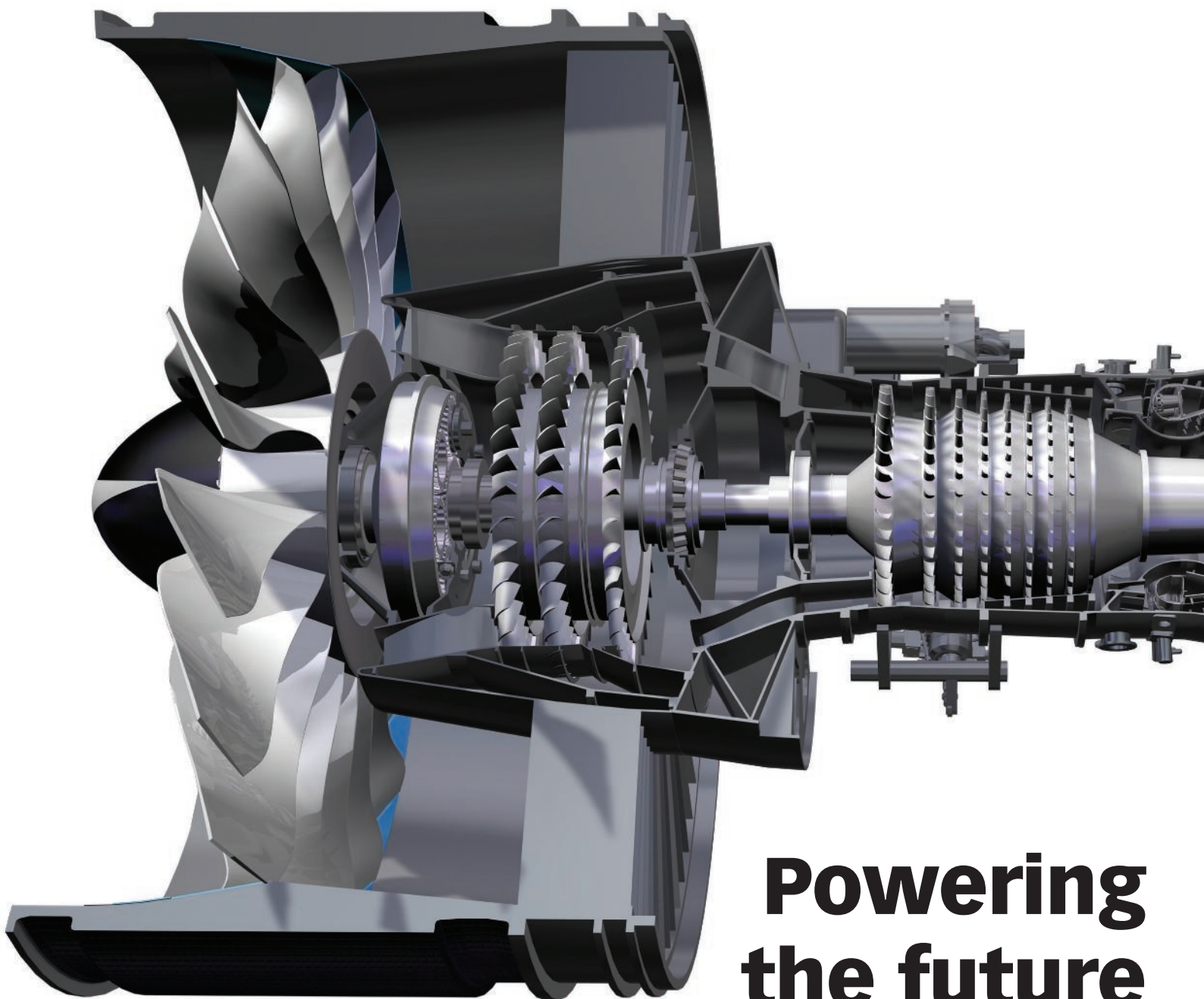


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In this issue: Bearings & Linear Systems • Sensors, Test & Measurement • Defence Special Report



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Designing tomorrow's
aircraft engines



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Elite Applications Engineer

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**Mark Wetherick, Drawing Office
Manager, Pascall Electronics.**

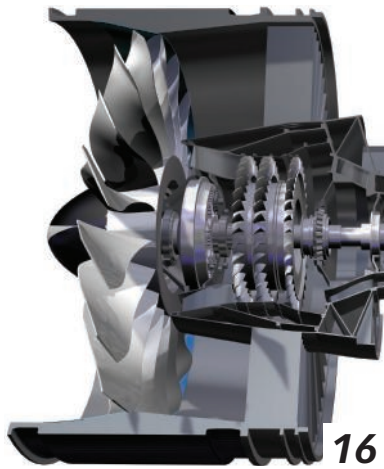
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Future aircraft engines aim to be as much as 50% more fuel efficient, while being lighter and more reliable. So how does an industry already at the forefront of technology plan to achieve this?

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This month's challenge seeks a zip fastener that is easier to use for those with limited dexterity.

+ PARTNERSHIP BASED ON TRUST –
AND TRUST BASED ON QUALITY



Bearings for pumps and compressors: maximum performance twinned with compact designs

Pumps and compressors are becoming more and more compact whilst also making advances in operating life, servicing intervals, energy efficiency and quiet running. These requirements present challenging demands for the bearings which are used. With NSK's extremely reliable high-quality ball and roller bearings, achieving even these demanding objectives is possible

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The lessons of experience



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

The opportunity to share information, experience and technical know-how is at the heart of any good industry event, be it an exhibition, conference or seminar.

Insights into the working lives of others are an invaluable tool for innovation. By hearing how other people in other disciplines and sectors have addressed and solved their problems, it becomes possible to see potential solutions to our own. This type of 'technology transfer' has always been at the heart of *Eureka's* editorial mission. We have always sought to offer inspiration to the design engineer from one of industry to their counterparts in another.

For this reason, when Findlay Media launched the Engineering Design Show in 2012, this philosophy was always at the heart of our wishes for the event. That is why, alongside the show itself, there has always been a high-profile Conference featuring speakers from leading innovators talking about how they do what they do.

The Engineering Design Show has grown hugely in the intervening two years, now incorporating the Electronics Design Show, Engineering Materials Live! and the Embedded Design Show. However, the commitment to a high-quality Conference programme has not changed one bit.

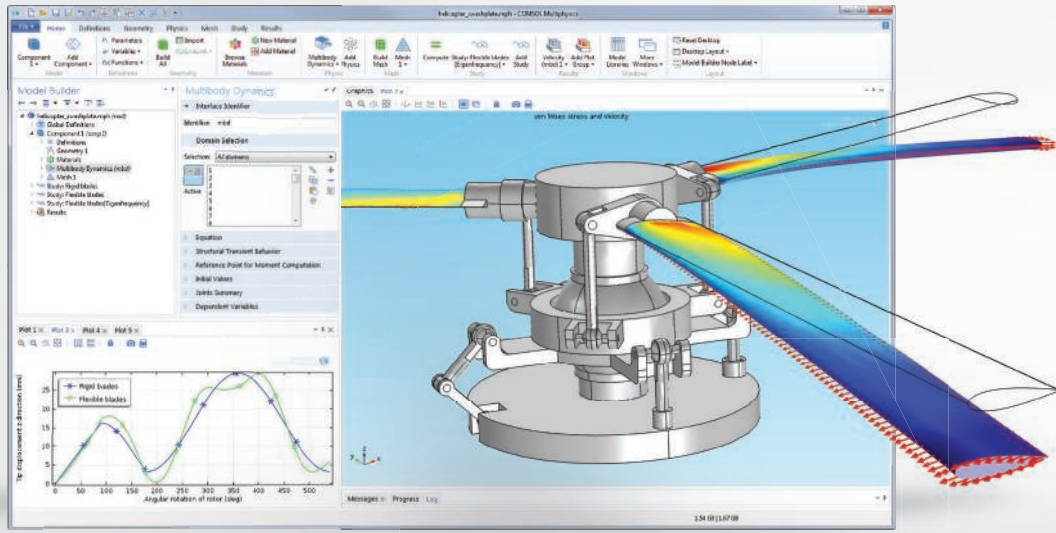
The truth of this can be seen from the Conference speakers we are announcing this month on page 26 of this issue. Here, you will find representatives of such illustrious names as GKN Aerospace, Infiniti Red Bull Racing, Rolls-Royce, Millbrook and Shadow Robot ready to grace the Conference on October 22nd and 23rd at the Ricoh Arena, Coventry.

From these illustrious individuals, we believe, delegates at the Conference will receive insights into industries, technologies, methodologies and disciplines that, while not perhaps their own, can nonetheless offer vital clues as to how to innovate successfully. You may not work in aerospace, motorsport or medical prosthetics, but the techniques and technologies used in those industries still have plenty to teach you. Equally, there may be things you have to teach them.

For these reasons, we hope you will come along to the Engineering Design Show Conference. We are pretty sure there will something for you there.

For details of how to register, go to www.engineeringdesignshow.co.uk

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Aerospace sector grows faster than UK economy



The UK aerospace sector has grown 10 times faster than the overall UK economy in the last three years, according an industry report from ADS Group, the trade organisation representing the aerospace, defence, and security industries.

Since 2011, the aerospace industry has grown 14%, currently employing 109,100 people, 3,300

of whom are apprentices and trainees.

Much of the growth has been attributed to the success of the Aerospace Growth Partnership, a joint Government and industry initiative designed to boost innovation, skills and technology development in the supply chain.

Paul Everitt, chief executive of ADS Group, said: "The Aerospace

Growth Partnership has worked hard to put the right support in place to help UK industry make the most of significant increases in demand for new aircraft.

"It is clear that the positive impact of this work is being felt, with almost three quarters of companies planning to increase investment in the next year, and one in four looking at reshoring activity back to the UK."

Its Outlook report is published to coincide with ADS' monthly commercial aircraft order and delivery data.

In May 2014, the aircraft order backlog reached a new monthly record of 11,392, worth around £150 billion to the UK. The monthly data also shows deliveries are up 5% compared to the same period last year and deliveries of aircraft in May were worth around £1.5 billion to the UK economy.

Call for 'elite apprenticeships'

Business Secretary Vince Cable has called for a new model of high level, high status, technical education that combines degree courses with more conventional apprenticeship style practical and applied training.

Speaking at the National Summit on Apprentices held at the University of Sheffield's Advanced Manufacturing Research Centre, Cable said that 'elite apprenticeships' should be introduced that include progression to degree level and beyond.

"We need to end the stereotype that apprenticeships are for those who do not get to university," says Cable. "Increasingly, apprenticeships are not just a valid alternative to going to university, but can actually include degrees.

"Degree level apprenticeships give businesses the opportunity to develop training and education programmes – combining theoretical education and [and more practical] technical training."

ReWalk system cleared for US home use

The ReWalk exoskeleton has been cleared for home use by the US Food and Drug Administration (FDA). The motorised exoskeleton, which has been available in the UK since 2012, provides powered hip and knee motion to enable individuals with spinal cord injuries to stand upright and walk.

After extensive performance testing and several clinical studies, the FDA has certified the technology's safety and effectiveness, paving the way for thousands more people to benefit.

Larry Jasinski, CEO of ReWalk Robotics, says: "This product will have an immediate, lifechanging impact on individuals with spinal cord injuries. For the first time, individuals with paraplegia will be able to take home this exoskeleton technology, use it every day and maximise on the physiological and psychological benefits we have observed in clinical trials."

ReWalk provides user-initiated mobility through the integration of a wearable brace support, a computer based control system and motion sensors. The system allows independent, controlled walking while mimicking the natural gait patterns of the legs, similar to that of an able-bodied person. www.rewalk.com



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NASA tests 'flying saucer'



The US space agency, NASA, has carried out a flight test on an experimental saucer

shaped descent vehicle as part of its ongoing research, design and development programme of future missions to the Martian surface.

The Low-Density Supersonic Decelerator (LDSD) undertook a 'near-space test flight' when it was dropped from a high altitude balloon, at over 120,000 feet, off the coast of the US Navy's Pacific Missile Range Facility in Kauai, Hawaii.

The test was to assess two concept technologies being trialled by the agency that aim to allow larger payloads to be sent to the Martian surface, as well as a safer descent. The technologies were a supersonic parachute as well as a more radical inflatable Kevlar ring.

Upon being dropped, the LDSD fired a rocket motor to accelerate it to Mach 4, mimicking the speeds likely to occur during entry in to the Martian atmosphere.

At this point, the Kevlar ring known as the Supersonic Inflatable Aerodynamic Decelerator (SIAD) was deployed. The large, doughnut-shaped ring inflates around the body of the descent vehicle to increase its cross sectional area. This helps to slow the vehicle dramatically from near-hypersonic speeds and in to lower Mach numbers.

The aim is to help slow the vehicle to such a point where the second system can be deployed; an enormous parachute known as the Supersonic Disk Sail Parachute. While parachutes have been used on previous descent vehicles to the Martian surface, opening parachutes and having them work effectively at higher supersonic speeds is still an area of intense development.

Ian Clark, principal investigator for LDSD at NASA's Jet Propulsion Laboratory, said: "All indications are that the SIAD deployed flawlessly. We got the opportunity to test the second technology, the enormous supersonic parachute, which is almost a year ahead of schedule."

The overall aim is to improve the ability to decelerate a larger and heavier descent vehicle to pave the way for future missions. At present a Martian surface descent vehicle is limited to around 1.5 tonnes. However, manned spaceflight is expected to require a minimum of 10 tonnes.

Initial test data indicates the parachute did not deploy as expected, and the team is still analysing data on the parachute so that lessons learned can be applied for the next test flights, scheduled for early next year.

Dorothy Rasco, deputy associate administrator for the Space Technology Mission Directorate at NASA headquarters in Washington said: "This flight reminds us why NASA takes on hard technical problems, and why we test – to learn and build the tools we will need for the future of space exploration. Technology drives exploration and yesterday's flight is a perfect example of the types of technologies we are developing to explore our solar system."

www.nasa.gov/spacetechnology



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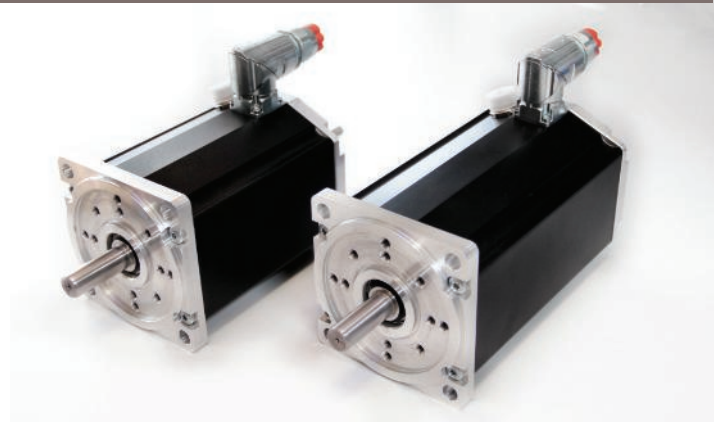
Compact and powerful brushless rotary DC motor

A larger, more powerful, brushless rotary DC motor that provides exceptional power to weight is available as an option from the established range of Dunkermotoren BG rotary brushless motors.

The BG XL (97mm) is a compact yet powerful, low-voltage three-phase brushless DC motor that delivers 600 to 1100W of power and is ideal for most industrial automation, automotive and other general OEM automation/motion control applications.

In common with the extensive BG range of brushless rotary DC motors the robust, modular design of the BG XL motor ensures exceptional durability and long life, combined with optimum application flexibility and adaptability.

It is designed with various integrated controllers, including SI (speed



control) PI (position control) and MI (master control).

These motors are also notable for high power density and efficiency, high dynamic acceleration and low noise levels. They feature Neodymium magnets, a no-cogging torque, coreless design with integral hall sensors for rotor position detection.

www.dunkermotore.de

Solution to last month's Coffee Time Challenge

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The solution to last month's Coffee Time Challenge of how to farm fish ethically and sustainably comes from Lockheed Martin, which has teamed up with Kampachi Farms of Hawaii and Illinois Soybean Association to develop an innovative system that could produce a sea change in fish farming.

Its mobile fish pen, or drifting fish cage, is hooked to a barge that drifts with the ocean currents.

The mobile system, which is constantly moving over the ocean's surface, in waters over 12,000 ft deep, solves the potential problems of impact on water quality or on the seafloor and appears to improve fish health and growth.

As the cage drifts, the highly-automated system controls feeding from the barge and cleaning by a remote operating vehicle inside the cage.

The system operates by integrating satellite communications, remote sensing data feeds, robotics, motor controls, and Lockheed Martin's command control and situational awareness software.

Gerry Fasano, president of Lockheed Martin Information Systems and Global Solutions-Defense, said: "We took technologies and software developed for defence-related applications and used them

to create a sustainable, environmentally-sound method of farming, which will undoubtedly have a lasting impact on our oceans and wildlife."

The beta trial of the mobile fish pen used fingerlings raised from wild broodstock in land-based hatcheries, so there was no genetic difference between farmed and wild stocks. The beta trial also used a highly efficient, soy-based feed, allowing fish to reach harvest size more quickly.

"The drifter cage allows us to marry revolutionary technologies to grow fish with literally no footprint on the oceans," said Neil Anthony Sims, co-founder and Chief Executive Officer of Kampachi Farms, LLC. "We're combining this technology with more responsible feeds, more sustainable proteins and oils, to grow this industry, to allow us to feed 9 billion people."

Using the mobile cage method, aquafarms

could produce large volumes of high-quality seafood with reduced costs, potentially reducing the \$10 billion U.S. annual seafood trade deficit.

Around the world, the new technology could enable countries without ample farmland or fresh water to farm fish more effectively, thereby allowing countries to open a new industry and achieve food security, along with the benefits of job creation.



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New threadlocking sticks from Loctite



The self-loosening of threaded fasteners is a leading cause of catastrophic failure in industrial machinery making maintaining appropriate clamping forces an important element in their effectiveness.

Loctite anaerobic threadlockers from Henkel have proven an excellent method of keeping fasteners firmly in place.

For applications where a liquid product may be too fluid to stay on the part or difficult to apply, Loctite 248 and 268 Sticks have been a popular choice. Continuous development of their formulation, however, has now allowed these wax-like, semi-solids to offer even more performance benefits.

The new Loctite 248 is the medium-strength, single-component product for threads up to M50, while Loctite 268 has a higher-strength. The colours blue and red differentiate the respective products visually.

As with the Loctite liquid anaerobic adhesives, both Loctite 248 and 268 cure in the absence of air when confined between close-fitting metal surfaces. These products are suitable for use on a wide variety of metal surfaces.

The health and safety credentials of these latest generation sticks are also improved, as is their tolerance of oil, making them less sensitive to improperly cleaned parts. And importantly these qualities have been achieved without compromising any of the products' other key properties such as chemical resistance and shelf life.

www.loctite.co.uk

Compact servo motors with inductive encoders

Maxon Motors latest flat motor is being increasingly applied to many demanding applications including pumps for diesel emission control, in valve positioners for aircraft, in lift door drives, in humanoid and industrial robots and more.

In addition, the motors are taking advantage of its MILE technology.

The abbreviation MILE stands for "Maxon's Inductive Little Encoder". The operating principle is based on measurement of high-frequency inductive fields, which generate eddy currents in an electrically-conductive target disk.

The advantages of a high-frequency inductive measuring method in comparison with classic encoders are high robustness against dust or oil vapours. This means that no additional protective measures, such as covers, are necessary.

These properties make the flat motors with MILE encoders an ideal solution for positioning tasks or high precision speed control. A significant advantage is provided by the small size of the encoder.

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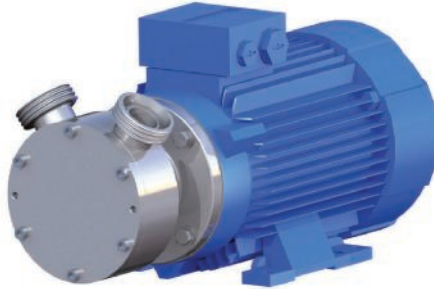
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Pumps for high pressure and low flow

The established range of CSF pumps available through fluids handling specialists Pump Engineering now includes the CP Series, a close-coupled, single-stage peripheral impeller pump ideally suited to high pressure, low flow hygienic applications. The range includes models which provide flow rates up to 6m³/h and maximum outlet pressures of 16bar.



The standard design models are suitable for transferring clean, non-abrasive liquids such as syrups and oils with viscosities up to 250cp. This design has the important benefits of smooth, pulsation-free flows that can be controlled more precisely than a centrifugal pump. This is important for liquid dosing, laboratory, pilot and micro-installations, spraying and in-line measurement applications.

The CP Series of regenerative turbine pumps generally requires a lower NPSH than a centrifugal pump and can handle liquids with up to 20% entrained gases, which is ideal for tank emptying where vortexing or cavitation can occur. The pumps are available with a choice of seal configurations to ensure optimum flexibility depending on the application.

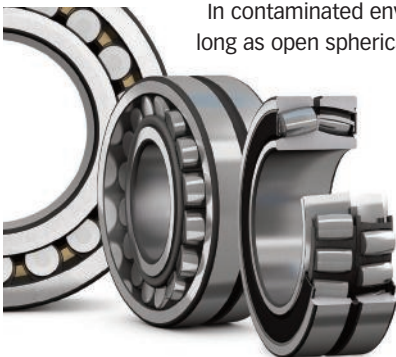
For example, the standard option has an internal mechanical seal wetted by the media and fitted behind the impeller in a chamber to ensure correct fluid flow and lubrication. The double mechanical seal option is designed for the circulation or flushing of cooling liquids and can be used with products that tend to crystallise, adhere, solidify, or are abrasive and corrosive.

www.pumpeng.co.uk

Sealed spherical roller bearings cut maintenance costs

SKF has extended its range of sealed spherical roller bearings, significantly increasing the number of applications where they can be used. Due to their sealed construction, the bearings can reduce maintenance, while offering consistently high performance under demanding conditions. In most cases, the sealed variant is dimensionally interchangeable with open bearings, enabling applications to be upgraded simply and cost effectively.

During installation, maintenance and operation, open bearings can be exposed to contaminants, which can significantly reduce bearing service life. With sealed SKF spherical roller bearings a high degree of cleanliness is maintained inside the bearing, to significantly increase bearing service life.



In contaminated environments, sealed bearings can last up to four times as long as open spherical roller bearings. Under certain operating conditions,

sealed SKF Explorer spherical roller bearings can be considered relubrication-free. As the bearings do not require external seals in all but the most aggressive environments, installation is simplified, further reducing downtime and maintenance costs.

Additionally, the seals virtually eliminate the risk of lubricant leakage often associated with conventional open bearings and external seals, minimising their environmental impact.

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Powering the future

Future aircraft engines aim to be lighter, more reliable and as much as 50% more fuel efficient. So how does an industry already at the forefront of technology plan to move forward? Justin Cunningham finds out.

A key driver in modern engineering design is efficiency. However, that doesn't just mean an elegant solution or using less energy. Efficiency, as a concept, should creep into virtually every aspect of an organisation, from the way individuals work to the management of suppliers.

Nowhere has this been more apparent in recent years than in the design and development of combustion engines. Energy and power generation throughout the world is built primarily around the effective combustion of fossil fuels to produce energy. But, scarcity and environmental concerns have given a clear imperative to combustion engines: to get more with less.



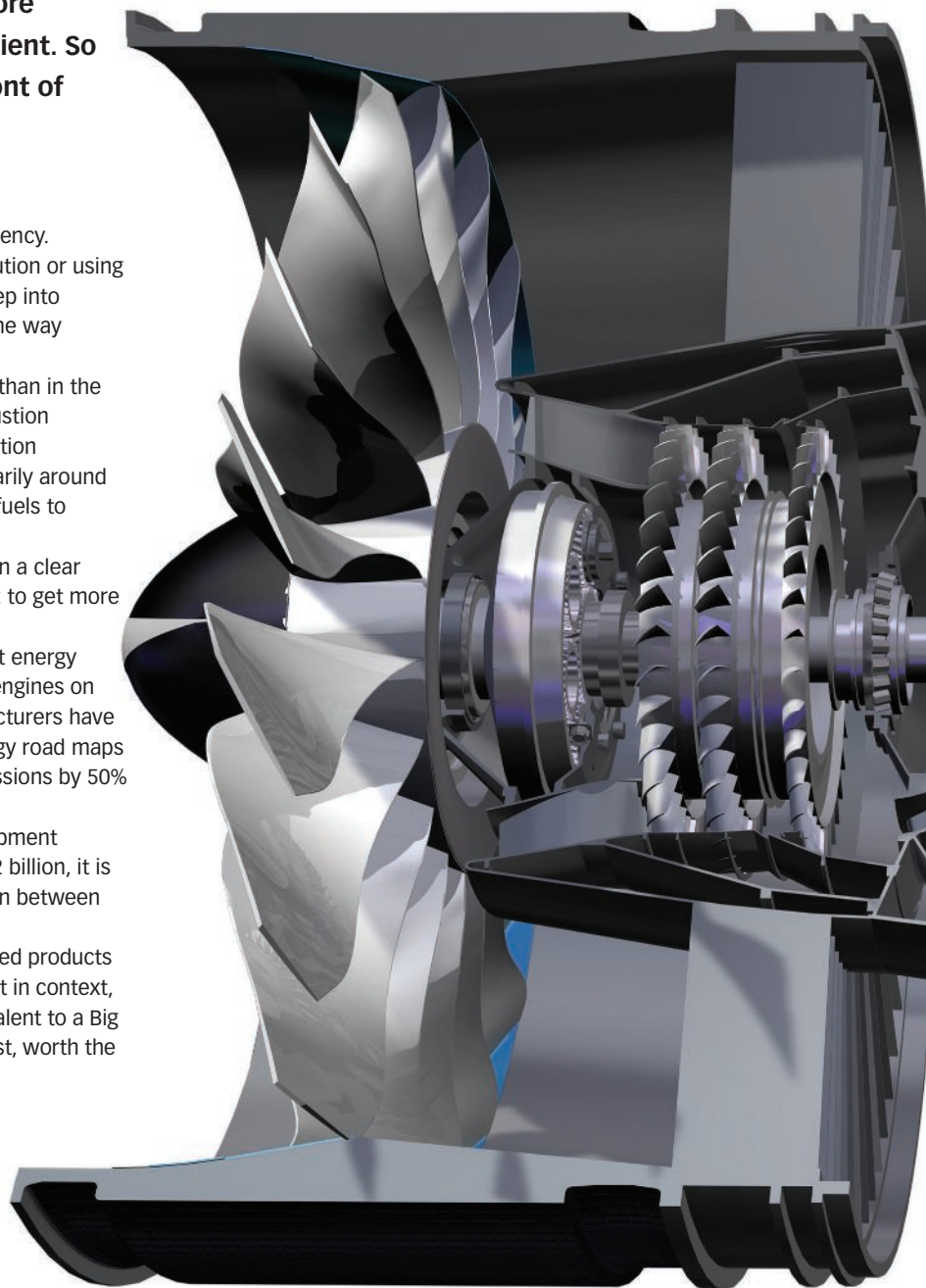
Despite being perhaps the most energy efficient and reliable combustion engines on the planet, aircraft engine manufacturers have been outlining plans and technology road maps that aim to help slash aircraft emissions by 50% over the next 10 years.

While an aircraft engine development programme can cost more than \$2 billion, it is money well spent in a market worth an expected \$3 trillion between now and 2030.

Aircraft engines are some of the highest value engineered products on the planet. To understand what that means, and to put it in context, a Ford Fiesta, weight for weight, has a value roughly equivalent to a Big Mac. An aircraft engine on the same measure is, by contrast, worth the same as a Rolex.

The need to change

To fly an airliner at transonic speeds requires an extraordinary amount of energy. On average, a mid-sized airliner will need more potential energy onboard than a Royal Navy frigate. It means the fuel of the future, for airliners at least, is likely to remain Jet-A or Kerosene,



widely regarded as the highest energy density, room temperature and fuel available.

Efficiency – specifically fuel burn improvement – is something the three largest aircraft engine OEMs have been developing since the beginning of commercial air travel. Pratt and Whitney, General Electric, and Rolls-Royce have all broadly been following the same technology development trend up until now: ie improving the thermal efficiency of the engine core (turning fuel into shaft power) and improving propulsive efficiency (turning shaft power into forward thrust). Multiplied together, this gives an overall efficiency estimated to currently be around 30-38%, depending on the aircraft and engine.

Broadly, this has been done by running the engine cores hotter and by improving the control of the combustion process through the engine. In addition, ever smaller cores have been used to assist in thermal efficiency improvements. The other area of improvement is in propulsive efficiency, which has seen front engine fans become much larger to increase the bypass ratio (i.e. the ducted air around the core of the engine).

This trend has seen low bypass turbofan engines with a bypass ratio of 2:1 being replaced by high bypass engines of 5:1, with a new generation of ultra-high bypass engines beginning to be used, typically aiming to be around 10:1 or more.

However, it is clear the status quo of smaller cores and bigger

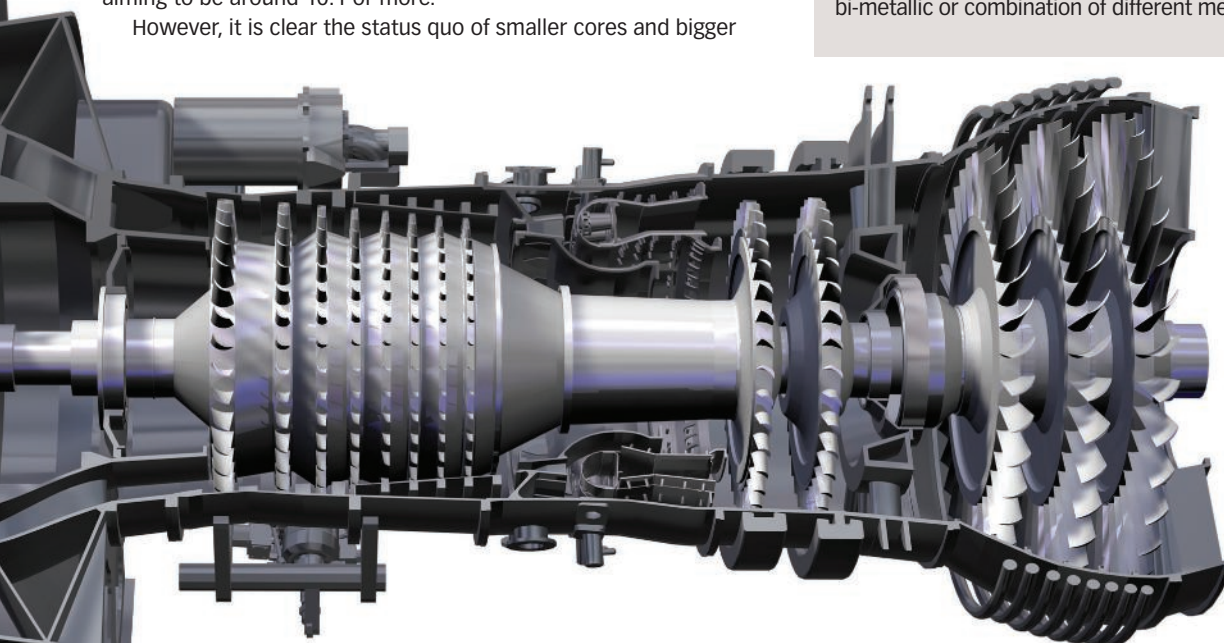
Not just composites

Though composites have become synonymous with lightweight and performance, engine components operating at higher temperatures have not been able to benefit quite as much due to higher operating temperatures.

A turbine structure is typically made using a nickel based super alloy at the exhaust of the engine. This is commonly produced using an advanced casting process. However, GKN Aerospace is exploring the option of replacing the casting process with a welded structure. Essentially it's the same material but in wrought and sheet metal form.

"It is a lot stronger as you use sheet or forged material, so you can go down to a thinner cross-section and get a 15% weight saving," says Robert Lundberg, director of European research and technology programmes at GKN Aerospace Sweden. "This is not a new material, but a new method."

"With such a welded structure you can add high temperature material where it is needed. This is a way of saving weight, having a bi-metallic or combination of different metals, welded together."



fans is reaching a practical limit. Engineering the next generation of aircraft engines is now pushing materials, mechanical knowledge, packaging, and reliability into new and uncharted territory.

"You want to get the core of the engine to spin very quickly for high power density, so you can make it smaller," says Dr Alan Epstein, vice president of technology and environment at Pratt & Whitney. "But, you also want to make the fan very large and allow it to rotate slowly. So, clearly, it's a good idea to change the speed ratio between the core of the engine, which makes the shaft power, and the fan that propels the aeroplane."

Up until now, shaft and fan speed have been the same. And, while it

sounds obvious, engineering a gear capable of transmitting the horsepower at the necessary efficiency has been the Holy Grail for aircraft engine manufacturers. Indeed, Pratt and Whitney's commitment to the geared turbofan is seen as risky and has at times been mocked by competitors.

"But, we have such a gear now," says Dr Epstein. "The gear is 0.5m in diameter, weighs

around 130kg, transmits 30,000hp at 99.5% efficiency and it will run for 20 years before it needs maintenance. That was the kind of gear we needed to make this work and be able to present it as a practical option. But it has taken a dedicated team of engineers 25 years to develop."

The geared turbofan offers much-needed longevity to Pratt and Whitney. Indeed it is believed it opens up areas for further optimisation and efficiency improvement, both of which have been getting harder to find on existing turbofan platforms and engine configurations.

However, the expected 15% or more improvement in overall engine efficiency of Pratt and Whitney's geared turbofan is also reliant on a number of other technical innovations. The fan blades will be much larger,

but need to be ultra-lightweight. In addition, they need to be stronger, more reliable, and able to take multiple bird strikes.

Fan blade technology development has seen increased consensus, with carbon fibre composite fan blades generally considered favourable. Indeed, General Electric has been the first to develop and certify composite fan blades for its GENx series of ultra high bypass engines.

"And we also thought fan blades would have to be a 3D woven composite," says Dr Epstein. "We developed them for the geared turbofan, but it turns out they're not.

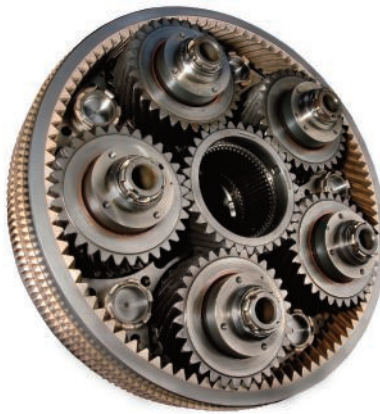
"Actually the best option is a hybrid metallic. It is a little lighter and can be made on any machine tool and is therefore half the cost. Also, we can make them thinner out of metal than we can out of woven composite, giving about a 1% improvement in efficiency."

Rolls-Royce, too, has chosen to stick with metal, at least for the time being, selecting titanium for the fan blades of its upcoming Trent XWB. It is, however, preparing to make the switch to lighter composite fan blades as the manufacturing technology matures.

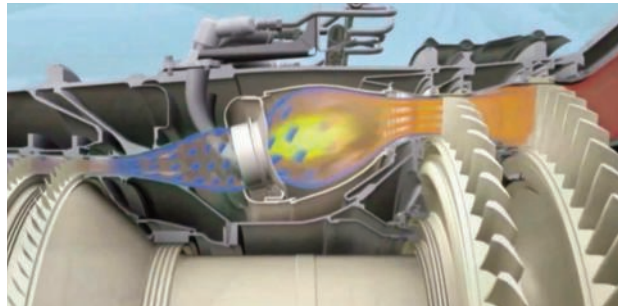
To assist in this development, it has set up a joint venture with GKN Aerospace to develop and test composite fan blades and the associated production systems. It coincides with another GKN Aerospace-led project called G5Demo, part of the Swedish Green Aerospace Demonstrator programme, which aims to contribute to reduction of aircraft CO2 emissions by 50% by 2020.

GKN Aerospace's contribution to the G5Demo project will include introducing innovative manufacturing technologies and advanced materials such as lightweight state of the art engine structural parts, which include turbine structures that are 15% lighter and able to operate at temperatures 200°C higher than today, as well as a metal composite hybrid fan-frame that is 30% lighter.

"The pressure to reduce weight and operate at higher temperatures has become really strong," says Robert Lundberg, director of European research and technology programmes at GKN Aerospace Sweden. "We are studying the replacement of the fan-



The gear for the geared turbofan has 25 years to develop. However, improvements in combustors (below) offer thermal efficiency advantages, with improvements in materials and manufacturing technology offering other advances (bottom)



frame, and the large fan structure with carbon fibre composite materials instead of titanium as it is today.

"The problem with designing these parts is actually one of manufacture. The target is to be able to produce composite parts with the complicated geometry, with the right technical requirements, and at a high rate."

Rolls Royce has also set out more clearly its plans for future developments, and it looks to be following Pratt and Whitney's lead of using a reduction gear between the shaft and fan. The expectation is that developments are some 10 years off.

Dubbed the UltraFan, the geared design will also use a variable pitch fan system as well as

having an advanced engine core to improve fuel burn efficiency and lower emissions. The aim is to offer a 25% improvement in fuel burn and emissions.

While Pratt and Whitney and Rolls Royce have committed to using a gear, General Electric is yet to announce such an undertaking and has instead already brought to market its advanced ultra-high bypass engine, the GENx.

The engine is highly optimised, but perhaps the most revolutionary component is its combustor. The Twin Annular Pre-mixed Swirlers (TAPS) allow an extremely uniform fuel and air mixture that provides uniform flame temperature through the chamber.

Systemic improvement

"Something unusual happens during integrations," says Dr Epstein. "If I know I have a gear, a large fan, and a lightweight nacelle, each offers a 2% improvement if I optimise the system architecture. But, instead of 6% improved fuel burn improvement, I get 16%. It works because of system integration and that is a key part of future engine design.

"The bad news is, if the engineers do not deliver one of these technologies, then we don't get that extra 10%, we end up with 4% fuel burn improvement, and that difference will be an utter disaster."

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Proof Positive

The new man in charge of Millbrook Proving Ground is overseeing some major changes for the company. Paul Fanning finds out more.

Millbrook is a name synonymous with the cutting edge of test and development in the automotive sector. There are few vehicles – be they road vehicles, commercial vehicles or military vehicles – that have not been put through their paces on its 45 miles of on- and off-road test tracks, variety of surfaces, features, terrains and extensive test and validation facilities.

Given this, it is no surprise that the new Chief Executive Officer of Millbrook should be a man well-versed in automotive expertise. Alex Burns, who took the helm at the proving ground in February this year, was with Williams F1 for 11 years, first as COO and then CEO for the last three years. During this tenure, he established Williams Advanced Engineering, which brought F1-inspired low carbon technology to the commercial and passenger vehicle markets, and led the design and manufacture of five hybrid supercar prototypes.

Even so, however, Burns admits to being overwhelmed by the sheer variety of vehicles and technologies that pass through Millbrook, saying: "The opportunity that Millbrook represents is one of the main reasons I took this role. So much happens here that I find I'm learning all the time."

The big reason why there is such an 'opportunity' at Millbrook is the fact that the company recently changed ownership. Having previously been owned by General Motors, the facility was purchased by Rutland Partners in December 2013, a move that was swiftly followed by Burns' appointment. Indeed, on the day *Eureka* visited Millbrook, the signage was being changed to incorporate the company's new logo.

Asked what customers and potential customers are likely to see as a result of this change, Burns is clear. "The new ownership is clear that it wants to release business value from Millbrook," he says, "so that's going to mean an increasing focus on serving external business."

By way of confirmation, Millbrook recently made a planning application proposing the development of 24,900m² of office/research development space on the site with the aim of creating a significant number of highly skilled jobs within the automotive engineering and technology sectors.

Of course, Millbrook has been undertaking non-General Motors

business for a number of years, but certain aspects of the company's capabilities are now available more broadly that had previously been exclusive to GM. One example of this is Millbrook's Vehicle Engineering Centre. Previously known as The General Motors Engineering Centre, this facility is now available for hire to all-comers who wish to take advantage of its vehicle design and modification capabilities.

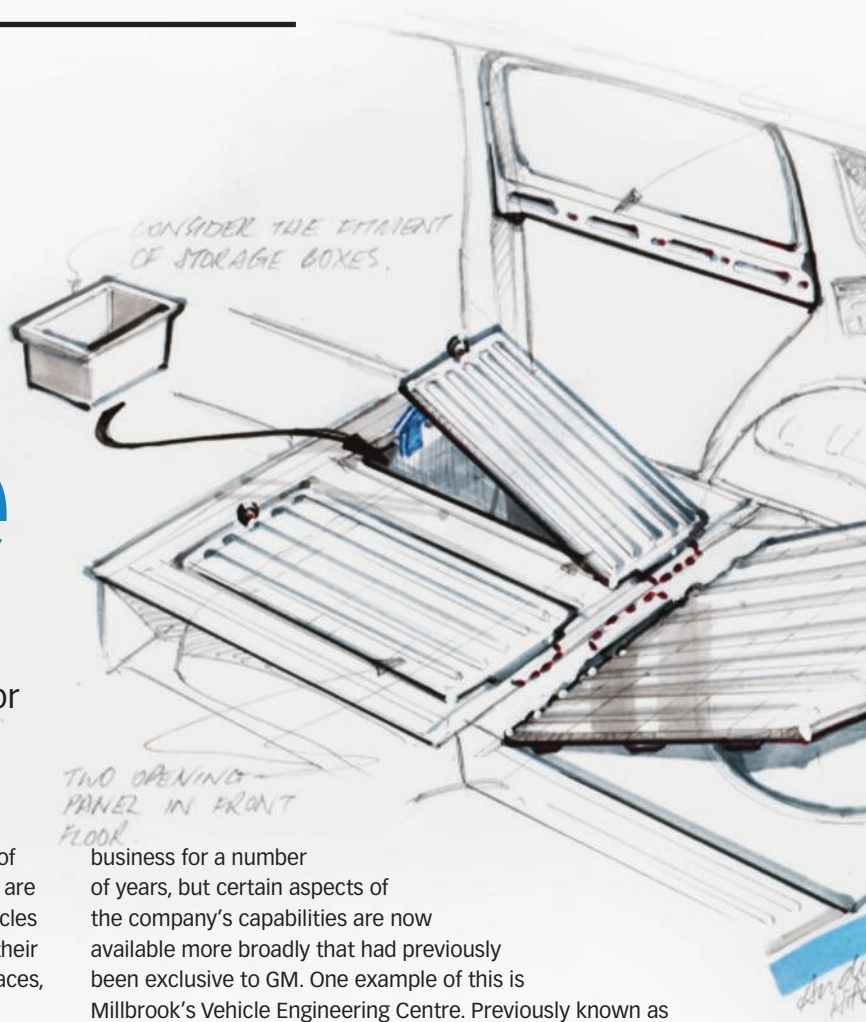
Says Burns: "One of the most impressive things about Millbrook is the 'can-do' attitude. With increased investment in the business, we are looking to integrate that more and more into our test offering. We're aiming to offer much greater co-operation between engineering and test for the overall benefit of our customers."

Investment, says Burns, is a key ingredient of the new regime, with the 'lab' side of the business likely to see a considerable amount of expansion, particularly as regards to powertrain and emissions testing facilities. Equally, he says: "We can make much greater use of the site as a whole – not just on the tracks, but in terms of other facilities. At the moment, our lab side is constrained by the facilities that we have. We're known for real-world testing and we don't want that to change, but we want people to know that there's a lot more to us than that."

One aspect of Millbrook's capabilities that Burns is keen to emphasise is its usefulness as a partner throughout the design and development process rather than just a facility for testing a prototype or near-finished product. He says: "Our knowledge of technologies and testing is such that our ability to develop an effective test programme for vehicles is obviously second to none."

So what should customers expect from the new Millbrook? Says Burns: "You can expect to see a broader service, with an increased emphasis on customer service. Ultimately, I want people to see Millbrook as an enabler – enabling our customers to arrive at the best possible end product."

www.millbrook.co.uk





CV

Alex Burns is a mechanical engineer and also holds an MBA from Cranfield University. He spent 11 years at the Williams F1 Team as COO and then CEO for the last three years. During this tenure, he established Williams Advanced Engineering, which brought F1-inspired low carbon technology to the commercial and passenger vehicle markets, and led the design and manufacture of five hybrid supercar prototypes. Prior to Williams, he spent 12 years in various senior roles at Meggitt PLC, and started his career at Westland Helicopters.



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TELLING THE TRUTH ABOUT CIRCULATION

Taking advantage

Despite the hype, many are struggling to identify how to integrate 3D printing as a business process and leverage it as a design tool. Justin Cunningham finds out how others have been able to exploit the technology's unique attributes.

Additive manufacturing is one of those technologies that gets engineers excited. The ability to print out different concepts somehow puts a smile on the face of most. Perhaps it makes the 3D CAD and design environment more real, more tactile, and brings dull 2D engineering drawings to life. Or perhaps it is just about indulging the inner geek in all of us. Who knows?

As the cost of additive manufacturing machines falls, more are seeking out the low-cost options, keen to explore what all the 3D printing hype is about.

In fact the story is often the same. Weeks are wasted printing out Star Wars figures, Eiffel Towers and maybe the odd bit of design work, but then the novelty begins to wear off. When the office is strewn with small plastic paperweights and figurines at various stages of completion, you are forced to ask what has really been achieved.

Now, low-cost small budget 3D printers have a place: for instance in schools to get students involved in design and engineering, in architecture, and maybe even for model builders. However, they are not going to replace traditional manufacturing methods and in an engineering design office they are in danger of being little more than a gimmick and distraction. Yes, you can show a 3D plastic representation to the sales and marketing teams so they can get started, but the finish and tolerance from most low-cost machines is going to do nothing to help their pitch.

You get what you pay for

Like many things in life, generally the more it costs, the better it is. With 3D printing this can mean a significant investment, so if you are serious about using it as a design and development process, clearly define just where and how you are going to use it. Seek advice



from those that have the equipment and know what they are doing.

One of the biggest uses of 3D printing has thus far been at the prototyping stage. Printing parts can allow different concepts to be passed around the room and also allow form and fit to be tested physically. Due to the better tolerance and finish of parts, it gives engineers confidence

that what they have designed will be sized correctly and fit its intended use.

However, advances in the process now mean that testing and pre-production checks can be carried out. Materials used in 3D printing processes can be made almost identical to production materials, as well as made from multiple materials in a single run.

One company that has been able to exploit the potential of additive manufacturing to the extent that it now acts as a 3D printing service provider, is East Midlands-based Rutland Plastics.

"We were originally looking at the technology as we wanted to leverage what we were doing," says Stuart Lovett, marketing manager at Rutland Plastics. "As an injection moulder that also offers design and technical support, we were often being asked to produce prototypes. When we came across the Objet Connex, we thought we'd be able to offer functional prototypes as a bureau service as that might lead to some injection moulding work longer term. In fact, that is exactly what it has done."

The art of prototyping is all about validating design, and this is where Rutland Plastics has found 3D printing to be very effective as a process. By printing out parts it can avoid 'redo's' during initial production runs and improve the quality of the serial production parts. Changes at the production stage of development, especially if the mould tool has already been made, can be extremely costly.

This is only possible as the materials being printed are virtually identical to those that will be used during injection moulding.

"Having a prototype in your hand has also helped to refine and simplify mould tools before," says Lovett. "That is something you do not always pick up on in CAD, as having a 3D image on a screen is very different to having something in your hand."

And it is also about confidence and knowing



Originally, Rutland Plastics thought that the Objet Connex would allow it to offer functional prototypes as a bureau service, leading to increased injection moulding work

what is going to actually be produced. When passing work to the manufacturing engineers, it gives confidence that it will be problem free and will not come back with a list of requested changes for production. Confidence is so important and although difficult to define, can add real time and money savings.

"We were making parts for a pump," says Lovett. "It was a pump for draining central heating systems and they were uprating the motor. They were concerned about a part on the bottom of the pump that produced a filter-like effect so it takes water in. So if they made it at the size that would give them maximum flow, they were worried this would create a flow back. So they were thinking about only going half way because of the cost of modifying or having to re-machine the tool during production. So we printed prototypes of the two versions for them to test, and they were able to test these parts on an the actual pumps and prove they could use the maximum flow without any problems.

"So it saved them compromising on the tool. They could not afford to go for the maximum flow on the pump and then have problems as there was no way back. So what they would have had to have gone half way and compromise performance."

Plastic producer Solvay has also been able to boost its materials offerings by using 3D printing as a prototyping process to aid in the design and procurement of products and

components. It has been particularly useful for the company as it enters new markets such as the automotive industry.

"We are doing a lot of work in terms of confidence building by 3D prototyping," says Peter Browning, automotive market director at Solvay Engineering Plastics. "We can print out functional prototypes of the products. What is novel and innovative is not that you can print this stuff out, but that the material you are printing is the same materials as you use for serial production. So what you are getting is a functional prototype, so you can actually run application tests on it rather than just look at the thing."

Solvay prints out in a polyamide 6, which is virtually the same material as you would use in an injection moulding process. The

biggest notable difference is the use of glass beads instead of glass fibre. Due to the nature of the process, the reinforcement is not quite as good – though it is close.

"But the performance is correlatable with moulded materials," says Browning. "So you can put the pieces in an application test bed, see what happens, and have a very good idea of what the moulded piece will do and how it will perform."

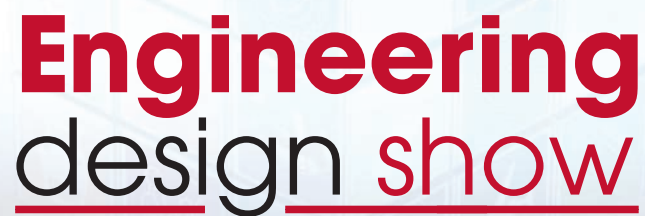
And it is also opening up unforeseen opportunities all the time. Lovett explains: "We use a lot of jigs and fixtures in the company for machining, and assembly, and these have traditionally been manufactured out of wood or aluminium, which can be expensive and time consuming. And because it is multi-material, you can have the hard jig and then a soft surface on



the ends, which was never easy with traditional manufacture. We are now printing jigs with the rubber surface on the contact areas so that it protects the part when it is being held. It saves us about 60% of cost. That is another area we are now exploring as offering as service to other companies."

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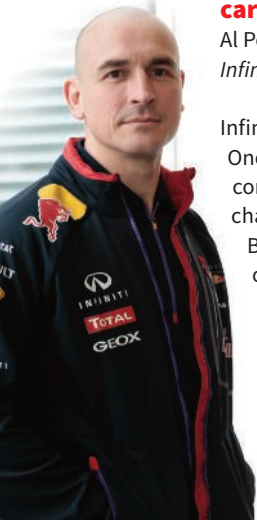
Learn from the experts at the Engineering Design Show

Bringing a Formula One car to life

Al Peasland, Technical Partnership Manager
Infiniti Red Bull Racing

Infiniti Red Bull Racing is the current Formula One World Champion, having achieved consecutive driver and constructor world championship titles for the past four years.

But race-winning performance on track is only possible with the dedication and commitment of a highly skilled team, coupled with the latest in technology and systems. In this presentation, Al Peasland, Head of Technical Partnerships for Infiniti Red Bull Racing, will give a 'behind the scenes' insight into this fast-paced and exciting environment.



Connecting sensors to the industrial internet... why this will determine the future of your business

Lynn Baranowski, Programme Manager - Products & System division
Cambridge Consultants

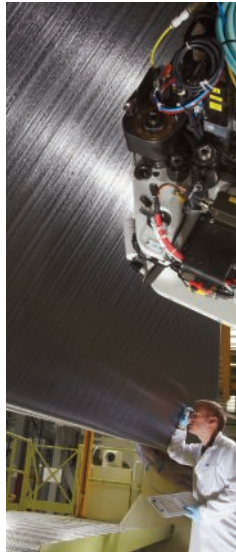
Companies everywhere are waking up to the changes that the industrial internet is bringing to their products, their customers and their way of doing business. In this presentation Lynn Baranowski, Programme Manager at Cambridge Consultants will discuss the steps required to connect industrial machinery, the opportunities to create 'brilliant' machines from 'smart' ones, and some of the challenges and pitfalls to be aware of. These steps will be illustrated with a discussion of the DropTag platform - a family of connected sensors, smartphone apps and backend data analytics systems that can be applied to a range of industries from parcel logistics to machinery condition monitoring.



Advanced manufacturing technology and its impact on future aircraft design

Ian Chatting, VP Technology
GKN Aerospace

Since GKN Aerospace took on the production of the composite sections of the Airbus A380 wings, it has had to develop the manufacturing technology to achieve its goals. Part of this has been to look at speeding up production to match the expected ramp up rates of Airbus and Boeing, which forecast deliveries of between 29,000 and 35,000 new single aisle and wide-bodied aircraft by 2032. This session will look at how GKN intends to meet this demand by using 'rapid deposition' of fibres and its own Automated Tape Laying (ATL) and Automated Fibre Placement (AFP) machine technology.



Testing vehicle design to the limit and beyond

Peter Stoker, Director of Vehicle Engineering
Millbrook

Millbrook is more than just a vehicle proving ground. It provides a complete range of design, release, development, test, validation and launch support for a wide set of vehicle engineering solutions. Perhaps less well-known, however, is the company's capacity for vehicle engineering design. In this presentation, Millbrook's Director of Vehicle Engineering, will talk about his department's expertise in designing new vehicle derivatives from base platforms, exterior parts, specific vehicle systems engineering and a diverse range of vehicle conversions, from passenger cars through to large commercial vehicles.



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Life-saving materials on the front line

Chris Davies, Technical Director
Morgan Advanced Materials

Morgan Advanced Composites has developed, manufactured and fitted the body armour that has been protecting British troops in Iraq and Afghanistan for over a decade. At the heart of this success is the company's unceasing development of new material solutions. Chris Davies, Morgan's technical director will explain the technical challenges such materials face and how the company continues to engineer solutions that offer lighter weight, but at the same time afford even greater protection.

Potential for robotics and strategies for innovation

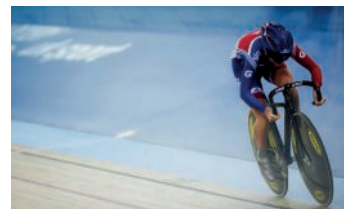
Rich Walker, Managing Director
Shadow Robot

Robotics is regularly styled a 'disruptive innovation', yet engineers have been using robots for decades. So has anything changed in the robotics world and how can you look at what you do with these new tools in mind? Rich Walker, MD of Shadow Robot will discuss this and the technology his company has used to produce innovations such as Dexterous Hand, which offers a truly anthropomorphic approach to robot manipulation.

Other conference sessions will include:

Designing Team GB's Olympic winning bikes

Dimitris Katsanis, Composites Engineer
Metron Advanced Equipment



Designing in quality from the start

Mick Carlisle
Chief of Commodity Strategy - Structure & Transmissions
Rolls-Royce



Product design in a virtual environment

Dr Joseph Darlington
Technology Manager
MTC



Designing a state of the art 3T MRI magnet

Simon Calvert, Director of R&D
Siemens Magnet Technology

SIEMENS

Transforming organ transplantation with Organox

Team Consulting

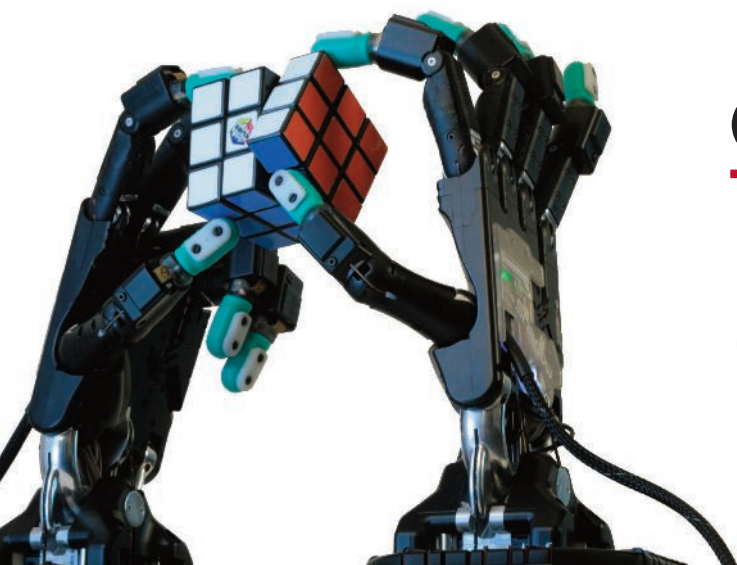


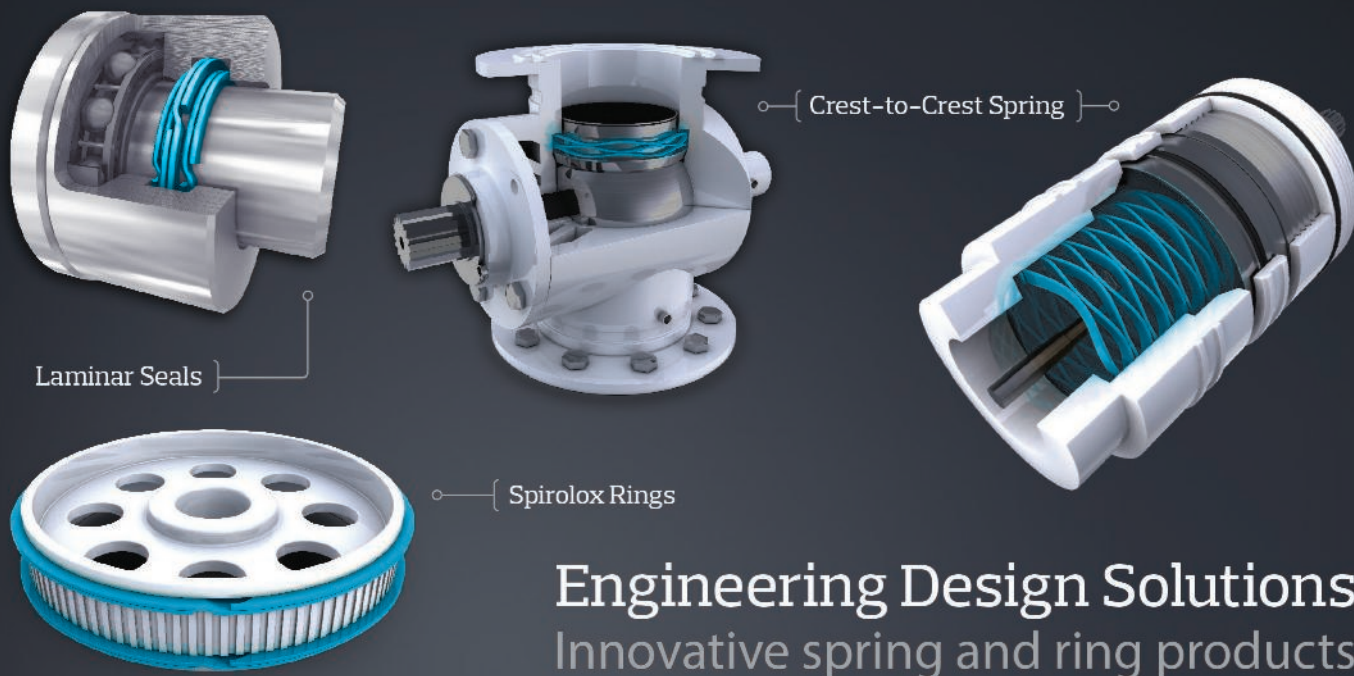
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BRITAIN'S FUTURE FRIGATE

The Type 26 Global Combat Ship will play a vital role in the future of the Royal Navy. So what will this next generation of surface warship offer in terms of capability? Justin Cunningham finds out.

The shake up of the armed forces is well underway, with the UK moving forward with plans for its future of defence and security. This has seen numerous projects announced and completed for use on the land, in the air, and sea.

One of the biggest recent procurement projects going through the system is the replacement of the Royal Navy's Type 23 frigates. The all-new replacement Type 26 will also have a primary role as a specialist anti-submarine warfare ship, but it will be expected to be inherently flexible in capability and able to carry out a wide range of roles.

"The Type 26 will be a world-beating 'best of technology' naval ship capable of a whole range of joint operations," says Brian Johnson, UK business development manager for prime contractor BAE Systems Naval Ship. "Its primary role will be to enable maritime manoeuvres by providing anti-submarine and anti-surface warfare protection to task groups and carrier strike forces. But it will also be able to undertake a broad range of other military tasks, from maritime security and stabilisation roles through to disaster relief and humanitarian operations.

"The Type 26 will be able to support troops ashore with surveillance, gunnery and helicopters and will be as capable in anti-

submarine warfare as it will securing against pirate attack off the East Coast of Africa or drug smuggling in the Caribbean."

Designing a warship

The ship has been designed using the latest in 3D CAD and virtual reality software. This has allowed design engineers to project in full size the size and layout of rooms and compartments and walk through the ship in full 3D. This has proven invaluable on previous programmes, including the Astute Class of Submarines and the Type 45 Destroyers.

"The use of 3D visualisation can make sure the layout is as effective as possible, and give engineers a dynamic and collaborative environment in which to work," says Johnson. "We also use this to produce virtual prototypes, so the shipbuilders can look at it and plan the most efficient way to build it."

The Type 26 is being designed to operate as part of a large task group as well as on independent manoeuvres. The vessel will be slightly larger than the Type 23, having a basic displacement of around 6,000 tonnes and length of 150m, but will require fewer crew, expected to be around 115. It will also have a similar range at around 7,000 nautical miles.

A key feature of the ship, and what makes it stand apart from other surface warships around

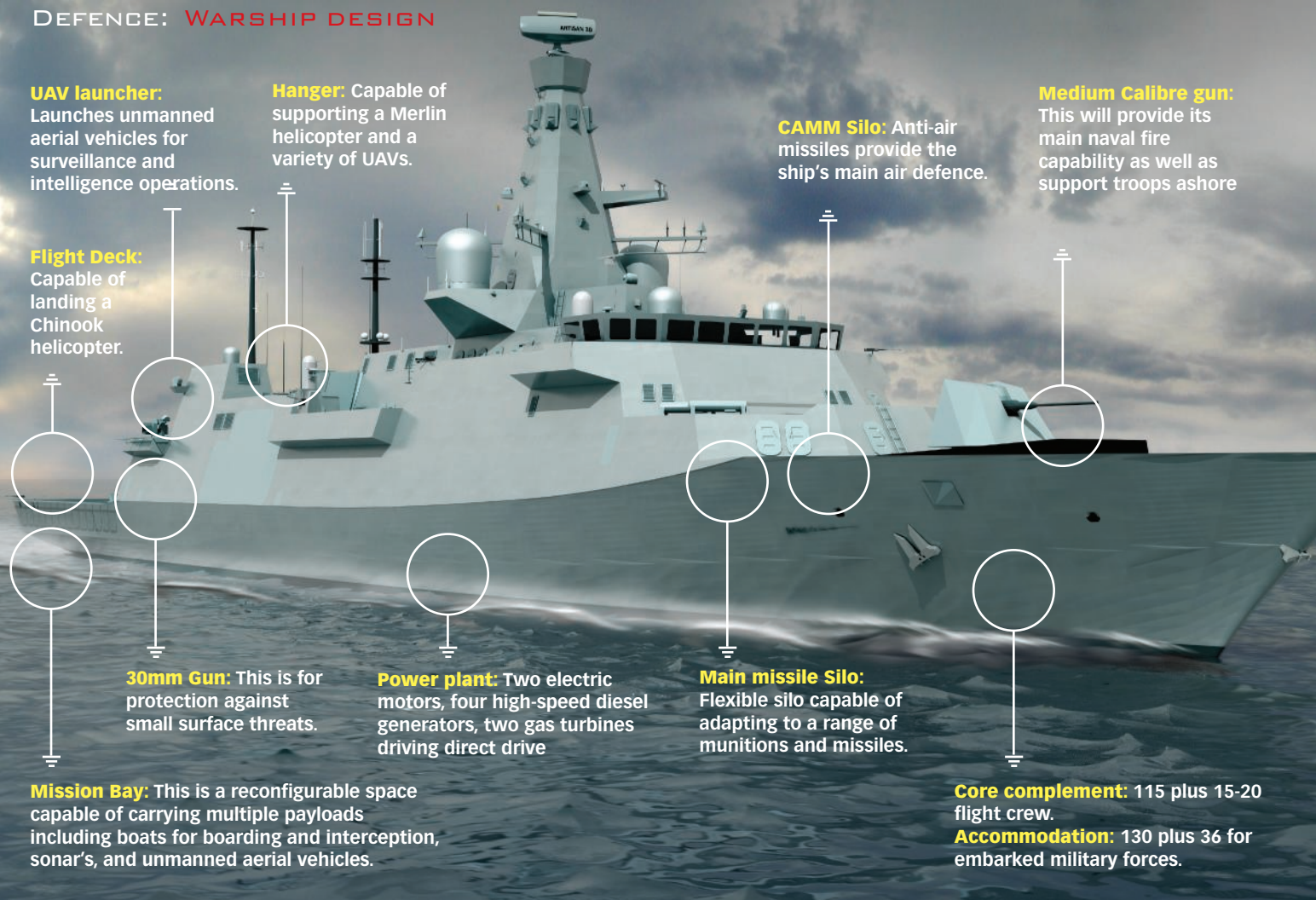
the world, is its mission bay. This flexible space can be used for a wide range of roles and payloads and is at the heart of the Type 26's multi-mission and flexible operational capability.

"The mission bay can carry a range of payloads, from small boats for maritime security to unmanned underwater, surface and air vehicles," says Johnson. "The wide range of modular mission loads include medical facilities for disaster relief, operation control rooms for unmanned vehicles and a wide range of other potential loads. It is a capable space that we can adapt to the future needs of modern warfare as we need."

The ship also features a specially-designed acoustically-optimised hull that produces a low wake by cutting a smooth and quiet path through the water. The hull form and the propeller design were fundamental to the capability of the ship in its anti-submarine role.

"As this is an anti-submarine vessel, we want the hull to produce the minimum amount of noise that we can," says Johnson. "So the shape of the hull will ensure a very smooth flow of water around it and minimise turbulent water in the ship's wake. There has been extensive work to optimise it both virtually and using physical prototypes and models."

The shape of the ship is also characterised by clean flat lines that minimise its radar



signature. In addition, the ship is able to run its engines in electric mode for near-silent operation. However, it avoids the use of batteries and instead opts for two diesel generators to operate the propellers on the induced electrical power.

"You can isolate the noise the diesel generators produce by putting them on acoustic mounts, in enclosures and so on," says Mark Dannatt, the director of GE Power Conversion's Naval Business.

Two Rolls-Royce MT30 gas turbine engines are used as the primary power plant. These turbines, when engaged, drive two propellers, with each gas turbine going through a splitting gearbox and then into a secondary reduction gearbox to then drive the two separate propeller shafts. These are isolated from each other to avoid single point failure. Fully engaged, the ship is expected to reach a speed of 28 knots.

The vessels will also be equipped with a flight deck capable of operating a Chinook helicopter if necessary. The corresponding hangar isn't quite that large but will be able to accommodate both Wildcat and Merlin

helicopters. The flight deck also includes an additional hangar door, and space, to accommodate the expected increase in the deployment of Unmanned Aerial Vehicles (UAV).

As a specialist anti-submarine warfare ship the primary sensor to be used will be the powerful Thales 2087 towed array sonar, which has proven its performance on the existing Type 23's. However, each Type 26 will be fitted with an additional Type 2050 bow sonar underwater systems, also built by Thales.

Programme update

At present the Type 26 is four years in to development, taken up predominantly by the honing of capability and designing the ships systems. Prime contractor BAE Systems is now finalising proposals, putting more parts of the ship out to tender, and announcing primary partners and suppliers.

"We are in to the second phase and the team has built up a huge amount of momentum on the programme," says Johnson. "We are increasing the maturity of the design and getting more confidence.

"We are currently in the process of finalising

our proposals to the MoD for the programme, with investment decisions to take place at the end of this year, where we'll secure the manufacturing contract of the Type 26 [13 are expected to be ordered].

"There will be in the region of £7 billion of contracts in the supply chain so it's a very significant programme for the UK."

BAE Systems is intending to invest in a new world class manufacturing facility in its Scotstoun shipyard in Glasgow to fulfil the type 26 build programme. Production of the first ship is earmarked to begin in May 2016 with the first ship to enter service in 2021, with the next 12 ships to follow on a 12-month build and repeat schedule. The ships will be in service until 2060.

Geoff Searle, Type 26 global combat ship programme director at BAE Systems, says: "By the 2030's, the Type 26 will be the backbone of UK's surface fleet and a strong industrial base is essential to sustaining this naval capability.

"UK suppliers are expected to account for around 80% of this significant programme."

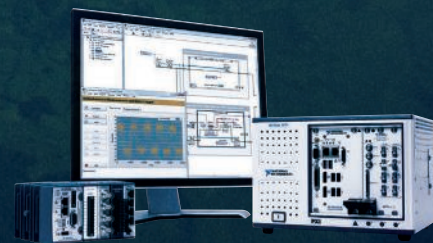
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Innovation in Miniature
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DDM takes flight

Direct digital manufacturing is being used to create a range of training aids for the US Air Force. Paul Fanning finds out how.

Based at Sheppard Air Force Base, Wichita Falls, Texas, the Trainer Development Flight (TDF) is a facility that designs, develops, and manufactures trainers and training aids for the US Air Force and all branches of the Department of Defense (DoD). These items are used in numerous training environments, including avionics, weapons and fuel systems, medical readiness, HVAC, and telecommunications.

The trainers and training aids may be either original products or replicas of existing ones, depending on the training need. Some devices are not required to be working units, so it usually isn't cost-efficient to purchase the actual item. For most training applications, it is more economical to train students on replicas.

The TDF uses direct digital manufacturing to fabricate a wide range of its training products. To do so, it employs four FDM additive fabrication machines in a centralised location with AFSO 21 (Lean) processes incorporated into the overall process.

Before adding direct digital manufacturing to its processes, the TDF used conventional manufacturing methods to make its products.



Producing replica UAVs using direct digital manufacturing has allowed the TDF to design on functional needs rather than manufacturing constraints

Conventional manufacturing typically requires longer lead times because there are often multiple steps, such as machining, lathe work, welding, sheet metal bending and cutting. A similar difficulty occurs when producing tooling to mould a part.

"Because most of our projects are either one-of-a-kind or very low volume, conventional methods become very expensive," says Mitchell Weatherly, chief of the TDF. "Only about 10% of our work is for prototyping, and 90% is production."

Before settling on FDM, the TDF considered 'a multitude' of other additive processes, says Weatherly.

"With FDM, the investment is up front, not ongoing," he says. "The parts are durable, and they have the high level of detail we require. In addition, the process is environmentally safe and 100% green, with zero waste."

The TDF is responsible for designing and manufacturing an exact replica of unmanned aerial vehicles (UAVs) or 'drones' for training repair technicians. It has built a variety of internal and external components using its FDM machines. The components include most of the body components as well as

several cowlings, propellers, and antennae.

Producing the UAV's large antenna using the FDM machines took about a tenth of the time it would normally, and it delivered an ROI of over \$12,000.

The savings go beyond time, though. For the antenna, it would have taken an outsourced machine shop up to 20 days to produce the part, where it took only two days using FDM — but only 15 to 20 minutes of labour. For the entire UAV project there was a total time saved of more than three years in some areas.

This project, along with other trainer savings has been very impressive, with an \$800,000 cost avoidance over the last four years.

"Major advantages to the FDM system include its speed over other processes or alternative build methods, the versatility of FDM versus injection moulding, and the ability to run multiple parts simultaneously through the system," says Weatherly.

Additional capabilities include the ability to design based on functional needs instead of manufacturing constraints, and the ability to implement design changes immediately and at minimal costs.

"The versatility to manufacture any item coupled with zero hazardous waste is one of the greatest advantages to the Air Force," says Weatherly. "The FDM-based machines have been used for a number of trainer projects with tight budgets.

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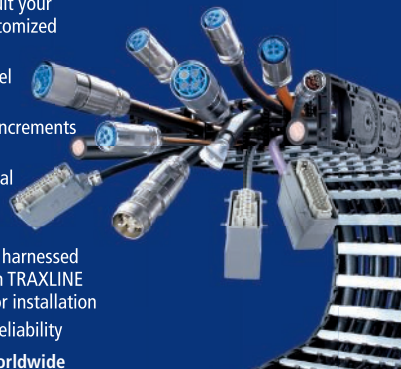
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Developing lifesaving material solutions

A UK company is developing some of the world's most sophisticated body and vehicle armour technology. Paul Fanning pays it a visit.

How do you protect a vehicle from a massive roadside bomb? Or an individual from a high-velocity armour piercing round? Or allow a bomb disposal officer to be both safe and able to perform his role effectively?

Morgan Advanced Composites has developed, manufactured and fitted the body and vehicle armour that has been protecting British troops in Iraq and Afghanistan for more than a decade.

As a leading supplier of advanced armour systems to the UK Ministry of Defence for more than 25 years, Morgan's Composites and Defence Systems business, formerly known as NP Aerospace, has supplied more than 100,000 Osprey body armour plates and 100,000 Mk 7 combat helmets for operations in Afghanistan.

Globally, Morgan has supplied in excess of a million combat helmets.

At the heart of this market success, of course, is the company's unceasing development of new material solutions. Chris Davies, the company's technical director, explains the technical challenges such materials face. "The issues for any armour are basically fragment protection, ballistic protection and blunt trauma protection," he says, "The problem is that different materials offer different protective properties, so finding a balance is the hardest part. For instance, on our latest AC904 model helmet a hybrid of materials are used; ultra-high molecular weight polyethylene, which is ballistically efficient, but not as structural as the Aramids we've previously used. At the same

time, ceramics are best used to stop armour-piercing ballistic rounds, but composites are excellent against fragmentation such as shrapnel from a blast."

The other significant factor in body armour is that it has to be worn by an individual and so needs to be as light as possible, while providing the greatest possible protection to the wearer. The next generation AC904 combat helmet developed by Morgan Advanced Materials improves on the exacting standards of the AC903 product, whilst being 30% lighter, providing a reduced weight burden of 0.4kg per helmet. Employing new materials technologies and leading edge manufacturing techniques, the new helmet can be fitted with both current and future head-mounted systems and protective



The Mastiff (above) had its armour improved significantly in just three months, reducing the overall 'edge' effect. Morgan has also played a significant part in improving body armour for troops (below).

eyewear – a key requirement for militaries around the world.

Morgan's other well known area of expertise is in ballistic plate armour. It has supplied 100,000 of its Osprey armour plates to the Ministry of Defence. These are ceramic inserts developed by NP Aerospace in just six weeks to cover the shortcomings of the previous body armour during the UK's Iraq deployment.

Says White: "Most of our developments have been dictated by a combination of operational requirements from the MoD and new developments in the different raw materials available. In the case of the Osprey plates, we have moved from heavy ceramics to polyethylene, which has reduced the overall weight of the plates by over 2kg in the space of 10 years."

However, the key point of these materials is to protect the user, meaning that no reduction in their capabilities is acceptable. In fact, though, the next generation of body armour is not only much lighter, but also it offers much greater protection.

The reason for this is that it is able to absorb more ballistic strikes than its predecessors. A few years ago, body armour plates could only absorb one shot before becoming structurally unsound. This was in no small part due to the cracks such an impact caused that served to weaken the overall effectiveness of the plate.

More modern systems are able to absorb two impacts, but even here there is still a danger that the cracks could cause weakness.

This problem has been overcome by Morgan Advanced Materials, whose crack mitigation technology on its next-generation body armour means that the impact is absorbed much more quickly and its energy is dissipated locally, meaning that the armour can absorb multiple shots should its wearer be so unfortunate.



Soldier protection systems are one aspect of Morgan's armour offering, but perhaps even more impressive is its work on 'Platform Protection'. This essentially means armour for military vehicles. Engineered using a combination of advanced ceramic and structural composite materials, its high-performance multi-hit armour weighs up to 50% less than equivalent steel products for high threat level systems.

Perhaps Morgan's most famous achievement in this sphere was in turning around the Mastiff project in just 12 weeks to meet an urgent operational requirement during the Iraq deployment. Designed to replace the Snatch Land Rover, which had proved vulnerable to roadside IEDs, the Mastiff came to Morgan as a basic vehicle from the US and was designed, fitted out and delivered by Morgan to the field of operation just three months later.

This project involved the fitting of Applique armour to the outside of the vehicles and shaped Spall armour inside, which means that fewer panels are required, meaning there is less chance of pieces of armour shearing off and becoming projectiles. These are compression moulded in ultra high molecular polyethylene, by the company, which not only reduces the number of panels required, but also reduces the 'edge' effect.

More recently, Morgan Advanced Materials, through its Composites and Defence Systems business has drawn on its extensive materials and engineering expertise to design and develop a bespoke armoured composite crew compartment for Tata Motors' Light Armoured Multipurpose Vehicle (LAMV) programme for the Indian Ministry of Defence. The LAMV prototype was successfully unveiled at Defexpo, New Delhi, in February.

The LAMV incorporates crew protection based upon Morgan's bespoke composite and ceramic 'pod' technology, which has been developed over the past 20 years. The pod creates a detachable, blast and ballistic-resistant crew compartment, which is easily integrated onto the Tata-produced chassis and can be modified to provide higher levels of protection as and when required. The Morgan composite and ceramic 'pod' provides a weight saving in excess of 1000kg, making it less than half the weight of a similarly protected steel structure.

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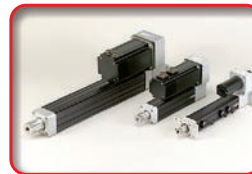
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Gaining leverage

Designing a wheelchair for rugged terrain threw up some unusual design challenges, especially when sourcing the components to enable its drive system. Justin Cunningham reports.

Mobility for people with disabilities is an area of considerable development. A significant trend is that these developments are coming from wheelchair users themselves, who are demanding chairs and walking aids that better suit them and their lifestyle.

Wheelchair users generally want to be able to go out and enjoy the countryside. However, activities as simple as family trips in the park, attending music festivals or ambling along country paths can be difficult or even impossible in regular wheelchairs due to uneven ground, steep terrain and mud.

While some traditional wheelchair designs are available with chunky, 'off-road' tyres, they still require the user to push the wheels to move the chair, resulting in muddy hands and difficult to move wheels.

It was this frustration that saw inventor Tim

Morgan come up with the Mountain Trike, a wheelchair specifically designed for off-road use in difficult conditions that was able to deliver the performance being demanded by active people who are wheelchair bound.

The Mountain Trike is designed for crossing ground that would be uncomfortable or even impossible in traditional wheelchairs such as woodland, sand, snow, mud and cobbles. The large front wheels mean users can easily ride up and over kerbs or other obstacles, yet the chair is narrow enough to fit through doorways. The chair is also able to fold flat, with the rear wheel folding neatly underneath the frame.

The chair uses an aluminium space frame to keep weight under control, and also features a smaller rear wheel, and two small, anti-tip front wheels to prevent the chair from rolling over if braking quickly or when going up or downhill. In

addition, independent suspension on each wheel not only gives a smooth and comfortable ride, but also means users can turn or travel across slopes safely and with confidence.

One notable difference is the use of two drive levers, pulled by users to transmit power to the wheels. This overcomes a number of shortcomings. First, on off-road terrain it stops the user's hands from getting covered in mud and dirt. Secondly, they are able to transmit more power to the wheels, using optimised gearing to give good speed on flat ground, but making hills less of a challenge to climb.

However, as mountain bike designers will know, operating in these conditions puts a significant amount of additional strain, debris





Overcoming durability issues was a big problem with the Mountain Trike, but springs in the clutch sprags overcame backlash and helped eliminate shock loads

However, rather than a standard bike freewheel, Morgan chose to specify an overrunning clutch to transmit the kinetic energy from the levers to the wheels.

"When the wheels are spinning freely on a mountain bike, without drive from the pedals, the freewheel clicks during the rotation," says Morgan. "The Mountain Trike is intended for use during family walks and other lifestyle activities so I wanted to make sure it would run silently. I also found that bike freewheel has a small amount of free travel before it engages. Because the levers are quite long, this translated to several inches of free travel, which was quite jarring for the user and resulted in less efficiency overall. Using an overrunning clutch eliminated both these issues."

However, while the initial overrunning clutches specified on test models performed as desired, it became apparent that longer term use brought questions of durability, which was likely to only be exacerbated when used off-road and on challenging terrain.

The reliability and durability issue was traced back to poor seals on the overrunning clutch unit. It meant that mud and contaminants could creep inside, causing seizing and undue wear, while the poorly machined internal components led to slipping and eventual failure, due to the shock loading caused by disengaging and

engaging the drivetrain with every push.

Morgan, aware that he needed to source an alternative component that could survive in the most extreme terrain, approached Stieber Clutch with the problem, hoping for a solution. He found that a similar configuration of overrunning clutch was available off the shelf and, persuaded by its promise of superior quality, decided to trial the component to see how it compared.

"I was supplied with Stieber's CSK PP overrunning clutch for testing and the superiority of the component was immediately apparent," says Morgan. "The seals were clearly far better protected and the movement was so much smoother."

The Stieber clutch offers a number of unique design features that help ensure it will last, even over dirty and difficult environments and terrains. The sprags of the clutch component are manufactured using the company's 'Formchrome' process, which diffuses a chromium carbide into the working surface of the sprag. This substantially increases the surface hardness and results in far superior wear protection. The sprags are also precision machined to ensure they are identical, to prevent any uneven rolling movement.

The sprag retainer assembly also features a free-action design that permits each sprag to have free and independent action. This independence allows the sprags to adapt to variations in annular space and eccentricities, so when the clutch is engaged the load is proportionally shared throughout. This is an important part of the component as it eliminates shock loads, jarring motions and the possibility of clutch damage from the entire load being absorbed by just a few sprags. In operation, springs energise the sprags into position for instantaneous engagement with virtually no backlash.

"During the testing process it was clear that the Stieber clutch offered far more in terms of reliable performance," says Morgan. "Since they have been installed, we have had no reported failures, even from some of our more adventurous customers. Overall, it gives riders an amazing feeling of freedom and independence."

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and wear on components.

From the outset it was clear that the Mountain Trike needed to be both lightweight and reliable in these rugged conditions. The clutch was a key component, which would enable the gears and lever system to be effective. The lever drive was essential to the design, as it not only allowed users the ability to propel themselves forward, but also to steer and brake.

The levers are connected to the wheels using a similar system found on mountain bikes.

established 1974

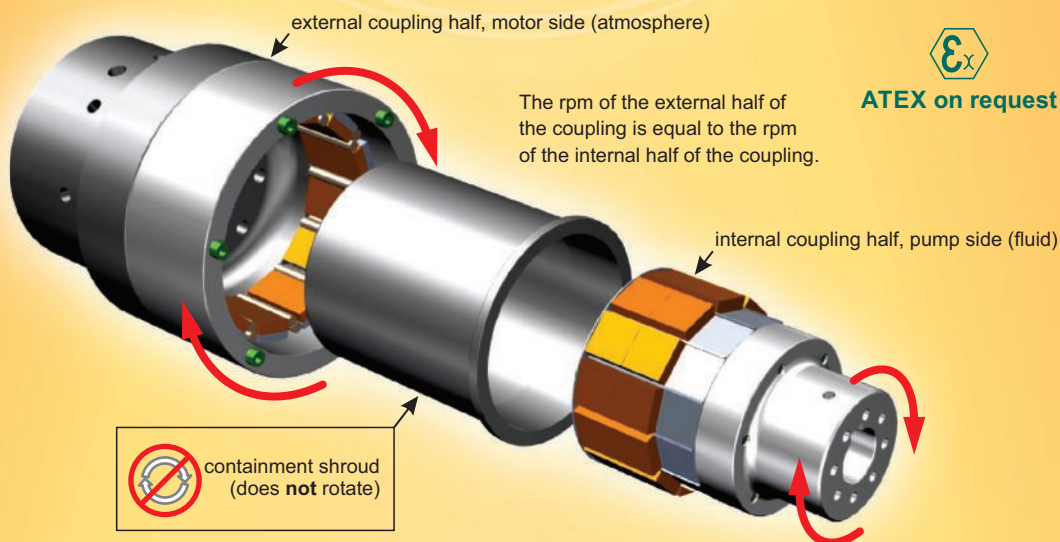


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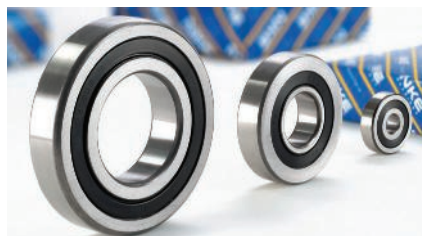
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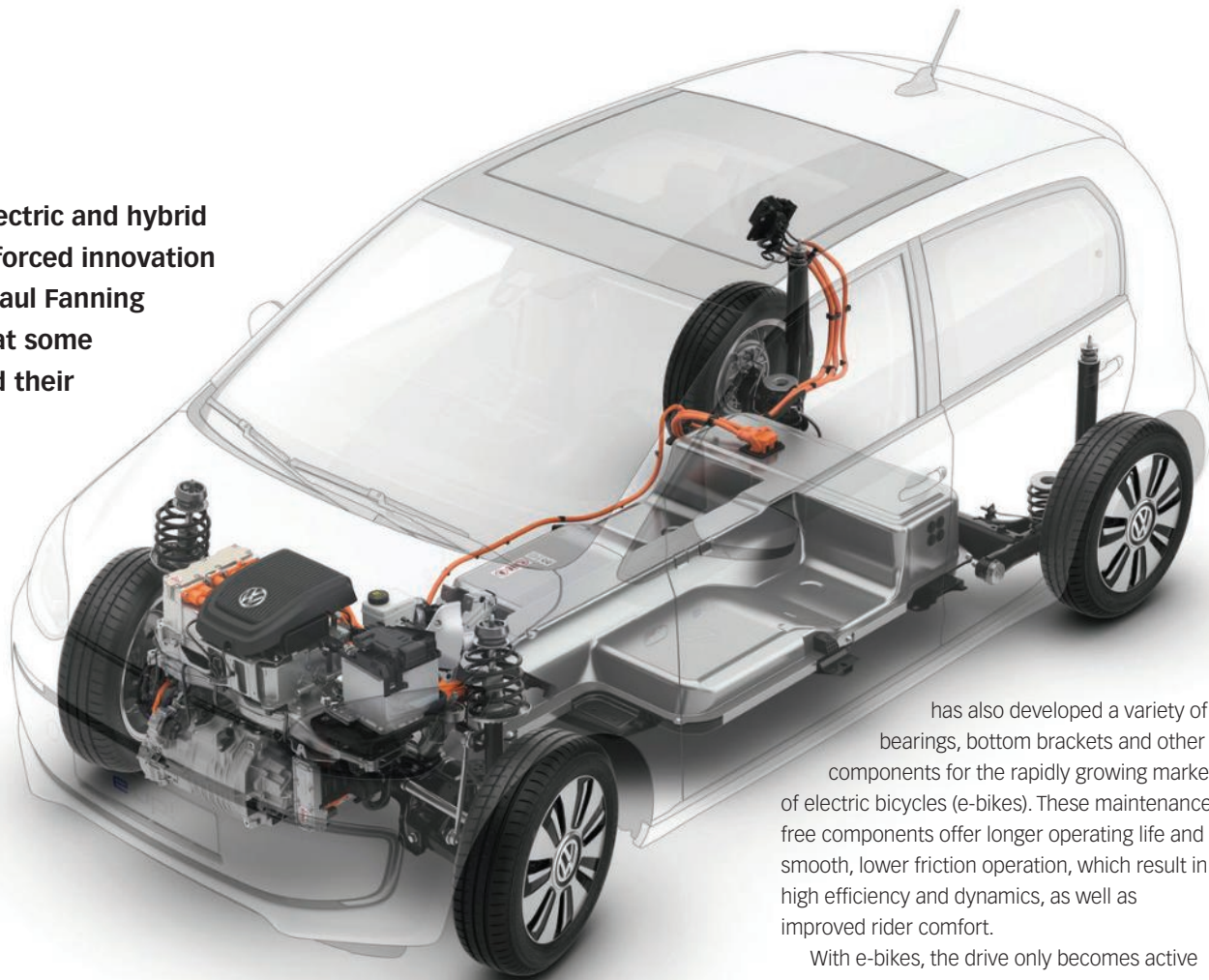


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More possibilities!

NKE
 BEARINGS

The rise of electric and hybrid vehicles has forced innovation in bearings. Paul Fanning takes a look at some examples and their application.



Electric vehicles drive bearing innovation

Electric and hybrid vehicles are a reality, rather than a pipe dream. Every major car maker has introduced some electric vehicle, while hybrid vehicles are an increasingly common sight on our roads. These changes have forced bearing manufacturers to adapt their offerings accordingly, and indeed, to undertake considerable research into the issue.

Schaeffler, for instance, has extended its range of innovative solutions for all-electric and hybrid electric vehicles.

"The electrification of the drivetrain is making rapid progress," says Professor Peter Gutzmer, chief technical officer at Schaeffler. "This means that engine start-stop systems, for example, are becoming standard, recovery of braking energy is gaining popularity on the roads, and the number of hybrid models is increasing."

Schaeffler has developed a series of innovations that are contributing to the further development of engine start-stop systems. These include the optimisation of components in order to accommodate the significant increase in the number of start procedures, as well as solutions for start-stop systems such as non-contact sensors, optimised bearings, specially-coated components, electro-mechanical camshaft phasing units, latching valves, and components for belt-driven starter generators and permanently-engaged starters.

But Schaeffler's work in this area is not restricted to cars. It

has also developed a variety of bearings, bottom brackets and other components for the rapidly growing market of electric bicycles (e-bikes). These maintenance-free components offer longer operating life and smooth, lower friction operation, which result in high efficiency and dynamics, as well as improved rider comfort.

With e-bikes, the drive only becomes active when the rider is pedalling and generating a certain level of torque. Deep groove ball bearings from Schaeffler are used in the front wheels, rear wheels and the central drive of e-bikes. The improved surface geometry of the bearing raceways and balls reduces noise generation by up to 50% compared to conventional deep groove ball bearings. These improvements, combined with improved surface quality, reduce friction by up to 35%. The lower frictional torque and reduced heat generation enable the bearings to operate at high speeds.

Seals also play a key role in terms of reliability and energy efficiency, particularly in dusty or wet riding conditions. Schaeffler's new efficient lip seal (ELS) offers an unbeatable combination of reliability and energy efficiency. At increasing bike speeds, this significantly reduces the frictional torque, and therefore the power loss of the wheel bearings. With its improved sealing, the ELS provides better protection for the bearing and smoother running.

At the connecting point between the handlebar stem and the fork, angular contact ball bearings from Schaeffler are fitted as headset bearings, which ensure the





required precision and safety. During riding, the forces acting on the stanchions of the suspension forks are supported and transmitted by ELGOGLIDE plain bearings from Schaeffler.

In addition, drawn cup roller clutches from Schaeffler are used as one-way clutches in the drive of the electric motor. These transmit high torque forces in one direction. The bottom bracket spindle connects the pedals and sensor unit in the drive. Various designs of the bottom bracket spindle are available as options. In addition, components can also be coated with Schaeffler's Corrotect coating, which is resistant to neutral, organic fluids such as oil, brake fluid, petrol and aqueous salt solutions.

SKF also has a range of energy-efficient ball bearings that can increase mileage for electric and hybrid vehicles. Addressing the specific requirements of high power density electric motors for electric and hybrid vehicles, SKF eDrive ball bearings enable lower levels of friction and heat dissipation, supporting higher electric motor efficiency and operating speeds.

This solution provided by SKF allows electric motors and e-powertrain manufacturers to improve the efficiency, power density and battery reliability of motors. Similarly, the manufacturers of electric and hybrid vehicles can offer their customers increased mileage, while battery lifetime is extended by a reduction in the number of charging cycles.

For example, in a typical electric vehicle, an extra 1% of mileage can be gained by using a set of optimised SKF bearings and seals on the

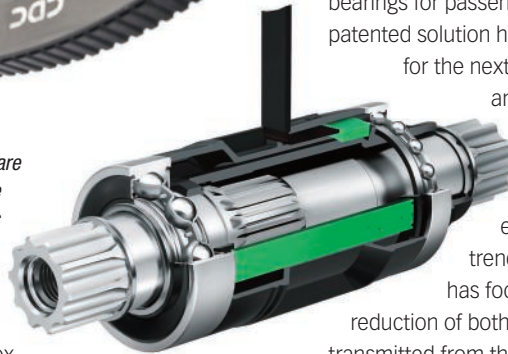
Bearing innovations are offering performance advantage to electric vehicles

electric traction motor and gearbox compared to conventional alternatives.

These bearings benefit from a number of innovative design features, including optimised internal geometry, ultra-low friction sealing and a patented, energy-efficient polymer cage. These features enable higher operating speeds with low self-heating and low friction torque with no variation of friction torque either during the product's lifetime or under axial loading conditions. The bearings also use validated, long life, wide temperature grease to enable optimum performance in high-speed applications.

SKF eDrive Ball Bearings can also be integrated with the SKF Rotor Positioning Sensor-Bearing Unit to enhance electric motor efficiency. The SKF Rotor Positioning Sensor-Bearing Unit has recently been enhanced for traction motors and can improve energy recovery during braking, reduce electric noise, and ultimately enable a total cost reduction. The SKF Rotor Positioning Sensor-Bearing Unit also offers high resistance to vibration, severe magnetic field disturbances, and temperatures up to 150°C.

In fact, SKF is supplying customised tapered roller bearings and SKF eDrive Ball Bearings to



the electric motor and gearbox of the Volkswagen e-up!, which was launched in Autumn 2013. The bearings help to reduce the friction and noise in the e-powertrain, enabling an extended driving range of the vehicle.

SKF automotive president Trygve Sthen says: "The SKF eDrive Ball Bearing is a product in our SKF BeyondZero portfolio and is one of our energy-efficient solutions for hybrid and full electric vehicles. Our partnership with Volkswagen has grown over the years and we both are taking positive steps to reduce the emission footprint of greenhouse gas globally."

SKF also offers angular steering column bearings for passenger cars and light trucks. The patented solution has been designed specifically for the next generations of luxury cars and electric vehicles, in line with the automotive trend towards a more comfortable driving experience. To transfer this trend to the steering system, SKF has focused its studies on the

reduction of both noise levels and vibrations transmitted from the road to the driver.

The design of this new, robust, angular steering column bearing replaces the standard wavy spring with a new patented rubber solution. This change has resulted in a considerable reduction of the torque variation and contributed to the smoother steering feeling.

NSK, meanwhile, has developed a silent needle roller bearing that reduces noise by a third compared to that made using conventional products. This innovation is perfect for electrical components mounted in vehicles with extremely quiet interiors while driving under the power of an electric motor, such as electric vehicles (EV) and hybrid vehicles (HEV).

The ends of the needle rollers used in automotive electric components are crowned (i.e. given a curved arc) to make the bearings able to withstand a heavy load. This improved roundness of the roller compared to the conventional product means noise levels are reduced by one third of that of the conventional product, helping to create quieter, more comfortable vehicle interiors in EVs, HEVs, and luxury cars where a very quiet ride is required.

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igus bearings drive to victory

A redesigned pedal box that used igus iglidur plain bearings was a crucial factor in Andy Napier winning the production class championship in the Lotus Cup UK series, in his Lotus Elise last year.



Napier clinched the title at the last round at the Snetterton circuit in Norfolk.

"The Lotus pedal box is an old design, even though they have improved this as the car has evolved," says Napier. "One of the main problems is that it is fixed to the front bulkhead and basically exposed to the elements. The unit is, as is most of the Elise chassis, bonded and then riveted to the chassis."

Over time, the rivet heads corrode and eventually fail so that the pedal box is only being held in place by the bonding agent, which also starts to deteriorate.

"We looked at ways to improve the design as we were not constrained by anything else on the bulkhead," says Napier. "We looked to see where it could be improved and our search led us to igus and its iglidur J bearings range... The correct bearing meant the pedal assembly lasts longer and is more reliable."

www.igus.co.uk

Technical Guide from Schaeffler

Precision bearing manufacturer Schaeffler has published a Technical Pocket Guide for the UK market. The publication is free-of-charge and is available in either printed hard copy format, or as an Apple/Android software App.

Schaeffler's Technical Pocket Guide is a useful technical reference book for mechanical engineers, technicians, apprentices and students across numerous technical and scientific disciplines.

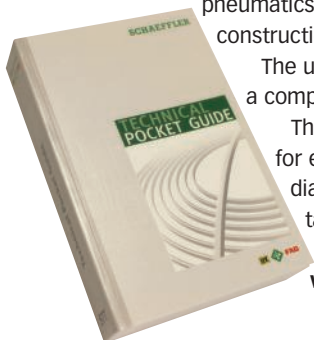
Practical and easy-to-use, the Guide is intended as an educational tool that becomes a trusted companion for many people in their day-to-day work.

The Guide covers a variety of technical subjects including units of measurement, mathematics, statistics, physics and chemistry, as well as specialist subjects such as mechanics, acoustics, hydraulics and pneumatics, mechatronics, tolerances and fits, construction materials and components.

The user-friendly Guide bridges the gap between a comprehensive textbook and purely tabular data.

The book comprises 14 colour-coded chapters for easy navigation. There are numerous diagrams and drawings, well-structured texts, tables and formulae, allowing the reader to quickly find what he or she is looking for.

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NSK extends service life of wheelset bearings

NSK bearings have been fitted to the first batch of Hitachi trains and are set to play a vital role in ensuring the trains built for the Intercity Express Programme (IEP) meet targets for minimum maintenance, high reliability and extended service life.

Based on designs that have been delivered in terms of performance and safety on the advanced high-speed Shinkansen trains in Japan, the NSK wheelset bearings have been engineered to match the operating life of the wheels themselves: over a million miles.

Tony Synnott, NSK European railway sector manager based at the NSK factory in Newark, Nottinghamshire, says: "Put simply, the wheelset bearings are the interface between the static parts of a train's undercarriage and the rotating parts, including the power



transmission and wheels.

"Their performance and reliability are essential to the continued running of the train, and what we have done with this project is to adapt some of the aspects of the design that have worked extremely well in Japan, and extend the maintenance requirements to coincide with wheel maintenance. This thereby

guarantees performance, while increasing train availability."

The working environment is extremely tough for these double-row taper rolling bearings, with high loads and lots of potential external contaminants present. In addition, temperature differentials and constant vibration are ever present.

The steel used to manufacture the races have been developed by NSK purely for extended life in bearings

used for extreme conditions.

The sealing arrangement and materials are also critical to keeping the grease fresh inside and other elements out.

"The lubricant we are using is of the highest quality and formulated specifically for this application," says Synnott.

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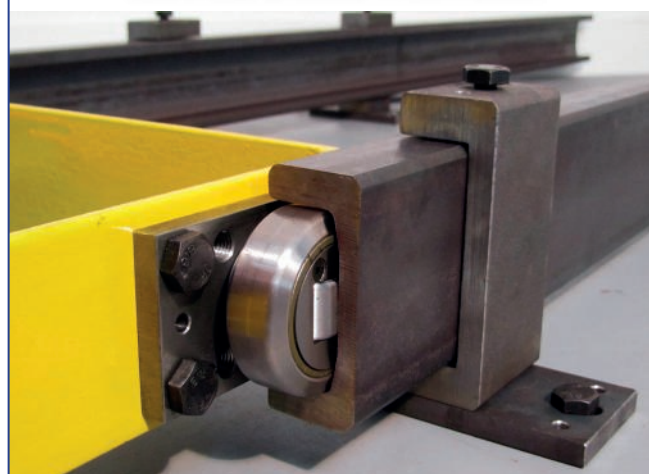
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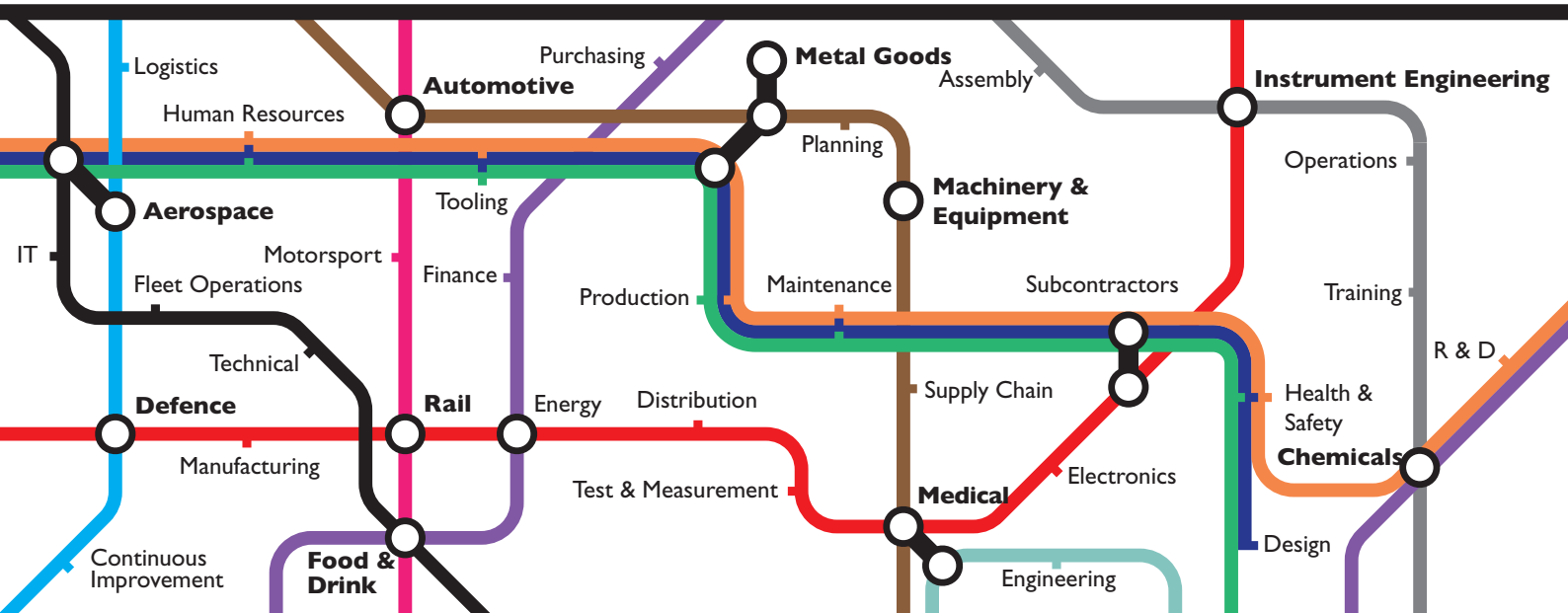
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A non-contact laser profile displacement sensor is playing a pivotal role in the development of an automatic inspection system to assess the surface and weld quality of ships structures. Eureka finds out more.

The inspection system, X-Scan, is a novel automatic inspection system that inspects the surface and welds of ship hulls by combining three sensing techniques; laser, ultrasound and electromagnetic methods. The system has also been integrated into a crawling robot that is able to provide automated inspection during the manufacture and servicing of ships and vessels.

Micro-Epsilon's scanCONTROL LLT 2700-100 laser profile sensor has become a crucial part of the X-Scan system, providing the control and performance required to verify and analyse the quality of steel used in ship hulls and the corresponding weld integrity at critical joins.

Structural failures

In the marine industry, structural failure is a major cause of ship, tanker and other marine vessel loss. Each year, dozens of ships sink, many as a result of leaking structures due to corrosion and poor weld quality. The results can be devastating and can result in long delays while repairs are carried out, pollution of waterways and, worst of all, loss of life.

Most of the inspection techniques used today are disruptive to the manufacturing process and are far from cost effective. And with the next generation of ships being built from thinner sections of steel in order to lower the cost of build and ship operations, typical assessment methods are not as effective as they were for thicker sections. Therefore, there is a genuine need for a more reliable, faster, cost effective and safer inspection technique.

This led to X-Scan being applied. The system uses a combination of an ultrasonic phased array, electromagnetic Alternating Current Field Measurement (ACFM) technique and an optical laser, to enable the detection and sizing of surface and sub-surface flaws and defects.

By developing the system alongside a laser-based tracking and self-controlled robot, X-Scan

now enables automatic inspection of welds following a weld run.

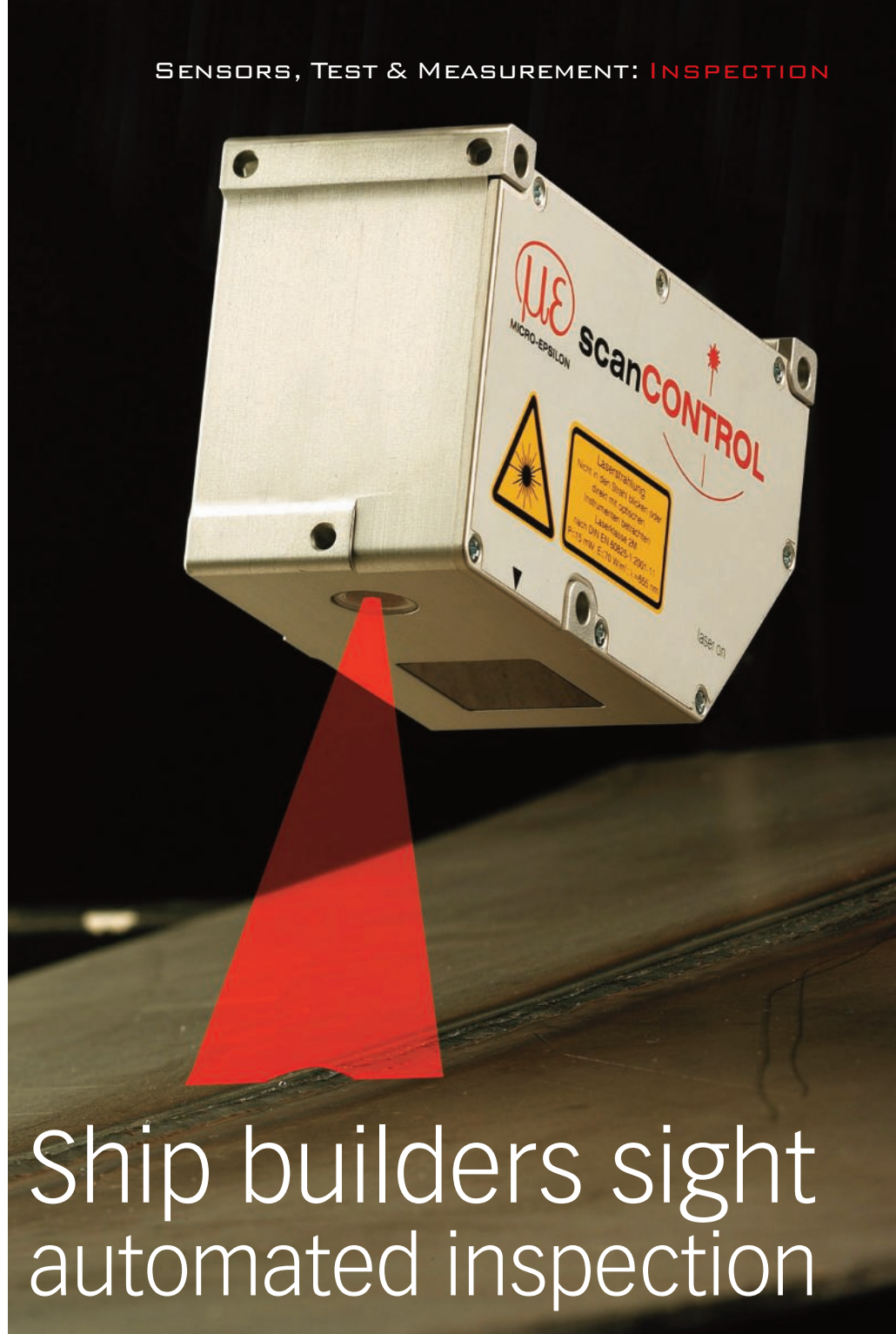
Alvin Chong, X-Scan project leader and a research fellow at the Brunel Innovation Centre, says: "The scanCONTROL 2700-100 has been very reliable and is a critical part of the X-Scan system. First, it provides very high-resolution measurements that we require in order to detect small weld defects, which may measure just a few millimetres in diameter, or even down to a few microns if the defect is a weld crack or notch.

"Second, the scanCONTROL sensor outputs the profile measurement data to the X-Scan's

robot control system for guidance purposes. This is very important too, as we need the robot to follow the centre of the weld line accurately at all times. The robot cannot be allowed to deviate from this centre line, otherwise the ultrasonic and ACFM inspection systems will not be effective."

X-Scan is a collaborative project between EU companies and research organisations. The objective has been to develop and produce novel inspection techniques and devices specifically for the inspection of thin steel section welds for the shipping industry.

The research leading to these results has



Ship builders sight automated inspection

received funding from the European Union's Seventh Framework Programme managed by REA-Research Executive Agency.

The X-Scan Consortium comprises seven collaborators from four member states, including three SMEs, each representing a different EU country. The members include TWI (UK), Brunel University (UK), Innora Robotics and Automation (Greece), Vernon (France), Spectrumlabs (Greece), Technitest Ingenieros (Spain) and Lloyd's Register EMEA (UK). For the X-Scan project, Innora was the research technology development provider and led the design and manufacture of the robot.

At present, X-Scan can be used for automatic inspection of ships in dry dock. However, the system could be expanded and further developed to include a 'marinised' robot, and by adding extra inspection techniques.

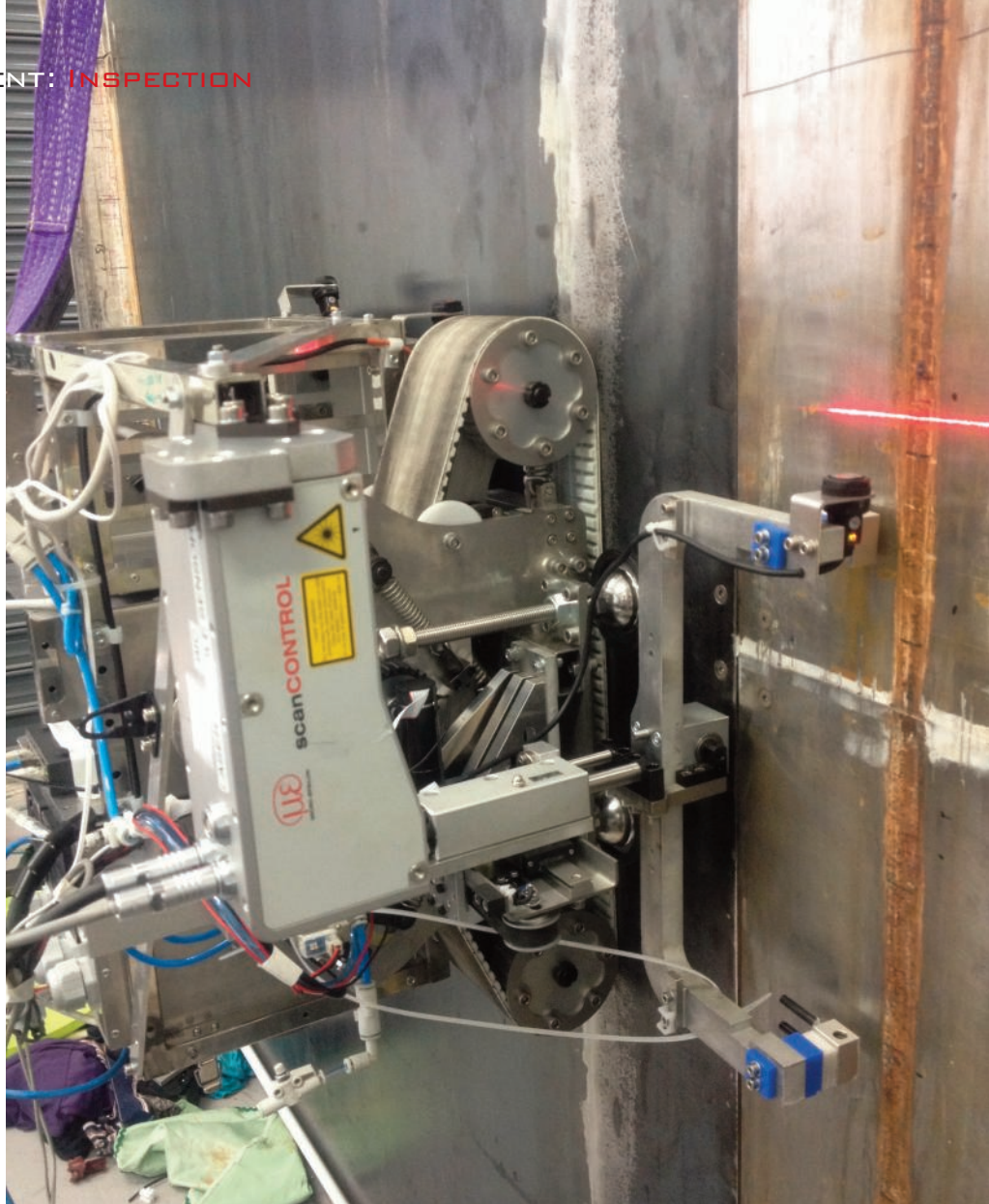
X-Scan is suitable for both new and old ships and vessels and the device enables the detection of flaws in material porosity, lack of weld penetration, lack of fusion and also cracking.

Combining three inspection techniques in a single automatic inspection system saves considerable time and money. In addition, the system eliminates both the need for working at height, and the need for high-risk radiography equipment.

Although the system is a prototype, the developers are working on making it more compact and user-friendly. However, even in its current form the system provides defect imaging and analysis at much greater speed and convenience than currently exists.

The scanCONTROL LLT 2700-100 used on the X-Scan system has a measuring range of 100mm and is supplied with a protective cover plate attached to the base of the sensor (with a protective window) through which the laser beam passes. The sensor provides a profile frequency of 100Hz and can measure up to 64,000 points per second.

The scanCONTROL 2700 series uses the laser line triangulation measurement principle. The sensor has an integrated, highly-sensitive Complementary Metal-oxide Semiconductor (CMOS) array, which enables measurements of almost any difficult surface, including those that are shiny or reflective, independent of the reflection from the target. This means excellent accuracy, resolution and reliability are achieved, even at high measurement speeds.



A line optical system projects a laser line onto the surface of the object being measured. The back-scattered light from the laser line is registered on a CMOS matrix by a high-quality optical system.

Along with distance information (z-axis), the controller calculates the true position along the laser line (x-axis) from the camera image and outputs both values in the sensor's 2D co-ordinate system. A moving target or traversing sensor generates a 3D representation of the object being measured.

The system itself comprises a sensor and integrated controller, which calculates the dimensions of the weld profile.

For the X-Scan system, the laser profile scanner operates in a scanning mode, where the sensor works in combination with the robot/motion control device. The CMOS array uses a real time, high-speed electronic shutter, which captures the entire profile and processes the information instantaneously.

Inspection for wider application

Micro-Epsilon's scanCONTROL 2700 non-contact laser profile displacement sensor provides an integrated controller in the sensing head, that although compact, has proven to be incredibly effective.

Users require no other components to evaluate measurement data and the unit is also straight forward to set up, configure and adapt for different applications.

The compact design and integrated controller makes the unit ideal for industrial automation tasks and machine building applications, where space is often restricted.

Typical uses include the measurement of angles, channels, gaps, edges, clearances, weld seams, adhesive quality inspection, door edge detection, robot guidance and positioning, groove width and depth measurements.

www.micro-epsilon.co.uk
www.x-scan.eu



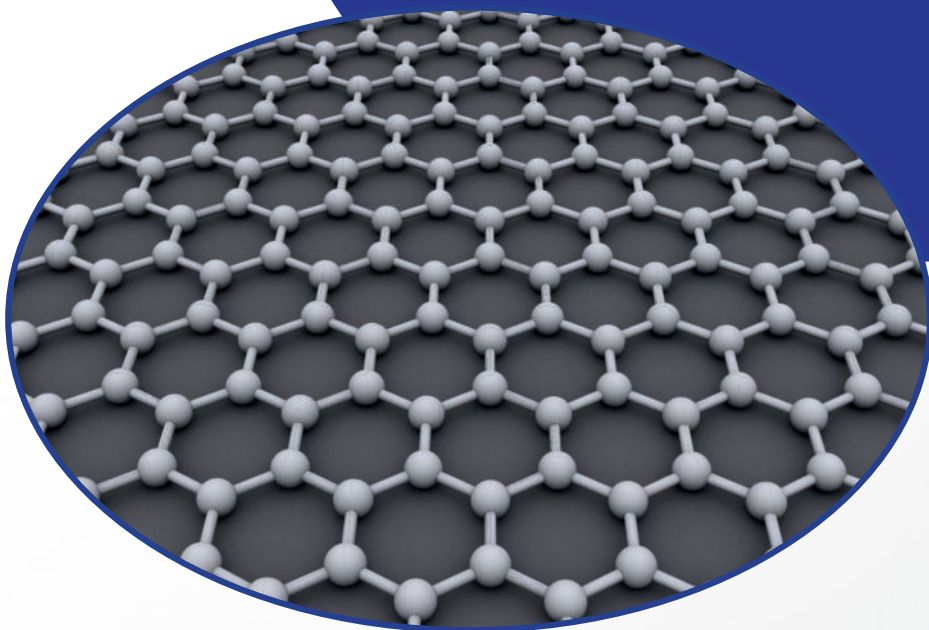
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Balluff High-resolution light grid BLA - Identify parts and determine positions

If different objects must be identified, compared or sorted during packaging, Balluff's newly-developed high-resolution light grid can score points with its high-resolution light grid for optical object detection with a width of 50 mm and a range of up to 2 metres. Consisting of a transmitter with a high-performance redlight laser and a receiver, the device works completely self-sufficiently, without additional accessories such as PC or special software. All settings can be made via a display in the receiver.

The high resolution of 0.01 mm opens up many application possibilities. Evaluated are not only the light quantity of the especially homogeneous red laser light, but also the location and position within the light grid. In addition, the emitter and receiver are encased in a rugged industrial housing and can be easily and quickly aligned using the live graphic display on the integrated multi-function display.

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Wanner International has introduced two new Hydra-Cell® Dosing Performance Pump ranges with mechanical flow rate adjustment.

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A Bright Future for Bifold

Ambitious valve manufacturer Bifold continues to grow and has acquired new premises to accommodate an increase in business

Bifold have moved to larger premises on Broadgate, Oldham Broadway Business Park, which means they will be better placed to expand the business in the longer term.

The new premises has meant that we have been able to achieve significant productivity enhancements with the emphasis very much on **Configurable Lean Manufacturing™ - cLean Manufacturing™** this gives the capability to configure engineered to order products over the mobile network and can be delivered within 24 hours.

Bifold is the leading manufacturer of instrument valves and pumps for the oil and gas sector and its profits have grown 50% per year since 2002.

Bifold are dedicated to maintaining the excellence of their products and their new facility confirms their commitment to shortening lead times and meeting customer demands.

They would like to take the opportunity to thank all their customers for their continued support.

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Avoiding the fiddly-factor

Ergonomics has become a major factor in modern engineering product design. This was, however, not always the case which means many older mechanisms can be difficult to use and in need of improvement.

A good example is the humble zip. After more than 100 years, the zip is still used ubiquitously to join fabrics and materials together from garments to bags to tents, the world over.

The zip (or zipper) is incredibly elegant in engineering terms, using rows of protruding interlocking teeth that can be made in a variety of sizes and materials for a variety of functions. There have been various iterations over the years that have seen the zipper enable waterproof and even air tight mating between the two different rows of teeth. There are two key areas of the zip, however, that can be the cause of frustration.

Bringing together the two halves of a zip at the bottom, to correctly align and start the zip, can be a tricky exercise in some circumstances. The 'Insertion Pin Boll', is the part that is inserted in to the 'Retainer Box', so that zipping can begin.

The problem, however, is that bringing these two halves together is not always straightforward. A classic example is when gloves are worn, perhaps in a hazardous environment or

indeed when it's rather chilly outside. Taking gloves off is not always an option, and even if it is (in the cold, for example) shivering and shaking makes bringing the ends together virtually impossible. And, of course, there are those with degenerative disorders that make using zips a frustrating and time consuming exercise.



The Challenge

The challenge this month is, therefore, to come up with an alternative for the base of a two half zipper: the Insertion Pin Boll and Retainer Box.

These two halves need to come together more quickly and much more easily, and in exact alignment, in all circumstances and conditions. The solution should clearly be simple and low-cost, as the zipper by its very nature needs to be cheap to make. The idea is to remove the fiddly frustration of a zip, so the acid test for any design is: can you do the zipper up one-handed?

While simply going larger is one solution, this still requires some element of inserting one element into the other, and with one hand it would still score high in 'fiddly-factor'.

This is what we want to avoid!

Clips that clasp together could be another option, but how would you bring these together?

The solution we have in mind answers this dilemma and has the potential to be applied to any zipper, of any size, and is due to make its debut in ski-wear later this year. In the meantime, however, see what you can come up to solve this conundrum.

The answer to last month's Coffee Time Challenge to farm fish ethically and sustainably can be found in our Technology Briefs section on page 11.

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