

Alone at sea



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inour opinion

Voyage of discovery



We're becoming used to the idea that machines that move don't necessarily need people to control them. While driverless cars are still in the future, we have a pretty good idea of how they'll work and under what circumstances. Pilotless aircraft are an established technology now. And as our cover feature (page 16) in this online issue explains, autonomous ships, while not as developed as other unmanned transport technologies, are well into development and seem certain to join the stable of self-piloting vehicles.

As our feature explains, technology isn't the only developing area for autonomous ships. Regulations also have to be developed, to ensure the safe operation of these vessels and to give their operators a sound legal framework for their business. Issues such as liability need to be resolved; while security is an important issue. But the absence of a crew could be distinctly advantageous; without the need to support people on board, naval architects could adopt simpler designs without drinking water, galleys or toilets; and ships could be operated to maximise fuel efficiency. Autonomous shipping could work out cheaper than today's crewed ships.

Elsewhere, this month's interview (page 24) looks at the technology that might replace the trackpad, touchscreen or mouse as the way we operate our computers: eye tracking. A device that can detect when it's being looked at can, to an extent, read our thoughts; or, as its inventors say, it can derive your intention from your attention. As well as forming the basis for human-computer interface, it can also help analyse signage; provide a 'third hand' for some systems; make driving safer; and help disabled people interact with their worlds.

Issues such as liability need to be resolved; security is also important

We're also taking a look at what has so far been a bit of a missing link in the field of additive manufacturing: its raw material, metal powder (page 21). This shouldn't be taken for granted: it has to behave a certain way for 3D printing processes to work

effectively, and it has to be recyclable. If you can't return unused powder to the process for a fresh printing cycle, you negate the economic advantage of additive manufacturing.

We'll be back in print for our September issue, when we'll be bringing you our full range of features, this time with a focus on defence matters and a look at our recent roundtable on Industry 4.0. Have a good summer!

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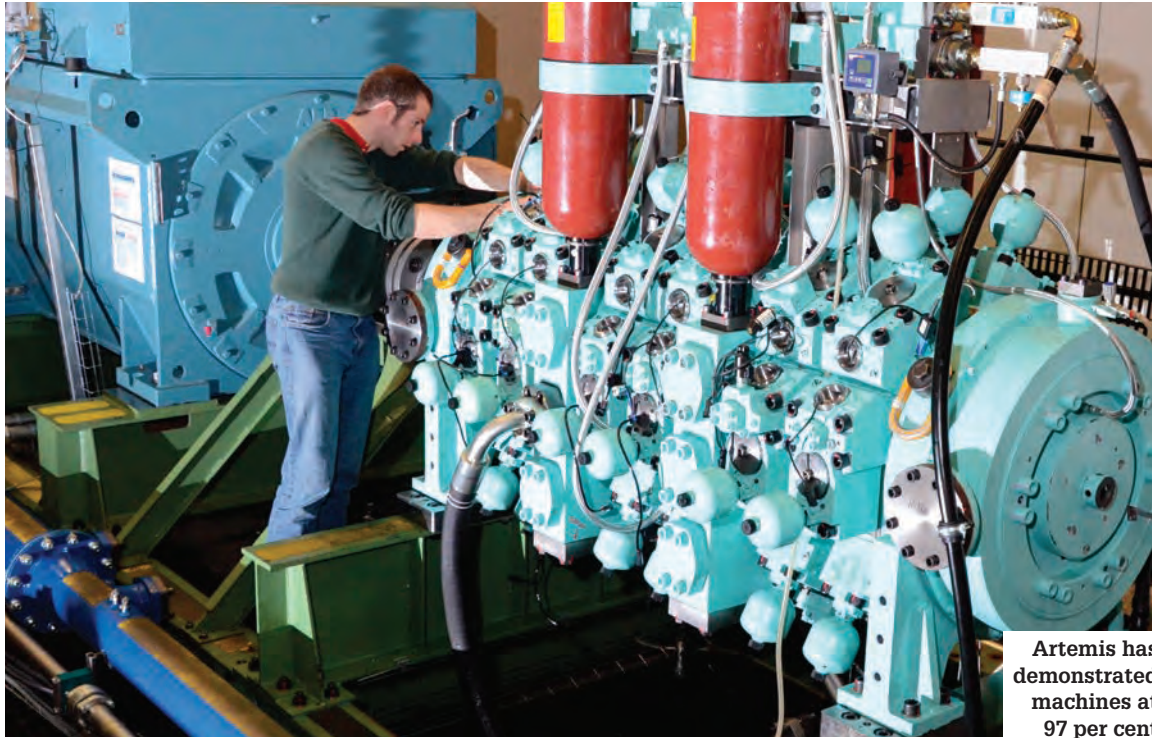
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Artemis has demonstrated machines at 97 per cent

ENERGY

The power and the glory

Artemis has won the Royal Academy of Engineering's top prize

BY BEN HARGREAVES

A British company that has developed a novel technology combining hydraulics with electronics said to be capable of reducing the cost of offshore wind energy has won the MacRobert Award, the Royal Academy of Engineering's most prestigious prize.

Artemis Intelligent Power received the award on 16 July from HRH Prince Philip. The technology can also be used to reduce the fuel consumption of trains and make hybrid buses more affordable.

But it is offshore wind power where the Edinburgh company could make the most impact. Although the UK could generate eight to 10 per cent of its energy from this source by 2020, and already provides 15 terawatt-hours (TWh) of electricity each year, the cost of the technology makes its deployment challenging.

A single offshore wind turbine with power output of 3.5MW can power around 3,300 households. Vast numbers are therefore required for even a small city. "By increasing the capacity, efficiency and reliability of each one, these problems could be significantly reduced," said Artemis Intelligent Power.

Its Digital Displacement system combines hydraulics with analogue control with a system of digital microcontrollers that switch each individual cylinder on and off in real time as the shaft rotates. This combines the advantages of hydraulics – high power density, compactness and low cost – with the efficiency of electric technology.

"We've demonstrated machines at 97 per cent efficiency; that is unheard of in hydraulics," Artemis managing director Dr Niall Caldwell told *The Engineer*. "It is a dramatic improvement that allows you to build a hydrostatic transmission system from shaft to shaft with a pump and a motor that is competitive with electric technology."

This meant hydraulic transmissions could be used for offshore wind, as opposed to conventional gearbox

transmission systems. The hydraulic systems could prove more reliable, Caldwell said, reducing offshore turbine downtime and maintenance costs. "There is a big issue in terms of the reliability of offshore wind turbine gearboxes, and, if they do start failing, how they are going to be repaired quickly and cost-effectively."

Artemis, which has been going for more than 15 years, is owned by Mitsubishi Heavy Industries. In 2014, Mitsubishi joined forces with Danish company Vestas to form a joint venture dedicated to offshore wind turbines.

Since its formation, the digital hydraulics technology has been scaled up from a 1.5kW machine by a factor of about 5,000 to demonstrate a 7MW wind turbine, said Caldwell. "The technology could rejuvenate the conventional hydraulic power supply chain in the UK."

The first turbine in the UK is deployed adjacent to the Hunterston nuclear power station, on the coast of Ayrshire, Scotland. The world's largest offshore floating wind turbine is also employing it, offshore of the Fukushima plant in Japan.

Floating platforms are necessary there because of the depth of the water, Caldwell told *The Engineer*.

Judging panel member Dr Gordon Masterton said: "The team has done for hydraulic engines what James Watt did for steam engines; they have transformed the efficiency and range of potential applications. The largest floating wind turbine in the world is to be powered with a digital displacement transmission, and I strongly believe there are many other exciting applications for this stunning engineering breakthrough."

Artemis scooped the prize against competition from Endomag, which manufactures medical technology for detecting breast cancer. Victrex, which develops advanced polymers in ultra-thin sheets for use in smartphones, was the other contender.

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AEROSPACE

Taking the edge off

Airbus Helicopters' Bluecopter lowers noise and fuel consumption



The Bluecopter is quieter than any other rotorcraft

BY HELEN KNIGHT

A helicopter that consumes up to 40 per cent less fuel and that produces significantly less noise than conventional rotorcraft has been developed by Airbus.

The Bluecopter demonstrator has been equipped with an advanced rotor, improved airframe design and intelligent engine power management system, in a bid to improve fuel efficiency and reduce noise.

The technology demonstrator paves the way for a new generation of quieter and more eco-friendly helicopters, said Marius Bebesel, programme manager for research and innovation at Airbus Helicopters.

The helicopter produces approximately 10 decibels of effective perceived noise (EPNdB), which is below International Civil Aviation Organisation certification limits, and well below any other rotorcraft, said Bebesel, who has overall responsibility for Bluecopter. "We compared Bluecopter with the world fleet, and we are the world champion; we are between 3EPNdB and 5EPNdB [quieter] than conventional helicopters."

The helicopter includes an advanced Fenestron – a rotor fitted inside a protective duct within the tail – that reduces losses caused by drag induced by rotating air trailing from the tip of each blade. It is also quieter than a conventional tail rotor design.

The demonstrator, built using a light-medium twin-engine rotorcraft as a platform, will also be equipped with an acoustic liner integrated into the rotor's protective duct, to further reduce the noise produced.

The helicopter has a newly developed main rotor. This consists of a five-blade rotor system incorporating the company's BlueEdge blades. These are designed to reduce the noise produced by helicopters as a result of blade-vortex interaction. The design of the BlueEdge blades means this interaction with the wake vortex is reduced, resulting in less noise being produced.

The rotor blades also have an increased diameter, and a reduced tip speed of 180m per second. That is because the lower the tip speed, the lower the amount of noise produced, said Bebesel.

To improve fuel efficiency and lower CO₂ emissions, the Bluecopter can switch to 'eco-mode' during cruise, by shutting off one of its two engines, and running the other at a higher load. This eco-mode alone cuts fuel consumption by up to 25 per cent, said Bebesel.

To reduce drag, the helicopter's main rotor and landing skids are both equipped with fairings.

The Bluecopter project was funded largely by Airbus itself. Some of the technologies were developed as part of the European Clean Sky programme.

MATERIALS

Melting method

Process could offer cheaper, greener way to de-gas aluminium

BY HELEN KNIGHT

Removing unwanted gas from molten aluminium alloys is a vital step in the production process, but it is costly and damaging to the environment.

Now researchers at Brunel University London have demonstrated a cheaper and greener method of de-gassing aluminium melt, using ultrasound.

Unless hydrogen gas is removed from aluminium alloys before casting, the resulting solid metals can end up being too porous, and therefore cannot be used.

The existing method, argon rotary degassing, involves submerging a graphite rotor into the melt from above. This releases a jet of argon gas that is forced through the melt by the rotating shaft, creating bubbles that float to the surface, collecting any dissolved hydrogen.

However, the process consumes a lot of argon gas, which is released into the atmosphere. The technique also produces turbulence in the melt, leading to the creation of 'dross' on the surface, or a mixture of metal and oxide, and thereby wasting some of the valuable material, according to

Prof Dmitry Eskin of the Brunel Centre for Advanced Solidification Technology, who led the research.

The researchers set out to show they could achieve a continuous process that would allow them to apply ultrasonic de-gassing to large volumes of molten aluminium. To this end, they submerged a flat plate into the melt. This plate vibrates at ultrasonic frequencies, creating cavitation bubbles in the melt that push upwards, drawing hydrogen into them. When the bubbles reach the surface of the melt, the hydrogen is released into the atmosphere.

inbrief

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Live and learn

ARM has launched the University Alliance Partnership to globally expand the range of learning materials available to engineering students. "This initiative will give universities expanded access to diverse, low-cost hardware, industry-standard software tools and academically rigorous educational materials," said Khaled Benkrid, manager of ARM's Worldwide University Programme.

Feel the force

A lightweight lining for aircraft holds that can withstand the force of explosions could help prevent terrorist attacks, according to its developers. Led by Sheffield University, the team has demonstrated the concept using retired aircraft at Cotswolds Airport, including a Boeing 747, and increasingly powerful explosive charges. Dubbed Fly-Bag, the lining is built up from layers of fabrics with high strength, heat and impact resistance.

Blow-by-blow account

A report from the European Commission Joint Research Centre has highlighted the growth of wind energy across the EU, with eight per cent of total electricity demand now met with onshore and offshore wind installations. The connected cumulative capacity of the EU grid reached 129GW last year, equivalent to the annual consumption of the Netherlands, Belgium, Greece and Ireland combined.

Mobility mission

The government has launched a £20m competitive fund for collaborative R&D into driverless vehicles, along with a code of practice for testing. The measures are hoped to put the UK at the forefront of the intelligent mobility market, which is expected to be worth £900bn by 2025.

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The paper test cartridges can be configured for use with a range of readers



MEDICAL

Printing diagnostic tests onto paper

Inkjet innovation marks advance in personalised health testing

BY HELEN KNIGHT

Diagnostic tests for flu or rare and deadly diseases could soon be printed easily and cheaply onto a single sheet of paper.

Product design specialist Cambridge Consultants has created a technology, called XylemDx, that uses an inkjet-style printer to fabricate different diagnostic tests onto paper.

The technology could allow patients to have personalised tests carried out at their GP surgery or local pharmacy, according to Nick Rollings, principal engineer at Cambridge Consultants.

"The vision is that a patient would go to the pharmacy and describe their symptoms, and the pharmacist would look online at the database of tests and download the relevant one," he explained. "The test could be fabricated on site, and handed to the patient to use at home or in the pharmacy."

The paper test cartridges can be configured for use with a variety of readers, from complex diagnostic instruments to a reader attached to a smartphone or a simple USB-powered device.

The technology can print a range of different diagnostic tests, including electronic, thermal, fluidic, optical and biological.

A conductive ink containing silver nanoparticles can be printed onto the paper and used for electronic tests, for example.

For fluidic tests, meanwhile, a wax is printed onto the paper and then heated to bind it to the surface, creating channels for the sample fluid to flow through. "The wax in the substrate contains the spread of the liquid, and we can create any pathway you desire," said Rollings.

The paper test cartridges can be configured for a range of samples, such as blood, urine, saliva or mucus.

Once regulatory approval is secured, the technique could be used to print any number of tests, according to Rollings.

"If you take a Word document, you would think nothing of printing two or 2,000 copies of the document, whereas with the current...diagnostics you have to set up a production line," he said.

"That is fine if you have a diagnostic test that will be used in really high volumes, but with the US Food and Drug Administration [FDA] pushing for what it calls companion diagnostics – where a diagnostic test accompanies every single drug – you may have a niche application area that may only sell 300 tests a year."

MEDICAL

Plan in operation

A 2mm wrist component will make robotic surgery in the head, face and neck possible

BY STUART NATHAN

A tiny flexible wrist component for needle-sized surgical equipment could enable surgeons to perform operations in tiny spaces, which would involve incisions so small that they could be sealed with surgical tape.

Measuring less than 2mm in diameter, the wrist, which would form part of the suite of equipment for a type of minimally invasive technique known as needlescopic surgery, has been developed by engineers at Vanderbilt University in Nashville, Tennessee.

Needlescopic surgery, also known as microlaproscopy, uses instruments about the size of a sewing needle inserted through incisions that are typically 5–10mm long. It causes less pain to patients, reduces tissue damage and scarring and speeds up recovery times; it is particularly useful for operations in the head and neck. But such tiny instruments are difficult to control.

The Vanderbilt team, led by mechanical engineer Robert Webster, is developing a surgical robot for needlescopic surgery, which a surgeon would operate remotely, like the Da Vinci robot,

which is now mainly used for abdominal operations such as prostate surgery.

"The Da Vinci uses a wire-and-pulley system that is extremely difficult to miniaturise any further, so it won't work in smaller spaces such as the head and neck," explained Webster.

Instead of Da Vinci's rigid rods tipped with pulley-operated instruments, Webster's team is working on a robot whose 'arms' are steerable needles made from a memory metal called nitinol.

These needles are curved, and nested inside each other in a telescoping configuration. By extending the telescoping sections and then rotating them, the surgeon can move the tip of the needle to the site of surgery with great accuracy.

The team is now working on the user interface and control software for the device, and hopes to test it first in transnasal surgery, which aims to remove tumours at the base of the skull by inserting instruments through the nose.

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AEROSPACE

Sea potential

Southampton team launches unmanned aerial vehicle from a Royal Navy ship

A team from Southampton University has launched its SULSA unmanned aerial vehicle (UAV) from a Royal Navy ship – a development claimed to mark an advance in sea-launched UAVs.

Weighing 3kg and measuring 1.5m, the airframe was created on a 3D printer using laser-sintered nylon and was catapulted off *Mersey* into the Wyke Regis Training Facility in Weymouth, before landing on Chesil Beach in Dorset.

The approximately 500m flight lasted less than few minutes but demonstrated the potential use of small lightweight UAVs that can be launched at sea.

SULSA, which stands for Southampton University Laser Sintered Aircraft, carried a small video camera to record its flight and Southampton researchers monitored the flight from their UAV control van with its onboard video cameras.

Called Project Triangle, the capability demonstration was led by Southampton researchers, making use of the coastal patrol and fisheries protection ship.

Prof Andy Keane, from Engineering and the Environment at the university, said that the UAV was flown under standard Civil Aviation Authority (CAA) rules for sub-7kg aircraft. **JF**

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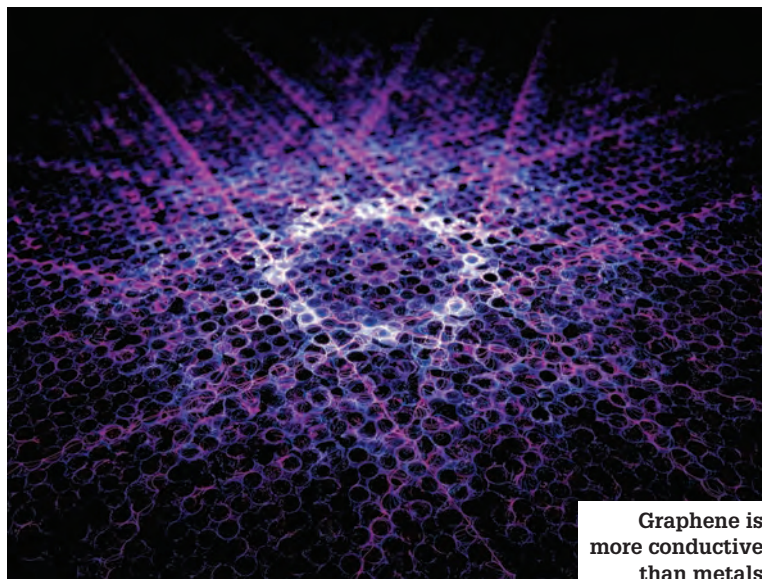


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Graphene is more conductive than metals

3D PRINTING

Graphene offers storage solution

Ink could one day be used to print batteries

BY HELEN KNIGHT

Batteries, supercapacitors and a number of other energy storage devices could one day be printed on your desktop from conductive graphene ink, thanks to researchers in the UK.

Consumers are constantly demanding ever-greater storage capacity from the batteries in smartphones, tablets and other devices.

And if solar, wind and wave power are ever to contribute a substantial proportion of our electricity mix, we will also need to find a more effective way to store the energy they produce.

To this end, researchers at the Manchester Metropolitan University are developing techniques to allow for the rapid 3D printing of energy storage devices using conductive graphene ink.

This would allow researchers to design novel 3D structures for supercapacitors and batteries, which could then immediately be built and tested in the laboratory, according to Prof Craig Banks, who is leading the EPSRC-funded project.

"Graphene is more conductive than metals, so it's a fantastic material, but the biggest problem is trying to get it into a structure that everybody can use," explained Banks. "What we're trying to do is put it into a conductive ink, so we can take the properties

of graphene and put it into a form that can be printed and manipulated into a structure that is beneficial for batteries and supercapacitors."

The ability to print unique 3D structures incorporating graphene ink should increase the charge storage of batteries and supercapacitors, according to Banks.

Researchers have so far developed so-called semi-graphene inks. These contain graphene but also carbon blacks and graphite, which are undesirable as they reduce the conductive performance of the material.

But printing 3D structures from true graphene ink is extremely difficult, as each layer must be cured for an hour in an oven before another layer can be added on top, said Banks.

"At the moment it takes ages to make anything above the micron level, so we want to shine a UV light onto the ink as it is printed, to cure it *in situ* and ensure it holds its structural integrity," he said.

Ultimately, we could all print our own batteries from a 3D printer in our office or home, Banks added.

"You could imagine just clicking in a cartridge containing graphene conductive ink, and manipulating it into a unique structure," he said.

CONSTRUCTION

East London homes not set in concrete

Timber construction will help cut carbon

BY BEN HARGREAVES

A new residential construction project in London – said to be one the largest of its type – is employing cross-laminated timber (CLT) instead of concrete in order to save carbon.

The Dalston Lane development in Hackney is to use more than 3,500m³ of the sustainable timber, making it the largest project of its kind globally, according to engineering company Ramboll.

The 121 units are spread over 10 storeys. The overall height of the building is more than 33m. It will provide "significant residential capacity" over 12,500m², and more than 3,400m² of commercial space.

Ramboll CLT engineer Gavin White told *The Engineer* that the timber was much less heavy than concrete, making it ideal for lightweight construction in an area of east London where Crossrail and High Speed 1 (HS1) passed underneath the streets. It has been used in other projects in the UK in Norwich and Bristol, he added.

The timber meant that the building would save 2,400 tonnes of carbon, White said. The Borough of Hackney is encouraging timber

construction as part of a 'timber first' policy.

Total emissions of carbon, taking into account development and transport of materials, and construction of the building, would mean 50 per cent less emissions, White added.

“ This project, given its scale, is a seminal piece of architecture

CLT panels are supplied in thicknesses of between 50mm and 300mm and lengths of between 3m and 13m. By using CLT, the embodied carbon is 2.5 times less than that of an equivalent concrete frame, Ramboll claimed.

Andrew Waugh, director at architect firm Waugh Thistleton, said the building at Dalston Lane was "important".

He added: "CLT structures are the only sustainable solution to provide high-quality, high-density housing, and as such this project, given its scale and ambition, is a seminal piece of architecture".

AGRICULTURE

Fruits of success

Berry producer seeks automated harvester

A cash prize of \$200,000 (£128,000) is being offered to the innovator who develops an automated blueberry-harvesting machine that can replace manual labour.

Naturipe Farms, a grower-owned producer of berries in the Americas, is calling for proposals via *yet2* for a machine that will carefully handle berries to avoid damage, fill field trays and/or baskets, pick around 500kg of fruit a day and operate 24/7.

Other main specifications require the machine to cost less than \$500,000 per unit, be able to differentiate the size and colour of berries for maturity calibration and be mobile enough to operate on uneven ground or under dusty conditions.

Some additional favourable features for the machine include the ability to detect firmness, pests and disease, register plant yield and be georeferenced.

According to Naturipe's website, the call for proposals represents "an opportunity to establish a strategic partnership with a global leader in berry production to deliver the next generation in blueberry harvesting worldwide." **JF**

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Solving the puzzle

Steven Barr of the Business Growth Service believes the manufacturing sector could hold the key to increased productivity

The 'Productivity Puzzle' is set to become one of the biggest business debates of 2015, with the chancellor expected to base a large part of his economic policy on helping the UK move up the international league tables.

Before I go any further, let me try to define what productivity means. There are numerous definitions being put forward, but perhaps the easiest one for us to relate to is: 'A measure of the efficiency of a person, machine, factory or system in converting inputs into useful outputs.'

The 'Productivity Puzzle' comes from the unexplained disparity between UK economic performance improving and labour productivity per hour worked actually falling.

Solving this appears to be the topic of choice for the media, politicians and economic commentators, and it's not difficult to see why.

We have seen more than one million new jobs created in the last two years and there is real evidence of growth in the economy, yet productivity does not match the levels we were seeing pre-2008. While we all welcome the economic improvement seen in recent years, labour productivity per hour worked has fallen by more than 15 per cent from the national level achieved before the financial crisis. If not corrected, this could be very damaging for the economy and living standards in general.

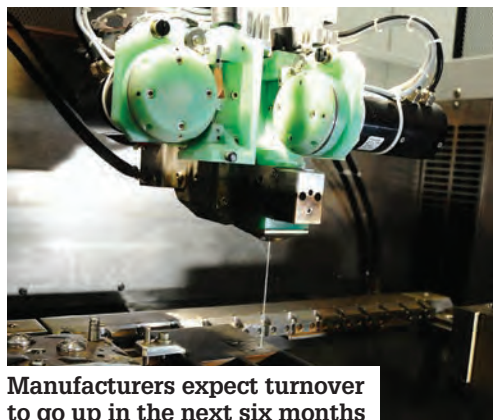
Experts have been struggling to explain the reasons for this collapse, pointing to low pay and misdirected investment in sluggish companies as possible culprits.

Others have suggested that a failure to upskill existing staff has restricted many companies from performing to their full potential, while the CBI suggest that a simpler tax regime could play its part in securing greater productivity.

The manufacturing sector is performing rather better, recording higher-than-average productivity when compared with the service and financial sectors.

Our recent 'Manufacturing Barometer' survey, which questioned the leaders of more than 500 businesses, provides strong clues as to why manufacturers are bucking the trend and, importantly, how they are doing it.

The overriding feeling from the report is one of optimism, with 70 per cent expecting sales turnover to increase in the next six months. The optimistic respondents believe economic



Manufacturers expect turnover to go up in the next six months

“ This isn't just a quick fix; it's about taking a more holistic look at your company

growth will be achieved alongside increased employment, with 55 per cent predicting a rise in staff numbers. The difference between these figures could suggest that better productivity will be a given, but that would be ignoring the 84 per cent of manufacturers who recognise the need to improve productivity even further.

That sets up the intriguing question: how could they grow and be more efficient? The answer can be partly found in targeted investment. More than half (53 per cent) of small and medium-sized enterprises (SMEs) expect to increase their investment in machinery and premises and 95 per cent will not let the level of investment fall. This commitment to investment is fuelling innovation in new product development and more efficient processes.

Over the last three years, the Business Growth Service has committed £18m of tailored manufacturing support through the Manufacturing Advisory Service (MAS) to assist businesses in making vital improvements with view to increasing the gross value added (GVA) and creating jobs.

Our business growth managers, who work with ambitious firms to help them overcome barriers to growth, were able to support management teams to introduce lean manufacturing, improve scheduling, put in better supply chain management controls and secure finance towards the purchase of new machinery.

One such example is precision presswork and stamping specialist Brandauer, which tapped into external assistance to boost its sales and marketing activity and improve its raw material utilisation by 45 per cent. The latter played a crucial role in the Birmingham-based company securing a £2m reshoring deal that will see it supply components all over the world.

It is now setting its sights on even more international 'wins', with a special focus on securing greater market share in Germany that could eventually lead to a £10m turnover by 2017.

However, investment in technology and process is only one part of the productivity equation. Equal priority needs to be given to developing your people and in ensuring they have the skills to implement improvements.

This isn't just a quick fix; it's about taking a more holistic look at your company, building a high-performance team, embedding a culture of innovation and identifying skills for the future.

Again, through the Business Growth Service, we have committed £35m of funding in this area so that firms will be better able to make the right decisions and complete the business improvements they need. We are also able to actively direct SMEs towards apprenticeship schemes and other training.

This positive outlook from our manufacturers and their commitment to invest all bodes well for improved productivity. The same strategies could be just as effective in solving the issue in other sectors, targeting improvements in people, processes and technology.

Get the balance right, and we may just have found the elusive answer to the 'Productivity Puzzle'. ©

Steven Barr is head of manufacturing at the Business Growth Service

Join the debate at theengineer.co.uk

Summer of inspiration

The holiday season provides a great opportunity for children to continue to learn and apply their knowledge in different ways



If you're looking for something to do with your kids over the summer months, we have some great ideas.

While it is important for school children to recharge their batteries during the long summer holiday, it is also an opportunity to continue to learn and to apply knowledge in different ways.

Days out and trips to science museums and discovery centres are real favourites. Seeing how things work and trying things out for themselves challenges young people and fires their imagination. At the end of July, Engineering Open House Day gave the traditional day trip an extra dimension, offering visitors an insight into the engineering at places such as ITV, the Royal Opera House and the National Space Centre.

As the final weeks of the school year drew to a close, we witnessed some incredible engineering developments and achievements. Apple Pay took the High Street by storm and never-before-seen images of Pluto were transmitted to Earth, joyfully greeted by space scientists the world over.

At the same time, hundreds of school children across the country were showcasing their amazing science and engineering projects to more than 40,000 visitors at Big Bang Near Me Fairs. From toothbrushes designed to save toddlers' teeth from decay, to 3D-printed water purification devices, to recommendations for healthcare and emergency workers and survivors in the event of a zombie apocalypse, these future scientists and engineers had applied their classroom learning to come up with innovative solutions to (mostly) real-world problems.

There are countless opportunities to highlight the world of engineering to young people and give them the chance to put their skills to the test. What you may not realise is that over the summer many young

people will be working on new (or refining existing) science and engineering projects for entry into the competitions at The Big Bang Fair. We first discover the many fascinating projects that young people have been working on at the heats I mentioned held at the summer's Big Bang Near Me Fairs. The most impressive of those have made it through to the national finals at The Big Bang Fair in March, while any who missed out have the opportunity to further develop and resubmit their projects.

If you're unfamiliar with the competition, you should know that it is open to 11- to 18-year-olds and recognises excellence in science, technology, engineering and maths. If you know of any young people that might be interested in taking part, it is still possible to enter the competition online via a written or filmed entry. The young people, as individuals or as part of teams, make it to the national finals to showcase their 200 or so projects to more than 70,000 visitors,

Over the summer, many young people will be working on science and engineering projects for entry into Big Bang Fair competitions

with senior winners named the UK Young Scientist and UK Young Engineer of the Year. While the winners may grab the headlines and the breakfast TV sofa slot, there is great talent and excellent project work on show across the age categories.

For her project, 11-year-old Sky Ballantyne took inspiration from watching a dad teaching his young child to ride a bike in the local park. Seeing how both child and adult struggled, Sky created a harness to address the problem. The Crikey Bikey project, which she developed with her sister, was the winner in the engineering/technology stream of the junior category this year and the harness is now

commercially available.

This could be the summer of inspiration for a budding young engineer near you, and if the lure of lazy days, trips and the great British climate is too strong, it is worth noting that online entries are open until Halloween. ©



Open house event: an insight into the engineering the Royal Opera House

Paul Jackson is chief executive of EngineeringUK

thehottopic

Is decentralising energy key for the future of the UK?



Could large power stations be a thing of the past?

Our recent online Viewpoint article on decentralising electricity generation led to some lively debate

I would be interested to read what steps are being taken to ensure the stability of decentralised electricity networks. My training and career were in the supply industry and I was taught that several hundred tons of rotating plant made the system stable. Surely low mass systems like those suggested will be inherently unstable, or am I missing something?

Owen Williams

The author offers decentralisation as a solution to National Grid's power shortages supposedly putting restraint on economic

growth of certain companies. He goes on to place the responsibility on the shoulder of said businesses and encourages their participation in renewable energy resources such as solar and wind. There are at least two flaws with this approach: (1) you would now expect the companies to bear responsibility in managing their own micro-grid, taking them away from their main line of business with possibly inadequate resources and insufficient skills in power management; and (2) the unreliability of renewable energy is hardly a substitute for the unreliability of National Grid. It is understood in the best possible scenario that the said renewable energy sources may take some burden off National Grid, but for them to play a national role, a large number of such systems must participate in co-ordination perhaps by National Grid. The author does not mention a possibly more reliable alternative: natural gas-powered co-generation. With natural gas prices at historically low levels, fracking in US and large reserves in Iran and Russia, I was not sure why this alternative was not mentioned and look to a possible explanation from an authority more familiar with UK energy costs.

Anonymous

The energy sector has been blighted by almost Greek levels of 'don't face the nasty problems, leave them to someone else' for decades. Now the birds have come home to roost. Renewables are just a blind fiddling while Rome burns. They will never be able to be more than a very expensive marginal unreliable source of power. They are just a sop to the greens. A proper long-term strategy is required.

Adrain Tawse

Many, including myself, have over the years tried to warn of the dangers of relying on potentially unstable countries supplying a significant proportion of the basic fuels used to produce our electricity or the electricity itself. For our own security, we must own our entire power generation capability from fuel to end user. Until that is achieved, we will always risk being held to ransom by others who want to push their own agendas.

John K

Start with efficiency. Reduce usage. Then the little that is still needed can be made using renewables such as tidal waves, biogas from landfills and manure, PV, direct daylight, solar heating, wind mills and new technologies such as heat recovery ventilation, daylight systems and heat pumps. Decentralisation

inyouropinion

Fighter aircraft

An opinion piece asking why the UK apparently cannot make fighter aircraft any longer when France and Sweden do generated lively response

■ I think the main point to note is that, unless the UK develops either an indigenous aircraft programme of some sort or is the lead partner (Tornado, Typhoon etc) with final assembly and test flying in the UK, the industry will go the way of the British volume automotive sector: it will vanish. This will take government/tax payers money to stop. Serious amounts of UK taxpayers' money should go into developing a new British regional jet while we still can or a follow-in to the Hawk, or such like.

Martin Bayliss

■ If you want a project of ambition and scale that could be a British success and ignite the industry, then... there's always Skylon.

Timothy Murphy

■ Of all the comments ever posted on *The Engineer*, this is the most likely to raise the passions of British engineers and have them weeping into their keyboards. Yes, yes, yes:

let's build UAVs of several sizes and see who can keep up with us.

Jonathan Douglas

■ We have the 'goods' to do it, but not the will nor will we ever. If it involves the UK government spending trillions on anything other than banks, regardless of 'return', forget it. Then there is the class-based manufacturing management issue to surmount – the one that resulted in good engineering turning out garbage, such as in the UK car industry of the 1970s and 1980s. In any event, do we have enough in the armed forces to actually fly them?

Martin Powell

■ Rather than waste our engineering talent on developing our own jet fighter, why not our own high-speed trains or advanced double-decker trains so as to increase passenger capacity?

Bill Hawthorn

■ We could make the finest as we have shown over the past 50 years, but lack of marketing to the appropriate nations is where we fail. We have always been the best in technology – we developed the jet engine, we had the first jet airliner with the Comet and we invented

the vertical take-off. We just lack the ability to exploit them and our government is too willing to outsource.

Anonymous

■ The money is here in the UK; whether the will is, is another matter. However, now is as good a time as ever to articulate such rationale to a listening government that desires a big and growing UK aerospace industry. Moreover, UK aerospace engineering, generally, needs to show a lot more ambition and investment over the next 15 years and disregard the financial freakery of messrs Rishton and King (share buybacks etc). Five new aircraft the UK could itself definitely design and build on a sovereign basis between now and 2030: (1) new Hawk jet trainer; (2) Taranis supersonic UAV; (3) Skylon satellite launcher; (4) LAPCAT/A2 civil supersonic; and (5) the Hybrid Air Vehicle. PS: (3) and (4) above would owe a big debt of thanks to Reaction Engines.

Mike Brennan

Crossrail tunnelling

Some difference of opinion was on display in responses to our blog about the progress of Crossrail

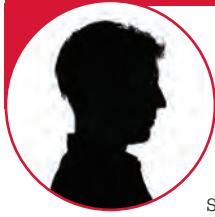
also works for companies. If Mr Smith can work in Lincolnshire, he doesn't need to commute to his company in London, and is closer to his customers in Yorkshire.

Ralf

Britain has accumulated the biggest stockpile of civil plutonium in the world. Most of it is stored at Sellafield and is ideal for use in fast neutron reactor design. We don't need imported uranium. But a modular reactor design of this type is still some years away. However, massively distributed generating capacity makes sense for security of supply. The ideal solution, now becoming available, are solid oxide fuel cells. These could replace domestic combi boilers and use natural gas (fossil or biofuel) and generate around 2kW of electricity as well as providing hot water. The useful energy output of the gas would be approximately double what we currently achieve. There is at least one UK company now manufacturing these machines. More than one million boilers in the UK alone are replaced each year. If half of these were replaced with solid oxide fuel cell units, it would provide about 2GW of additional capacity per year. And the usage of boilers, peaking morning and evening, ties in well with the peak demand on the grid.

Charles Hogan

thesecretengineer



Industry is missing a trick when it comes to using big projects to inspire future engineers. Let's tackle the shortfall head-on

We keep banging on about the projected shortfall of engineers, and the need to attract young people into our profession. Lord knows its formed the basis for these articles a few times.

However as an engineer metaphorically 'out in the field' – or maybe literally for all you know – it does remain a matter of concern.

Instead of bemoaning the fact, we could petition the institutes and suggest ways to tackle the problem?

I think Bloodhound remains a fine example of actively engaging with the public in general and children in particular, highlighting the doors that can be opened within the world of engineering. I would like to see the mainstream media pick up on it even more, but the assertive use of multimedia platforms coupled to practical hands-on activities at least gives an initial template of how such things can be undertaken.

What then of other whizz-bang projects that don't do this (hopefully that won't prove to be an unfortunate choice of phrase)?

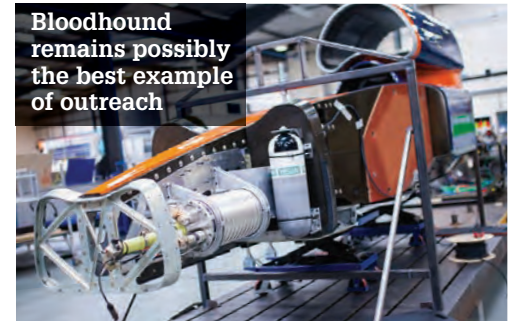
I have yet to see any evidence regarding actively reaching out to the public with the new America's Cup contender being built in Portsmouth. The main team are undoubtedly flat out getting the boat built and race ready, but surely there is scope for employing someone to harvest the undoubted support and enthusiasm? This being to the greater

good of both the project specifically and engineering as whole. An international competition that uses bespoke carbon-fibre hulled boats skimming feet above the water at insane speeds – what's not to like?

Then there's Skylon. When was the last time you saw something about this phenomenal aircraft outside of industry publications? Yes its been a long haul to get this far, but we know that major strides forward have been made. This is truly a revolutionary vehicle – yet how many 14-year-olds even know about it?

Perhaps the solution actually lies in a small dedicated team to select projects to use and, in return, helping them through the exposure gained? I say let's take a lead in influencing the policies of those who head up our profession and start bombarding them with ideas. After all, we achieve nothing by merely sitting and wringing our hands.

Bloodhound remains possibly the best example of outreach



Join the debate at www.theengineer.co.uk

■ It may have been quiet tunnelling, but a surface, multi-tier artery along the Euston/Marylebone Road would have been completed at a third of the cost, five years earlier, and have 10x capacity. Just like the Jubilee line, when Crossrail suffers any glitch the entire line will immediately be halted – Europe's biggest transport disaster, of modern times, in terms of planning, outcome and economic output.

Marcus Gibson

■ Marcus Gibson has his own view, but who wants a multi-tier artery on the surface? Anyway, the collateral destruction necessary would have added serious costs.

Anonymous

■ Marcus, I think the purpose of Crossrail is to take cars out of the equation in Central and Greater London and regenerate outer London. Crossrail will be a positive 'game-changer' for London, in so many ways. As for the surface, it would be politically feasible for London's planners to implement an overhead line (OHL) for a trolley bus network. Vancouver's buses use an OHL in the centre and diesel/petrol propulsion thereafter, hence its cleanliness.

Mike Brennan

Intelligent life?

Our poll on a \$100m effort to contact extraterrestrials uncovered readers' scepticisms... and nervousness

■ Whatever we think of the great, brave Prof Hawking, this a colossal nonsense. Spend the money on terrestrials, not extraterrestrials.

Jonathan Douglas

■ The future? I'm banking on the Good Book and Revelations Chapter 21: "This Earth will fade away... and a new one in its place."

Andy Burns

■ ... And pray that there's intelligent life somewhere up in space because there's buggar-all down here on Earth.

Frederick the Average

■ This might serve to widen perspectives (e.g. by questioning absurd religious beliefs) and encourage people to engage with science so is well worth the \$100m, but is ultimately doomed to fail due to the immense distances involved. Even the most optimistic interpretation of the Drake equation or its derivatives predicts only a handful of advanced civilisations in our

galaxy, which is 100,000 light years across – any emissions from a distant radio transmitter would fade into the background radiation over such distances and the nearest 1,000 stars, which are allegedly within range, are a miniscule fraction of the Milky Way. Although we can detect RF emissions from distant pulsars, these sources are immensely powerful – it is estimated that just 1cm³ of the magnetic field of the Crab Pulsar (the spinning of which produces the RF emissions) contains as much energy as a year's output from a nuclear power station; it would take quite a big radio transmitter to compete with this. As I work in laser communications, I can comment that the 100W laser, which it is hoped will be detectable, will have to be extremely well collimated and precisely aimed at the receiver if its photons are not to be scattered to an undetectable degree. We are marooned by the distances involved and the limit of the speed of light; *Star Trek* has a lot to answer for in raising our expectations and blurring the boundaries between science fiction and science fact.

Robert Taylor

Have your say, visit us at theengineer.co.uk

The tide is turning

Autonomous systems
could revolutionise
the shipping industry
by reducing costs and
improving efficiency.
Andrew Wade reports

Autonomous vehicles are slowly but surely infiltrating the world we inhabit. Google's work with driverless cars in California is well documented, with several big automotive names also showing an interest and investing heavily. For better or worse, unmanned aerial drones are now a major component of military operations, used to both gather intelligence and deliver airstrikes. When it comes to rail, metro systems around the globe are beginning to embrace automation, and a London Underground served by driverless trains in the near future is not difficult to envisage.

Up until now, however, shipping has tended to buck the trend somewhat. Research into autonomous ships is under way, but the same level of progress that we have seen across other modes of transport has yet to be realised. With more than 90 per cent of world trade taking place via the oceans, autonomous systems represent an opportunity to revolutionise shipping, significantly reducing both its cost and environmental impact.



Oceans of opportunity: Rolls-Royce is to lead a project that could pave the way for unmanned ships

The industry is busy making strides to address the emissions issue, as rising fuel costs and stricter regulations governing emission control areas (ECAs) force shipping companies to seek efficiencies and operate greener. Autonomous ships represent an opportunity for a big leap forward, with vessel redesigns potentially delivering hydrodynamic improvements that would improve fuel efficiency.

After fuel, the next biggest cost for shipping companies is labour. Unburdened by concerns over crew costs and onboard facilities, unmanned vessels could spend longer at sea, reducing speeds and further improving fuel efficiency. It has been estimated that a 30 per cent drop in speed by a bulk carrier can lead to a 50 per cent reduction in fuel use. Combine this with the savings on crew salaries, as well as the overheads associated with maintaining a crew on board, and the scope for a more efficient shipping industry becomes clear.

Despite the potential for these gains, there are plenty of legitimate concerns around the prospect of autonomous ships. Naturally, safety must top the agenda, and building intelligent unmanned vessels that can navigate the oceans with minimal oversight will not be easy. Robust communications systems will need to continuously deliver information from ships back to land-based operation centres. For ocean-going vessels, this means a satellite infrastructure capable of handling large amounts of traffic, with built-in redundancy and back-up systems.

No crew on board also means no engineers to fix problems in engine rooms, or anywhere else throughout the ship for that matter. For this reason, reliability is a major concern. If an autonomous car senses an engine problem on the road, it can pull over and wait for assistance to arrive. A ship adrift in the middle of the ocean is an entirely different prospect. And what if that ship happens to be a fully loaded oil tanker off the horn of Africa, with pirates operating nearby? What if the threat is more remote – a team of hackers holding a ship to ransom as they threaten to steer it to disaster?

These issues are real but can all be addressed, said Oskar Levander, vice-president of innovation, engineering and technology at Rolls-Royce's marine division. The company recently announced that it is to lead a new €6.6m (£4.6m) project that could pave the way for autonomous ships, in collaboration with a number of industry partners and academic institutions.

Known as the Advanced Autonomous Waterborne Applications Initiative, the project is being funded by Finnish technology agency Tekes, and will run until 2017. Its stated aim is to deliver specifications and preliminary designs for the next generation of advanced ship

solutions. According to Levander, progress towards an autonomous future for shipping will be incremental, with individual flag states taking the first steps before the International Maritime Organisation (IMO) develops international agreements.

"The technology will be there before the regulations," he told *The Engineer*. "But it's not only about the regulations; it's also about international law: who is responsible for autonomous ships. Today it's easy – you have the captain. But if there is no captain on board, then who is responsible? Is it the owner, the programmer, the supplier?"

The relatively low speeds and big expanses of ocean involved in shipping mean that, in some respects, autonomous and remote-controlled vessels should be a more straightforward prospect than other modes of transport, where higher speeds and fewer margins for error exist. But the communication challenges with autonomous shipping are entirely different, with reliable satellite connectivity essential.

"Whereas in a car you can maybe rely on land-based communications, with ships you need to have good enough satellite coverage in all weather conditions around the world," said Levander. "You have it in certain places, but it's not really worldwide yet."

As a result, early adoption is likely to happen first on a local level, near to coastlines where communications are more reliable than in mid-ocean, and where human intervention is not too far away if required. Levander said that the first unmanned vessels will most likely be ferries,

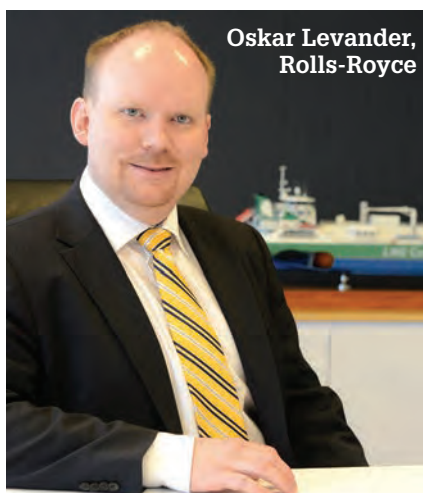
harbour vessels or coastal cargo ships, with individual countries legislating for their territorial waters.

"The first real unmanned ship applications that we will see will most likely be locally operated ships that are within one or two countries' waters, because then that flag state can basically give permission to that ship's operators before there are international regulations," he added.

Regarding piracy, Levander was quick to point out that an unmanned ship is a less attractive prospect for pirates, as there is no crew to hold ransom. Vessel redesigns could also make it more difficult for pirates to board, as crew mobility would not have to be considered and gangways could be removed.

Nonetheless, Levander admitted that boarding from pirates could not be ruled out completely. However, if the ship was being controlled remotely, the controls could be coded, so the only option left available to pirates would be to disable the vessel and potentially try to tow it.

This of course presents its own difficulties, and would not escape the →



**Oskar Levander,
Rolls-Royce**



Sea change: the project aims to deliver specifications and preliminary designs for the next generation of advanced ship solutions

attention of naval forces for very long. With no hostages for protection, a group of pirates towing a ship slowly across the ocean might find themselves in a very sticky situation.

"The problem is really IT security, and making sure no one else takes control of the ship," said Levander. "But these things are of course already in place" He cited Rolls-Royce's experience in aviation, and the security protocols that already exist to prevent hackers gaining control of aircraft. Similar systems for ships could be easily applied, he added. Once the safety and reliability issues have been addressed, the business case for unmanned ships is strong. No crew means more space for cargo, reduces operating costs and potentially allows for dramatic vessel redesigns.

"When you really start thinking about it, a lot of the way a ship looks today – not only the deckhouse, but how it's laid out – is determined by the fact that you have crew that need to walk around and access things," said Levander. "There are also lots of functions on board a ship that are there basically only to provide for the crew – functions such as air conditioning, water production, sewage treatment, refrigerators for food, the galley."

He added: "[Unmanned ships] will be simpler to build; [there will be] less waste, less energy consumption and less cost. So we actually foresee that the unmanned ships might be cheaper than manned ships."

A ship's crew members are also hungry energy consumers. Levander estimated that unmanned vessels could reduce fuel consumption by about 15 per cent purely through the crew's absence. Optimum speed without a crew is also lower, allowing further savings to be made on fuel. Furthermore, Levander argued that unmanned vessels are inherently safer, with a lower level of risk and consequently lower insurance payments.

All this sounds like great news for shipping companies, but perhaps less so if you are currently employed at sea. Levander acknowledged that some unions are already expressing reservations about autonomous ships and the future livelihoods of seafarers, but he claimed that the general reaction has been more positive than negative. He also noted that the shipping industry has been fixed on this course for a long time, with the number of crew required on board diminishing steadily for more than a century.

"If you go back 150 years or so, you had 250 persons on board an ocean-going cargo vessel, and that has been coming down to where today you have maybe 50," he said. "So it has been reducing, and it would be odd to say that you have reached the optimum now, and that we will not further improve the efficiency of ships."

"Any other industry you get the same thing. A factory producing cars is trying to produce more with less people all the time, so why would you assume that shipping would not go in the same way? It's a continuous drive to make things more efficient."

Levander said he believes that when the autonomous revolution takes off, new jobs within the industry will be created. These will of course be

different jobs than those that currently exist, so there will be an onus on those in the industry to evolve in order to survive.

"I think the winners are those who see the change and adapt to that," he said. "Those who try to fight it to the end, those are the ones that lose."

Being an early adopter is clearly part of Rolls-Royce's strategy, as it takes the lead on the Advanced Autonomous Waterborne Applications Initiative. It is a project that will see it work alongside other major players in industry, some of which are competitors. At this stage, however, Levander believes co-operation is a better strategy than competition to move forward with.

"It's very clear that as a company we have a broad portfolio in the marine industry, but we can't do this alone, and that's also why we've been so public about it," he explained.

One industry partner is DNV GL, the world's largest classification society. These are non-government organisations (NGOs) that establish and maintain technical standards for the construction and operation of ships. UK satcom giant Inmarsat is also involved, reinforcing how important satellite connectivity will be to the future of autonomous shipping. Remote control will be a

key step in the path to autonomy, and will likely remain a key component even when full autonomy is achieved. According to Levander, this should greatly increase the amount of data that is shared over satellite systems.

"In this regard, we see it as better to co-operate and work together to take this forward, because we think we can accomplish more if we work together than if we start competing at this point of the journey," he said.

After the project ends in 2017, a 'proof of concept' phase will begin. Specific goals are in place for the current phase, but Levander could not share details at this stage. He did say, however, that the aim of the project is to take genuine steps towards the introduction of unmanned vessels, and not just produce academic research. The hope is that those steps will see a gradual incorporation of remote control and autonomy, with crew numbers reducing slowly as less labour is required on board.

"It's important to note that it won't be happening overnight," said Levander. "What we will see is many different steps in this direction, and before we are there with unmanned ships we will have ships with reduced crew, ships where we move more and more functions ashore and do certain things on board by linking in remotely."

It is also important to remember that unmanned ships will not entirely bring an end to life at sea. While transporting cargo is well suited to an autonomous future, other types of ships will retain their crews for a variety of reasons, according to Levander. "Not all ships will be unmanned," he said. "Cruise ships and certain other ships are not really ideal for being unmanned. We're not talking about a future with no people at sea at all." ©

“A lot of the way a ship looks today is determined by the fact crew need to walk around and access things

Oskar Levander, Rolls-Royce

For more on this story visit www.theengineer.co.uk

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KySat-2: Small Sat successfully launched into orbit - Image courtesy of Kentucky Space LLC.

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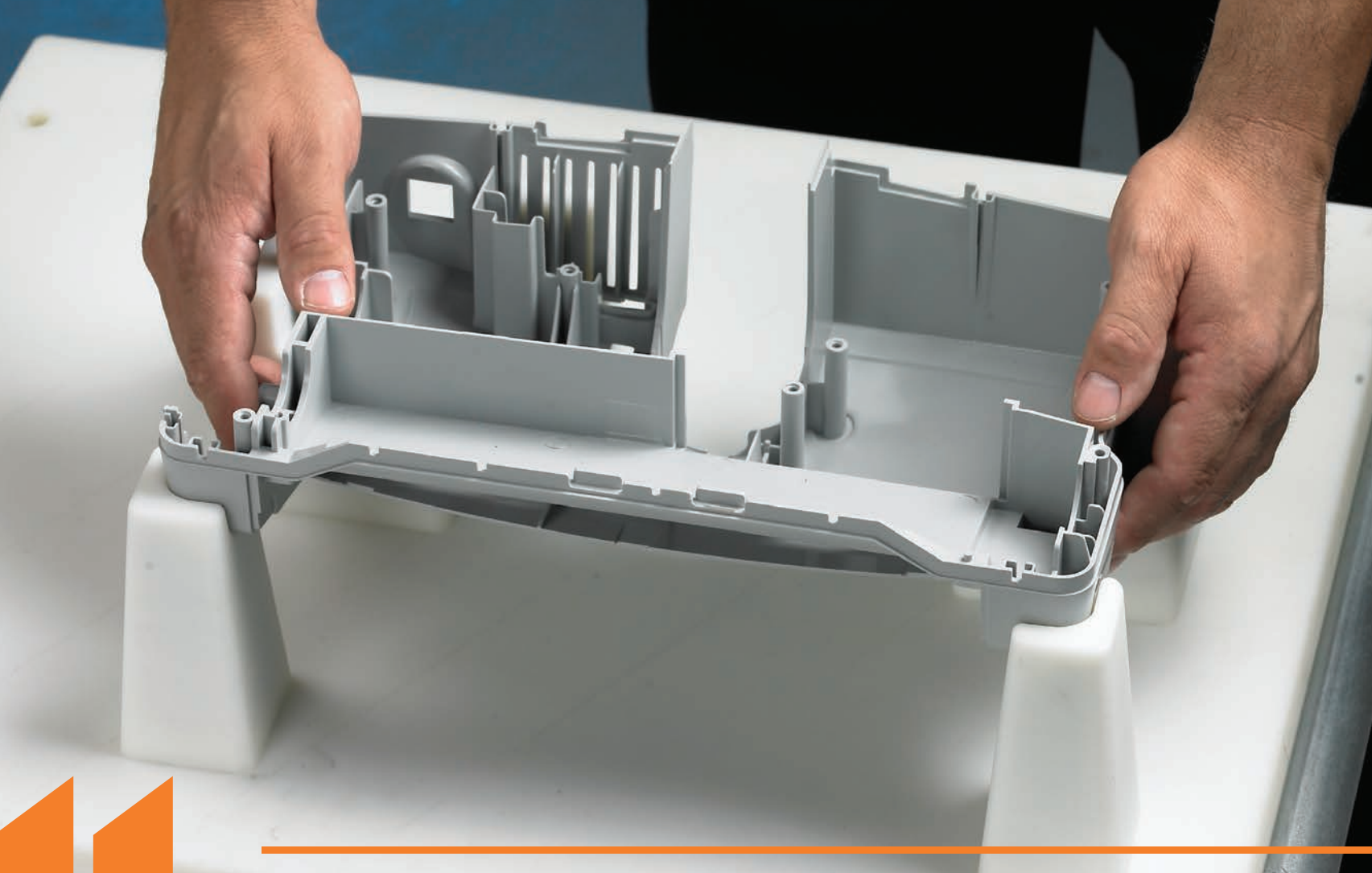
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Taking care of the fine detail

The success of 3D printing depends on understanding the properties of the metal powders that are its raw materials. **Helen Knight reports**



Added bonus:
3D printing allows
engineers to build
complex parts at the
touch of a button

Ask any engineer where the future of manufacturing lies, and high on their list of technologies will be 3D printing.

The technology, more often known as additive manufacturing in an industrial context, allows components that are too complex to be built using conventional methods to be produced from powders at the touch of a button.

Additive manufacturing also makes it possible for engineers to design and build individual parts using different materials, each of which give the finished component a particular property.

In this way, engineers can precisely design the material of their part at the same time as they design its shape, according to Prof David Wimpenny, chief technologist at the Manufacturing Technology Centre (MTC) in Coventry, which recently opened the government- and industry-backed National Centre for Net Shape and Additive Manufacturing.

"The strength and integrity of components and products made by additive manufacturing often exceeds that of conventionally produced parts," he said. "Complex shapes and structures can be made with no joints or weaknesses."

However, any part produced using additive manufacturing techniques will only be as good as the metal powder used to print it. Unless additive manufacturers precisely control the materials they use, they can end up making parts with significant defects, added Wimpenny.

This can prove extremely costly, since the materials used for additive manufacturing are often very expensive. Titanium powder, for example, can account for up to one third of the overall cost of the process.

"It seems obvious, but industry has been a little slow to focus on the materials," he said. "Companies have spent a lot of time looking at the hardware and not at the materials coming in."

All of the materials entering the MTC's laboratories are thoroughly tested, and the researchers have found that not all batches of powder meet their specifications. "We find subtle differences between powders, including both new and recycled powders, which do not manifest themselves using more traditional test methods, and are critical for the performance of the machinery," said Wimpenny.

Since not all manufacturing companies have the ability to test their incoming powders this thoroughly, these variations can lead to significant problems, he said. "The machines can fail to build parts, even though the powder passes conventional specification tests."

feature: advanced manufacturing

As the field of additive manufacturing is still relatively new, many specification tests carried out are based on those used for more conventional powder metallurgy processes. However, these tests can prove unreliable when applied to additive manufacturing, he said.

"We've found there can be significant variability in the [results produced by] more traditional tests, whereas with automated testing using more advanced equipment we see less variability, and we can also obtain more information," he explained.

Researchers at the MTC test incoming powder in three ways, according to Dr Jason Dawes, technology leader for particulate engineering at the centre. First, the researchers analyse the powder's chemical properties.

"The chemistry is arguably the most important thing to test, because if the material is not within its chemical specifications it will affect the way the part forms, in terms of its mechanical properties and how it fatigues," said Dawes.

In particular these tests look for the presence of chemicals such as nitrogen, hydrogen, carbon or oxygen, with the latter a particular concern in aerospace components.

They then analyse the flow properties of the material. If the powder does not flow freely, it will not form an even layer over the base of the build chamber. This in turn results in gaps in the powder coverage, said Wimpenny.

"It doesn't matter how good you are at controlling a laser or an electron beam, if there isn't the metal in that position there to melt, you will end up with defects in the part," he said.

Typically, these defects can take the form of voids, or holes, within the part. When more material is applied on top of these holes, fresh powder can fill the void and may not be melted by the laser or electron beam. This results in a defect within the part that can be difficult to spot using non-destructive testing techniques, as the loose powder masks the hole.

Existing techniques for analysing the flow properties of the powder tend to be quite simplistic and do not provide detailed

information, said Dawes.

"We're interested in how the material flows from a storage hopper, and how it then spreads across the build chamber, and how it packs in a thin layer," he explained. "This is information that you can't get from simplistic techniques; you need to use much more advanced technologies."

The researchers are using a technique called shear cell analysis, which effectively measures how easily a powder, initially at rest, can be made to flow. The force required to shear the sample tells the operator how free flowing it is.

Finally, the researchers analyse the material's particulate properties, by testing the particle size, shape, distribution and surface area.

Conventional measurement techniques have tended to define the size of particles using what is known as the equivalent sphere, said Dawes. They do this by taking the volume of a particle, and defining its size as that of the diameter of a sphere of the same volume, he explained.

However, since the gas atomisation technique used to make powders for additive manufacturing often produces irregular shapes, this can be an imprecise way to measure particle size.

"The further you deviate away from a sphere shape, the more potential error there is in your measurements of its size," said Dawes.

Instead, researchers at the MTC are investigating a process known as image analysis, in which a machine captures images of the particles and measures their dimensions on an individual basis. This allows the researchers to quantify both the size and shape of particles, and understand how spherical the distribution of particles is throughout the powder.

These analysis techniques are important, not just for new powder entering the additive manufacturing process, but also for powder



already in the build chamber that must be recycled, according to Dawes.

A build chamber may contain 190kg of unfused support powder for every 10kg worth of printed part, he said.

"One of the big selling points of the technology is that you can get much closer to the geometry [of your finished part], or what's known as near-net shape," Dawes added. "But there is no point in that if you have 190kg of wasted material, so you have to be able to recycle the powder or the process can never be economically viable."

However, there are uncertainties as to the effect of recycling on the properties of the powder, and how this in turn affects the build process. Recycled powder should be treated in the same way as new powder and should be tested to the same specification standards.

So the researchers are using the same testing technologies to understand how the process affects the powder, Dawes said.

Meanwhile, GKN Aerospace is similarly leading an effort to explore the recycling and reuse of titanium powders, and to study the potential applications of the recycled material, as part of a three-year research programme.

The £3.1m programme, called TiPow (Titanium Powder for net-shape component manufacture), is aiming to develop titanium powders specifically formulated and blended to meet the needs of additive manufacturing of aircraft components.

The programme, backed by the Aerospace Technology Institute and Innovate UK, will also develop techniques and equipment to produce large quantities of the powder at a consistent quality, and for a lower cost.

The alloys and powders currently used in additive manufacturing have not been developed specifically for this purpose, and so are not optimised for the process, according to Dr Rob Sharman, global head of additive manufacturing at GKN Aerospace.

The TiPow programme will work to develop titanium powders and alloys with characteristics specifically suited to additive manufacturing, Sharman said.

"Additive manufacturing is in its infancy and there are many further improvements to be made, of which raw material is one," he explained. "By developing powders tailored to additive manufacturing, we can improve the economics and possibilities of the technology." ©

**Powder room:
the particles can
be measured
using image
analysis**



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Forward looking

Eye-tracking technology is not only close to becoming the main way users navigate computer screens; it could also soon help control machinery and assist people with disabilities. **Stuart Nathan reports**

john elvesjö

Founder and chief
technology officer,
Tobii Technology



Education

1997–99 Royal Institute
of Technology, Stockholm

Career

1998–99 Researcher/project
manager, Institute for Surface
Chemistry, Stockholm
2001 Founded Tobii
Technology with Mårten
Skogö and Henrik Eskilsson
1999–2003 Founder and chief
executive officer, Jenser
Technology; developed
instruments to monitor
surfactant levels in processes
2011 Board member at
consumer electronics firm
Mutewatch; saw first product
through final development
2011 Board member at cloud
computing firm Xcerion;
sold iCloud product to Apple
2010–13 Advisory board
member at Stockholm
Innovation and Growth
2015 Board member
at Resolution Games
2015 Finalist in the SME
category at EPO European
Inventors' Awards

The eyes, as the saying goes, are the windows to the soul. It's not a statement that would stand up to any scientific scrutiny, but nonetheless studying the eyes can tell you a great deal. Notably, being able to tell exactly what somebody is looking at gives vital information about their thoughts at that particular moment.

This is the part of the thinking behind the technology of eye tracking, the technique that uses optics and processing to determine how somebody's gaze is moving over images on a screen or any other parts of their field of view. Its Swedish inventors, John Elvesjö

mårten skogö

Co-founder and chief
science officer, Tobii
Technology



Education

1997–2001 Royal Institute
of Technology, Stockholm

Career

1999 Co-founder of Jenser
Technology with Elvesjö
2001 Co-founder of Tobii
Technology with Elvesjö
and Eskilsson
2015 Finalist in SME category
at EPO Inventors' Awards

and Mårten Skogö, believe it could be only a few years from replacing touchscreens, trackpads or mouse control as the main way that users navigate their computer displays; it could also help with the control of heavy machinery and greatly assist people with disabilities that affect their hands and dexterity.

Like many technologies, luck played a role in the development of eye tracking. Elvesjö, a physicist, was working on a project involving following the movements of pulp particles in water as part of an engineering physics programme at the Royal Institute of Technology in Stockholm. He noticed that a sensor designed to follow the particles was, in fact, capable of doing other things. "I accidentally turned the camera around and it picked up the orientation of my eyes," he said. "I realised that if we could get a computer to record how my eyes were moving, it could be huge."

This insight led to him quitting his course and eventually setting up a company to develop and commercialise the technology with two friends: Skogö, who is also an engineering physicist, and computer hardware specialist Henrik Eskilsson. Sixteen years after Elvesjö's first insight, their company, Tobii Technology, holds key patents for eye tracking and now has 570 employees, with offices in six countries.

The Tobii eye-tracking system works by combining different technologies. It uses a camera to locate the eyes, then projects a pair of infrared beams onto the face that create patterns on and around the eye. Infrared sensors in the tracking device detect the reflections of the infrared (IR) projections, and a series of computational algorithms translate the information on the moving reflections into where the users' eyes are focused. "We look



at the face and the eyes, taking account of corneal curvature and things like that, which tell us which way the eyes are pointing in relation to the position of the head," Skogö said. "Then we have a mathematical model that describes how the person's face and eyes map onto the computer screen. It gives us that information continuously, even when the person is moving around. That gives us information on the user's attention, and that in turn gives us insight into their intention."

He added: "It's actually very difficult for a computer to track eye movements, and part of the reason for that is that the movements are actually very small. Bear in mind that if you're tracking someone



On display: eye tracking could replace a mouse

Road worthy: the system could be used by drivers



Eye catching: the technology can help assess the efficiency of signage

looking at objects on a screen, those objects are themselves small and close together. You also need to compensate for lighting conditions, whether the observer is wearing glasses and even if they have facial piercings that are in the detector's field of view."

Even though most laptops and smartphones, and even desktop monitors, are now equipped with built-in cameras, these are not sufficient; dedicated technology is needed. Elvešjō explained.

"In theory, you can do eye tracking with the camera on a laptop but it's not reliable," he said. "It could only be relevant if 100 people use the computer, all looking at the same thing in a controlled environment."

The Tobii equipment is streamlined for simplicity. "We added the optical specs to design a pattern that it could pick up easily, and elaborate about what is unique about the human eye, so we pick up that and nothing else," Elvešjō said. "The less we pick up, the easier it is to process the images. Ideally we want to do the calculation on one tiny chip."

Skogö and Elvešjō believe that giving a device information on gaze fundamentally and instantly makes the device more intelligent. "You always look at something before you interact with it," Skogö said. This might allow a computer to tailor how its display is used. "For a start, it can tell whether somebody is looking at it at all,"

“The less we pick up, the easier it is to process the images. Ideally we want to do the calculation on one tiny chip

John Elvešjō, Tobii Technology

Elvešjō said. "If nobody's there, it doesn't need to be switched on; it can conserve energy and switch itself off." It can also detect whether attention is being paid to any pop-ups on the screen, and automatically close any that are being ignored.

In addition, it can help to prioritise processing power. "You can render graphics with higher resolution where you're looking. It can refresh information more quickly where you're paying attention, for example at stock price information; the price you're looking at would update more often."

One of the challenges of developing the system was how vision itself works. "There's an optical eye and a mental eye and they're not aligned," Elvešjō said. "If you look at something, your eye actually moves around all the time; if the eye stops, you stop seeing. The eye is more sensitive to changing conditions. We can't measure the mental eye, but with a bit of understanding of the way vision works, we can derive the intention." The gaze-tracking hardware, with the camera, IR projector and detector, also houses the processor that detects the gaze point, but the gaze engine, which relates that to what's on the display, runs on the host computer. "That's the part that knows whether you're looking at a hyperlink, for example."

But computer displays are not the only target for Tobii technology. The team has mounted the technology into a wearable pair of glasses, which can be worn by shoppers or museum visitors, for example, to detect what catches their eye as they look at a display; it can also evaluate the effectiveness of the placement and design of display labels, or of signage in airports.

Another potential location for the system is in a car. Here, the rough location of the driver's head is always known, but gaze can be used to detect when the driver's attention is straying or if they are getting sleepy, and to check when they are looking at dashboard instruments. Defining sensitive gaze areas, for example on the windscreen, can also be used to control in-car features such as communications or entertainment. "That's an example of applications

where the gaze acts like a third hand, when both of your hands are occupied," Elvešjō said. "We have done things with radiology, where the user is looking at a scan or X-ray; a surgeon might need to do that with both hands occupied, so looking at the scan can give them access to more information or call up a surgical plan. And with professional musicians, for example, it can follow their eyes down a score and turn the page when they get to the end." Similar systems are already in use to help handicapped people use computer systems.

Elvešjō thinks the system is already at a point where it could replace a touchscreen or mouse as a way of interacting with a computer. "We could steal a key on the keyboard to use as an eye confirmation button. You could look and click, look and scroll; and if you want to use a trackpad for gestures, we can provide that gesture with precision. We can anchor a gesture by pointing with the eyes; you gesture where your hands are and that affects the display. So look at a picture and perform the pinch or expand gesture and it'll zoom in or out."

Another possible use is in image or video compression. "If I show you a video or a photo, it can help you compress a movie; you can compress the parts where the viewer is less likely to be looking. If I show a movie to 20 people, that gives a good heat map to where attention is being placed. You compress the other bits. You can do even do it in real time with gaming, with 4K screens and wirelessly. That tells you where on the screen you need high resolution and high refresh rate, and frees up processing power for the game itself."

Tobii holds 60–70 patent families describing the technology. "It's been a huge task over the past three to five years to figure out what eye tracking would best be used for. Now sensors are small and cheap enough so they can be used on a standard laptop or a smartphone; but there are all sorts of things you could do. We need to figure out what is actually best to do," Elvešjō said. ☉

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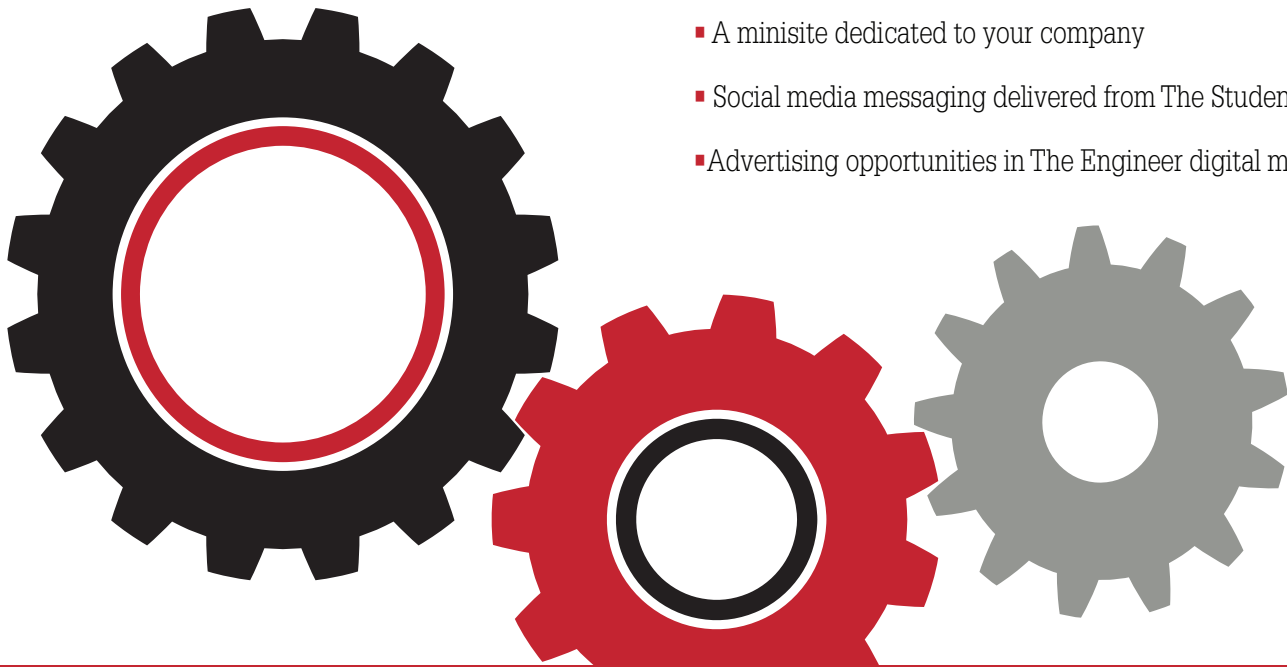
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july 1873

The Engineer pondered whether travelling at 100mph would be possible on existing tracks

Of all the topics covered in *The Engineer* over the past decade, few have been more divisive, or attracted more comment, than the ongoing debate over the UK's proposed high-speed rail network HS2.

But as an editorial from the early days of *The Engineer* pondering the likelihood of us ever developing a 100mph train illustrates, our desire for rapid rail travel is far from a modern obsession.

Commenting on the advantages of such a breakthrough, *The Engineer* wrote: "It can scarcely be disputed that to possess the power of traversing long distances at a velocity of 100mph would be advantageous to a very large section of the community."

The article continued: "The benefits to be gained by the power

of reaching Liverpool in two hours would be quickly recognised by the nation."

In 1934, the Flying Scotsman became the first steam engine to officially pass the 100mph mark. However, despite identifying some compelling advantages to the 100mph train, the article – written when

top average rail speeds were around half that – pondered whether such an achievement would ever be possible on existing tracks.

"On a first-class line there can be no question but that a speed of 65–70mph may be available with safety. It is doubtful, however, whether a much higher velocity, such as 100mph, would also be available without incurring enormous risks of derailment. It is not to be disputed that nowhere can 100 consecutive miles of permanent way in perfection be found, and as a chain is no stronger than its weakest link, so a few hundred yards of bad track would spoil for

the purpose of travelling at 100mph a whole line."

Turning its focus to the engine, the article asked: "Is it possible to construct an engine at all, which, with a moderately heavy train, will attain and

maintain a velocity of 100mph, on a line with no grade heavier than one in 300?" It is impossible, concluded the article, to do much more than guess, but it suggested that "we shall be going too far if we take it for granted that an engine can be constructed that will weigh in running order 30 tons only and yet be able to develop 1,000hp".

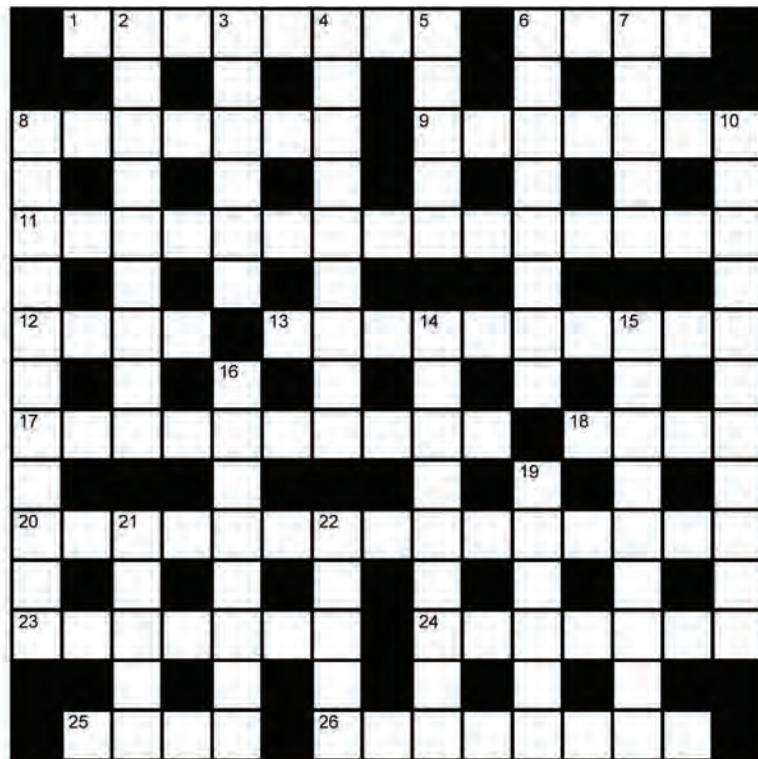
It wasn't until more than 60 years later that the Flying Scotsman became the first steam engine to officially hit the 100mph mark, although many believe the City of Truro got there first in 1904. Both locomotives are now on display at the National Railway Museum in York. **JE**

For more on this story visit www.theengineer.co.uk



crossword

Our prize crossword will recommence with our next print issue in September. This one is just for fun.



Across

- 1 Overly harsh or strict (8)
- 6 A curved shape that spans an opening (4)
- 8 A hinged blind for a window (7)
- 9 Covered and often columned entrance (7)
- 11 A system of measuring temperature (10,5)
- 12 One of several layers one atop another (4)
- 13 Mechanism that regulates the operation of a machine (10)
- 17 0.3937 inches (10)
- 18 US space agency (4)
- 20 Durability of material under stress (7,8)
- 23 Sheltered port for ships (7)
- 24 A strong mooring post (7)
- 25 A small pond of standing water (4)
- 26 Cause to be alert (8)

Down

- 2 Shaped without finishing (5-4)
- 3 Large and densely populated urban areas (6)
- 4 Extreme point of the Earth's axis (5,4)
- 5 An island in the Bay of Naples (5)
- 6 Erosion by friction (8)
- 7 High-quality porcelain (5)
- 8 Locking device on a dangerous machine (6,5)
- 10 Failed by aiming too high (11)
- 14 A rotatable platform (9)
- 15 Material used in high quality crystal (4,5)
- 16 Rubber-like synthetic compound (8)
- 19 Sleep disturbance resulting from flying (3,3)
- 21 An inhabitant of Scandinavia (5)
- 22 Structure engineered by a bird of prey (5)

originengineering

Anthony Poulton-Smith explores the origins of everyday engineering terms

This piece of equipment turns the basic movement of the piston (reciprocating motion) to a movement that can be useful (rotational motion). The term is unknown before 1820, at least as one word, and thus can only be a modern creation – or is it? Used in Latin as a single word, the two elements were seen in Old English and only came together in English in the 19th century.

'Crank' can be traced to Old English 'cranc' meaning 'handle for turning' and also as part of 'crencestre' or 'female weaver' and

always used to describe a weaver's instrument. Originally this was seen in Proto-Germanic 'krank' meaning 'to bend or yield'.

The original English usage was in the context of a shaft as in the handle of a spear. It comes from Proto-Indo-European 'skep' meaning 'to cut, scrape' and is related to the Greek 'skeptron', 'a staff'. From this, we can deduce the shaft is from an older word describing something long and narrow – thereafter being used to describe this as the shape of the handle of a spear and the narrow excavation at a digging.

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