TECHWATCH

MARCH 2023

Green sky thinking

More Power to You
Fuels of the Future

Technology Transfer
Q&A with Natasha Allden, CEO of Multiply

Lifting the Veil
Distributed ledgers in defence

CES 2023
News, trends and products

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QINETIQ

FOREWORD

Hello and welcome to the twelfth edition of TechWatch.

For our twelfth edition of TechWatch, we are exploring future fuels, reporting on new technological advancements, and assessing the role of commercial technologies within Defence, with a special feature on distributed ledger technology.

Our first deep dive explores future fuels through a sustainability lens, where we have collaborated with the Aerospace Technology Institute (ATI). This piece delves into current and upcoming sustainable fuel alternatives, and assesses the benefits and challenges of adopting these fuels into the Defence industry.

It is essential that we continue to reduce our Greenhouse Gas (GHG) emissions and adapt to climate change, innovating and collaborating across the value chain, in order to reach Net-Zero by 2050 or sooner. To do this, the Defence sector needs to play its part in embracing more sustainable technologies.

In the past, the Defence sector has relied heavily on developing technologies from scratch, but we are now seeing the benefits of "dual-use technology", where established technologies are being transferred from other industries. Not only can this transfer of technology support our Net-Zero goals, but it can also diversify our capabilities, providing Defence organisations with security in the volatile global market in which we operate. To complement this theme, we feature a spotlight Q&A with Natasha Allden, CEO of Multiply, who talks to us about how the Defence sector can gain from a more systematic approach to the transfer of established technologies from different industries.

Following this Q&A we discuss distributed ledgers, which are the underpinning technology behind cryptocurrencies, and not something commonly associated with Defence. We explore alternative applications of distributed ledgers and their potential role within Defence, focusing on how they can contribute towards smarter supply chains and more efficient operations, whilst also considering the challenges of these technologies.

Finally, to complete our 12th edition, our innovation team report on their visit to the Consumer Electronics Show (CES) 2023. They discuss key trends and challenges, whilst outlining the newest technology developments in the commercial world.

As always, we hope you enjoy the read - if you have any feedback or would like to speak to a member of the QinetiQ team, please contact us at TechWatch@qinetiq.com.

MIKE SEWART
Group Chief Technology Officer at QinetiQ

CONTRIBUTORS

QinetiQ contributors

David Taylor
Dr Dan Reid
Grant Williams
Gary Mepsted
James Bamborough
Leah Daly
Dr Mark O'Dell
Mike Sewart
Paul Thorlby
Patrick Smith
Rob Jackson
Simon Galt
Simon Tomlinson
Vanisha Hirani
Victoria Doherty

External contributors

Natasha Allden, CEO at Multiply

Harry Malins, Chief Innovation Officer at the Aerospace Technology Institute

Editors

Amber Bradbury
Bryony Chinnery
David Rosewell

Design & Production

David Stephenson
Jaime Newberry

CONTENTS

NEWS

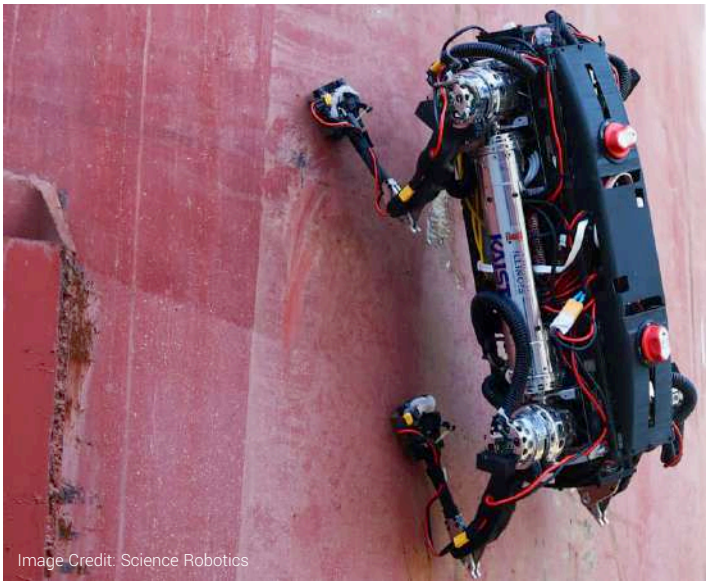


Image Credit: Science Robotics

4-legged 'robodog' can climb straight up walls and across ceilings

Researchers at the Korea Advanced Institute of Science and Technology have engineered a quadrupedal robot called 'MARVEL', which uses its magnetic feet to climb up walls, across ceilings and even over gaps and obstacles, as long as these surfaces are ferromagnetic (attracted to magnets). MARVEL stands for 'Magnetically Adhesive Robot for Versatile and Expeditious Locomotion', and researchers are serious about the 'expeditious' part. MARVEL can climb 70 cm of vertical wall in just one second, and move across 50cm of ceiling every second too. With its four legs, MARVEL resembles a small dog, leading to some reports calling it a magnetic "robodog".

MARVEL's magnetic feet are cleverly designed to take advantage of magnets known as electro-permanent magnets (EPMs). These EPMs are different to conventional magnets in that they only require power to change state between magnetic and non-magnetic, rather than needing to be continuously powered to maintain magnetism. This means that MARVEL doesn't need to use any power to stay stuck to walls or ceilings, and only requires power to switch the magnetism of each foot off and on again as it takes a step.

Obstacles and gaps pose distinct challenges to wheeled climbing robots, but do not pose a problem for MARVEL. The ability to step over obstacles up to 5cm high and gaps up to 10cm wide sets MARVEL apart and demonstrates its versatility. Furthermore, researchers also showed that MARVEL's magnetic feet still work on a curved surface covered in rusty and dusty paint, albeit slowing the robot to a pace of 35cm per second. The researchers hope that their work can be adapted for automation of remote inspection, repair and maintenance, especially relevant in higher risk environments.

SOURCE: KAIST NEWS CENTER

ESTIMATED TIME TO MATURITY:
0 to 2 years.

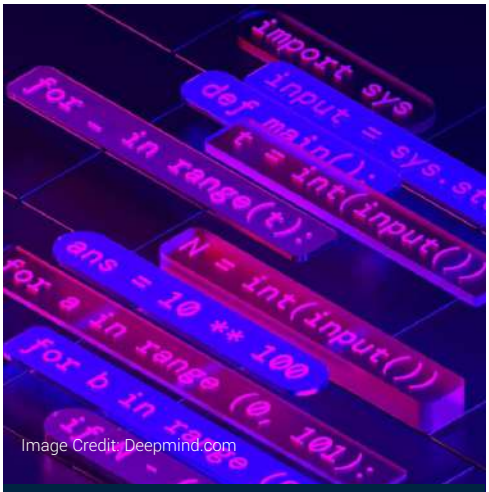


Image Credit: Deepmind.com

Software writing itself – AI learns to write computer code

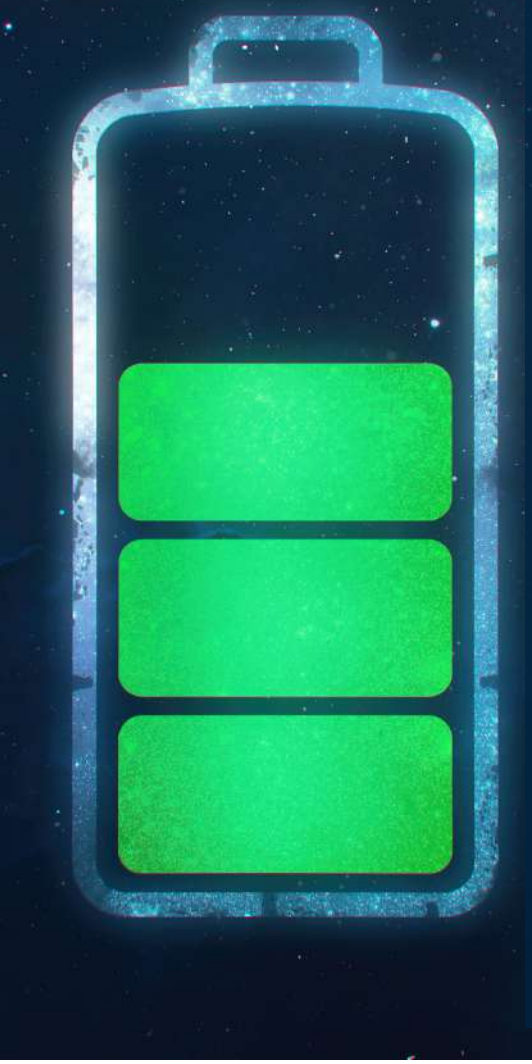
In recent years we have seen AI software assist us with more and more of our daily tasks. From improving the images we take on our phones, to powering self-driving cars, AI systems are becoming increasingly widespread, and capable.

It is likely the next area we'll see AI working is in writing the very code that powers it. DeepMind, part of Google's parent company Alphabet, has developed an AI it calls 'AlphaCode'. This AI understands programming languages and can even write computer code for a user. By training the AI on a library of existing pre-written code, the system understands (and is able to translate) a written description of what the user wants the code to do into real code, which can be run on computers.

AlphaCode isn't ready to take over from trained programmers just yet though; the vast majority of the code it produces still needs testing against pass criteria and refining until it works. As a first attempt, the system might produce hundreds of sets of codes, employing a range of varied approaches to solve the problem, then narrowing these down until one is found that completes the task. In recent tests, the system performed in the top 54% of human programmers in competitions, like Codeforces, and was able to complete 34% of tests it was put through. That might not sound impressive, but previous AI systems completed less than 10% of these tests, showing the progression that this technology has made.

SOURCE: deepmind.com

ESTIMATED TIME TO MATURITY:
2 to 5 years.



High performance battery uses sea-water materials

Researchers from the University of Sydney in Australia have produced a sodium-sulphur battery with four times the capacity of previous generation sulphur batteries. Sodium and sulphur are both abundantly available, and can be extracted from sea water, making this technology particularly interesting for cheaper and more sustainable future energy storage systems.

Typically, sulphur-based batteries have suffered from a range of issues limiting their performance, especially when compared to lithium ion batteries. For example, poor stability of their materials results in low storage capacity retention, meaning the battery cannot be charged and discharged as many times as a lithium ion battery. They also suffer from low total energy storage, meaning you get less energy out of an equivalent size or weight sulphur battery. However, the researchers' new battery improves on all of these issues, promising a battery system that is cheap to produce, long lasting, and with a high level of energy storage, making this new design able to compete in performance with today's lithium ion batteries.

The new battery is also safer than lithium ion systems, and promises to be cheaper and easier to recycle at the end of its life.

The next challenge will be to demonstrate this breakthroughin larger batteries, taking a first step to commercialising this new technology. If the technology can be successfully scaled up while maintaining a competitive price, it could drive down the price of electric vehicles, grid-based storage systems and portable electronics, while providing safer and longer lasting battery power.

SOURCE: The University of Sydney

ESTIMATED TIME TO MATURITY:
2 to 5 years.

New adhesive spells quicker and safer assembly and disassembly routes

Adhesives are an essential (but often overlooked) component used in nearly all technologies, equipment, and defence assembly processes. Adhesives have uses beyond simply holding components together,, such as tolerance/gap filling, thermal management, and as an assembly aid. Using an adhesive material with the correct properties is essential to the successful through-life operation of any system. For years, these materials have only been considered for their adhesive strengths, ignoring other considerations, such as environmental or disassembly issues. To address this, a team of researchers from Sichuan University in China have developed a reversible adhesive that can be recycled and reused.

This material also offers tuneable properties, allowing customisation for specific end-uses, as well as offering a simplified disassembly route. Rather than risk damaging key components when attempting to remove the bonded adhesive, these materials provide a reliable and safe disassembly route (like ethanol exposure) to reversibly reduce the adhesion. The materials have also been demonstrated to be stable under a wide range of conditions, such as exposure to hot and cold temperatures, moisture, acidic or basic chemistries, and can be reused hundreds of times without loss of performance.

This presents huge benefits, eg. allowing designs to easily incorporate disassembly routes, saving valuable operator time and minimising risk.

SOURCE: Science Advances

ESTIMATED TIME TO MATURITY:
0 to 2 years.

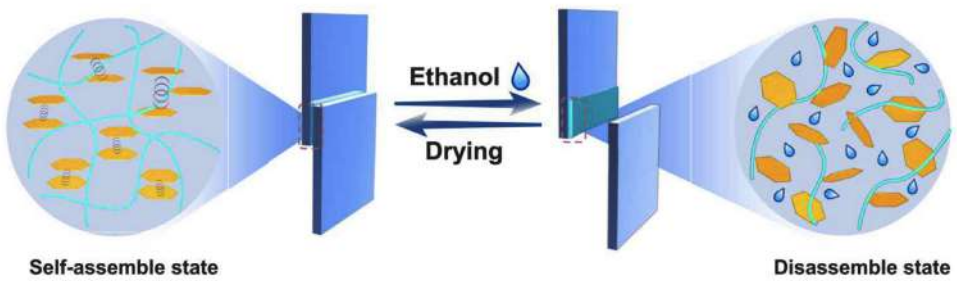


Image Credit: Sichuan University

NEWS

Could starlink be a better alternative to GPS?

A team of researchers at the University of Texas Austin's Radionavigation Lab have been listening for the signals that SpaceX's Starlink satellites send to their ground-based receiver units. The researchers hypothesised that they would be able to use these so called 'synchronisation sequences' as the foundation for a new navigation system. Their theory is that, with some software changes, Starlink could be used for precise positioning as well as the provision of broadband internet it was designed for. The researchers have also demonstrated that this positioning is possible, even without the support of SpaceX.

They found that Starlink satellites did indeed send predictable repeating sequences, and that there were more of these sequences than expected. By combining the orbital information SpaceX releases online for each of their satellites with the regularity of the synchronisation sequences received, a receiver is able to calculate the distance between itself and a given satellite. Repeating this for multiple satellites allows location to within approximately 30 metres. That said, this is not as accurate as GPS navigation. For example, some GPS receivers can pinpoint their position to within 30cm, whilst even consumer devices like mobile phones can use GPS to provide a location within 5m. However, Starlink satellites offer more redundancy and are potentially more robust than GPS navigation. This is due to the sheer number of operational satellites; some two thousand compared to about thirty.

Finally, the researchers theorise that Starlink position navigation accuracy could be improved to less than a metre, if SpaceX were to include actual satellite position data in the synchronisation sequence signals. This would make Starlink satellite navigation competitive with GPS.

SOURCE: MIT Technology Review

ESTIMATED TIME TO MATURITY:

2 to 5 years.

This chip can transmit more than 1 quadrillion bits of data in just one second

The average global internet traffic per second amounts to about one petabit (1015) of data. This means that in any one second period, one quadrillion (or one thousand million million) bits of data travel through the internet's backbone. Now, researchers from the Technical University of Denmark have succeeded in transmitting nearly double this every second. They used a single photonic chip and just one laser to transmit data at an unprecedented speed of 1.84 petabits per second along a 7.9 km long optical fibre cable.

To put this into perspective, internet connection speeds of around 25 megabits per second will let you stream something in Ultra HD. With an internet connection speed equal to that demonstrated by the researchers, you would be able to stream around 70 million Ultra HD videos, at once.

This is the fastest data transmission achieved by any system using only one laser and an optical chip. Light from an infrared laser is fed into the custom chip, which transforms it into a comb-like pattern of individual colours (ie. frequencies) that can be used as data carriers, avoiding the need for multiple lasers. Transmitting data in different colours prevents interference effects, hugely increasing the data capacity of the fibre optic cable the data is sent through.

A single laser source could drastically improve the power consumption of internet communication networks, replacing thousands of power hungry lasers that would otherwise be used. This technology could mean an internet with a smaller environmental footprint, whilst still having enough bandwidth to keep up with the ever increasing consumption of data.

Researchers predict that their current chip will be able to transmit up to 100 petabits of data per second, offering great potential for scalability. That said, the system will require additional development to ensure integration with current communication systems.

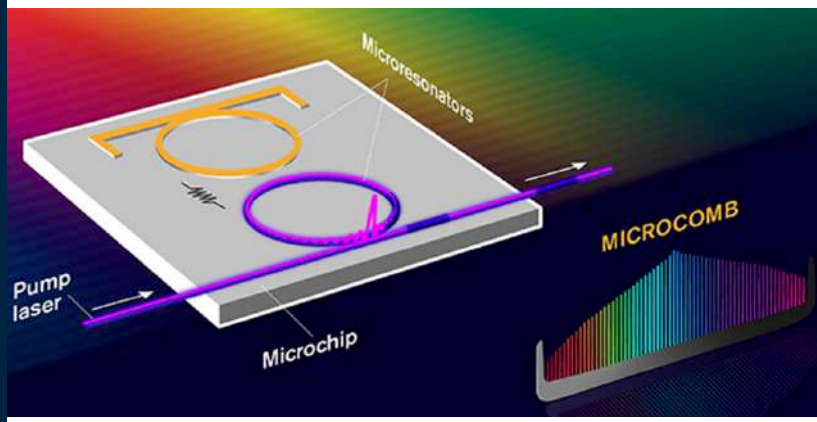


Image Credit: Technical University of Denmark, via The Register, via TechPowerUp

SOURCE: New data transmission record (dtu.dk)

ESTIMATED TIME TO MATURITY:

2 to 5 years.

Wearable ultrasound patch provides organ monitoring on the go

Many of us use wearable technologies that provide us with health measurements from onboard sensors, monitoring things like sleep quality, activity levels, heart rates, and even blood oxygen levels. Now DARPA-funded research at MIT is hoping to take this even further, developing a wearable ultrasound device that can be attached to a user's skin. This patch can be worn for at least 48 hours, providing a means to take ultrasound images throughout the day. This can be used to investigate a user's health, physical performance, or organ function and, importantly, avoids the need to continually re-apply gel, as is typically associated with ultrasound scans.

Currently, the probe needs to be attached to an ultrasound system to produce images, but the researchers hope to incorporate wireless ultrasound probes, such as those already being developed at the University of Toronto. Once mature, the technology presents the option of a self-contained wearable sensor that can beam images and 3D scans to a smartphone or other device for viewing. This could allow long-term monitoring of patients, or soldiers on the battlefield, helping to protect their health and understand their performance. Further development and miniaturisation of the tech may allow it to be included in future wearables, like smart watches and heart rate monitors, proving additional and greater depth to the health data these devices provide.

SOURCE: news-medical.net

ESTIMATED TIME TO MATURITY:
2 to 5 years.

Image Credit: C. Wang, MIT

This AI material can change its shape to adapt to surroundings

Flexible Research Group at UCLA via TechBriefs

We all know that a material's properties and performance are critical to making sure it works correctly and efficiently, but ensuring it has the optimal shape and size for its job is also crucial. Typically, the shape of a part (think of an aeroplane wing, or the front of a car) is pretty much fixed, with maybe a couple of flaps and vents that can be moved. This restricts how much it can be tailored for different situations.
By adapting concepts from machine learning, engineers from the University of California, Los Angeles have built a material that can measure its environment and then change shape to adapt. A special algorithm analyses the measurements and calculates which shape is best for each situation and task. Being able to change shape in real time could allow designs to adapt to changing situations, like air conditions, or earthquakes.

The current system only operates in two dimensions and is very mechanical, using strain sensors, motors, and flexible beams to produce the change in shape. It is hoped that future systems will shrink the size of the parts to less than a millimetre. This could let designers build thousands of them into three dimensional parts. So far this is only a proof of concept, but if developed to a usable level, the technology could see a range of uses, for example, in fighter jets, armour plating, and acoustic imaging technologies.

SOURCE: Tech Briefs

ESTIMATED TIME TO MATURITY:
5 to 10 years.

NEWS

Injectable hydrogel is activated by the body's own temperature to stem bleeding – and it can be removed with cold salt water

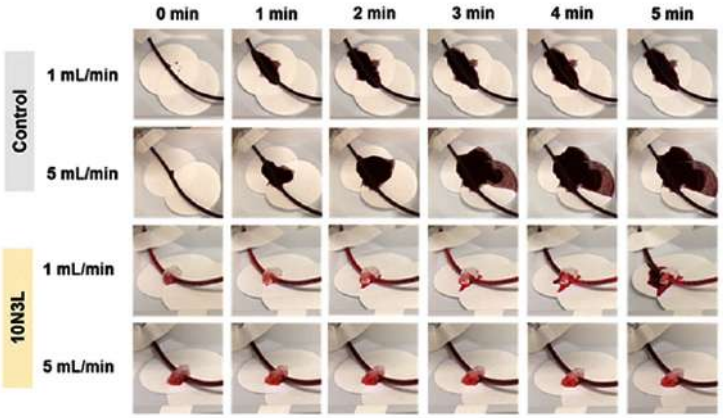


Image Credit: Mecwan, M. et al. (2023)

Severe blood loss is the leading cause of potentially survivable deaths occurring due to trauma in the battlefield. Researchers from the Terasaki Institute for Biomedical Innovation in Los Angeles have combined a blood clotting agent with a temperature sensitive polymer to create a hydrogel (a type of polymer that can store a lot of water) that shows promise for stemming blood flow in emergencies.

Researchers used a syringe to pump body-temperature human blood through plastic tubing, an experimental setup designed to model human blood vessels. Researchers were then able to puncture the tubing to create 'injuries' and compare the blood loss when the 'injuries' were treated with their hydrogel, vs. when untreated. The hydrogel works by creating a physical barrier at the 'injury' site which stems blood loss, eventually forming a plug which prevents further loss. These experimental results were combined with standardised animal tests and found to demonstrate that the hydrogel significantly prevents blood loss and is comparable in performance to a commercially available agent, Floseal.

Moreover, this hydrogel is non-toxic and reversible. A simple cold saline wash will remove it without leaving residue, meaning that hydrogel injected in the battlefield can be easily removed once a patient is stabilised or before surgical intervention.

In future, the researchers aim to improve on the current formulation of the hydrogel by incorporating agents that clot blood faster, antibiotics to control infection, and even molecules that promote the regeneration of tissue. They also intend to explore alternative application methods, like a sprayable version of the hydrogel, for treating blast injuries, lacerations, and abrasions.

SOURCE: Terasaki Institute

ESTIMATED TIME TO MATURITY:
2 to 5 years.

Net energy gain achieved by controlled fusion experiment for the first time

Nuclear fusion is often referred to as the holy grail of energy production. An alternative to the burning of fossil fuels, this clean energy source produces no carbon dioxide or other gases harmful to our atmosphere and generates only a small amount of short-lived radioactive waste. But fusion can only be useful so long as the process produces more energy than is put into it.

Nuclear fusion is the opposite of nuclear fission, the process that current nuclear power plants exploit to produce energy without using fossil fuels. While fission is the splitting of heavy atoms to produce energy, fusion reactors produce energy by using pressure and temperature to force light atoms (like hydrogen and helium) together.

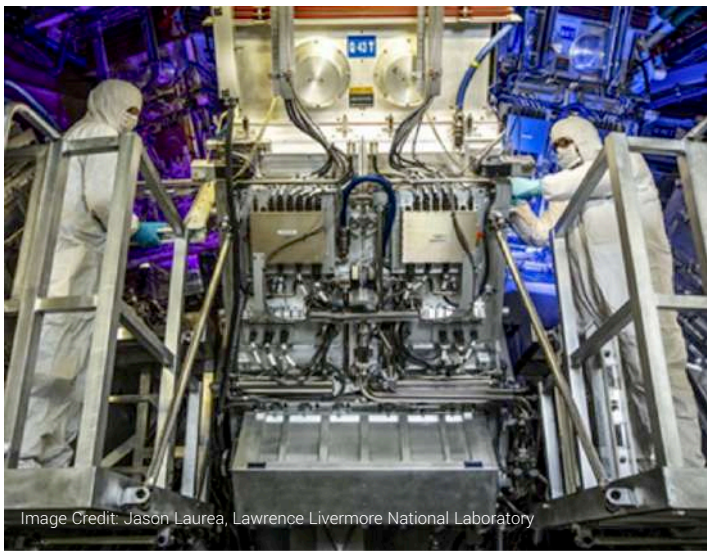


Image Credit: Jason Laurea, Lawrence Livermore National Laboratory

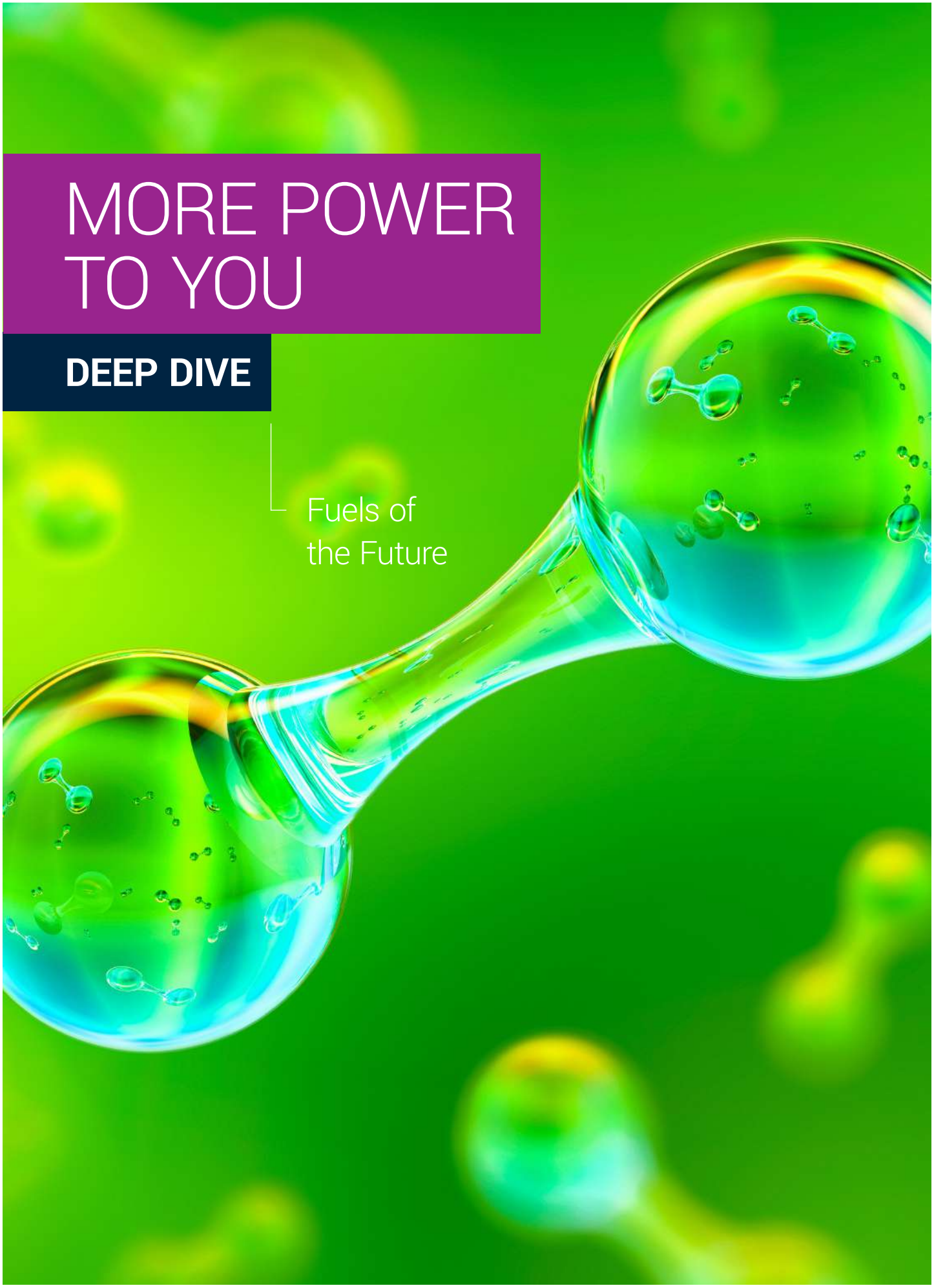
This produces a lot more energy than nuclear fission (for the same mass of fuel), but these high temperatures and pressures are expensive, requiring a lot of energy, and hugely expensive materials to sustain them. Because of these energy demands, fusion experiments have previously used more energy than they have produced.

Researchers from the National Ignition Facility at the Lawrence Livermore National Laboratory in California have conducted the first example of a controlled fusion experiment that achieves net energy gain. Their experiment produced 3.15 megajoules (MJ) of fusion energy from an input of 2.05 MJ of energy. The net energy gain was 1.10 MJ – about the amount needed to boil a kettle – a long way off powering cities.

Nevertheless, this experimental result proves that the science underpinning fusion reactors works and that they may yet be the holy grail of energy production. However, this is only the first step towards the ultimate goal of nuclear fusion power plants, which will likely still require decades of research and engineering effort to realise. With this in mind, it is also worth considering what real positive effect fusion energy can have on the climate crisis. Most certainly, this result is no reason to become complacent in the investment and establishment of more readily renewable energy production, like wind and solar energy.

SOURCE: National Ignition Facility

ESTIMATED TIME TO MATURITY:
10+ years.



MORE POWER TO YOU

DEEP DIVE

Fuels of the Future

MORE POWER TO YOU **DEEP DIVE**

Fuels of the Future: more power to you

The climate is changing. And the social and political climate is changing too.

Human influence has unequivocally contributed to the warming of the planet. What we must do is scientifically clear: limit warming to no more than 1.5°C above pre-industrial levels to avoid the most significant climate change impacts on human and natural systems. It is essential that business plays its part, reducing emissions, adapting to changes and innovating in order to reach Net-Zero by 2050 or sooner.

As such, the global energy system is now, out of necessity, reorienting itself around sustainability. A number of nations have publicly proclaimed their commitments to, one day, achieving Net-Zero emissions. To this end, electrification and the development of alternative liquid fuels are happening in different ways and in different places all across the world.

Militaries, which are major resource users (estimated currently to contribute to about 5% of global emissions), now have their part to play in this shift, but face a problem set that the civilian world does not. Amidst a backdrop of supply chain fragility, which became more apparent during the pandemic; and a renewed interest in national defence, highlighted during Russia's invasion of Ukraine, there is now a growing demand for defence to perform at ever-increasing levels of capability, whilst also driving down emissions.

Trading survivability for sustainability is not a sacrifice that can be made, even with political pressure mounting. That said, the defence industry is making advancements which are likely to negate this choice, eventually. For example, the RAF achieved a world-record first with a 100% synthetic flight in November 2021. The force has set itself the ambitious challenge of becoming the world's first Net-Zero Air Force by 2040. It's also trying to deliver its first Net-Zero airbase by 2025.

Supply chain risk and liquid-fuel security

Fuel security is national security. Many nations rely on other countries for the hydrocarbons that fertilise their crops, heat their homes, and, quite literally, drive their infrastructure and economies. Put simply, these nations rely on liquid fuels to function. As do their militaries, which would find themselves unable to field the vast majority of their land, air or sea capabilities without a reliable supply of liquid fuel.

The question is, how can we continue to operate our militaries (and our countries) whilst driving emissions down? Part of the solution involves a new set of 'drop in' liquid fuels which can be partially or wholly substituted for conventional fuel. Indeed, automotive giant Porsche may have helped set a precedent here in December 2022, when it opened a synthetic fuel plant in Chile. The plant aims to produce 130,000 litres per year of automotive fuel that is CO2-neutral and compatible with unmodified combustion engines.

Other fuel candidates (like liquid hydrogen) can replace fossil fuels entirely, but require major platform modifications and infrastructure investment.

This is all good in principle, however, nobody said that such a sustainable transformation would be easy. Quite the opposite, in fact.

Carbon challenge

Today, hydrocarbons are still the best way to meet the majority of defence's needs across its various domains, and the needs of the civil world too. Here's why.

Energy density

When compared with more sustainable, low-carbon liquid equivalents, hydrocarbons can't be beaten for stored chemical energy content. This makes them ideally suited to uses that require large amounts of energy to generate kinetic power (eg. fast air), but also favourable when considered from a power-to-weight ratio for non-supersonic platforms that still have limits on how big their fuel tank is.

Cost

Despite recent price fluctuations, conventional fossil fuels are still cheaper than sustainable alternatives, and are likely to be for quite some time. For defence, which tends to prioritise performance over cost (though must also factor cost) - this presents a surmountable challenge. But, for the private sector (particularly aerospace), which thrives or dies based on cost margins, this is a dealbreaker.

Infrastructure

In addition, our civil and military infrastructure is almost entirely geared towards fossil fuels. It's had many decades to develop that way. Engines and propulsion systems are historically designed around fossil fuels, as is the supporting infrastructure; from the gas pipelines running across national borders to the gas-fired boilers in our homes.

You can't simply start piping liquid hydrogen down a liquefied petroleum gas pipeline, and you can't just drop any kind of fuel into the engine of a vehicle designed specifically to operate on a precise chemical formula without implications, most of which are bad.

So, beyond the obvious imperative to reduce pollution, what else might these future fuels have to offer us? There is one major benefit.

Resilience

Again, back to supply chains. Reliance upon foreign exports of oil, for example, creates clear vulnerabilities and weak areas that can be exploited.

Recent attacks on transnational pipelines offer timely examples, but thinking back a little further, resupply at the tactical level poses much the same problem on a smaller scale. The British Army states this clearly in its Approach to Battlefield Electrification:

"The demand for power has grown exponentially. In 1945, one litre of fuel was needed per soldier, per day; today it is 20, increasing resupply convoys and exposing troops to greater risk. One litre of fuel provided to a Forward Operating Base requires another seven to get it there. 70% of fuel used generating electricity for HQs goes to waste in maintaining capacity to deliver notional peak demands. Between 2003 and 2009 over 3,000 US soldiers or contractors were killed while supplying fuel in Iraq and Afghanistan."

In addition, a 2009 US Army Environmental Policy Institute report calculated one casualty for every 24 and 39 fuel resupply convoys in Afghanistan and Iraq, respectively. And, outside of a military setting, many people in off-grid and rural areas rely upon the regular resupply of kerosene heating oil to keep their homes liveable.

Reality check: electrification, offsetting and neutralisation

So, it's clear that a transition is on the cards. When will it happen? By 2050 ideally, to be in-line with many of the social and political targets. And what will it take? A number of rapid technological advancements, the financial and human capital to drive them, and the political will to create the environment for this all to happen.

Where do liquid fuels fit? Well, they're just one part of a Net-Zero picture that will also include liquid hydrogen, electrification and carbon neutralisation (for example, via carbon capture technologies, which are still in their infancy, and carbon offsetting via old-fashioned, yet controversial, tree planting).

To quote Harry Malins, Chief Innovation Officer at the Aerospace Technology Institute (ATI), an organisation that promotes technology development in the UK civil aviation sector, and which creates the technology strategy for UK civil aerospace:

> "Offsetting is still a viable strategy, it's Net-Zero, not gross zero. Defence will have to rely upon offsetting to one extent or another, as it's unlikely that zero-carbon fuels will be able to meet all of its needs by 2050."

Question: why not just electrify everything? Answer: you can't

Electrification (namely, the use of batteries instead of liquid fuel) reduces upfront emissions but does have some challenges to overcome – not only does it require the infrastructure for recharging, it can also push negative environmental outcomes down into the supply chain, particularly around batteries and the rare earth elements these batteries require.

It is likely to be more suitable in certain domains, eg. land, which tends to have more forgiving size, weight and power (SWaP) requirements. For a recent example, see QinetiQ's work with AM General to electrify the HUMVEE. And one need only look at the booming electric car industry, in which electric vehicle sales overtook diesel in 2022, and which has bet heavily on electrification over the hydrogen fuel cell alternative. However, increased electrification in the civil space (for example, people charging their electric cars in their driveways) has clear ramifications for nations that are already struggling to generate enough power through alternative routes, like renewables.

Of particular interest for electrification are robotics and autonomous systems (RAS) - which do not require space or weight for human inhabitants. In fact, the British Army is evaluating front-line resupply (or 'last mile' resupply) through the use of uncrewed ground vehicles (UGV), powered by battery-driven electric motors with on-board liquid fuel generators to recharge the batteries when necessary.

In the aerial space, various large electric UAVs (eg. Malloy Aeronautics' Hoverbike) have been under evaluation by several NATO militaries for some time. Such vehicles have also been trialled with humanitarian organisations working in the third world and disaster zones, to perform a variety of roles including resupply, provision of emergency aid, first aid/blood delivery, and casualty evacuation. These drones are set to potentially replace small aircraft and helicopters in areas with contested airspace or risky landing arrangements.

We are, however, unlikely to see electrification make serious inroads with heavier aircraft any time soon - it simply cannot meet the size, weight and power requirements of such craft, especially high-performance ones, like fast air.

The naval domain also sees further potential in electrification, as ships tend to have plenty of space and the ability to take on a lot of weight. Indeed, some ships going back to WW1 used electric generators that were powered by steam turbines - in a system known as 'turbine–electric' transmission. One example is USS Langley, the US Navy's first aircraft carrier.

For a more modern example, the Royal Navy's Queen Elizabeth class aircraft carriers have hybrid propulsion systems that use a combination of electric motors fed by gas turbines and marine diesel engines. Fully electric shipping is also developing quickly in the civil space, with various electric ferries, cruise ships and cargo ships now operating around the globe. For example, in November 2021, Norway launched the world's first electric autonomous cargo ship.

For more on electrification in defence, please download Edition Two of TechWatch.

Choices, choices

As a relatively new area, the sustainable liquid fuel space has a number of overlapping and sometimes competing formats. Whether or not we see Betamax/VHS style 'format wars' amongst sustainable fuels, consideration will have to be given to NATO's single fuel concept, which aims to 'maximise equipment interoperability through the use of a single fuel'.

Put another way; defence will have to make some joined-up decisions at some point about which of these formats show the most promise. But what will they have to choose from?

Sustainable aviation fuel (SAF)

SAF (sometimes referred to as 'synthetic' or ''synthesised' aviation fuel) is chemically similar to conventional jet fuel. This can make it suitable as a 'drop in' fuel source; that is to say, to be used in the place of conventional fuel, without the need for any modifications to the fuel infrastructure or the platform itself.

SAF is something of an umbrella term which describes a variety of reduced-carbon fuels, some greener than others, each created in different 'production pathways'. Generally speaking, reductions in emissions vary; but carbon savings typically range from 50% up to 80% when compared to A1 jet fuel. Reductions are also made in other kinds of lesser-known (but still harmful) emissions, like sulphur and particulates.

SAF can also be produced from a wide variety of sources (sometimes known as 'feedstocks'). This makes it easier to access than oil, for example, which can only be found in certain regions.

SAF Production Pathways

- **Alcohol to jet (ATJ):** The ATJ process utilises dehydration, oligomerisation, and hydro processing to convert alcohol feed stocks to a pure hydrocarbon fuel blending component.

- **Catalytic Hydrothermolysis Jet fuel (CHJ):** In the CHJ process (also called 'hydrothermal liquefaction'), clean free fatty acid (FFA) oil from the processing of waste oils or energy oils is combined with preheated feed water and then passed to the CH reactor. There, under very high temperature and pressure conditions, a single phase is formed, consisting of FFA and supercritical water (SCW), wherein the FFAs are cracked, isomerised, and cyclised into paraffin, isoparaffin, cycloparaffin, and aromatic compounds.

- **Fischer Tropsch synthesized isoparaffinic kerosene (FT-SPK):** Coal, natural gas, or biomass feed stocks are gasified into a syngas, comprised of hydrogen and carbon monoxide. This syngas is then catalytically converted to a liquid hydrocarbon fuel blending component in the FT reactor.

- **Hydroprocessed fatty acid esters and fatty acids (HEFA):** In the HEFA process, lipid feedstocks like plant or algae oils, animal fats, or waste greases (like cooking oils) are deoxygenated and then hydroprocessed to produce a pure hydrocarbon fuel blending component.

- **HH-SPK (Hydroprocessed Hydrocarbonssynthesized isoparaffinic kerosene) or HC-HEFA:** Describes the hydroprocessing of bioderived hydrocarbons (unlike the fatty acids or fatty acid esters found in HEFA production) which comes from oils found in a specific algae, Botryococcus braunii.

- **Power to liquids (PtL):** Describes a production pathway for liquid hydrocarbons based on CO2, electricity and water as inputs. Uses either Fischer-Tropsch (FT) synthesis and upgrading or methanol (MeOH) synthesis and conversion.

- **Synthesized isoparaffins (SIP):** The SIP process utilises fermentation to convert a sugar feed stock into a hydrocarbon molecule that can be blended into conventional jet fuel.

Source: saf-technical-certifications.pdf

In the UK, a 50:50 mix of SAF and standard A1 jet fuel has been approved for use in existing engines and platforms, however a greater percentage of SAF in the mix requires further testing and safety certifications. Though it can help to significantly reduce emissions, SAF is certainly not a carbon neutral alternative and as a result, it is not the definitive solution.

Hydrogen

Hydrogen's use as a fuel isn't entirely futuristic - though to date, such use has been quite limited. NASA has been using it in liquid form as rocket fuel as far back as the 1950s, and astronauts used to drink the water produced on the fuel cells used to power the space shuttle.

And as the universe's most abundant chemical element, you might assume hydrogen to be an easily accessible fuel source. This, unfortunately, is not true. It must first be liberated from the other elements it is bound to. Today, hydrogen can be produced by splitting water molecules (H2O), which produces oxygen as a byproduct. This can be done using clean energy sources ('green' hydrogen) or non-renewable sources ('blue' hydrogen). However, currently, the majority of hydrogen is produced via non-renewable means, which tends to be cheaper, usually through a process called 'steam reformation', which releases CO2.

Once liberated, this hydrogen can be used in hydrogen fuel cells - often seen in the context of 'fuel cell electric vehicles' (FCEVs) - which are widely acknowledged as the most viable way to harness hydrogen as a vehicle power source. They produce electricity by combining hydrogen and oxygen, which releases electricity, heat and water.

There has been some progress; for example, the late 1990s saw the limited introduction of fuel cell buses in a number of US cities. Today, there are various hydrogen-powered buses in operation around the world, including examples in Bolzano, Groeningen and Cologne. There are also several hydrogen-powered trains in operation around the world, with the UK's trailling its first, the 'HydroFLEX', in 2020.

Separately, within industry, several heavy engineering machinery manufacturers (eg. JCB, SANY, MAN trucks and Manitou) have already produced hydrogen-powered vehicles, as has New Holland, the agricultural machinery manufacturer.

In the private market, 2014 saw the debut of the Toyota Mirai, the world's first mass-produced FCEV. However, fuel cells are still very expensive, and, frankly, there are not enough fuelling stations to make this a practical form of private transport, yet.

As an alternative, hydrogen can also be burned as a fuel in internal combustion engines, but, unlike in FCEVs, this can produce nitrogen oxide (NOx) emissions through the tailpipe, which occurs through the combination of nitrogen and oxygen.

Hydrogen might be key in the air

The ATI's FlyZero project, which investigated the technical and commercial feasibility of zero-carbon flight, concluded that green liquid hydrogen is the most viable fuel to meet this goal.

According to the ATI, liquid hydrogen is forecast to become cheaper, as well as greener, than Power-to-Liquid (PtL) SAF, which is expected to become the primary SAF as demand increases. According to ATI's research, PtL also requires more electrical energy to produce than liquid hydrogen. The scalability of other SAFs is also limited by the availability of raw materials.

ATI believes that revolutionary technology breakthroughs are required in six areas to achieve zero-emission flight: hydrogen fuel systems and storage, hydrogen gas turbines, hydrogen fuel cells, electrical propulsion systems, aerodynamic structures and thermal management.

On a timely related note, in January 2023, cleantech startup Zeroavia demonstrated the use of a hydrogen-electric powertrain to power a 19-seat Dornier 228 testbed aircraft.

Green-sky thinking

So, we clearly have plenty of options, but there will not be an overnight leap. Turning promising early technology readiness level (TRL)' to 'TRL (technology readiness level) technologies into successful commercial technologies that meet the needs of civil society and defence is a long, long road that many promising technologies take a wrong turn on and are never seen again.

Promising technology demonstrators, like the previously mentioned 2021 RAF voyager flight, have set a precedent, but we will need more of them to create momentum; investors need proof that these technologies have legs (or wings) and are worthy of a large amount of capital investment. Because, of course, it will require a lot of capital. A lot of which will have to come from the private sector...

Follow fast - or fall behind

In the future fuels landscape, defence will largely depend upon technological developments in the civil space, along with the development of sustainable infrastructure. So, why can't defence go it alone?

To quote Harry Malins again: "Defence must be a 'fast follower' because it can't generate enough demand to influence civil fuel manufacturers and technology developers. Militaries must carefully align; avoiding the case where the fuel of choice in the civilian space is different from the fuel of defence."

It is quite likely that defence will look to 'militarise' advancements made in the civilian world. Defence must also avoid making funding or procurement decisions that lock it into any more fossil-fuel based reliant capabilities. Admittedly a big ask in these troubled times.

The bad news for the planet is that fossil fuels are likely to be around for quite some time yet in defence. Recently (or soon to be) fielded capabilities with decades of service life ahead of them, like the M1A2 Abrams and the F35 Lightning II, require these high-carbon fuels.

According to Harry, it's a long road ahead:

"Time is relatively short, especially in complex capability timeframes that can take decades to implement. We have to think about how we incentivise investors to fund green tech developments, like these, where the ROI may be a decade or more away.

And how will we incentivise energy producers? They will want to know that there's demand before they invest in scaling production of these kinds of fuel. But users (like airlines) will want to know that the fuel is available before they invest in alt-fuel techs. And regardless, defence must get involved early on, so as to ensure that it is part of this conversation."

Technology transfer

Natasha Allden, CEO of Multiply

In the past, defence research has offered commercial organisations a vision of what technologies are coming over the horizon. Today, industrial innovation drives new intelligent tools and services into the open market where they can be accessed by anyone with sufficient resources. In both the past and the present, defence has relied heavily on developing technologies from scratch. Could it gain more from the transfer of established technologies from businesses in other markets?

Natasha Allden is CEO of Multiply, a company that specialises in business-to-business (B2B) technology transfer. She is currently undertaking a PhD at Cranfield, looking at the benefits of this practice.

Q: What do we mean by the term 'B2B technology transfer'?

A: This is one of the fundamental challenges of this topic – we don't currently have a common definition. In essence though, we are talking about the flow of ideas and technologies from one application to another – from a university to a business, or between academic institutions, or even between businesses in different sectors. Key to understanding B2B technology transfer is understanding the direction of technology flow; 'inbound', 'outbound' or both directions.

Inbound is about scanning the horizon to identify new technologies and innovative ideas that can be proactively employed by an organisation to improve its capabilities and performance. This is a well-established practice with formal processes, and proven pathways to success.

Outbound is less well-defined. It is about businesses looking at their existing technology and capabilities, and exploring other fields where they could be applied to expand their impact. Though less established, this could have a huge impact on defence and security businesses that have technology ready to exploit.

Q: What makes outbound B2B technology transfer so interesting?

A: Maximising the value of existing technology and capabilities is often an untapped advantage for companies and governments. It provides additional new revenue streams through the commercialisation of technology into new applications or/and through new business models. In the volatile global market in which we operate, I believe it is essential for organisations to de-risk and build sustainably to weather market challenges. B2B technology transfer diversifies an organisation's portfolio, as you would with a financial portfolio. This diversification reduces risk and provides security and a route to sustainable growth.

MULTIPLY operates as a social enterprise and the impact, socially, environmentally and economically, that can be realised from effective B2B technology transfer can't be underestimated. It provides a viable vehicle to empower organisations to operate purposefully, maximising impact locally and more broadly through supply chains, customers and partners.

Q: Why has that not already happened?

A: In some cases it has. NASA is awash with examples of spin-offs from space exploration that have been applied to terrestrial markets like health, construction, and farming. And ESA's Space Economy programme has delivered new approaches for remote monitoring in healthcare, and new methods relieving water scarcity on Earth through novel recycling. But there are two reasons why this is not a more common practice.

Firstly, business to business (B2B) outbound technology transfer is a poorly trodden path and as such, there are fewer formal processes and mechanisms for using this approach. In part this is because, typically, an organisation will lead with the market need, developing products and services in response to that need, being market-led is the recognised best practice in industry. However, B2B technology transfer is about the exploitation of existing technology. Ergo, this is a technology-led process, and requires us to rethink how we identify market opportunities. The poorly trodden path in academia and industry means that the lack of knowledge, and therefore lack of confidence, can make B2B technology transfer appear risky.

Secondly, there is a deficit of skills and tools to support outbound B2B technology transfer. The process is about taking products or services, unpacking them into the core capabilities they offer, meaningfully identifying suitable applications, testing, quantifying and ultimately designing and delivering programmes. This is what my PhD at Cranfield University focuses on, answering the question of how we can effectively deliver technology transfer.

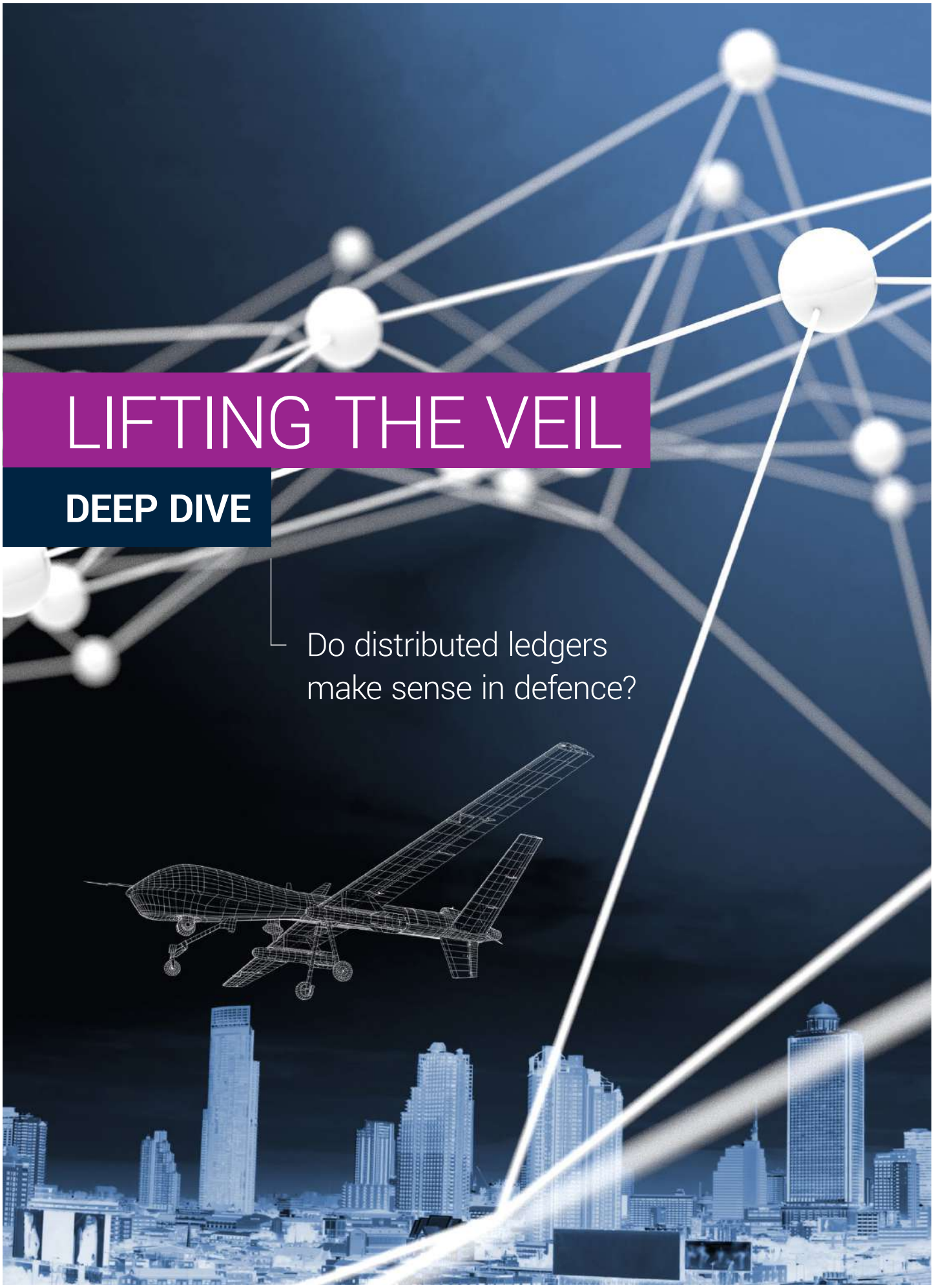
Q: What needs to change for outbound B2B technology transfer to become an established approach for defence and security companies?

A: Access, understanding, and support.

Access to skills is paramount for effective outbound B2B technology transfer in defence. That includes access to transfer agents and technology transfer networks that can empower businesses to engage in the required activities.

There needs to be a greater and more uniform understanding of what technology transfer is, who it takes place between, what entities are involved, why it is valuable in this sector, and why outbound specifically makes sense for defence and security organisations. That is going to require guidance, collaborative exploration in the sector, and standardisation.

And it will also require some visible government support. In the UK, we invest a lot into early-stage innovation but much less into commercialisation and technology transfer. There needs to be a national strategy that demonstrates how we will diversify defence and security innovation into other markets - something definitive that the whole ecosystem can get behind. This is not about using scarce public resources to underpin technology transfer processes. It is about investing in the creation of an environment that enables B2B outbound technology transfer to thrive, so defence and security organisations, and the country's economy as a whole, can benefit..



LIFTING THE VEIL

DEEP DIVE

Do distributed ledgers make sense in defence?

LIFTING THE VEIL **DEEP DIVE**

Do distributed ledgers make sense in Defence?

Concept

Distributed ledger

Distributed Ledger Technology (DLT) refers to the technological infrastructure and protocols that allows simultaneous access, validation, and record updating in an immutable manner across a network that's spread across multiple entities or locations.

Technology framework

- **Blockchain**
- **Hashgraph**
- **DAG**
- **Holochain**
- **RADIX**

Access type

Public
A public DLT is one where anyone is free to join and participate in the core activities of the blockchain network. Anyone can read, write, and audit the ongoing activities on a public blockchain network.

Private
A private DLT is one in which only specific users have access and abilities and is generally used only by the entity it belongs to.

Permissioned
A permissioned DLT is a hybrid of public and private blockchains where multiple users are given permissions and abilities.

Markets where issued

Digital currencies; cyber security; smart contracts; insurance; healthcare; property

Individual applications

Obyte, IOTA, HYPERLEDGER, CONSENSYS, r3, ripple, fidentiaX, HYPERLEDGER SAWTOOTH

Beneath the volatility of cryptocurrencies lies a stable, secure and effective technology that could play a significant role in a range of industries. Is defence one of them?

Economic theory considers money a 'mere veil' obscuring real underlying activities. When it comes to the implosion playing out in the world of cryptocurrency, this has never been more true. Because under the volatile surface of digital currencies, lies a stable, promising and proven technology that has countless valuable applications beyond the finance industry.

Distributed ledgers are 'blocks' of digital information that link together to form a single ledger, or 'chain'. This is why one well-known approach to using these technologies is called 'blockchain'. It is the approach used as the basis for administering the digital currency, Bitcoin. The ledger is decentralised and can be viewed and accessed by all approved users. Any time the data is changed, all users in the network validate it before it is added into the chain with a time-stamp. Once incorporated into the ledger, this data cannot be amended or reversed and is validated by approved users. This enhances the provenance of the information and reduces the chances it can be tampered with. For this reason, distributed ledgers offer increased visibility, traceability and efficiency – all traits valued highly by regulated markets and critical industries.

Since 2020, the value of digital assets stored using Blockchain - just one of many distributed ledger technologies - has climbed from less than $1bn to more than $200bn today and is set to grow exponentially in the years to come.

But distributed ledgers have far outgrown their original use in finance. They are now extensively used across all commercial sectors, including healthcare, automotive, supply chain, academia, and document verification. The technology is also now attracting the attention of many tech enthusiasts because of its ability to bring trust into previously trustless systems and provide greater confidence in the decisions based on the information decentralised ledgers hold. Developers working with distributed ledgers are hard at work devising innovative applications for the technology across a wide range of industries.

However, Defence may not be one of the industries openly embracing this innovation. Demonstrating the value of distributed ledgers in this sector is difficult. The environments where this technology has already been successfully employed are characterised by decentralised systems; 'trustless' systems; and the ability for multiple users to make changes. This is the direct opposite of how NATO and other ally Defence forces are structured. The entrenched hierarchies and central command and control models for operations do not fit the decentralised environment in which distributed ledgers can add value.

Even if Defence was to move towards a decentralised model, there are other challenges hampering adoption. Latency is the first. On average, the publicly available blockchains such as the ones used to manage financial transactions for Bitcoin, take approximately 10 minutes to confirm a transaction. That is acceptable for day-to-day administrative tasks but not for live battlefield operations that require a minimum execution time. Private blockchains such as Hyperledger Fabric are faster. They are also less reliable and that makes their use equally, if not more, detrimental for defence.

The volume of data traffic is also an issue. The sheer amount of data used for defence operations is vast and growing exponentially. Considering the bandwidth of the ledger and the technology that makes it work, not everything can be handled effectively through distributed ledgers. This makes decisions about how much and which data should be recorded on a ledger essential, and an additional determination commanders do not have the bandwidth to have to consider during a live operation.

All this adds up to a challenge of scalability. According to Nasdaq, the number of transactions on Ethereum, a popular public blockchain, rose from 3000 per year in 2015 to more than 400 million in 2022, thanks to the growth of digital currencies and the explosion of non-fungible tokens as legitimate tradable assets from 2019 onwards. It is expected to grow by double digits in 2023. That rapid rise affects transaction fees and total waiting times for transaction completion/verification.

Beyond the battlefield

If distributed ledger technology does not represent an opportunity for defence operations today, could it be useful beyond the battlefield? There are certainly areas where the traceability offered by the technology can be helpful. Military aid is one. Larger militaries often help smaller ones – especially those whose objectives align with their own. But that help often comes with strict rules on how the assets provided can be deployed. A distributed ledger could allow those providing the aid to have traceability over how they are used, giving the originator 'line of sight' and ensuring there is no chance they could be used unethically or in ways that were not originally agreed. This can also help with tracking the environmental, social and governance (ESG) impact when aid and humanitarian programmes are initiated, helping defence forces prove the role they have played and justifying the resources expended. Furthermore, it can be used to record broader military ESG performance as part of the creation of an index to track that performance across divisions, domains, or even countries. With increasing focus on sustainability goals for the industry - this could be an open source way to collaborate, report and learn.

Service and maintenance on complex assets is another scenario to consider. Most defence platforms and systems are staggeringly complex. They require collaboration among a number of entities to build them, and keep them operational and mission-ready. The F-35 jet for example, contains more than 300,000 components, manufactured by a worldwide network of more than 1,900 suppliers. The prime contractor, Lockheed Martin, doesn't just manufacture the aircraft; but is also responsible for maintaining these incredibly expensive and complex assets long after the customer has taken delivery. The contract stipulates that the customer must always be able to deploy 80% of its F-35s. If it cannot, Lockheed has to pick up the cost of addressing that issue - a considerable potential financial risk.

Traditional manufacturing models are not designed to cope with such challenging contractual requirements for highly complex assets. They rely on strong relationships, auditing and documentation to manage the supply chain effectively. In defence's complex environment, this approach introduces greater risks for suppliers. Those risks are often mitigated through higher pricing meaning the customer loses out too.

Distributed ledgers can address both. Across the supply chain, they can provide greater traceability of equipment and components, recording each stage of a product's life from raw material to customer delivery. This ensures a component's authenticity, as well as providing an end-to-end pathway, complete with licencing and condition of usage information, for that product through the supply chain. Information can therefore be traced and recorded at each step, providing a clear audit trail for approved users to see, significantly reducing the need for traditional manual methods, and providing much improved warranty management. For many organisations which currently have little visibility beyond first tier suppliers, this also offers the ability to identify and contain any quality issues much more efficiently and obtain the information required to respond to regulatory compliance requests much more readily.

Distributed ledger technology can also enable the use of Smart Contracts. These are pre-programmed transactions that enable the automatic execution of specific actions once a predetermined condition is met. This reduces the time required to deliver and it removes human error from the equation for repeatable tasks – such as triggering a payment or a dispatch. But it can also help smooth out supply chain situations where multiple interdependencies and constant uncertainty can lead to a deficiency in one part of the supply chain and excess in another. In 2020, Harvard Business Review reported that Walmart Canada had begun implementing Smart Contracts on Blockchain with its trucking suppliers. It was designed to automate payments based upon tracking data that confirmed when deliveries and pickups had completed. The use of a shared blockchain made it possible to synchronise logistics data without significant changes to the trucking firms' internal processes or information technology systems, so meeting contract obligations now requires very little hands-on administration all round.

Overhyped or undersold

There are clearly some areas where the value of a distributed ledger in Defence could be evidential. But there are many more where it is unlikely. The very structure of NATO and other ally forces may be a barrier that is simply too big to overcome. Ultimately though, Defence organisations may have no choice. Distributed ledger technologies are fundamental to the success of adversaries, who depend on a decentralised system of command to succeed and grow. As the number of adversaries who depend on this approach increases, conventional models of defence and organisational culture may require reshaping to ensure they can be defeated.

Image Credit: CES 2023

Consumer Electronics Show 2023: News, trends and products

Earlier this year, our innovation team attended the Consumer Electronics Show (CES) 2023. CES is the largest technology expo in the world, showcasing the newest technology innovations to more than 120,000 attendees, 5,000 media and more than 2,000 exhibitors.

Those companies represented a diverse range, from industry-leading blue-chips through to tech start-ups from around the world in a multitude of sectors including automotive, agriculture, health, cyber and robotics.

The QinetiQ team attends CES every year. Our aim is to capture a snapshot of the world's newest technology developments in the commercial world, scan the horizon for future evolutions in tech, and develop an understanding of which commercial sector technologies and solutions could be applied to support our defence and security customers.

Key trends

While there were less 'brand new' technologies presented at the show this year, there was a clear step-change in many big tech movements, such as the metaverse, augmented reality, virtual reality and artificial intelligence; with a phenomenal shift in the quality and performance of enabling hardware and displays.

The experts at CES provided some key tech trends to watch out for:

- 5G industrial Internet of Things (IoT)
- Connected Intelligence
- Autonomous Systems
- Quantum Computing

While the first three were showcased in abundance throughout the exhibition, there was clearly a much smaller scale of quantum technologies, reflecting its relatively early stage in the market.

Key challenges

Whilst emerging trends are exciting and filled with promise, in his keynote speech, Steve Koenig, VP Research for Consumer Technology Association (CTA) identified some key challenges that will impact the rate of technological change. These included:

- Recognition that supply chain challenges will continue to hinder the rate of technological change (although the demand for semiconductors is levelling out)
- Rising interest rates that have flatlined consumer spending
- Labour and skills shortages that will impact the future development (and rate of growth) of all technologies

Product showcases

While there were thousands of technologies on display at the show, here are some of the more notable products and services that we saw demonstrated at CES or unusual applications of new and innovative processes.

Image Credit: Releaf Paper

Releaf Paper

Ukrainian start-up Releaf claims to have developed "a unique technology that turns deciduous biomass into paper that is not inferior to ordinary." The company is developing a solution that turns collected debris leaves into sustainable, recyclable paper products. It claims that its technology creates 78% less CO2 emissions when compared to traditional paper manufacturing, fifteen times less water consumption and 17 trees saved for every tonne of paper produced.

Meetkai Reality

Reality is described by Meetkai as "a new software platform that supports users in digitising physical spaces to create instant 3-D replicas using nothing but a phone". Meetkai claims that its tech "…can be used to bring objects and spaces from the real world into the metaverse without the need for complicated scanning equipment or countless hours of custom 3-D modelling."

The ability to quickly build digital twins of physical spaces could be invaluable in a training context.

Image Credit: Meetkai Reality

BHaptics TactGlove

BHaptics claims its TactGlove to be the 'first consumer-ready haptic glove', and is compatible with the video hand tracking built into existing commercial head-mounted displays (HMDs). The company claims that its neuromorphic algorithm "brings senses to every virtual interaction from pressing a button, lifting a dumbbell, petting a cat, shaking hands and even hugging a virtual avatar".

The glove's tactile feedback, combined with such hand tracking functionality, will help to increase immersion and realism in XR environments. Similar to the previous example, as a way to increase XR fidelity (particularly, for example, in complex tasks that require dexterous hand use), this technology could be invaluable in a defence context for training and mission rehearsal.

Image Credit: BHaptics TactGlove

Image Credit: Sleepium

Sleepium

Sleepium's developer describes the tool as "a virtual reality sleep meditation app to improve sleep through learning to self-manage your anxiety." Users train with a wearable EEG headband that measures brainwave data during the day and then view the same immersive content on their VR headset before bed at night.

As most people above a certain age will agree, proper sleep is a major performance enhancer, so the military applications of such a technology are obvious.

Nuralogix Anura

With the slogan "Take a selfie, know your healthie" Anura's intended use is to increase people's awareness of their general wellness. The company claims that, by using your phone's video camera, Anura can measure, track and record your general wellness based on your facial blood flow.

Such a technology could be very useful in a military context, perhaps as a means to monitor the health of personnel when deployed and far away from medical support.

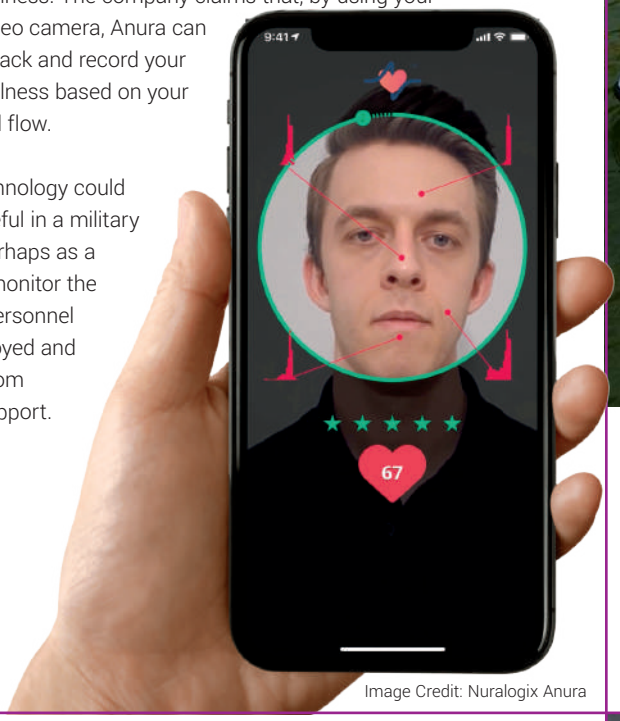


Image Credit: Nuralogix Anura

Image Credit: The WasteShark

The WasteShark

RanMarine Technology describes the WasteShark as "the world's first autonomous aquadrone designed for clearing marine plastic waste." It also claims to operate at "a running cost of 20% of other marine waste removal solutions and with zero emission operation."

Considering military commitments to reducing carbon and pollution (a significant proportion of which is produced by Maritime activity), such a technology could prove itself useful in a naval context.

The Indy Autonomous Challenge (IAC)

Where the previous section showcased individual innovations, the Indy Autonomous Challenge showcased the design (and driving) skills of nine teams from 21 universities, all in competition to demonstrate their autonomous automotive engineering prowess as their vehicles tore around the track at speeds exceeding 190 mph.

This year's winners were team PoliMOVE, from Politecnico di Milano (Italy), and the University of Alabama (Alabama), who have previously set a land speed record with their autonomous racecar.

Asides from entertainment value, IAC, (the event's organisers) hope that such showcases will help to "speed the commercialisation of fully autonomous vehicles and deployments of advanced driver-assistance systems (ADAS) to increase safety and performance."

For more information on the technologies and trends from the Consumer Electronics show, visit the CES website or QinetiQ blogs and social channels.

Image Credit: The Indy Autonomous Challenge (IAC)

David Taylor: focus on XR technologies

David Taylor is a Senior Principal Systems Engineer, and co-leads the QinetiQ Immersive Capability. He is the technical and industry lead for many projects, including digital learning, human-machine interfaces and immersive technology.

In terms of XR devices, every year we see improved form factor, increased processing capability and more capable software. These, however, are incremental changes, not 'quantum leaps'. Nobody has created a revolutionary headset, yet, but it is inevitable - we just don't know when.

We're noticing form factor changes across the board, the bulky front sections of earlier headset generations disappearing, as the frontal weight is balanced out by heavy components, like power supplies, at the back in newer systems. This is being driven by recent developments like the 'pancake lens' - which reduces the space between the lens and the display, meaning less housing is required at the front of a device.

That said, we're still quite far away from something as small and light as a pair of glasses that is as capable as these headsets. When looking for a headset for defence, what should we be looking out for?

Security: Features which include storage encryption, multistep authentication, and native VPN support would potentially allow XR devices to operate at a higher classification.

Toughness: None of the devices I've seen is durable enough for military use, you certainly wouldn't be able to drop them, let alone take them out into the field for a week. Work would need to be done to ruggedise them, which could have implications for the weight and shape of the device. That said, this is probably more of an issue for untethered devices, with tethered ones less of an issue due to their likely use (namely, attached to computers, in more forgiving environments).

Image Credit: AntReality

David's CES top 3

AntReality 'Crossfire' lens

AntReality is a AR/VR hybrid optical component manufacturer – not a supplier of end-user devices. Basically, it makes components that will be used with other devices.

I found that Crossfire's overall user experience was excellent – a sharp, bright display with 120 degree field of view, although noticeable light blocking to the real world. This demo was indoor, so difficult to comment on what performance would be like outdoors, but AntReality claims 3000 nits - which would be recommended for "average" outdoor use. Very bright sunshine may still ruin the experience.

Crossfire's ability to present a VR capability alongside AR could be a solution to challenging use cases.


Image Credit: Lynx

Lynx R1 Headset

This is a mixed-reality headset with a 90 degree field of view. It offers up to 3 hours of battery life and is 200g lighter than Meta's Quest Pro. The mixed reality capability was also better than the Quest Pro in terms of the clarity of the video feed. However, digital content didn't always seem to track well against the passthrough, with latency seemingly a problem from time to time.

The company claims that its software development kit (SDK) will be open source, which could lead to many possibilities in future - perhaps, for example, allowing defence to build a variety of reusable software modules that extend the capability of the device.

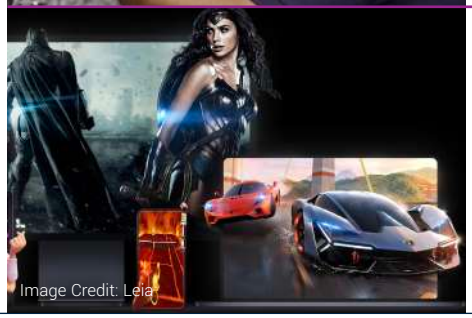


Image Credit: Leia

Leia Tablet

Whilst not strictly an XR device, this tablet uses eye-tracking technology to provide content that conveys depth. The user is required to stay within the tracking area, ie. fairly central to the device. It provides an 86 degree field of view at a distance of 20-60 cm.

The demonstration software gave a strong sense of depth to the dynamic content shown. It was generally impressive, but there is a need to re-develop software to work on the device, which will be a barrier to uptake. For highly portable immersive capability, it would be worth examining further.

QINETIQ

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5 types of Distributed Ledger Technologies

Advantage on the Battlefield

UK

Cody Technology Park
Ively Road, Farnborough
Hampshire, GU14 0LX
United Kingdom

+44 (0)1252 392000

TechWatch@QinetiQ.com

www.QinetiQ.com

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