outcomes, this report is the first to assess the impact of countries' policies on the broader innovation system. The authors examined 14 factors that not only support innovation domestically but have positive spillover effects globally, such as supportive tax systems and investment in R&D and human capital, and another 13 factors that have negative spillover effects, such as forced localisation and weak intellectual property protection.

The UK's 3rd-place ranking reflected a combination of policies that the report found to be 5th best in its positive contribution to the global innovation ecosystem and also the 7th least damaging.

The report also found a strong correlation between countries' contributions to global innovation and their levels of domestic innovation success, meaning that doing well domestically on innovation policy can also mean doing well for the world.

ITIF argues leading nations should establish a Global Science and Innovation Foundation to fund scientific and engineering research on key global challenges, particularly through collaborative international research.

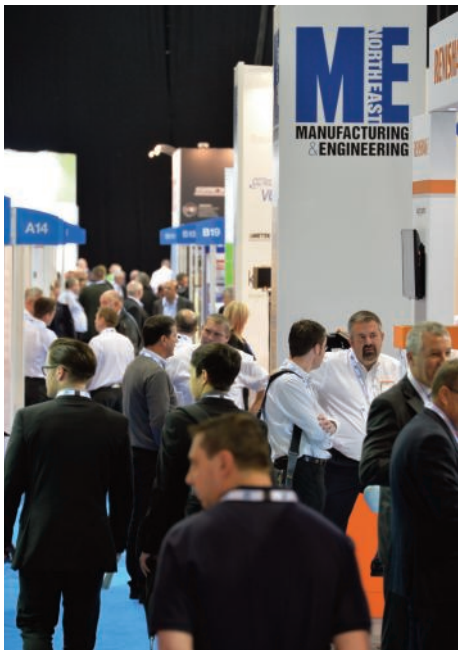
Northern Powerhouse POWERS on

'Back by popular demand' is the old catchphrase that is relevant for a new show – Manufacturing & Engineering North East. The debut event held in Newcastle in July 2015, exceeded expectations - more visitors came than was expected, drawn by a high quality conference and workshop programme alongside many of the region's leading suppliers in the exhibition. And this was despite some typically North Eastern summer weather – a deluge that soaked Newcastle but didn't dampen enthusiasm. In fact such was the response that the show won three industry awards at the back end of 2015.

Manufacturing & Engineering North East is returning to Newcastle again in 2016 to support the industrial innovation of the region. This vibrant exhibition, its workshops and conference sessions will open its doors for two days on July 6-7th at the Radio Metro Arena, Newcastle.

The inaugural Manufacturing & Engineering North East attracted more than 1300 design engineering and manufacturing professionals to and from the region. The 2016 event will build on that award-winning success and once again bring the best of British industry to the Northern Powerhouse, whilst showcasing the best the region has to offer as well.

Companies looking to grow their business in the North East are encouraged to participate. Schaeffler UK exhibited at the inaugural event and commented: "It was great to be involved with an event targeted at engineers in the North East. We had a successful show, with good attendance at our workshops and quality leads as a result."



Visitors to the inaugural event were equally enthusiastic. A production engineer from Progress Rail Services UK, said: "This is a local event with world renowned suppliers, it has the latest technology on display for manufacturers and has been very informative."

Manufacturing & Engineering North East brings together first class speakers and innovative engineering and manufacturing companies from across the UK in one location. To date, 80% of the exhibition space has already been filled, the practical workshops are booking up fast and the exciting speaker line-up will be unveiled shortly. The show gives visitors and exhibitors a great opportunity to source new suppliers, test equipment, acquire expert knowledge and forge new supply chain relationships.

Manufacturing & Engineering North East is organised by Findlay Media, in turn part of the Mark Allen Group, which is the publishing group behind Eureka. Findlay Media also publish Machinery and Works Management magazines, which are involved in the MENE organising team. Leading trade bodies and institutions, including the North East LEP, Gateshead & Newcastle Inward Investment, Advanced Manufacturing Forum and the Institution of Engineering Designers (IED) support the event.

For full details and to pre-register interest for 2016 visit: www.menortheast.co.uk

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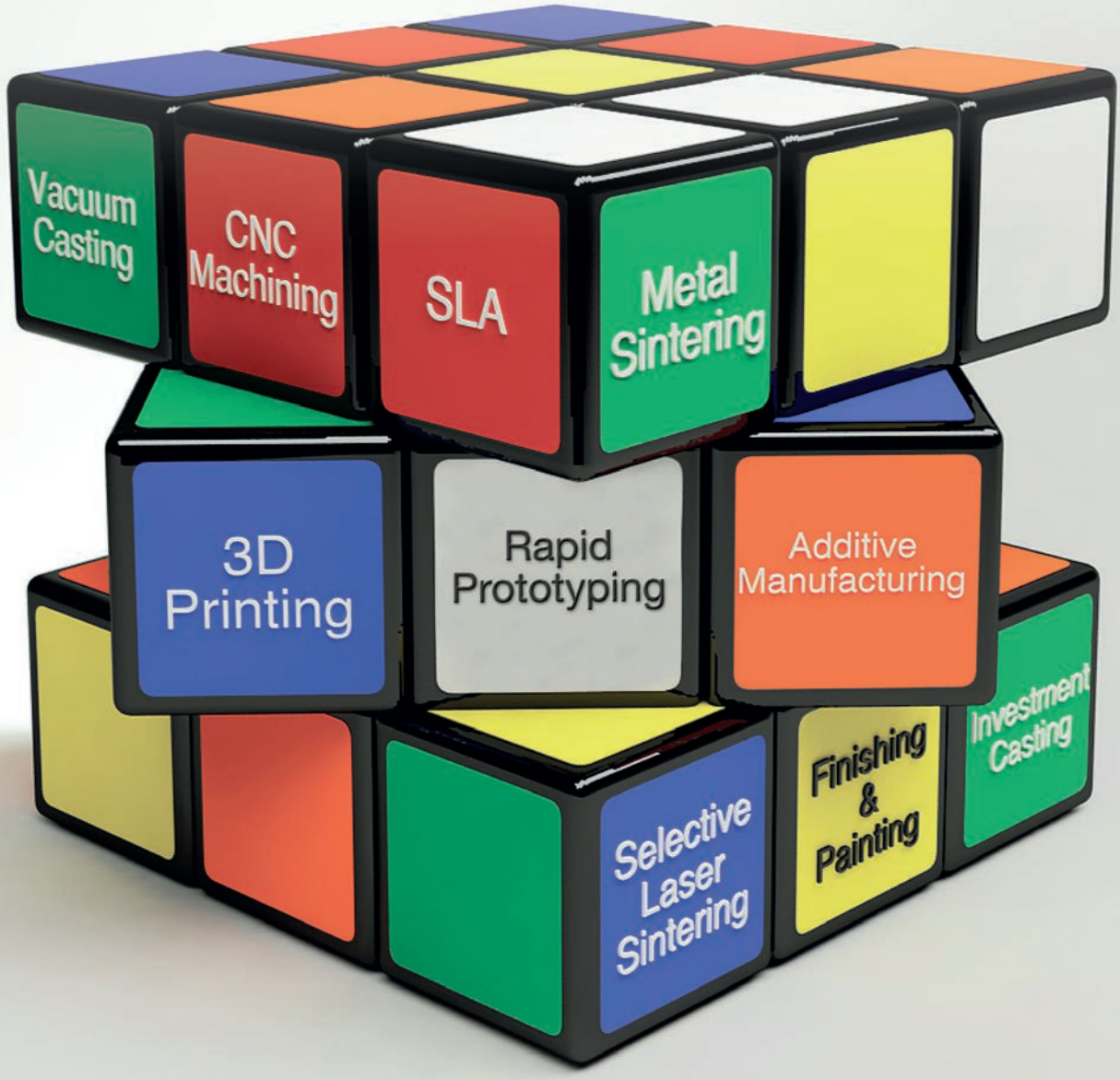

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Rising tide

Turning on the lights is taken for granted by most, but with a quarter of the UK's electricity capacity being lost over the next decade, the search is on to find cleaner, sustainable power for the next generation. Justin Cunningham reports.

Producing adequate power is vital to daily life, yet the process is largely neither clean nor efficient. Indeed, in many parts of the world, smog from coal fired power stations remains a visible reminder of the problem. And, it is not just the threat to human health, all kinds of ecological systems are suffering as a consequence. Despite some sceptics dismissing evidence on climate change, pollution and its adverse effects are largely undisputed.

The past decade has seen the rapid roll out of wind farms both in and around the UK, a move mirrored throughout much of Europe. It is the first major step in cleaning up power production. Despite a slower start than many would have liked, last year wind based renewable electricity made up 11% of generated power.

Despite the success, however, a fundamental problem remains: the baseload requirement. Baseload is the minimum level of power demand on the electrical network over a 24 hour period. And since baseload power sources are those plants that generate continuous and dependable power – wind turbines are never likely to take over completely.

"The UK baseload requirement comes from nuclear," said Peter Oram, global renewables sales at General Electric Power Conversion. "You can't cycle it, it is on or off. But, overnight you find there is no demand."

As electricity can't be stored in volume, if it is not used at the point of production, it is lost. And with plants only shutting for maintenance, baseload thermal power plant operations can be inherently inefficient.

The unpredictability of wind combined with the need to keep nuclear plants on, means the current infrastructure is far from ideal. But, not all renewable sources of power are created equally.

For years many have questioned why tidal and wave power have not featured more highly in the mix. In all probability it's likely they will, once the engineering is more fully developed and better understood. Offshore wind power has had its fair share of unforeseen maintenance issues, having equipment underwater only compounds the difficulties.

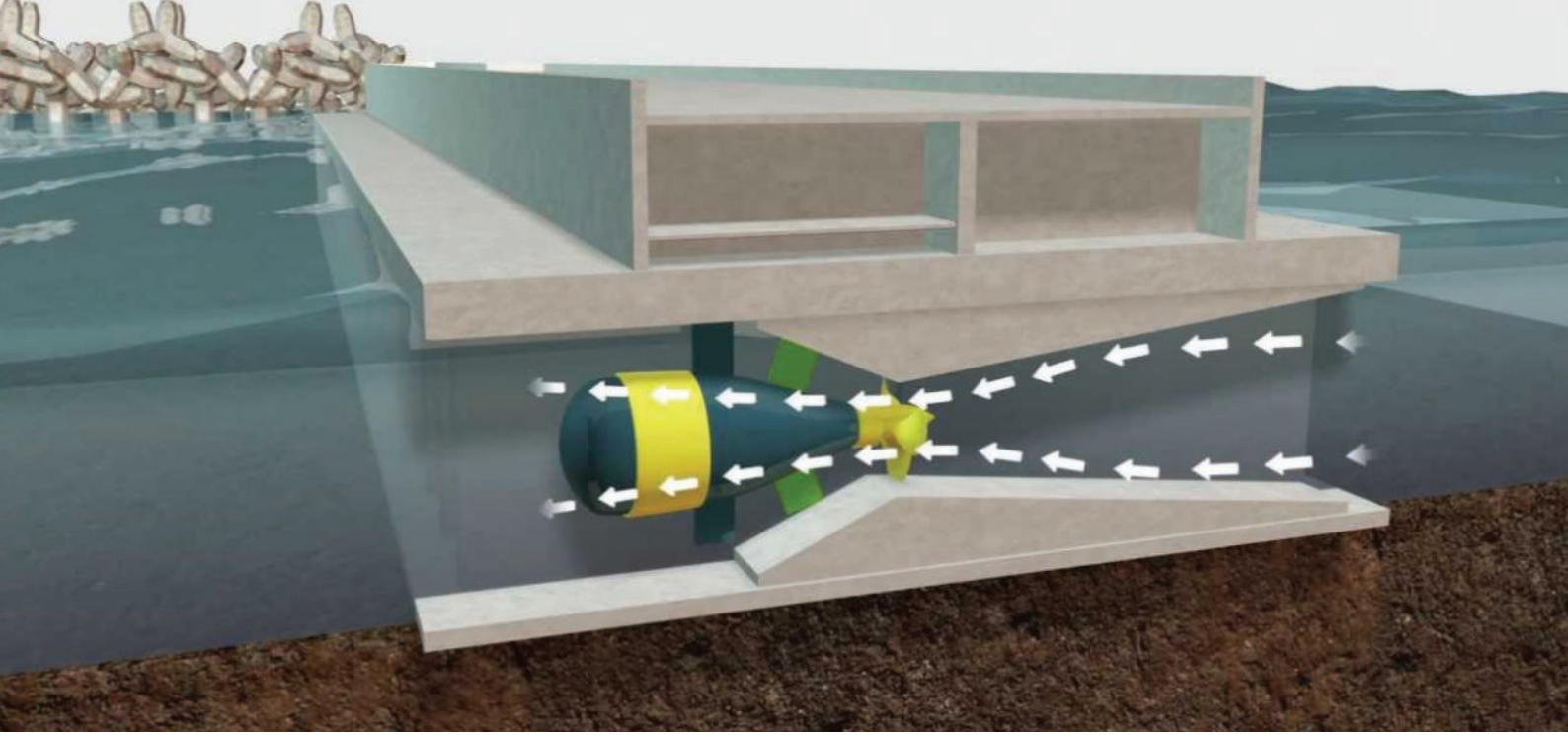
Take a step back, though, and the global renewables picture is very

Tidal Lagoon – not without controversy

Despite strong initial backing, the Government's stance has softened significantly in recent months. The Prime Minister admitted last month his enthusiasm had been 'reduced'. The reservations were reportedly related to engineering concerns raised around the turbines, and the merit of the Lagoon's power producing capability. While the site is a prototype to prove the concept, in practice, any significant unforeseen side effects would spell disaster for the £1 billion project. The Government does not want the lagoon to turn in to a money pit and political embarrassment.

The turbines are developed off the back of experience gained in hydro generation facilities, but there is lack of practical measurements using them in this way. Using the turbines to generate power in two directions assumes equal efficiency, yet some experts have called this a theoretical prediction that will not hold up in real operation.

Tidal Lagoon Power said questions on the engineering and environmental impact had been addressed in depth by experts through a robust planning and validation process.



of *clean power*

different. Producing power from moving water is actually the planets biggest source of renewable energy by some margin. Hydro plants are common, reliable, efficient, well understood, and clean. The trouble is, not everywhere has the nature channels and lagoons to exploit the resource. So then, why not build them instead?

This is the principle being put forth by Tidal Lagoon Power. The company wants to build artificial lagoons in areas that have high tidal ranges. It is currently developing its first project in Swansea Bay to show the principle, but aims to have lagoons built all around the UK and beyond.

The concept is simple; as water floods into the lagoon it rotates turbines that produce electricity. This process is mirrored at lower tides as the water is released out of the lagoon producing predictable and reliable clean power. What's more, due to regional differences in the time of high tide and low tide, the system can be made up of a series of lagoon networks that can produce 24 hour power.

"Tidal is the new baseload," said Oram. "Nuclear is about 18GW in the UK, so if you follow that tidal pattern around the UK you almost get yourself a baseload replacement for nuclear, but this lasts 120 years."

General Electric is partnering with Tidal Lagoon on the project, developing the turbine systems and power electronics that will make the system smart, flexible, and responsive to grid demand. GE brings years of operational experience in maintaining thermal and hydro power plants to give the project technical soundness and genuine commercial credibility.

At the heart of this work is GE's large induction generators and variable speed drives (VSD) based on its medium voltage drive technology and hydro turbine technology supplied by partner Andritz Hydro. The equipment is well proven across multiple industrial and renewable energy applications such as onshore and offshore wind, oil and gas and marine.

"We are able to connect remotely to our plants and every single inverter," said Oram. "We can then take that data, feed it back to optimise operations, and improve products in the future."

The UK is currently in transition with eight nuclear reactors and nine coal fired power stations closing over the next eight years. It means 21,000 MW, around one quarter of total installed capacity, will be lost.

This has prompted the Government to commit to a new generation of nuclear reactors, potentially built by foreign contractors. While nuclear is certainly a low carbon option, the nuclear waste generated is far from environmentally inert. Tidal Lagoon, however, has ambitions to offer an alternative renewable option that will last longer, and potentially fill the energy gap.

> "TIDAL IS THE NEW BASELOAD GENERATION," PETER ORAM, GENERAL ELECTRIC

Chief executive of Tidal Lagoon Power, Mark Shorrock, said: "Our ambition is predictable baseload renewable energy. Our first project at Swansea Bay is playing with 10m high tides. The concept is to build a big break water wall, 9.5km long. That is 11.5km^2 of water that we impound.

"We put generators between the lagoon and ocean, and wait three hours for the tidal difference. Then we exchange a 100 million cubic metres of water over the next four hours through turbines as we empty the lagoon. We generate electricity in the same way when water comes in. We can also delay generation by up to 90 minutes."

Swansea Bay will use 16, 7.5m turbines, giving 320MWs of installed capacity and 14 hours of reliable generation every day. At an expected cost of £1 billion, many have pointed out a similarly priced gas-fired power station could produced as much as 1000MW. Tidal Lagoon argues that purchase cost can be deceiving and it is through life cost that really shows the true comparison.

Fuel costs for a gas fired power plant over a 25 year life are high, volatile, and dependant on supply from other countries. It is also polluting and needs significant maintenance. Tidal Lagoon states its hydro powerstations have an operational life span of 120 years, with no major refurbishment needed for the first 50 years of operation. In short, far less maintenance and zero fuel costs.

"You put in this infrastructure, and it goes and goes," said Shorrock. "And we are adamant we are not making these turbines in China or the Far East. We want to source equipment, use the expertise and manufacturing base that is here in UK for as much of this project as we possibly can.

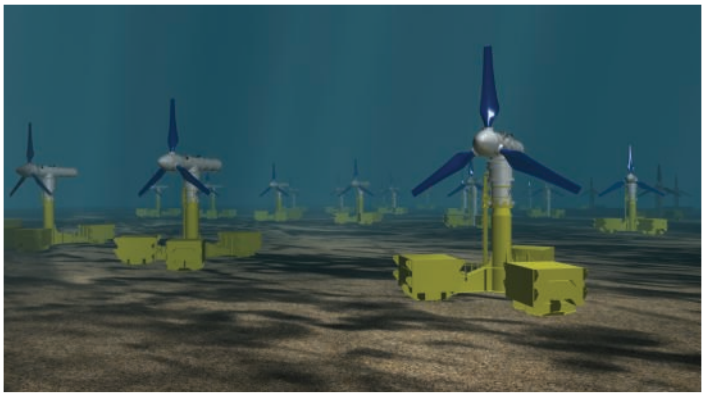
"We have a fundamental theme in the company that is we have to be reverent towards nature in what we do. To try and live in harmony with it. We want the birds to still live there, the molluscs and nature to thrive."

Shorrock doesn't want this to be a one off project and he has big plans for expansion. "Swansea Bay, we hope, gives birth to an industry," he said. With construction of the break water due to start in 2017, and operation due to start in 2020, it remains to be seen if this prototype project will deliver on its promises and live up to high expectation.

Not alone

However, the Tidal Lagoon project is not the only tidal renewable energy project that is gaining traction. The MeyGen Project, for example, claims to be the largest planned tidal energy project in the world. Here, energy generation takes perhaps the more traditional form of turbines placed on the ocean floor, a concept known as tidal stream generation. As tides flow in and out of channels, they turn the turbines and generate electricity in much the same way as wind turbines.

The turbines are being produced by Atlantis / Lockheed Martin and Andritz Hydro Hammerfest and the project is scheduled to install four 1MW turbines in 2016. These will prove the concept and power approximately 3000 homes, before the array is scaled up to 80+ turbines, and finally, in early 2020, the remaining turbines to make up the 396MW of



capacity. The MeyGen array will be located 2km off the north Caithness coast within the Pentland Firth. The area is recognised as a highly active site for tidal flows with a maximum current speed of 5m/s.

Atlantis chief executive, Tim Cornelius, said: "We are witnessing the transformation of a sector. MeyGen is one of the most exciting and innovative renewable energy developments in the world, marking the long-awaited arrival of tidal stream generation as a serious, large-scale player in global energy markets."

Suppliers step up

The tidal renewable development has required many in the supply chain to procure equipment and sub systems that are capable of withstanding the underwater environment.

"There is a lot customisation in MeyGen," said Callum McConnell, global business development manager, at supplier to the project Parker Hannifin. "But we are trying to do it with as many standard components as possible."

Parker has played a critical part in providing many components including gearbox lubrication and thorough sealing of equipment. However, a major part of keeping the underwater turbines moving has been the condition monitoring systems.

"Condition monitoring plays a big role in the project," said McConnell. "We need to know what is happening inside the nacelles, with the lubrication, hydraulics and power electronic systems.

"It allows the operator to more easily predict problems. You might see water in the oil, or metal particles, and that will tell a certain story about what is going on so you can accurately predict how long it might last before something fails. If you know when something is going to fail, it allows you to plan ahead and not wait for unscheduled breakdowns."

Despite the ongoing wait for the broader roll out of renewables, it looks as if many of the known problems of tidal energy are being overcome. However, this is all before the build phase has even started. It is an anxious time, no doubt, for engineers as this is when the unknown problems tend to arise. In the short term expect some increases in cost and delays in the project. But long term, perhaps the prospect of cheap and clean power. A fair compromise?

FACT FILE

Tidal Lagoon vs MeyGen

	Swansea Tidal Lagoon	Pentland Firth MeyGen
Turbines:	16 x 20MW	269 x 1.5MW
Capacity:	320MW	398MW
Start:	2017	2015
Complete and operational:	2020	Early 2020s
Life:	120 years	20-25 years
Tidal range / flow	8.5m	5m/s
Homes powered:	155,000	175,000
Total cost:	£1 billion	£1.5 billion

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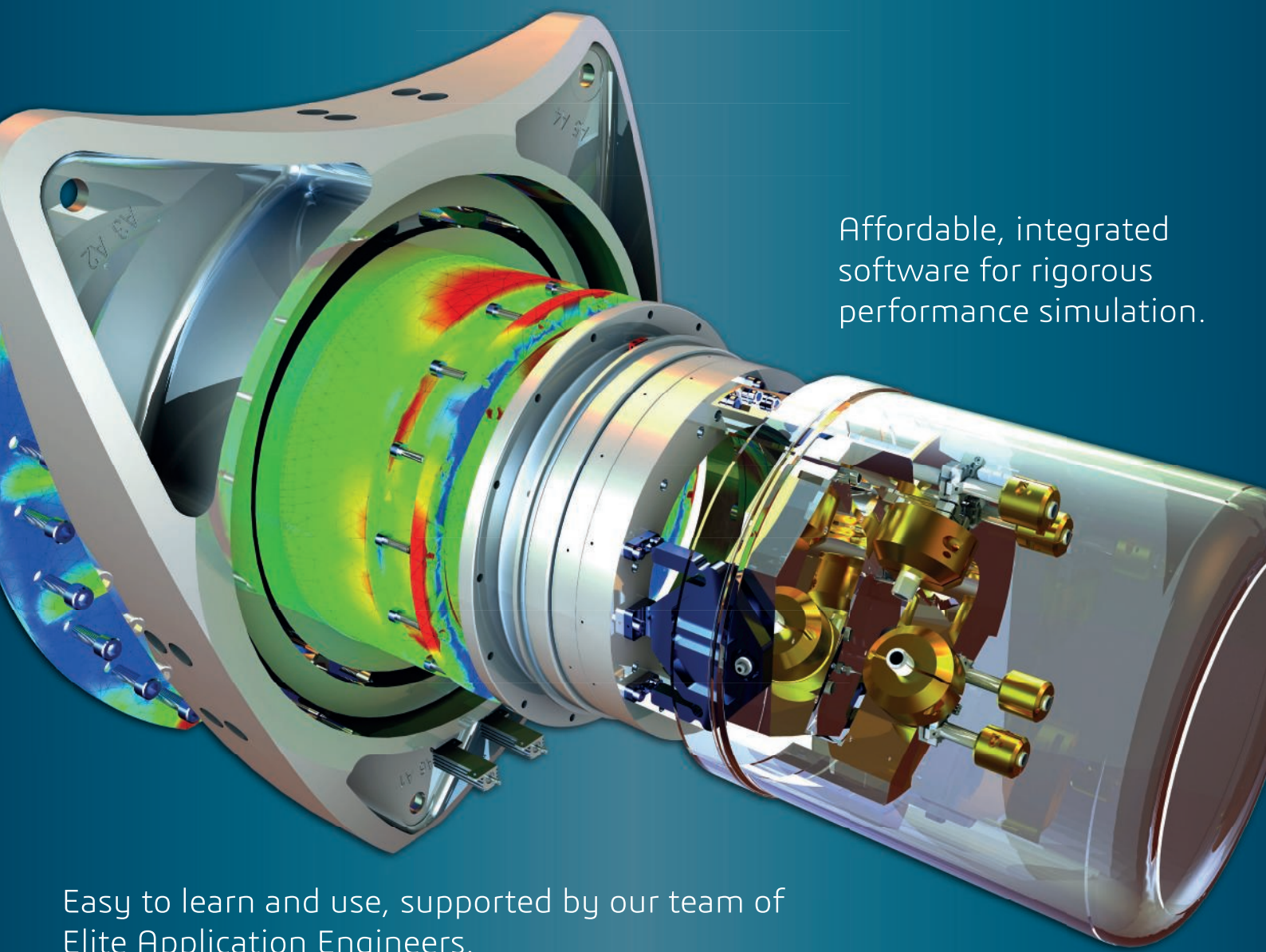

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CV

Previously, Mascarenas served as Chief Technical Officer and Vice President at Ford Motor Company. In that role, he led Ford's worldwide research organisation, overseeing the development and implementation of the company's technology strategy and plans. He also led the establishment of Ford's Silicon Valley Research and Innovation Center, which supports the company's vision to provide uncompromised personal mobility for people around the world.

A fellow of the Institution of Mechanical Engineers, Mascarenas was elected a fellow of the Society of Automotive Engineers in 2009. He served as general chairperson for the 2010 SAE World Congress and Convergence and has served on the FISITA board since 2012.

Mascarenas holds a Mechanical Engineering degree from the University of London, King's College. In 2015, he was awarded an OBE for his services to the automotive industry.

Accelerating towards autonomous autos

The automotive industry, technology wise, is motoring along quite nicely, but is the industry, or the public, ready to take the next step towards autonomous vehicles? Tim Fryer puts the questions to FISITA's Paul Mascarenas.

The International Federation of Automotive Engineering Societies (FISITA – that's the Fédération Internationale des Sociétés d'Ingénieurs des Techniques de l'Automobile) is a global automotive body that brings together institutions, societies and federations from around the world. Its president Paul Mascarenas oversees membership that comprises both member societies like the Institution of Mechanical Engineers, the Society of Automotive Engineers and the BDI in Germany, with around 200,000 individual automotive engineers around the world represented.

FISITA's mission is to promote knowledge sharing among its members in a way that positively contributes to the development of safe, sustainable and affordable mobility solutions that guide the future direction of the automotive engineering profession. So what does he make of the UK and of the future of the automotive industry at large?

Firstly, Mascarenas points out, the UK's automotive sector has started to reverse the downsizing of the industry that started in the early eighties. "I think recently, particularly with the UK Government initiative around the Automotive Council, the availability of financial incentives and improved competitiveness in the UK, we've seen the start of a comeback both in terms of manufacturing and engineering," he said. "And now with the drive towards intelligent and connected vehicles or autonomous vehicle development, including the infrastructure, and being on the leading edge of many alternative forms of mobility and next-generation mobility solutions, I think the UK is really very well positioned. It's very exciting to see that coming back, and it gives me a lot of optimism for the future."

There are many technologies that contribute to making a vehicle semi-autonomous, such as adaptive cruise control, lane-keep assist or automatic braking. Some of these features are starting to appear in premium models and even migrate down as standard features in more affordable vehicles. Some features, like advanced emergency braking, are becoming legal responsibilities for manufacturers – since November 2015 new heavy goods vehicles are required to have this fitted as standard.

"I think the rollout of semi-autonomous or highly automated driving features is moving very quickly," said Mascarenas. "And they really provide the building blocks, in a technical sense, for higher levels of automation because they allow you to control the throttle for powertrain controls and therefore the speed, and they allow you to control the braking, the steering and so on. So you've got both the sensing capability and the actuators on the vehicle to provide much higher levels of autonomous function."

The two key component families are the actuators and the sensors. And while the technology behind the actuators is reasonably established and robust, the sensors, claims Mascarenas, do need to have the higher capability which then needs equally robust software algorithms.

"I feel a momentum and an energy around automotive like I haven't felt for many, many years now - it's great to see."

"These combine to allow the vehicle to anticipate or predict what other vehicles, a cyclist, person or even what an animal might do, in much the same way that a human driver is able to," said Mascarenas. "That is what starts to differentiate these very highly automated driving features, which are fundamentally based on line of sight type sensing – so cameras, radar, LiDAR – from the more advanced type of sensing that's building an entire image in three dimensions of the world around it. And starting to use predictive algorithms to anticipate what others might be doing as opposed to just controlling the path of the vehicle.

"The fundamental technologies are there. They need advancement in terms of cost because these sensors are at a development level and are extremely expensive. They need to be driven down to levels where they would be affordable on regular vehicles. But also, they need a lot of development in terms of being able to ensure the statistical reliability of those systems in terms of detection and vehicle behaviour."

The building blocks, then, are there but need further refinement before the fully autonomous vehicle becomes a regular sight on our city streets. But how long will this take?

"You've already got companies like Tesla providing a very advanced level of automation on the vehicles that they have in production," said Mascarenas, "But I think we'll go beyond that in the next five to 10 years. I think it's still going to be a long time before vehicles that, for example, don't have steering wheels, don't have pedals and so on, are available to the general public, if ever. I think they are more suited to public transportation networks."

Which brings into question the reason for having autonomous vehicles in the first place. Is it for safety, for efficiency, or is it about mobility for the masses?

"They're all motivators," said Mascarenas. "With safety, there's the vision of cars that can't crash or at least are very unlikely to. That's driven by the number of fatalities around the world, still well over 1 million a year are killed in automotive related accidents. Just in the US alone, something like 35,000 people a year are killed in vehicle accidents. So we can use either full automation or high automation to significantly reduce the number of fatalities.

"Somebody right now who is 10 years old and is used to doing everything on a smartphone might have a completely different view on transportation in the future, they might not want the hassle of owning a vehicle."

"Secondly, efficiency, which is really two things. One is more efficient operation of the vehicles in the sense of energy usage, whether it's fuel economy and emissions on petrol engine vehicles, or whether it's better utilisation of battery electrical energy on an EV. Or we can mean efficiency in the sense of reducing congestion.

"And then thirdly, just from a pure mobility perspective, being able to deliver to the end user a mobility experience which is more relaxing, more convenient, more comfortable than driving oneself. Now you can use the time when you're in that vehicle in either a more productive or entertaining way."

Indeed, the notion of directly replacing our existing, personally owned vehicles with autonomous ones is not the way forward according to Mascarenas. Currently people use their cars typically for maybe an hour in the morning to go to work, an hour coming back and for recreation at the weekend. Maybe 10% of the time.

"The advantage of an autonomous vehicle is if you can put it into a public or shared service, you can really significantly increase the utilisation of those vehicles," he said. "You imagine if you pushed it up to 80% or 90% as opposed to 10%. That reduces the number of vehicles in total that are on the roads. So you get a compounding effect in terms of reduced congestion, reduced environmental concerns and so on.

"If you just think of population growth, density in terms of urbanisation, the numbers of vehicles for congestion that we see, I think anything that can actually reduce the number of vehicles in operation, whether those vehicles are driven by a human driver or whether they're driven by computer, has to be a good thing."

Beyond the direct technology required to create autonomous vehicles there are other issues that will inevitably need to be looked at. This will include privacy, as passengers will be entering a network when they get into the vehicle, and also security of that network from potential hackers. Also liability issues if there is an accident is something that will cause potential operators and manufacturers sleepless nights.

"So as well as the involvement of engineers around the world, clearly the legislators and regulators are equally involved," explained Mascarenas. "The ability to win the race is totally dependent on the technical community and the regulators coming together to provide the necessary ecosystem. And I think actually the UK is doing all of the right things."

He highlights the work of organisations such as the Transport Systems Catapult developing the infrastructure and the Automotive Propulsion Centre looking at the vehicles themselves, pulling on resources of other initiatives like the Digital Catapult. Despite this there remains a problem that affects many other parts of the engineering sector; getting the right skill set to take advantage of the opportunities.

"Historically automotive engineers have been mainly mechanical engineers," said Mascarenas. "But if you look at the technologies [for autonomous vehicles], there's a rapid need for a different skill mix. There's more dependency on electronics, on controls engineering, on software, on information technology. So when we talk about suitably qualified and experienced people, we're sort of casting the net broader than just the traditional definition of largely mechanically qualified engineers.

"It's a very competitive time because the auto industry is competing with other industries for those types of skills. You've got the obvious consumer electronics industry for the software engineers, you've got aerospace for the controls engineers, and in fact industrial applications as well. One of the things that we do at FISITA is to help promote a career in automotive engineering as an attractive, challenging, engaging, rewarding career for young engineers to consider."

It could be that this new generation of engineers will be ideal for the task as they may well be the ones who embrace this different route for the transport sector. It could be, after all, that young people may be the most open to change when they are currently faced with the expense of learning to drive, buying a first car and then having to insure it.

As Mascarenas concluded: "They might actually not want the hassle of owning a vehicle. I think that generational change is what is more likely to drive the adoption of these types of technologies than is a shift of today's existing drivers into something different."

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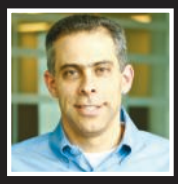
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The digital twin creates a fully symbiotic relationship between the virtual and the physical across the product's whole life cycle to bring hidden benefits that engineers never thought existed.

The impact of the digital revolution on product development has been exponential in the last 25 years. Today, tools are capable of simulating products accurately and without considerable cost. Cloud technology has meant businesses and manufacturers of all sizes are able to create virtualisations of products without having to buy serious infrastructure.

As computing power and connectivity increases we are able to build a 'digital twin' that is a complete virtualisation that lives and evolves as physical products live and evolve. It is a concept of physical and virtual objects co-existing in the world, connected by networks, communicating between one another allowing and enabling seamless streams of information to be shared, controlled and passed between the two models.

The concept of a digital twin requires sensors and components to provide real time data for multiple inputs. The fusion of technology, fast networks and significant computing power enables such information to be processed and acted upon. The more computing power that is used, the more real-time the interaction. So with more ubiquitous computing power comes more applications, processes and diagnostics that will further enhance, evolve and expand the concept.

In some cases the physical model is created completely from the digital model, for example a car. Aspects of the digital data are then used throughout the life of that vehicle until the end of both the physical and virtual products. Therefore the digital model lives in parallel alongside the physical model. As the physical or virtual model evolves the changes are passed onto its opposite number. The benefits and advantages of the digital twin are numerous to both the manufacturer and the consumer. For the manufacturer, having a digital twin of the whole production system has the potential to significantly enhance cost efficiency and productivity.

By equipping a factory with completely virtualised assembly lines and materials, manufacturers are able to collect data reflecting and measuring their operating systems, which allows the optimisation of labour while developing the most proficient prototypes for cutting. Once outside the factory, the digital twin will allow the manufacturer to monitor the real time performance data of a product to support the research and development of future models as

well as understand and foresee the existing product's maintenance problems.

For the consumer, the advantages of the digital twin are centred on the ability to give the user more control and interactions with the product. The development of a digital twin ensures that the consumer doesn't need to be within the physical space of the product to interact with it, as they can have control in the virtual space.

For example, Tata Technologies is helping one of its global automotive clients to gain a competitive industry advantage through the digital twin concept. New models enable its drivers to start their car and turn on its heating on a cold morning from their phones in the comfort of their own kitchen while having a cup of tea.

The ability to interact and control products, such as the car, is just the start of the potential impact of the digital twin concept. Digitalisation can be used to control transport infrastructure and even the running of an entire city.

Virtual Singapore, a £36m research and development programme launched in December 2014, aims to create a digital 'master model' to contextualise the big data collected by the 'smart city' in order to better evaluate the impact of processes such as traffic optimisation, planning infrastructure development and risk management.

Closer to home, digitalisation must play a prominent role in the UK Government's Northern Powerhouse strategy, as a smart and connected region is integral to creating a stronger and greener, more sustainable local economy.

However, trust remains a major constraint to the growth of the digital twin concept. A cultural change is needed if decision makers are to embrace the role and importance of the virtual space. It should not be underestimated what smartphones have already achieved in helping society to understand and trust the ability of technology to intuitively improve everyday life.

However, much more needs to be done at a commercial level. It is the role of industry specialists, such as Tata Technologies, to educate and reassure manufacturers about the advantages and the benefits of developing and utilising a digital twin, as well as ensure that digitalisation is as vertically integrated throughout a product's supply chain as possible.

As trust and education continue to advance, the next exciting development will be complete collaboration in the control of the virtual and physical spaces. Having a single entity controlling both worlds will help to remove all duplicity – the holy grail of product development. However, there is likely to be a battle around who gains this control. In the automotive sector, as Google and Apple seek to establish their presence in the industry through the self-driving car, German manufacturers Audi, BMW and Mercedes have acquired Nokia's navigation system, HERE Maps, to gain back control of their information systems.

The best way to manage this evolution may well be through regulations and licensing rather than propriety development. However, it is clear that manufacturers will not want to lose access to the information that a digital twin provides as they increasingly embrace the role of digital telepathy.

This article was written by Phil Botley, technical manager, ICEM Products, at TATA Technologies
www.tatatechnologies.co.uk

The 'Digital Twin' concept is one that is being explored by various CAD companies and their supporting industrial partners. The basic premise is the same: create a digital companion for the physical product that is continuously updated with real world data, gathered by sensors on the product that are connected to the internet.

It is a continuation and sub-group that comes under the general banner of the Internet of Things, and brings in elements of augmented reality that blend both the physical and digital worlds. 'Things', or products as non-marketing people might say, are increasingly becoming connected. Nest and Hive are 'smart' thermostats, JLR is building apps that allow its cars to be controlled by phones, and a host of technology start ups are targeting anything and everything.

There are heavyweights involved ready to provide the hardware, systems and software including General Electric, National Instruments, and PTC. Many are keen to leverage the technology to improve design, manufacture, servicing, or indeed all of the above by developing 'digital twins'.

PTC has been increasingly keen to develop its software products to enable engineers to integrate the connectivity and sensors needed to make them smart. CEO Jim Heppelmann explained the strategy. "We really don't learn much about what the customers' experience is," he said. "How does our design operate, what bits do users like or not use? We have had very little feedback, traditionally, once products leave the factory. In most cases, you don't know anything about how it is actually being used or how it's working, unless a customer calls you when there's a problem.

"The digital data and information in CAD designs, historically, only flows in one direction, from the engineer, to the factory, to the customer. It is a lifecycle that flows from digital to physical, but it doesn't flow back. There is a brick wall that separates the world of digital and physical. These worlds are distinct and separate."

But, 'things' are changing this. PTC has made a

Two worlds collide

Physical products are about to get a digital doppelganger that is going to follow them around. The concept might sound a bit abstract, but many feel this is a natural evolution as more smart connected devices come to market. Justin Cunningham finds out more.

series of acquisitions in the last 24 months to the tune of $600 million to build a new product portfolio that reflects this change to product design and functionality.

"We are going to help our customers build the next generation of transformative products," said Heppelmann. "This new reality is part physical and part digital all at the same time, it is a new experience, and is the yin and yang of these worlds coming together. We are going through the biggest product metamorphosis we have seen in decades."

This evolution means that while the physical and digital aspects of a product remain distinct, they will be inseparable. It means that anything that is learnt from the physical world can be brought in to the digital world, and vice versa.

To demonstrate this notion, PTC has taken a traditionally simple, non-smart or connected product, the humble push bike, and made it a digital twin. Mike Campbell, heading up PTC's new Digital Twin group, explained: "This is a great example of a mechanical design, that we have retrofitted with Intelligence. Seven sensors and connectivity allow us to monitor and measure different attributes of the bike, tracking things like the wheel speed, angle of the handle bars and compression of the suspension."

"There is a brick wall that separates the world of digital and physical. These worlds are distinct and separate."
Jim Heppelmann, CEO, PTC

The sensors feed in to a National Instruments MyRio to collect the data and provide the connectivity to stream it up to the cloud. Thingworx, acquired by PTC in 2014, can then be used to create a 'dashboard' to tell designers and engineers about the bike. From anywhere in the world, engineers can see what is going on with a real product.

The digital twin will bring together PLM, IoT and CAD all at the same time. Data can be streamed off the bike and presented on its digital twin. The model is no longer a virtual prototype or idealised model, it's an exact digital replica of what is actually happening to the bike.

It's possible that the information could be gathered for 1000s of bikes so engineers can see what the failure modes are, how components age and how that effects different components, and if the design assumptions are accurate or not.

"There are hundreds of applications here for service to sales," concluded Heppelmann. "It is a powerful idea. You can capture a given scenario and then replay that against future integrations of the design to see how it compares."

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'Digital twin' brings together the digital and physical design worlds with augmented reality (left) showing real world data that can be harvested en masse, and utilised in the future to improve products

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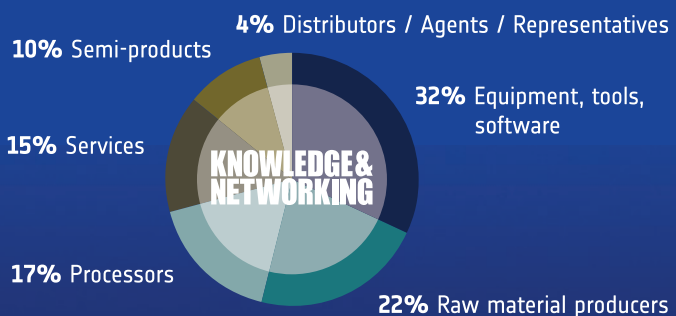

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Something to smile about

There is no toilet humour in Madagascar's sanitation problems. But, as Tim Fryer reports, a British design team has given the locals something to smile about.

According to Water.org, about 2.6 billion people, approximately half of the developing world's population, lack even a simple 'improved' latrine and 1.1 billion do not have access to improved drinking water. These people obviously inhabit the poorest countries and the ninth poorest country in the world is Madagascar, which unlike most of the countries below it in the list is not in a state of conflict, it is just inherently poor.

From a sanitation perspective around 22 million of Madagascar's 24 million population don't have access to a safe toilet – i.e. improved sanitation that meets health and safety standards. What is more is that every year much of it is prone to flooding, meaning buried waste does not stay buried for long. It is a massive problem.

A start-up in South London has developed a solution and trials in Madagascar's capital, Antananarivo, have already proved promising. It started at the Royal College of Art with a master's degree project from Virginia Gardiner, who is now CEO of Loowatt.

The philosophy was not just to create a toilet, but a whole closed loop system that produces energy and fertiliser rather than waste. There are several components to this system – the toilet itself, waste collection and the processing of that waste.

The clever bit is the design of the toilet. Kaitlin Zhang, public relations and brand manager at Loowatt, outlines the operation: "It has a biopolymer film inside it, and that is taken down through the toilet in what we call a 'flush' by the mechanism inside, and that's where the first one of our patents is based. And then that waste is captured within that film, and that means that anyone handling it doesn't come into direct contact with that waste."

Tsiky, the Malagasy word for 'smile' is the name given to these toilets, and another reason to smile is that the flush system creates a continuous mechanical seal, which means that odours do not come back up. "This is quite exciting, because that's one of the things that we wanted to solve," claimed Zhang.

Clean Tech Partner Program

The Autodesk Clean Tech Partner Program supports early-stage clean technology companies by providing design and engineering software that accelerates their development of solutions to the world's most pressing environmental challenges. Clean tech companies can benefit from Autodesk solutions for Digital Prototyping and can receive up to €120,000 worth of software for only €50.

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An installed unit (left) and Chris Holden testing the 'flush' mechanism

Two years ago the company was growing fast as it progressed from prototyping to the trialling stage. One thing requiring resolution was the quality of the finish in the end product.

"We were looking at the issues of ramping up quickly, understanding the product lifecycle and putting good systems in place," said Chris Holden, the company's head of design. "We were also in some respects starting afresh in terms of the design because we didn't have a particularly great finish to the product. So we were looking at that and just came across the opportunity that Autodesk had with Clean Tech Partners that fitted really well. It actually really suits us because we have an engineer and a designer in Madagascar working on things like the superstructure."

The superstructure may need to be altered for an installation depending on how the Tsiky is sited. As the Clean Tech Partner programme allows licenses up to a certain value, the teams are able to work in separate locations, but on the same designs, without having to pay for additional software.

Another interesting aspect of the project is how the company is supporting the project in Madagascar. Already there is an operational team of 14 on the African island, but that doesn't get round the problem of what happens when something breaks or additional parts are required.

"What we've seen from our work in Madagascar is that the supply chain is one of the most difficult things to get right," admitted Holden. "There is little manufacturing infrastructure and shipping parts from the UK involves time - no one wants to wait for a toilet to be fixed - and the cost of imported parts can carry a hefty tax of up to 40%."

The solution lies in additive manufacturing. Holden said: "We've been printing parts since we started because of how convenient it is and it provides pretty good value as well when you want to make custom parts in small volumes. It's an option we're definitely going with in the short term and what we want to find out is does it translate into a large-scale solution for us?"

Currently the company has an Ultimaker in the UK for prototyping and a RepRapPro printer in

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Glamping at festivals

A summer music festival in the UK does not initially bear any comparison to Madagascar's poverty – it might be seen as a snapshot of winners and losers in life's lottery. But one recurring complaint of festival goers is the provision of clean toilets. This is turning into a potentially lucrative business for Loowatt as it shares the same attributes that are required in Madagascar – no power and no water. Loowatt is offering its toilets as a service to such events, and tying it in with 'pampering services' – a premium pampering package with luxury loos!

Madagascar, mainly used for printing the flush mechanism gears and associated components.

Loowatt has designed a small digester (25m^3) but there is no reason why other commercial operations cannot be used. The key point is that the bag material is biodegradable ensuring that from toilet to digester there is no part of the cycle where waste is exposed to come in contact with users or operators.

Zhang explained how the waste is processed: "A biological process [anaerobic digestion] first of all breaks all the waste down to acids and then micro-organisms eat the acids and creates biogas." Biogas is two thirds methane, which is clean burning and used to make electricity.

"But then you have the liquid by-product, which after digestion is around 95% pathogen-free," continued Zhang. "But in our new treatment facility we pre-pasteurise the waste, so that we make sure there are no harmful pathogens going in, in the first place. Pasteurising it means you can use it as a direct fertiliser."

To take this one step further, Loowatt is exploring the options for adding composting processes and improving the quality of the end product by using worms. Although it may seem obvious to use this fertiliser directly in the community, not all people grow their own produce. The nitrogen, phosphorus and potassium (NPK) content of the end product can therefore give it a market value.

The real value will be in improving hygiene in Madagascar and already 40 units, serving 260 people have been installed in the capital in a project funded by grants from the Bill & Melinda Gates Foundation's Grand Challenges Explorations initiative.

www.autodesk.co.uk
www.loowatt.com

Fastener production forges into the future

Saving weight and material, improving component strength and boosting productivity are key considerations for any futuristic design. Paul Gay identifies some benefits of metal forging fastening components, rather than machining them, to enable engineers to keep up with the trend.

In industry today, complex metal components can be forged completely with the need for only minor finishing operations, thus keeping machining operations to a minimum. Because these parts cannot be manufactured in a single operation, the work stock is taken through a series of forging operations that alter the geometric shape of the material in stages until the desired forging is achieved.

Thread rolling is a metal rolling process used extensively by the manufacturing industry to produce screws, bolts and other fasteners. A common thread rolling process, used in industry to manufacture threaded parts, involves forming the threads into the metal of a blank using a pressing and rolling action between two die. The die surfaces hold the shape, while the force of the action forms the threads into the material.

Thread rolling offers higher productivity rates than manufacturing threaded parts by machining, the alternative method to manufacture the parts. And, thread rolling has several other benefits over machining. Forming will harden the metal through cold working, does not waste material by cutting, and produces a favourable grain structure to strengthen the part with respect to its function.

Why forge?

A cast structure will typically contain defects such as some porosity caused by gases, shrinkage cavities and solid inclusions of foreign material that becomes trapped in the metal, such as metallic oxides. By rolling a metal above its recrystallization temperature, grain boundaries are destroyed and new tougher ones are formed, along with a more uniform grain structure. Metal rolling pushes the material so it closes up vacancies and cavities within the metal. Hot rolling also breaks up inclusions and distributes the material throughout the work piece. The advantages of metal forming are not just in the creation of useful geometric forms but also in improved material properties.

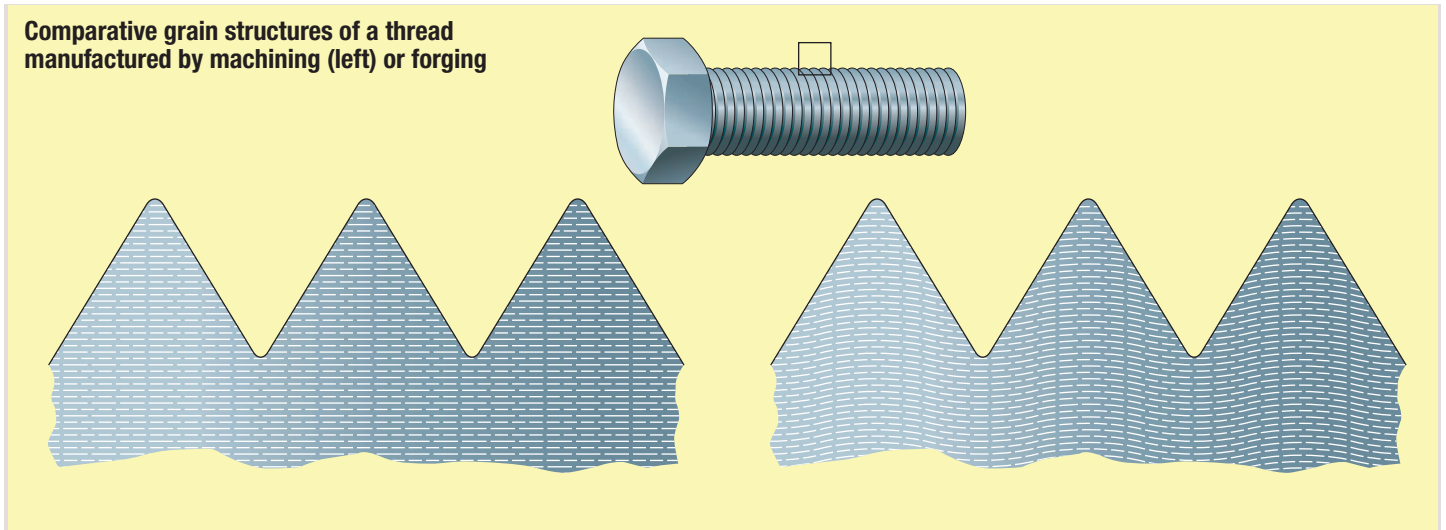
In cold rolling, a part can be worked to create grains oriented in a direction such that they give directional strength to a part useful to that part's specific application.

An example of this can be the difference in grain structure between the threads of a machined bolt and a rolled bolt. The favourable grain orientation of the cold rolled bolt will give it directional strength beneficial to its application.

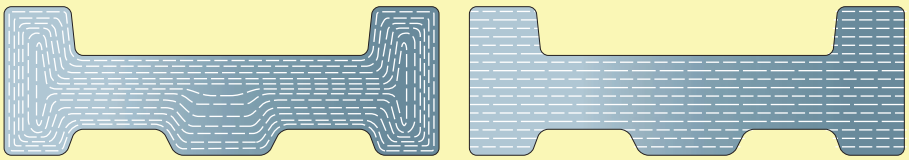
Metallic properties are altered with a change in temperature so the material will react differently to the same manufacturing operation if it is performed at different temperatures. The manufactured part may then possess different properties as a result.

In industrial metal forming manufacture, there are three basic temperature ranges that metal can be formed: cold working, warm working, and hot working.

Comparative grain structures of a thread manufactured by machining (left) or forging



Components manufactured by forging exhibit a grain structure which can enhance the part's strength



Cold forming is carried out at room temperature, or a little above it, and during the process plastic deformation of the work causes strain hardening. The yield point of a metal is also higher at the lower temperatures, hence the force required to shape a part is greater in cold working than for warm or hot working.

At cold working temperatures, however, the ductility of a metal is limited and only a certain amount of shape change may be produced. This is one of the main disadvantages of this type of process, but there are many advantages to be gained. The part will be stronger and harder due to strain hardening, as cold forming causes directional grain orientation, which can be controlled to produce desirable directional strength properties.

However, fasteners manufactured by cold forming can be created with more accurate geometric tolerances and generally yield a better surface finish. In addition, a large amount of energy can be saved and faster production is possible, since low temperature metal forming processes do not require the heating of the material. Despite the higher force requirements, the total amount of energy expended is much lower in cold working than in hot working.

Warm working is a metal forming process carried out above the temperature range of cold working, but below the recrystallization temperature of the metal. Warm working may be preferred over cold forming because it will reduce the force required to perform the operation, and also the amount of annealing necessary, compared to a cold formed part.

Hot forming is a process that is carried out at a temperature range that is higher than the recrystallization temperature of the metal being formed. The behaviour of the metal is significantly altered, due to the fact that it is above its recrystallization temperature. Utilisation of different qualities of the metal at this temperature is the characteristic of hot working.

Advantages and disadvantages

Although many of these qualities continue to increase with temperature, there are limiting factors that make overly high temperatures undesirable.

During most metal forming processes, the die is often cold or slightly heated. However, the metal stock for hot working will usually be at a higher temperature relative to the die. For metal forming manufacturing, in general, the temperature gradient between the die and the work has a large effect on metal flow during the process. The metal nearer to the die surface will be cooler than the metal closer to the inside of the part, and cooler metal does not flow as easily. High temperature gradients, within the work, will cause greater differences in flow characteristics within different sections of the metal, and these could be problematic.

Another consideration is that the higher the temperature needed to form a component, the more reactive the metal is likely to be. Also if a part for a hot working process is too hot then friction, caused during the process, may further increase heat to certain areas causing melting, in localised sections of the work, which is clearly not desirable.

When above its recrystallization temperature a metal has a reduced yield strength, also no strain hardening will occur as the material is plastically deformed.

Shaping a metal at the hot working temperature range requires much less force and power than in cold working. Above its recrystallization temperature, a metal also possesses far greater ductility than at its cold worked temperature. The much greater ductility allows for massive shape changes that would not be possible in cold worked parts. The ability to perform these massive shape changes is a very important characteristic of these high temperature metal forming processes.

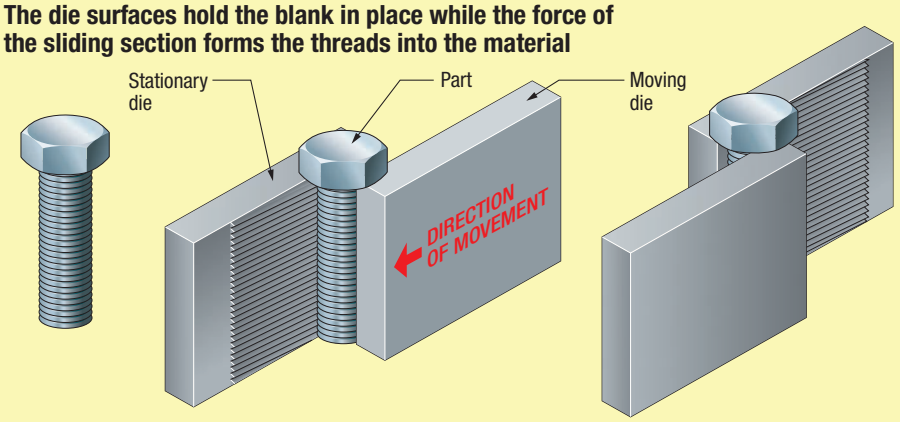
The metal will recrystallize, after the process, as the part cools. In general, hot metal forming will close up vacancies and porosity, as well as break up inclusions in the metal by distributing the material throughout the work piece, destroying older, weaker, cast grain structures to produce a wrought isotropic grain structure.

These high temperature forming processes do not strain harden or reduce the ductility of the formed material. But, strain hardening of a part may or may not be wanted.

Complex metal parts can be forged completely with the need for only minor finishing operations, even though these parts cannot be manufactured in a single forging. The work stock needs to be taken through a series of operations that alter the geometric shape of the material until the desired component is fashioned.

There are many possibilities and trade offs that can be made, and there is no clear beneficial method of production. It all depends, of course, upon the application.

The die surfaces hold the blank in place while the force of the sliding section forms the threads into the material



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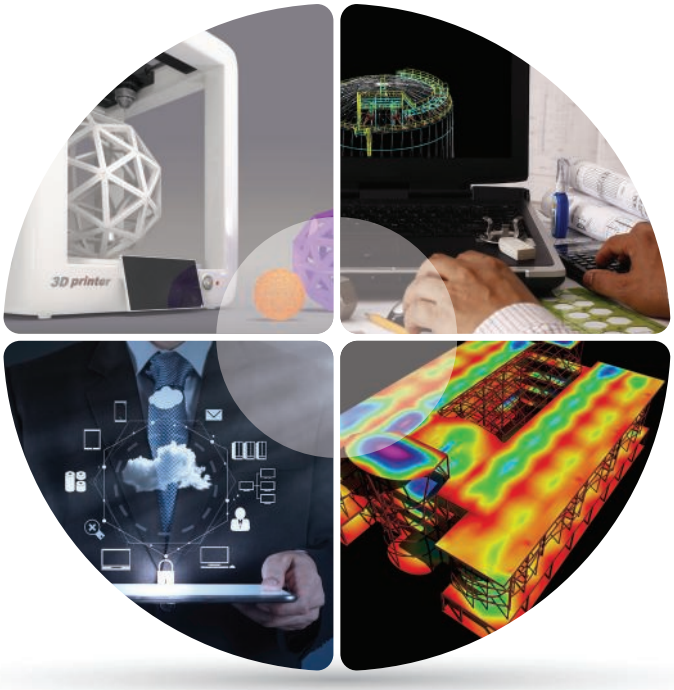

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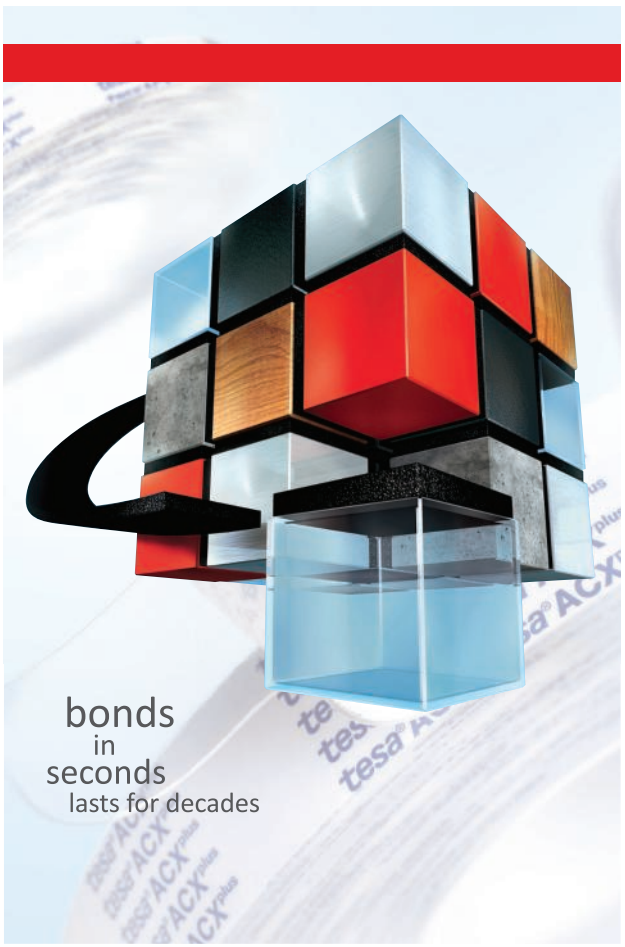

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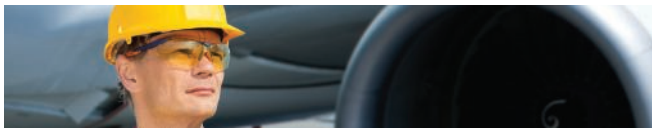

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A **space** oddity

It is a fundamental question most people, at some point, have asked themselves: 'Are we alone in the universe?' While the specifics of alone probably vary greatly from little green men to bacteria, it is the latter that the European Space Agency's (ESA) ExoMars mission is looking to shed light upon. Justin Cunningham reports.

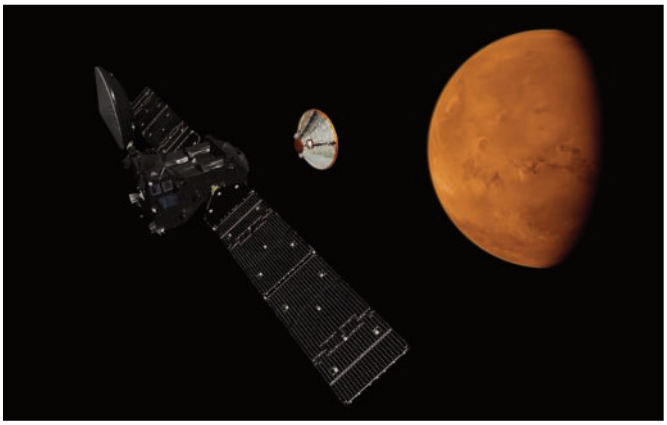
It seems ExoMars could not escape the standard medley of indecision and confusion that has, unfortunately, become the norm for large space projects like this. It has resulted in years of delay and concept iterations, and a circus of planning and financing problems continue to cause problems.

Despite all this, ExoMars is, without doubt, the most ambitious European-led space mission to date. While the project initially had heavy US involvement, it is now partnered with the Russian space agency, Roscosmos. Despite the US completely dominating Mars landings and rover exploration on the planet's surface, could it be Europe (and Russia) that will be remembered in the history books with the ultimate accolade, 'first to confirm life on another planet?'

"We are about to begin a new era of Mars exploration for Europe," said Alvaro Gimenez, ESA director of science and robotic exploration. "It's been a long road for ExoMars to reach this point, but we are now ready to launch in the spring."

The name ExoMars states its core mission: examine the exobiology of Mars. It wants to shed light on that fundamental question, whether life is possible elsewhere in the universe?

A suite of instruments, both on the surface of the Red Planet, as well as in orbit, will search for any and all kinds of 'bio-signatures' past and present. The array of equipment being deployed requires two separate launches, with the first scheduled for March this year.



This first mission will carry the 'Trace Gas Orbiter' or TGO. From an altitude of 400km, it will gaze down at the Martian surface and look for important trace gases such as methane, water vapour and nitrogen dioxide, which could represent signatures of active biological processes.

The TGO will also monitor seasonal climate changes in the atmosphere's composition and temperature in order to create and refine Martian atmospheric models. Its instruments will also map the subsurface for hydrogen, to a depth of a metre. This could reveal deposits of water-ice hidden just below the surface, which, along with locations identified as sources of trace gases, could also influence the choice of landing site for future rovers.

"Even though trace gases make up less than 1% of the atmospheric inventory, they provide key indicators to the nature of any active processes, helping us to determine just how

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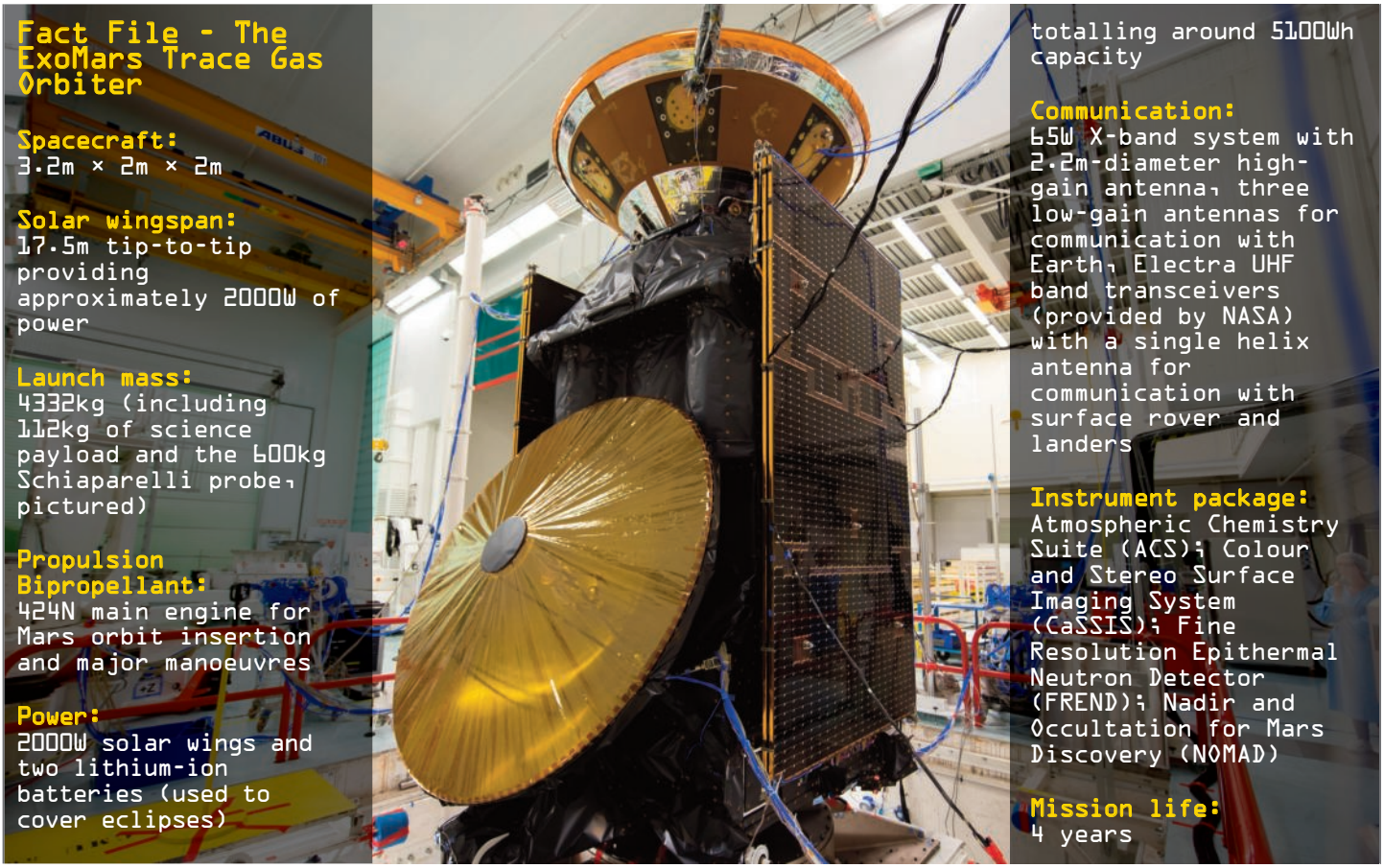


Fact File - The ExoMars Trace Gas Orbiter

Spacecraft:
3.2m × 2m × 2m

Solar wingspan:
17.5m tip-to-tip providing approximately 2000W of power

Launch mass:
4332kg (including 112kg of science payload and the 600kg Schiaparelli probe, pictured)

Propulsion Bipropellant:
424N main engine for Mars orbit insertion and major manoeuvres

Power:
2000W solar wings and two lithium-ion batteries (used to cover eclipses) totalling around 5100Wh capacity

Communication:
65W X-band system with 2.2m-diameter high-gain antenna, three low-gain antennas for communication with Earth, Electra UHF band transceivers (provided by NASA) with a single helix antenna for communication with surface rover and landers

Instrument package:
Atmospheric Chemistry Suite (ACS); Colour and Stereo Surface Imaging System (CaSSIS); Fine Resolution Epithermal Neutron Detector (FREND); Nadir and Occultation for Mars Discovery (NOMAD)

Mission life:
4 years

'alive' Mars may be today," said Håkan Svedhem, an ESA project scientist. "TGO will also monitor seasonal changes in the composition and temperature of the atmosphere."

Piggybacking on the TGO will be a small probe lander called, Schiaparelli. Reminiscent of the Beagle 2, the lander will remain static on the Martian surface once it has completed its troublesome descent.

Donato Amoroso, deputy CEO of contractor Thales Alenia Space, said: "The entry, descent and landing module for in situ exploration of Mars entails huge technological challenges."

While it doesn't have anywhere near the instrumentation of Beagle 2, it hopes to do the one thing that Beagle 2 didn't, land in one piece.

Mars has a reputation for destroying spacecraft and landers, and ESA does not want to travel all that way to suffer the same fate. Schiaparelli is essentially a dummy run to test the landing systems and protocols.

Schiaparelli will collect valuable data on the landing orientation, control during descent and touchdown velocity as well as test some of the technologies being pioneered including the heat shield, the parachute system, a radar Doppler altimeter system, and crushable material for impact load attenuation.

Schiaparelli will enter the Martian atmosphere at 21,000kph, before being decelerated with the aid of a parachute. Finally, it will use a thruster system to gently land it on the ground. An instrumentation package called COMARS+ will monitor the heat flux on the back cover of Schiaparelli as it passes through the atmosphere with a Descent Camera (DECA) recording images of the landing site as it approaches the surface.

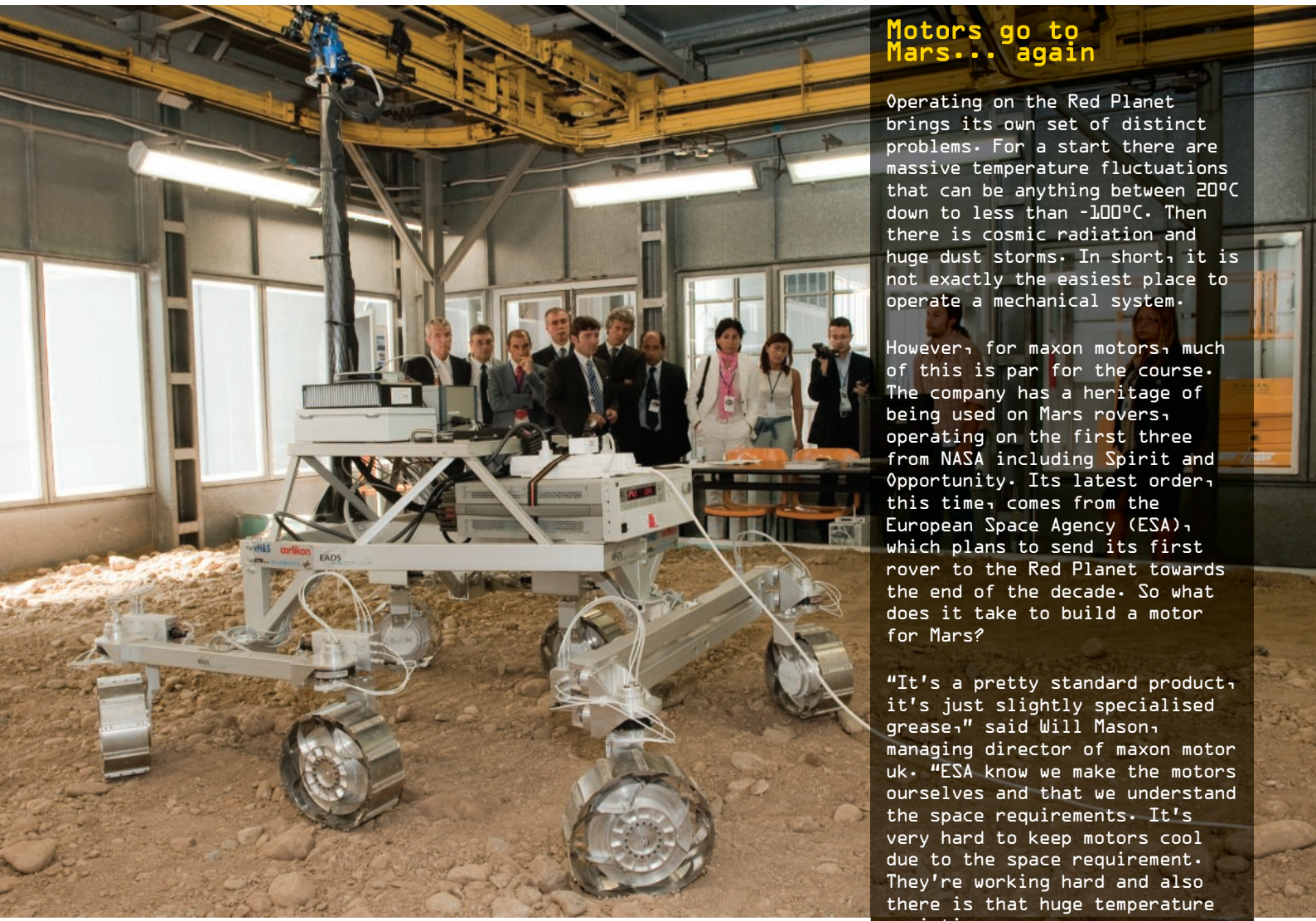
If Schiaparelli survives, as it is expected to, it will be able to transmit signals and apply its small sensor suite to analyse the local environment, until the remainder of its batteries are used up. TGO, along with ESA's Mars Express and NASA satellites already orbiting Mars, will relay data for the few days that Schiaparelli is expected to operate.

The surface payload is called DREAMS, standing for Dust Characterisation, Risk Assessment, and Environment Analyser on the Martian Surface. It consists of sensors to measure the wind speed and direction, humidity, pressure, atmospheric temperature close to the surface, the transparency of the atmosphere, and atmospheric electrification. The package will operate for between two to eight Martian days, known as sols.

Rover to follow

The follow up mission earmarked for 2018 is then set to cement Europe's transition from remote observation to surface exploration of Mars. The mission will see a full sized 4tonne rover and stationary Russian surface science platform landed on surface, to begin a search for exobiology. The ExoMars rover is expected to travel several kilometres during its mission and will be able to drill below the surface for samples, which will be able to be analysised onboard.

The primary objective is to land the rover at a site with high potential for finding well-preserved organic material, particularly from the very early history of the planet. The rover will establish the physical and chemical properties of Martian



samples, mainly from the subsurface, as underground samples are more likely to include biomarkers due to the effects of radiation and photochemistry on the surface.

The drill is designed to extract samples from various depths, down to a maximum of 2m. It includes an infrared spectrometer to characterise the mineralogy in the borehole. Once collected, a sample is delivered to the rover's analytical laboratory, which will perform mineralogical and chemistry determination investigations.

Jorge Vago, ESA's ExoMars 2018 project scientist, said: "At the same time, the rover will travel several kilometres to search for traces of past life below the surface. It's a very powerful combination of instruments."

To get it there, the rover and surface platform will be integrated together in a carrier module that will be launched on a Russian Proton Heavy Lift rocket. A descent module will separate from the carrier shortly before reaching the Martian atmosphere. During the descent phase, a heat shield will protect the payload from the severe heat flux. Parachutes, thrusters, and a damping system will reduce the capsule's speed, and allow a controlled landing on the surface.

After landing, the rover will disembark from the module via a ramp and is expected to carry out its search for at least one Earth year, enabling images of the landing site to be sent back to Earth, as well as data on the Martian climate.

ExoMars serves as reminder that exploration isn't something once done by those in the history books, but is something that engineers are doing today. This, could be, history in the making. Is there life on Mars?

Motors go to Mars... again

Operating on the Red Planet brings its own set of distinct problems. For a start there are massive temperature fluctuations that can be anything between 20°C down to less than -100°C. Then there is cosmic radiation and huge dust storms. In short, it is not exactly the easiest place to operate a mechanical system.

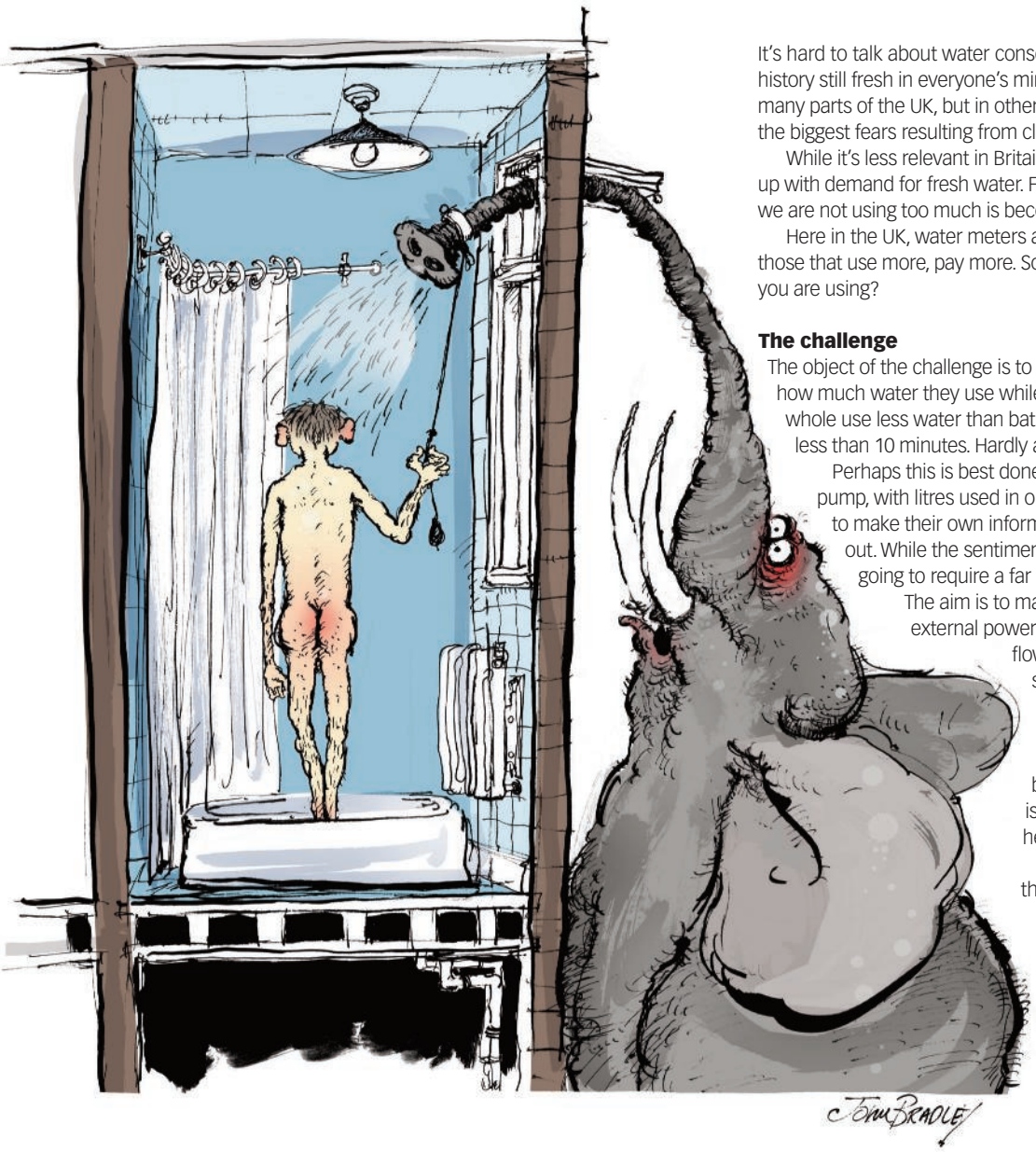
However, for maxon motors, much of this is par for the course. The company has a heritage of being used on Mars rovers, operating on the first three from NASA including Spirit and Opportunity. Its latest order, this time, comes from the European Space Agency (ESA), which plans to send its first rover to the Red Planet towards the end of the decade. So what does it take to build a motor for Mars?

"It's a pretty standard product, it's just slightly specialised grease," said Will Mason, managing director of maxon motor uk. "ESA know we make the motors ourselves and that we understand the space requirements. It's very hard to keep motors cool due to the space requirement. They're working hard and also there is that huge temperature variation.

"Also, a lot of our products are developed to not need adhesives, instead using laser welding to hold components together. If you use glues on dissimilar metals you get different rates of expansion and contraction, and that is how things fracture."

To overcome the problem of heat on the motors, maxon has designed in a front flange made of metal that is in turn bolted to something metal. This acts as a soak to dissipate the heat away. The company also limits the amount of current to the motors as that also creates excess heat.

Taking a shorter shower



It's hard to talk about water conservation with the wettest month in recorded history still fresh in everyone's mind. Widespread floods continue to harass many parts of the UK, but in other areas of the world water scarcity is one of the biggest fears resulting from climate change.

While it's less relevant in Britain, many parts of the world struggle to keep up with demand for fresh water. From cities to isolated homes, making sure we are not using too much is becoming an ever more pressing issue.

Here in the UK, water meters are continually being rolled out to make sure those that use more, pay more. So, how can you keep an eye on how much you are using?

The challenge

The object of the challenge is to make people aware, and ultimately reduce, how much water they use while taking a shower. Though showers on the whole use less water than baths, modern power showers can fill a bath in less than 10 minutes. Hardly an advert for resource efficiency.

Perhaps this is best done by using a screen that tallies up like a petrol pump, with litres used in one column, cost in the other, allowing people to make their own informed decision about when to finish and get out. While the sentiment is there, any such additional system is going to require a far bit of installation.

The aim is to make everything as efficient as possible. No external power source should be used, though the water flow itself can be used to produce power. Any solution should also serve to be advisory and not too prescriptive, so any thought of stopping the shower after 30 or 40 litres is far from ideal. With everything else becoming 'smart' these days, the challenge is essentially how to make a 'smart' shower to help with the issue of water conservation?

As always, your ideas are welcome - email the Editor at tfryer@findlay.co.uk.

Our solution to last month's Challenge, how to improve or reinvent the British three-pin plug, can be found on page 11 of this issue.

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Stainless Steels and Titanium are both prone to galling and seizing. WS2 is a very low friction dry lubricant surface treatment, developed by NASA for use in deep space. It has been shown to provide a very cost effective solution, preventing both problems on threads and other sliding surfaces.

WS2 works well from -273° to 450° C and down to 10-14 Torr. WS2 has been applied to bearings and gears to extend life.

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3D Electromagnetic Field Solver

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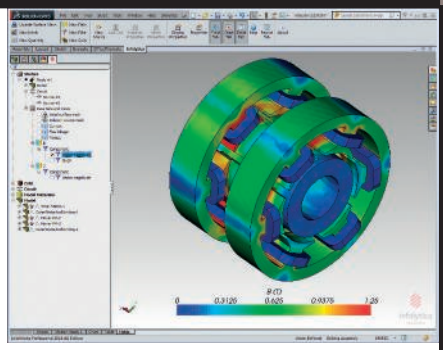

MagNet for SOLIDWORKS is the foremost 3D electromagnetic field simulator embedded in the industry leading CAD software. A combination beyond compare: just one design environment for drawing the model and analyzing the performance of any EM device such as power transformers, sensors, MRI, actuators, solenoids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

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

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

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

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