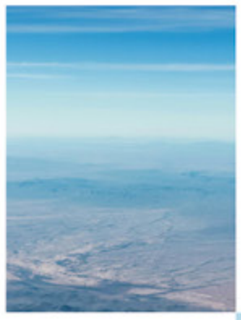
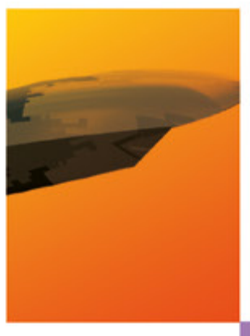
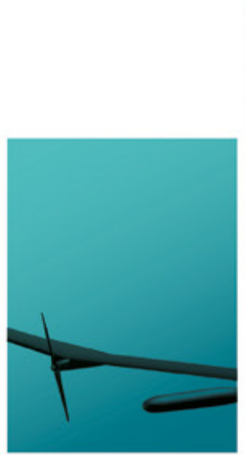
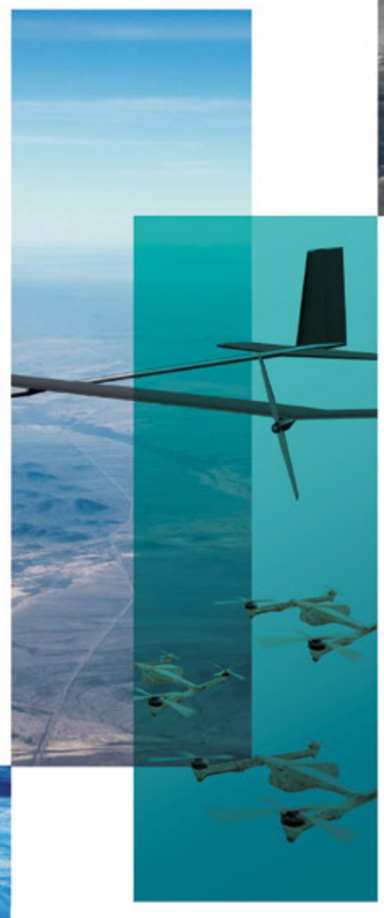
Innovators

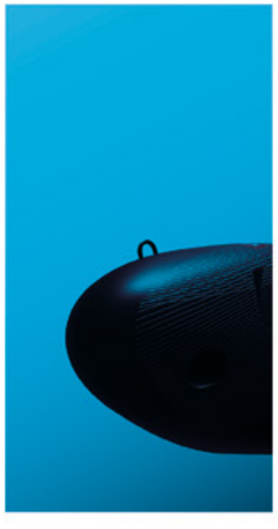
News and perspective from our
Research and Development teams

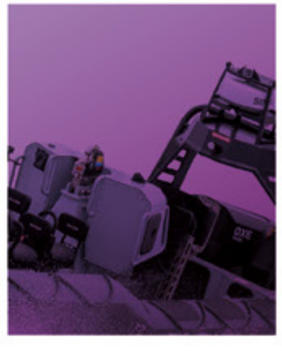












BAE SYSTEMS

Innovators contents

Click on the story title to take you to the relevant page

QR codes have been included within many of the articles.

These will enable you to link through to further information.

BAE SYSTEMS

Technology is at the heart of defence

At BAE Systems our people are driven by knowing that the work that we do makes a genuine difference.

For me personally, the opportunity to drive and leverage advances in technology in support of our mission is especially exciting. When I see the support that our physical equipment is giving to Ukraine as well as our work in cyber-hardening the country's digital systems, it makes me immensely proud to be part of this industry.

In this year's Innovators book, we look at recent achievements in autonomy. These include our uncrewed submersible, missile integration onto one of our uncrewed air systems and trialling our automated combat vehicle turret. You'll also read about our natural language voice controller, which can control an uncrewed vehicle by voice alone, just as you would talk to another human being.

As well as building equipment, we digitally integrate it across military domains. This is brought to life in our tactical battlefield network, which we are now extending to under the sea. We do something similar for national security customers, where we've integrated tools to help prevent child sexual exploitation around the world.

We always strive for agility and efficiency, so several of the stories here explore how we improve manufacturing, design and development to increase our productivity, continually improve value for money, and ultimately deliver capability more quickly to our customers.

I hope you enjoy the book. Please get in touch if you want to discuss anything at **ctocomms@baesystems.com**

Julian Cracknell,
Chief Technology
and Information Officer

"As well as building equipment, we digitally integrate it across military domains. This is brought to life in our tactical battlefield network, which we are now extending to under the sea."

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Technology to protect today

What's more disruptive, a small remotely-controlled drone or digitally-connected mobile artillery that can fire six rounds, pack up and move half a kilometre in less than the two minutes it takes the shells to reach their destination?

I recently heard from frontline teams in Ukraine who use drones and artillery in combination, delivering a much greater effect than either product on its own.

This is the real 'disruptive capability' – helping our customers leverage their most powerful equipment in new ways. Digitally enabled artillery systems such as Archer, along with the uncrewed systems that we and others are developing in air, land and maritime domains, are all critical elements of defence's digital transformation.

We've been investing in uncrewed systems for more than 25 years and recently added to our own developments by acquiring companies with great fixed wing and multi-rotor technologies. These acquisitions, combined with our investment in counter-drone technologies, have seen us establish ourselves as one of Europe's leading producers of drone and anti-drone capabilities.

Disruptive capability is not limited to the operational equipment we supply. We are also helping customers to rehearse new missions and tactics in our Project OdySSEy® family of synthetic environment capabilities. This allows new concepts to be tested without the need to buy or develop physical prototypes, new tactics to be optimised, and future missions to be rehearsed to better prepare users for ever evolving threats.

This book is all about new technology and getting it into customers' hands rapidly. Whether that's something completely novel or through quickly updating existing kit to meet the challenge of a changing adversary. This is technology to protect today.

Rob Merryweather,
Technology Director

"We've been investing in uncrewed systems for more than 25 years and recently added to our own developments by acquiring companies with great fixed wing and multi-rotor technologies."

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Game of drones: wargaming tool explores missile and drone defence options

Multiple drone and missile strikes have already been seen in the Red Sea, as well as attacks involving more than 200 ballistic missiles elsewhere. These are only likely to become more intense in future warfare, so how can we prepare now?

Chris,
Lead Analyst

Simultaneous attack with hundreds of missiles and drones is already a reality, but how would an attack by a combination of ballistic and hypersonic missiles be countered? Our MAST (MarLabs Analytic Synthetic Toolset) digital wargaming suite helps find the answers.

MAST is a highly realistic synthetic environment designed to test current and future capabilities across multiple military domains. MAST draws on our decades of experience in ship sensor systems and effectors such as missiles and other countermeasures, and models enemy units and platforms, including missile and drone threats. MAST has been designed to run test scenarios multiple times to generate statistically valid results. It can also be used to support human in the loop experiments and wargames.

Our analysis lead and wargaming expert, Chris, explained why it's such an important problem to solve: "Once a ship has used up its weapons, it has to withdraw. It may not be damaged, but if it can no longer defend itself then it can no longer fight. Now that raids of hundreds of threats attacking simultaneously are becoming common, new and better ways to address this problem are needed." Now imagine this scenario: the radar display in the operations room lights up with hundreds of incoming threats. Artificial Intelligence (AI) helps triage these threats and proposes appropriate responses. The lowest category threats, such as drones, could be allowed to get close enough to use point defence solutions, such as conventional munitions or even Direct Energy Weapons (such as microwave or laser). Some threats could be countered with microwave defences, which can disrupt their electronics. More demanding threats, such as sea-skimming, ballistic or hypersonic anti-ship missiles, would require longer range effectors, such as Sea Viper and Sea Ceptor missiles. MarLabs' extensive analysis points to the following improvements:

- A single common operating picture, built up from multiple sensors on the ship as well as radar data from other maritime and air-based sensors. This allows long range identification of threats, so that they can be countered at the optimal point.
- AI-assisted selection and tasking of the task group's defensive measures, overseen by a command team with high situational awareness (which could be described as 'human in the loop'), to speed up the response and allow more threats to be countered. This will include targeting weapons, selecting the appropriate response for each threat (considering there may be hundreds of targets to assess), and constantly reviewing the common operating picture fused from all the available sensors.

> "Once a ship has used up its weapons, it has to withdraw. It may not be damaged, but if it can no longer defend itself then it can no longer fight."

MAST is helping to explore the optimal missile loads and responses to incoming threats, to help inform future ship design.

The battlespace is a multi-domain problem. While air-based drones are a prevalent threat, in future we expect greater numbers of uncrewed vehicles on land, sea and under the sea to be used. MAST is also being used to explore the impacts and solutions.

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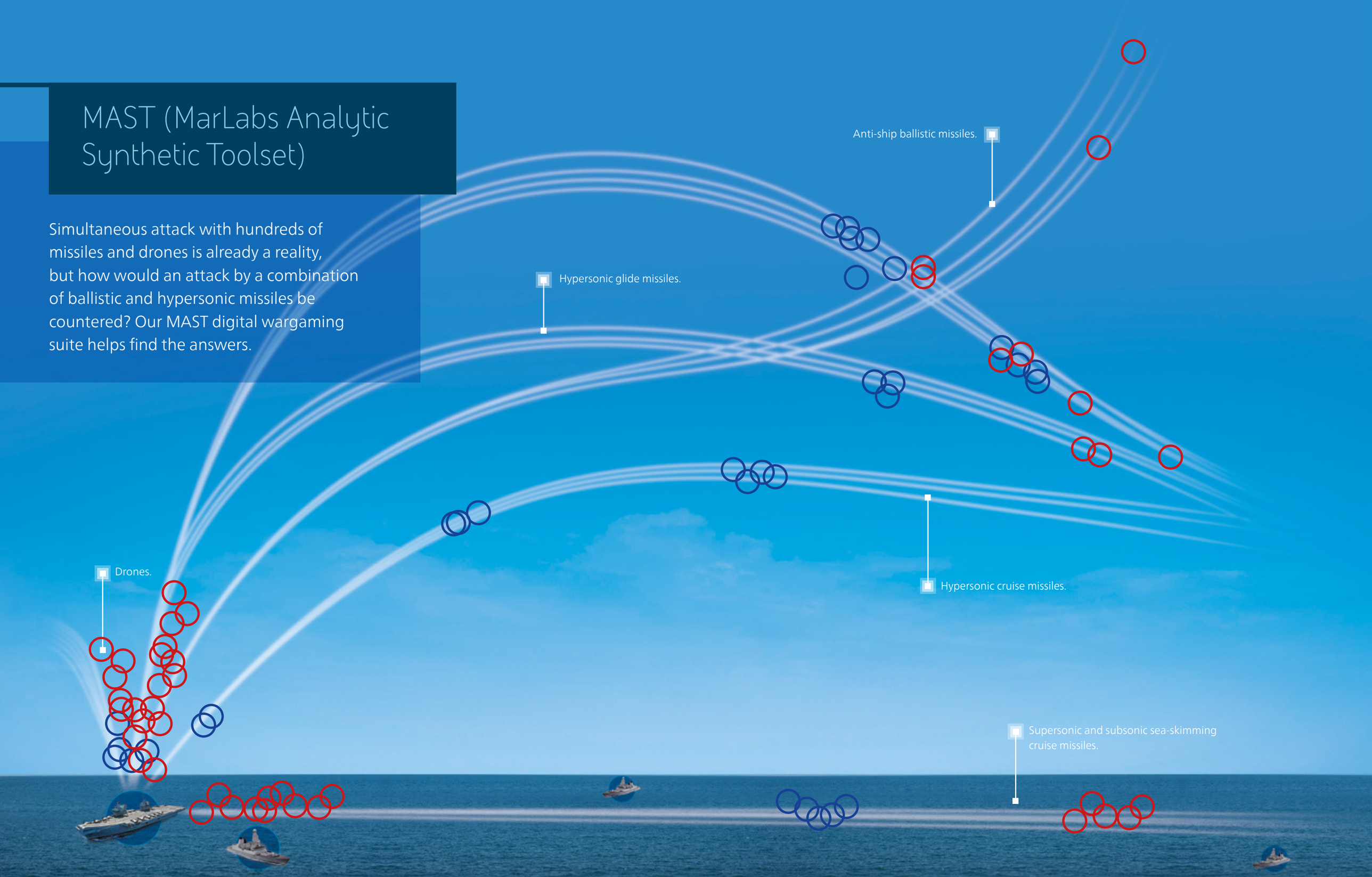
MAST (MarLabs Analytic Synthetic Toolset)

Simultaneous attack with hundreds of missiles and drones is already a reality, but how would an attack by a combination of ballistic and hypersonic missiles be countered? Our MAST digital wargaming suite helps find the answers.



In this snapshot of an engagement, the red circles indicate the presence of a threat (these can be various types, as indicated), while the blue circles show the position of task group effectors (such as missiles, close in weapons systems, etc) that have been deployed to counter these threats.

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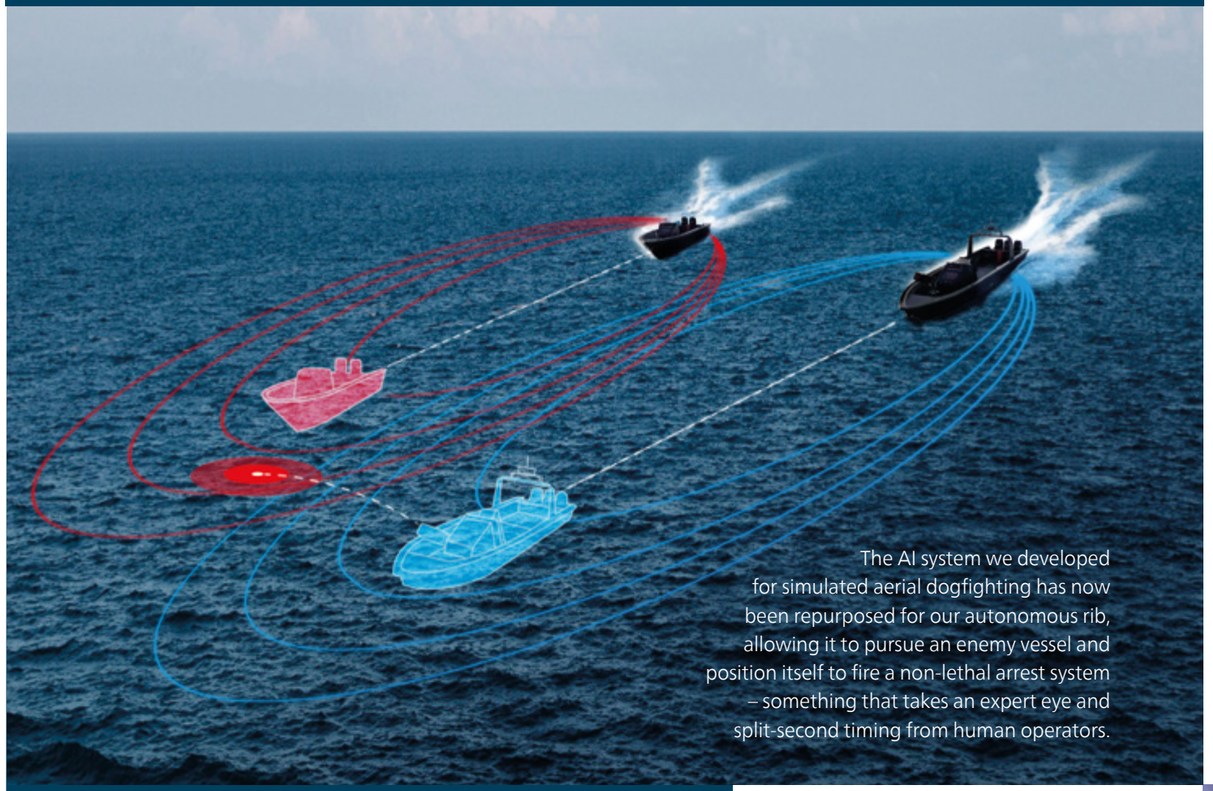
Artificial Intelligence (AI) dogfighter on a boat?



The AI system we developed for simulated aerial dogfighting has now been repurposed for our autonomous rib, allowing it to pursue an enemy vessel and position itself to fire a non-lethal arrest system – something that takes an expert eye and split-second timing from human operators.

It turns out that an AI engine trained to win at air-to-air dogfights can also control fast boats pursuing or evading enemies.

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As seen in Ukraine and in the Red Sea, there is a growing threat of surface water drones, loaded with explosives and remotely piloted to attack large ships. How do you counter these multiple threats at a distance and without depleting your limited countermeasures? We've brought together our AI dogfighter system with our Lloyd's certified autonomous boat to develop a rapid counter-drone solution, which will identify, pursue and disable enemy boats with its 'stinger' non-lethal arrest system.

Autonomous boat armed with non-lethal arrest system.

Tests earlier this year at sea have proven that the technology works. As well as physically demonstrating this at sea, we've created a highly accurate virtual environment to rapidly train the AI model. In our at-sea trial we combined the two, with a physical autonomous boat armed with the stinger arrest system pursuing a virtual enemy boat, which was piloted by a human in our Portsmouth-based lab. The position of the remotely piloted target boat was shared with the autonomous 'brain' of our boat via a satellite communications system, so as far as it was concerned, it was chasing a real boat trying to evade it.

In a real-world scenario, these types of autonomous boats would be a valuable addition to perimeter defence for a ship. Each boat has several 'shots' available from its 'stinger' non-lethal arrest system, which can easily be replenished at minimal cost. To rapidly deploy these autonomous boats, we've also developed a launch and recovery system (see page 38 of this book) designed to integrate with ships such as the Type 26. This avoids the need for additional crew to deploy the boats, saving people for important tasks on the ship itself.

Firing the stinger arrest system takes expert timing, which is why AI is such a good solution to pick the right moment. Mike, Chief Technologist for Autonomous Systems, set out the challenge: "You're not only moving in two dimensions across the surface of the water, but the boat itself is also pitching and yawing due to wave action and changes in speed. Timing is essential, as not only does the shot need to land in the right place, but if you fire too early the enemy boat can avoid it, whereas too late and you miss."

"For human operators, the stinger system requires a specialist user with skill and training, which is even more difficult when being operated remotely. However, our trials with the AI system have shown a tremendous success rate, without requiring a dedicated human operator for each boat."

Given the success of the trials, we're pursuing several opportunities to demonstrate this during customer events.

We expect to use the AI engine in other applications in future, including our training suites and uncrewed air vehicles. Our relationship with Cranfield University has helped us build a body of expertise in AI and autonomy, both academically and within our business, which we'll continue to develop as we progress the AI engine further.

Autonomous underwater vehicles to patrol and deter

How do you protect thousands of miles of critical underwater infrastructure, such as gas or electricity pipelines?

Meet Herne®, our new autonomous underwater vehicle, designed to patrol silently beneath the waves for weeks at a time. Herne has a large mission bay designed to support a number of missions, from surveillance through to anti-submarine warfare and more.

The demonstrator vessel has now sailed in both Canada and the UK, proving it can operate autonomously in the depths accurately, while making its own decisions on how best to complete the mission safely and responsibly. With further planned improvements, the intention is for the production vessel to be capable of ranges of thousands of kilometres, including periods of 'hibernation' on the sea floor while it waits for further instructions or scans for enemy vessels.

Nick, who led on the design and engineering for the integration of BAE Systems' capabilities into the platform, explained: "Herne is designed to operate entirely on its own, but also to raise the alarm to humans on the loop if it finds a threat. We're fitting it with advanced AI identification so that it can accurately predict whether an object it detects is a threat, along with over the horizon communication systems so that it can tell commanders what it's found and ask for direction. The large mission bay makes it even more useful, as it could carry effectors such as small rover vehicles, allowing it to disable explosives, remove eavesdropping devices or disable mines.

"We have an incredible team who took the demonstrator vessel from whiteboard to water in just 11 months. Not only did we bring our own decades of experience in submarine design and engineering, but we teamed up with specialist Canadian company Cellula Robotics to reach this demonstration phase. In what was a highly accelerated programme, we worked alongside Cellula to bring the whole capability to life."

Putting together the first demonstrator vehicle was a rapid process, as Nick told us: "In order to move quickly, we designed everything in a digital engineering environment, making it much easier to collaborate with Cellula Robotics. The first time we integrated the systems and the platform was just a few weeks before the first trial and customer demonstrations, so it really put our design to the test and I'm glad to say everything worked! It is a credit to our team and Cellula's that we were successful."

The autonomous 'brain' on Herne is called Nautomate® and is already proven on our Pacific 24 autonomous surface boat, which was the first uncrewed military vessel to achieve the Lloyd's Register Unmanned Marine Systems Certification. Nautomate is an advanced and highly configurable autonomy solution, which can be enhanced through plugins. Examples of plugins are remote weapons systems, surveillance sensors and vessel arrest systems.

The team is working hard to make further enhancements to Herne to ensure it is tuned to deliver a wide range of tasks for customers around the world.

Nick,
Design and Engineering Lead

"Herne is designed to operate entirely on its own, but also to raise the alarm to humans on the loop if it finds a threat."

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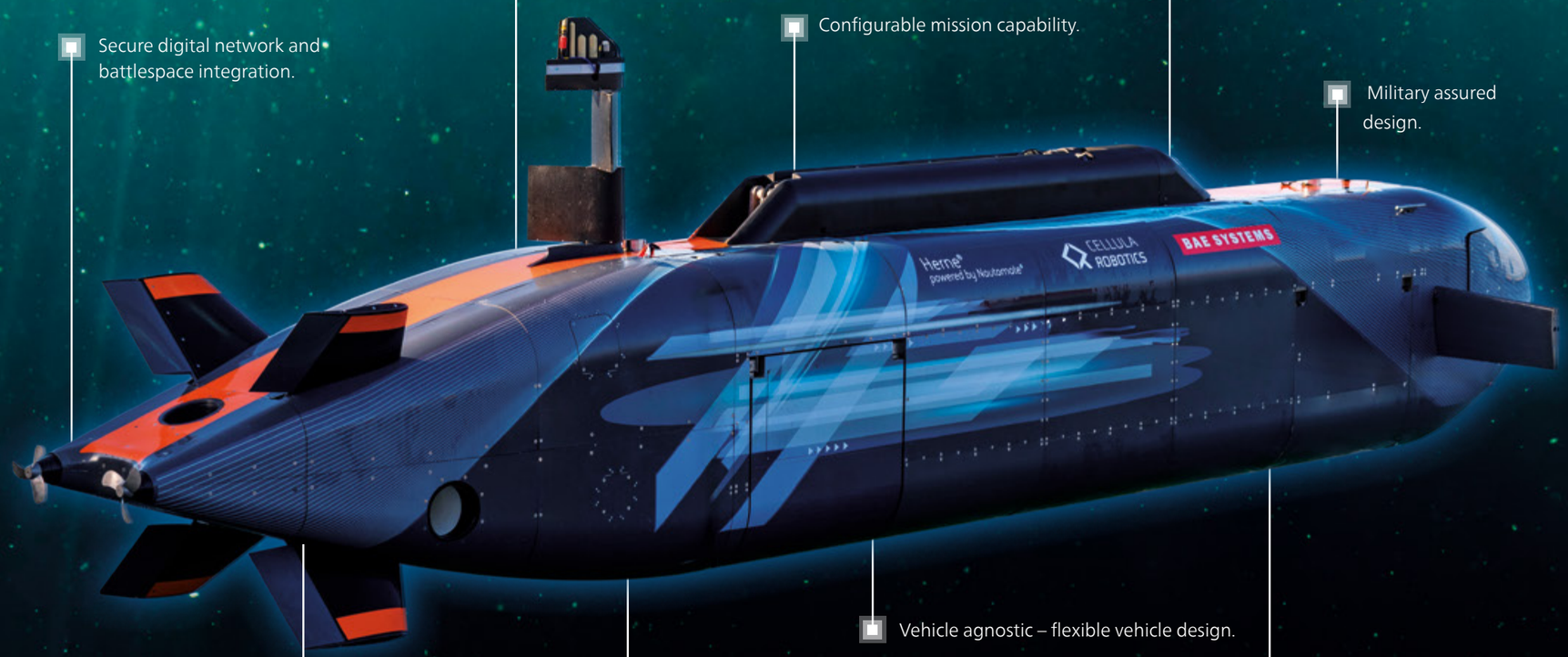
Herne® extra large autonomous underwater vehicle (XLAUV)

Herne is at the forefront of the underwater battlespace. With a flexible and innovative design approach, the Herne XLAUV provides a new military capability, enabling navies to cover more of the underwater battlespace than ever before.



Digitally secure and assured data and communications systems.

Trusted mission autonomy powered by Nautomate®.

Configurable mission capability.

Military assured design.

Secure digital network and battlespace integration.

Vehicle agnostic – flexible vehicle design.

Flexible payload integration – sensor to effector.

Covert signature management.

Host platform integration.

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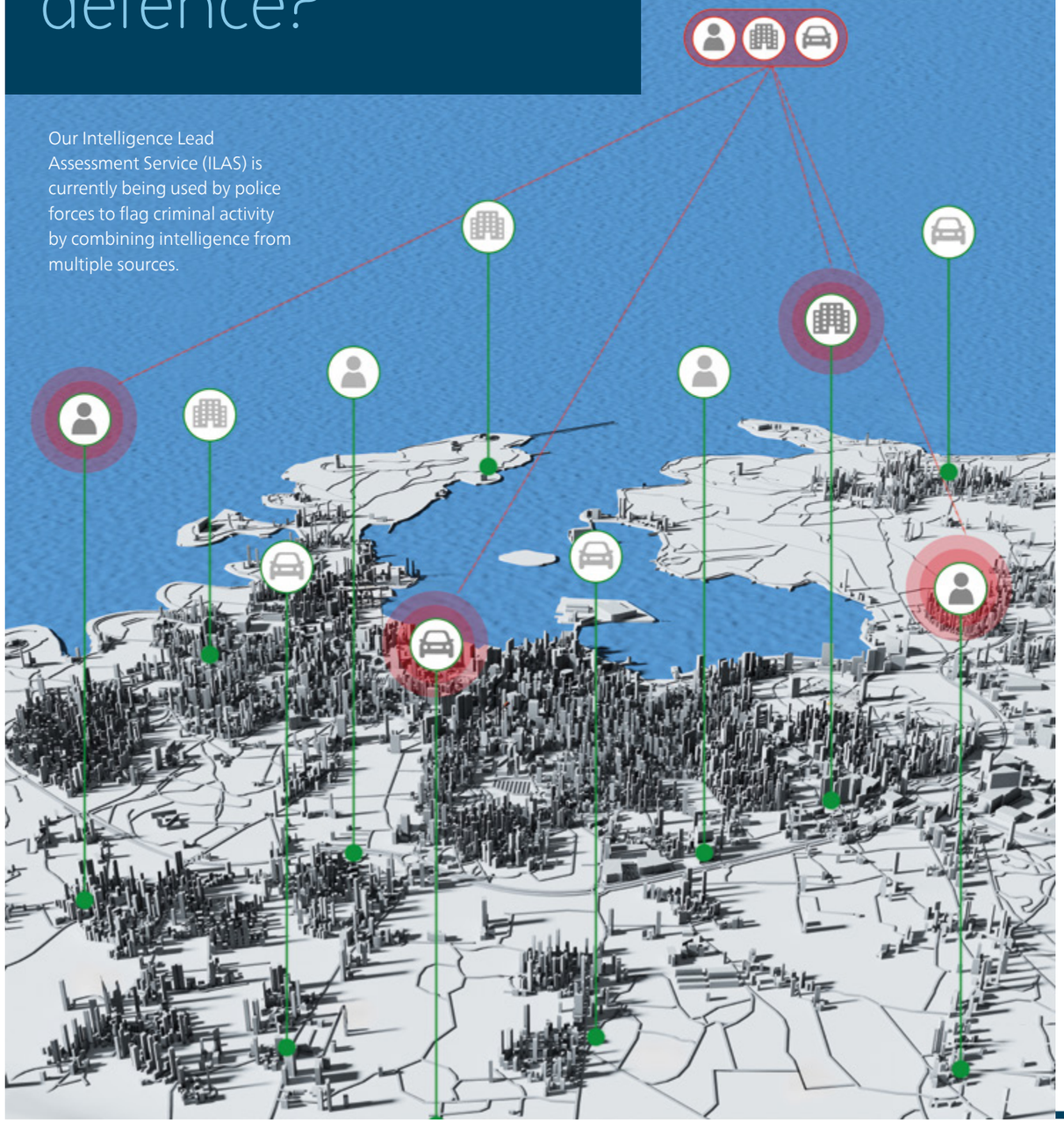
AI analysis for security and defence?

Our Intelligence Lead Assessment Service (ILAS) is currently being used by police forces to flag criminal activity by combining intelligence from multiple sources.

High risk pattern of smuggling: ILAS has linked vehicle number plate data with CCTV of target individuals and money transfers, resulting in a flag to law enforcement operatives.



At its heart, ILAS is a tool for taking multiple data types from multiple sources, then finding actionable intelligence.

Initially proven as a concept to help the police identify vulnerable children, our Intelligence Lead Assessment Service (ILAS) is now being adapted to help armed forces spot emerging threats.

Elsa,
Security Consultant

Elsa, who has led on developing the tradecraft elements of ILAS, explained further: "ILAS is a really powerful AI tool for finding connections based on human tradecraft principles – the 'tells' that an expert would use to spot a crime or enemy activity. I was previously doing academic research into domestic abuse suffered by women and girls, so I was able to apply this knowledge into ILAS so that it could flag this early. As a result, the tool has helped the police identify and tackle abuse that they otherwise wouldn't have found.

"That ability to translate human tradecraft into AI algorithms works for any discipline, so that's why ILAS is now also helping tackle knife crime and drug smuggling, as well as supporting the national counter-drones team and even firearms licensing. In addition, we've been speaking to the British Army and other customers about using it to help them." BAE Systems is also building a Battle Management Intelligence System (BMIS), designed to collate intelligence from multiple sources and then allow you to task assets accordingly. By incorporating ILAS, we plan to use its AI algorithms to help spot emerging threats from that collated intelligence. This could mean discovering ground-based air defence systems based on radio frequency (RF) chatter combined with optical and hyperspectral imaging from different sources, or spotting the forward deployment of field hospitals along with troop movements presaging a land attack.

Elsa summed up ILAS and the future of the tool: "At its heart, ILAS is a tool for taking multiple data types from multiple sources, then finding actionable intelligence. BAE Systems' expertise is in first understanding our customer tradecraft, then translating that into algorithms that ILAS can apply. It's been proven to be hugely useful to police forces, saving them thousands of hours of time and identifying risks that otherwise could have been missed. We want to bring a similar success story to our armed forces customers in helping them spot threats."

The ILAS software has been used by three police forces in the UK, with interest from others and national agencies. International customers, in Europe and the US, are also interested.

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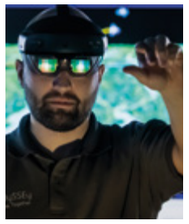
AI-based training for fighter pilots and apprentices

Nick,
Project Engineering Manager for Project CanDLE



The same personal AI-based trainer application, known as Project CanDLE, is helping everyone from fighter pilots to apprentices improve their skills, all with personal tailored feedback from a virtual assistant and automatically generated content to support their learning. In one of our own training courses, Project CanDLE has reduced training time from five weeks down to two, along with lifting the pass rate significantly.

Distributed: can be used in any environment, requiring a laptop and can be further enhanced with a virtual reality headset.

Classroom: in a formal setting as part of an existing course. Project CanDLE can also import your existing training courses and add aspects of gamification.

Deployed: can be used in deployed military locations for training, on everything from flight skills through to aircraft maintenance.

Nick, Project Engineering Manager for Project CanDLE, explained: "We've woven together several great packages from small and medium-sized enterprises (SMEs) to create an amazing integrated training environment. You can create new courses by just dragging and dropping existing course materials into it, then it does the rest. For pilots we're using this to test their take-off, circuits, taxiing and landing skills against an ideal performance, giving ratings and automatic plans for improvement. For our apprentices, we're using the same tool to help teach everything from aerodynamic engineering through to building physical aircraft components – all with a personal AI-enabled assistant who can answer questions on the way."

Project CanDLE can be applied to almost any learning requirement. We're currently using it for our overseas customers for both English-language learning and aircraft maintenance, with great results. For example, if a student is struggling in a specific area, the AI-powered system will focus on those areas to provide measured improvement. It also looks for broader trends, so if lots of students are asking questions about hydraulics, for example, it reviews and seeks to improve that aspect of the content.

Nick also set out how it makes training more fun: "People learn much more easily if they're enjoying themselves, so the way Project CanDLE gamifies training gives the students a clearer and more enjoyable goal to aim for. I think that's one of the reasons that students are achieving better pass rates in a shorter time."

So, what's next? The Project CanDLE team is looking for more opportunities to deploy the training package for our customers and our employees. Since we've built the package to follow the industry's Learning Tools Interoperability standard, it can integrate much more easily with other training packages. If a customer already has a learning management system (LMS) in place, then we can look to incorporate Project CanDLE and provide rapid improvements.

OBRIZUM

Obrizum – provides the underlying AI learning platform, which is able to ingest training materials and even technical manuals, then generate training courses as part of an interactive software package.

VRAI

VRAI – specialises in transforming data from virtual simulated training into actionable insights, including both the actions that an individual takes and psychophysical measurements such as heart rate indicating stimulation or stress response.

Aquila Learning

Aquila Learning – specialises in the provision of a training management system for complex workplace operations, whether that's in high-risk or high-compliance organisations. The company works with clients to establish clear learning goals and ensures these are met by the training offered and allows users to schedule training and manage their resources effectively.

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Enhancing Typhoon's multi-domain capabilities – dynamic intelligence sharing

We've now demonstrated that Typhoon can receive and transmit new intelligence securely to and from other military domains, during flight, while avoiding additional burden on the pilot. This could significantly enhance situational awareness during high-tempo missions.

James, the Lead Systems Architect for the project explained why this matters: "Fast-jet pilots are already managing multiple activities, so the new system only delivers information relevant to their current mission. For example, new intelligence regarding ground-based air defences will only be flagged to the pilot if it affects their current mission, based on its geographical location. Similarly, if there's new information about the location of friendly forces, it only appears on the pilot's display if those forces are close to the mission target."

Delivering the new system meant we had to tackle two major challenges: the available bandwidth in Link16 (the tactical network that transmits information securely to and from NATO forces); and creating an interface that presented only the relevant information to the pilot without affecting any other systems.

Link16 is very stable and secure, but has limited bandwidth. It also has to support multiple assets, so we can only use a small portion of it. To overcome this, we developed a technique of encoding complex information by simple text message, for which the bandwidth required is negligible.

We were also determined to do this work rapidly, so we found a way to isolate the new software from any of the critical systems of the aircraft. This meant we were able to write the code in just a few weeks and even use a non-specialist programmer – usually this kind of application would require a military coder. Using this approach also means we can rapidly update the system in future, making changes in a few hours.

The new system has been designed to integrate with the RAF's NEXUS data platform, which is a secure, Ministry of Defence-owned cloud system for facilitating real-time data sharing and distribution across various platforms including aircraft, ships, and land units. This means that while we've designed this system to run on Typhoon's interface, it would be equally usable by any other vehicle.

James,
Lead Systems Architect

"Fast-jet pilots are already managing multiple activities, so the new system only delivers information relevant to their current mission."

James expanded on the next steps: "We're looking at integrating our new multi-domain intelligence sharing system into smaller uncrewed air systems as well as other assets. This will help them share information to help form a common operational picture but will only use information that's applicable to their mission and with very low bandwidth requirements. This could grant a significant advantage in complex missions."

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Enhancing Typhoon's multi-domain capabilities

This new system dynamically delivers new information to a pilot, but only if that information is relevant to the current mission. This reduces the chance of cognitive overload while aiding vital situational awareness.

One example is that if new intelligence regarding enemy ground-based air defences were to be received, the system only flags this to pilots if it could affect their current mission.

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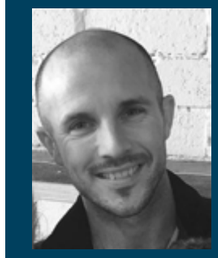
An instant, software defined NATO network?



Dave,
Network Product Manager

How BAE Systems' NetVIPR™ is extending NATO's Federate Mission Network (FMN) and accelerating multi-domain decision advantage.

Tested successfully at 2024's NATO Coalition Warrior Interoperability Exercise (CWIX), our NetVIPR™ networking product proved it can easily connect a host of different platforms from different alliance members.

While there are many networking products available for military customers, NetVIPR is unusual in being entirely software-defined - meaning it can run on any standard hardware. This unlocks customers from being tied to a single vendor, which also means they can re-use existing physical equipment rather than buying new.

Dave, who has been working on NetVIPR since it was a concept, explained why it's so useful: "On military operations today, you often need to spend hours setting up a network and manually adding individual nodes. Given all the different protocols and hardware used within a single service, let alone between NATO allies and services, this can really slow things down. The beauty of NetVIPR is that it largely automates this process with just a few button clicks required, while at the same time working on any hardware. If your allies are using a different set of boxes to you, that's not a problem."

Increasingly, military planners recognise that bandwidth and interoperability are crucial to success, with 'hyperscalers' such as Microsoft and Amazon getting involved in network provision. However, there's still a need for integrating individual pieces of equipment at the tactical level to first get that data on to a network. That's where NetVIPR comes in, as you can use it to connect any device with a standard processor and radio frequency (RF) connection. It also allows you to easily set up security levels for sharing permissions. BAE Systems has a close working relationship with the hyperscalers, so we're able to integrate NetVIPR with their vast cloud networks.

Dave set out the nature of the network challenge for a lot of our customers: "Most military customers are purchasing drones from lots of different providers, but a lot of them use different network and control methods. NetVIPR is a way to get all of these things talking to one another quickly and efficiently. We demonstrated this at the 2024 Army Warfighting Experiment, where we also integrated one of our small business suppliers' compression technology to share video requiring lower bandwidth. The users were really happy that it just worked – they got the video quickly from multiple drones and at a high enough quality to use in decision-making."

The other stand-out feature of NetVIPR is its ability to intelligently re-route data transmission to travel through nodes that offer the highest bandwidth, which might not be the shortest physical route. It constantly looks for the best path for data and is able to re-route dynamically if a node is disabled or degraded.

NetVIPR continues to be tested in customer trials and is set to be provided alongside the British Army's new tactical network, Trinity.

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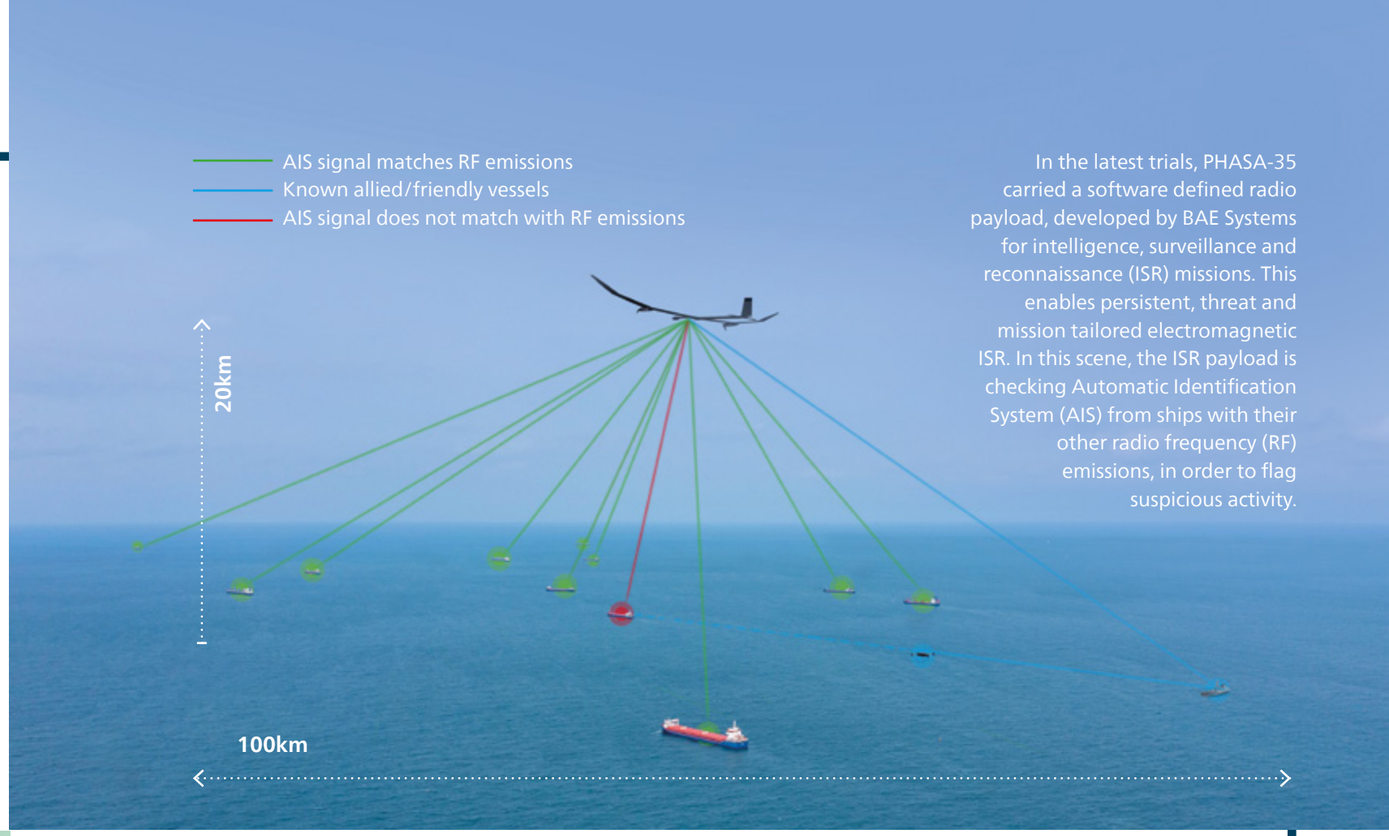
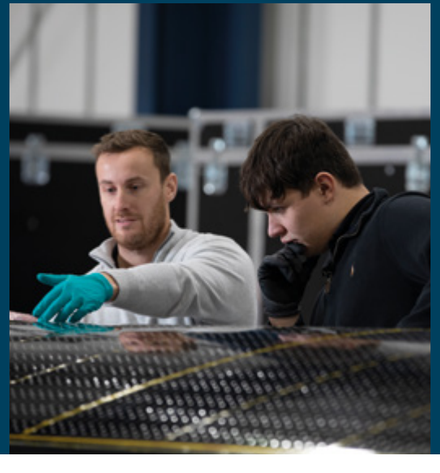
PHASA-35® flight trials step towards stratospheric operations

Our PHASA-35 team has taken a leap forward in the race to harness the stratosphere for earth observation and communications, completing a series of test flights – including two in quick succession – of BAE Systems' High Altitude Pseudo Satellite Uncrewed Aerial System, PHASA-35.



In the latest trials, PHASA-35 carried a software defined radio payload, developed by BAE Systems for intelligence, surveillance and reconnaissance (ISR) missions. This enables persistent, threat and mission tailored electromagnetic ISR. In this scene, the ISR payload is checking Automatic Identification System (AIS) from ships with their other radio frequency (RF) emissions, in order to flag suspicious activity.



During the flight at Spaceport America® in New Mexico, US, the solar powered aircraft flew for 24 hours climbing to more than 66,000 feet and cruising in the stratosphere, before successfully landing in a serviceable condition, meaning it was ready to fly again just two days later.

This was a major milestone in the development of PHASA-35, named after its 35-metre wingspan, demonstrating its ability to be launched, flown, landed, potentially reconfigured and then relaunched again so quickly.

Designed by BAE Systems' subsidiary Prismatic Ltd to operate above the weather and conventional air traffic, PHASA-35 has the potential to provide a persistent and stable platform for uses including ultra-long endurance intelligence, surveillance and reconnaissance.

Bob Davidson, Chief Executive Officer, BAE Systems' Prismatic, said: "As well as taking on some missions that satellites would be used for, PHASA-35 can actually complement an existing satellite network by collecting higher resolution surveillance data and then using satellite comms as a backhaul to get it more rapidly to customers.

"What's really special about PHASA-35 compared to many other High Altitude Long Endurance craft is that it can carry a heavy payload – currently around 10-15kg – at a single point on its body rather than distributed throughout the airframe. This is much more suitable for the majority of sensor payloads that customers use today."

The latest trials saw the aircraft carry a high-performance intelligence, surveillance and reconnaissance (ISR) sensor, which incorporated a software defined radio developed by BAE Systems. The payload, in combination with PHASA-35, enables persistent, threat and mission tailored, electromagnetic ISR that could be delivered under a service model.

At Prismatic's site in Hampshire, UK, the PHASA-35 team completed build of the next iteration of PHASA-35 at the end of 2024. The new aircraft has more than twice the onboard solar power generation and storage capacity of the current version. These modifications are expected to allow it to demonstrate stratospheric missions of increasing duration and complexity.

Dave Holmes, Managing Director of FalconWorks at BAE Systems, added: "These latest trials draw on a huge amount of collaboration between Prismatic, the wider BAE Systems business and industry partners, including Honeywell and the UK Met Office. They demonstrate the credibility and capability of the system for operational use."

The PHASA-35 team will now use data from these most recent trials to further improve and mature this novel technology.

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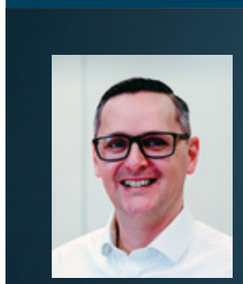
Supporting intelligence officers in the fight against child abuse



Andy,
Consulting Director

One of the most harrowing but vital roles in the intelligence community is finding the source of child abuse images, to help find and stop the gangs who make them. It means hours of looking at horrific images, then cataloguing and cross-referencing with other intelligence officers to track down the criminals and help the victims.

We've now been able to help these teams substantially improve the speed and efficiency of this task, meaning less time looking at images and more time stopping the crime. Andy joined BAE Systems after working in this area and was eager help his former colleagues: "On my second day at BAE Systems, I described the problem faced by intelligence officers trying to stop child sexual abuse images online and asked if I could develop a new set of tools to support them. I'm pleased to say that my new manager agreed immediately and we started working on it straight away, as project 'SeaCAT'.

"The three tools we've built make a huge difference to both the wellbeing of intelligence officers and their ability to find and stop the sharing of abuse images."

"We first worked with our customer to create a new digital platform where officers upload image data and can share this much more easily amongst the wider team, which removes hours of human interaction with the images. Second, automated software actively scans tens of thousands of websites every day for abuse images, flagging those that should be taken down – this often happens the same day, which is a huge improvement. Third, a new tool tracks how long officers are exposed to images, encouraging them to take appropriate breaks. Psychologists who are there to help officers cope with this task have worked with us to develop this welfare tool."

In the hands of our customer, the work that Andy and his team have done is having a positive impact around the world, being used to work across borders to identify offending websites and take them down.

This is transformational to ending abuse, as criminal gangs increasingly can't rely on posting images publicly to advertise their sites, making it much harder to generate revenue. Other countries are also talking about establishing their own SeaCAT teams.

The customer teams using the new tools estimate they have saved a full nine months of analyst time in just the first 18 months. Andy explained: "SeaCAT's mission is to significantly reduce the harm to children online by placing automation and data at the heart of the process. The result is a quicker, more accurate, more proactive and more thorough analysis of the child sex offence landscape, enabling more proactive actions from civil servants who now also have much less exposure to harrowing content."

The intelligence officers themselves have also publicly recognised the difference that SeaCAT has made: "We're thankful for everything the team did to enable this flow – it's been a game-changer for the mission team. Everyone's hard work will tangibly support our work to find, assess and seek the removal of online child sexual abuse, making the internet a safer place and stopping the repeat victimisation survivors experience every time images and videos of their abuse are shared or traded online."

SeaCAT won the Management Consultancies Association Project of the Year award in 2024, in recognition of the positive impact it continues to make. The tool is owned and operated by the Government.

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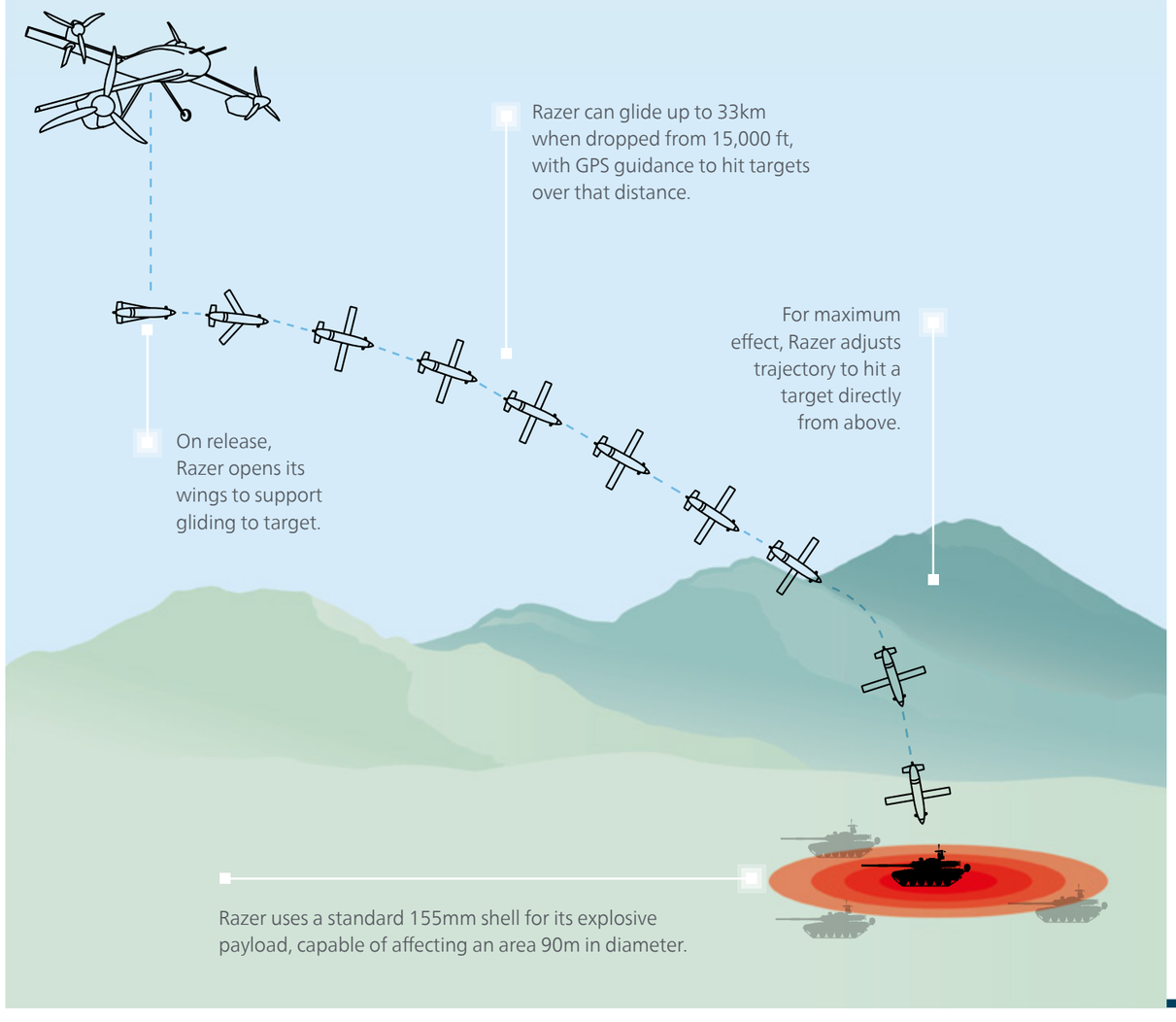
Cutting through the sky – the Razer™ glide munition

Leon,
Programme Manager

The Razer glide munition.



The latest iteration of the Razer low-cost precision guided munition has been put through its paces and successfully tested during a new round of flight trials.

With refined aerodynamics and onboard systems, the new Razer prototype achieved a series of successful trials during testing in Queensland. This major milestone highlights the cutting-edge engineering being achieved under the project's fast-tracked development.

Razer has a modular design and, with its wing/body kit and tail unit, will transform a 40-50kg 155mm unguided artillery munition into a precision air-launched projectile.

The trials involved an inert Razer flight vehicle detaching from a helicopter and gliding to a ground target. This allowed the team to collect crucial data on aerodynamics, avionics, navigation and other systems that will help moving forward into the next phase of the project.

Leon, the Programme Manager for the project, said his team is taking an approach on the Razer programme never before attempted by a team in BAE Systems Australia: "Razer has progressed at a breakneck speed and these flight trials were the accumulation of many months of hard work. We're all incredibly proud of the team and the accomplishment."

Under development since its announcement at the Avalon Airshow in March 2023, the Razer programme is breaking new ground. Its first flight trials occurred a short nine months later and provided critical insights for the team. This led to a more robust and advanced design in the new prototype for the recent round of flight trials.

Leon added: "Razer is innovative because it's a multi-purpose system that will cater for a variety of light munitions in different sizes and masses.

"Defence forces will be able to take an available unguided munition and configure it with Razer to make it go much further, hit a target more accurately and better protect service people by allowing them to stay further out of harm's way."

"Razer is innovative because it's a multi-purpose system that will cater for a variety of light munitions in different sizes and masses."

BAE Systems has a long history with guided weapons in Australia and the project is helping to establish the next generation of experts in missiles and munitions.

Leon is incredibly proud of the team's achievement in such a short space of time: "They approach each challenge with an outside-the-box solution and have become a really tightknit group who were forged under pressure."

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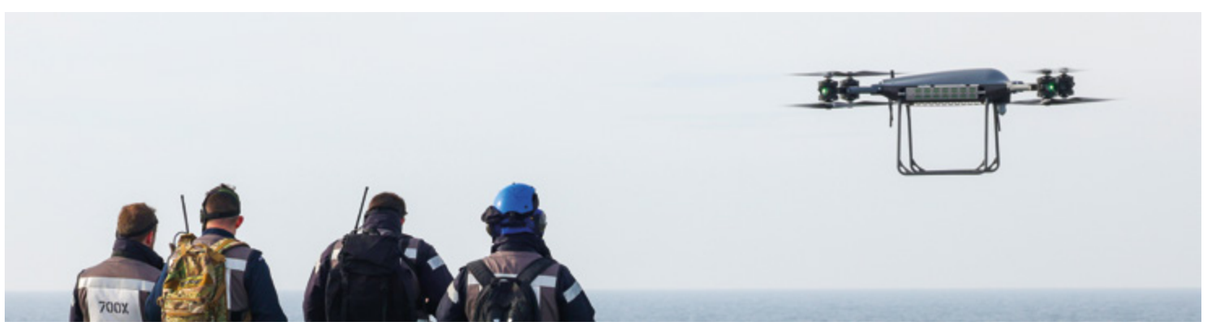
Industry and defence working closer together

Longreach 70 is one example of rapid innovation made between BAE Systems and an SME.



Defence innovation: a perspective from James Gavin, Deputy Director UK Defence Innovation.

I've seen how working closely with industry really helps us innovate faster, something we learned a lot from our experiences in Ukraine.

By allowing engineers to talk directly with users, we can remove the need for extra procurement processes and make quicker progress. This is important for developing both software and hardware improvements, which are key to making our forces more effective. It keeps things efficient and focused on what's needed, with procurement teams only getting involved where strictly necessary.

These lessons from Ukraine are now influencing our broader efforts, as we bring that spiral procurement approach into more of our programmes. We've committed to significantly increase the lethality of our forces in the recent Strategic Defence Review, so to do this, we need to focus on the outcomes rather than getting bogged down in exhaustive lists of requirements. For example, we need to specify what we want – like delivering a 300kg payload in a contested area – and let industry figure out how to do it.

Do I have any tips for industry? Yes, look at long-term demand signals and invest in those areas now. Mass effect, lower cost weapons are vital but also make it easier for us to use them. It'd be great to have a common control station for drones, for example. No soldier wants to carry three different controllers in their backpack.

Our forces need to fight further and fight longer, so I'd like to see more investment in reducing the need for maintenance, so that equipment keeps working for longer with less downtime and saves us money. We want industry to come to the MOD with ideas for saving money – we'll listen.

Also, we need new equipment to be able to keep up with the crewed platforms, in terms of speed and endurance – we can't start building extra bases for uncrewed assets to stop and refuel more often. I think we can work more closely in all of these areas with industry, which will be good for all of us.

James Gavin,
Deputy Director UK
Defence Innovation
Head of Technology
UK MoD National
Armaments Directorate

"I've seen how working closely with industry really helps us to innovate faster."

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Precision munitions launched at air and ground targets from airborne drone

For the first time, we have launched a precision munition from a multi-rotor uncrewed air system (UAS) and successfully destroyed both air and ground targets during trials in the US.

This marks a major step forward in the development of a low-cost strike and counter UAS option for frontline troops.

The launch of munitions upgraded with BAE Systems' APKWS® laser-guidance kit from a TRV-150, a modified version of the BAE Systems' Malloy T-150, marks the first air-to-air engagement of an APKWS guidance kit from a UAS, building on its decades-long presence on combat aircraft including the F-16, F-18 and Apache helicopter.

The successful trials demonstrate the multi-role capability of the platform and are a significant boost to showcasing how advancements in drone technologies can be harnessed to offer militaries highly effective and affordable tactical options to tackle both emerging UAS threats and more traditional targets.

Anthony, Business Development Director, BAE Systems' FalconWorks, said: "Uncrewed systems are an increasingly important part of our customers' arsenals and I'm delighted that we've been able to show how UAS technology can further help them maintain an edge on the ever-evolving modern battlefield.

"These trials have significantly advanced our ability to deliver this new tactical option at a fraction of the cost of conventional means, showcasing that we continue to address the challenges of tomorrow through innovation and collaboration."

The tests took place at US Army Dugway Proving Ground in Utah using a modified version of BAE Systems' Malloy T-150 adapted to meet the US Marine Corps logistics requirements known as the SURVICE TRV-150.

BAE Systems' engineers in the UK provided expert weapons integration knowledge and experience to integrate the APKWS guidance kit. It transforms unguided rockets into precision-guided munitions and provides a low-cost, highly effective solution that has multi-role capabilities. With its integration onto the TRV-150 the tests exceeded expectations in all aspects, including platform performance and target engagements, with zero misses.

The successful integration on display during the trials highlights the possibility of providing operators with a unique solution for engaging targets at greater range than ground-launched solutions, using a system that can easily be deployed to the front line.

The trial was a result of efficient collaboration between BAE Systems FalconWorks®, BAE Systems, Inc., SURVICE Engineering, bringing together knowledge and expertise from across our UK and US teams. The trials were also supported by Invariant Corporation, Arnold Defense, General Dynamics UK and L3Harris.

The team behind this cross-Atlantic partnership will now build on these successful trials to further refine the new system so that it is ready for use on the battlefield. This includes integrating more autonomous technology.

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The team who worked on the launch and recovery system.

Integrated autonomy on the high seas

The autonomous launch and recovery system in action.

Deploying any kind of dinghy or RIB from a ship during bad weather can be difficult. Usually, people on board the RIB release docking attachments and then re-attach when they return, but what if you're deploying an autonomous boat?

Laurence, our Autonomous Systems Lead explained our solution: "Anyone who has tried to climb into a dinghy from a moving boat in rough seas will know it's not easy. Imagine being lowered on to an uncrewed boat while it's trying to maintain its position relative to your ship, then trying to attach a carabiner to haul it up. Surely there's a better way? We believe that an autonomous boat should be autonomously deployed, so we've designed, built and successfully tested a launch and recovery system that can work with no human involvement."

While the system was tested on the P-24 autonomous boat, it's been designed to also work for a host of other autonomous vehicles, including submersibles. It's intended to work with third-party boats as well, leaving customers open to buying autonomous crafts from different companies and still being able to use the same system.

It's not just for convenience and reducing manual human input, as Laurence explained: "We think there'll be situations where autonomous vehicles need to be deployed fast, so we expect the launch and recovery cradle to be stored with a vehicle in it at all times, meaning it should be able to be deployed fast, in minutes."

The system is designed to integrate with the Royal Navy's new ships, which are built to be modular – i.e. it's easier to design something that will integrate with them. The Type 26 mission bay is one such example, which means we can design the launch and recovery system around a clear standard and be confident it will fit any mission bay in the fleet, as well as integrate with the other fittings on board.

Integration is important in every aspect of the design: "It's not just the physical part of the launch and recovery system we're making easy to integrate, but how you control it from the ship's command system. The autonomous vehicles themselves, whether surface ships or submersibles, will also share a common control system accessible from the ship's combat management system. We want to make it as easy and intuitive to use these vessels as we can."

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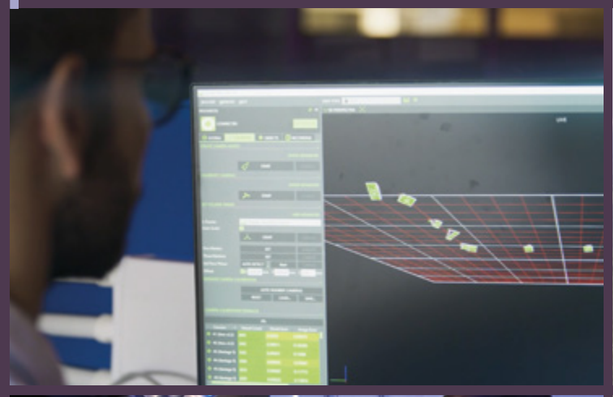
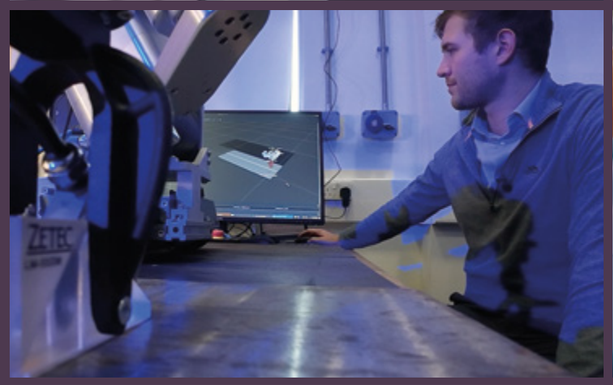
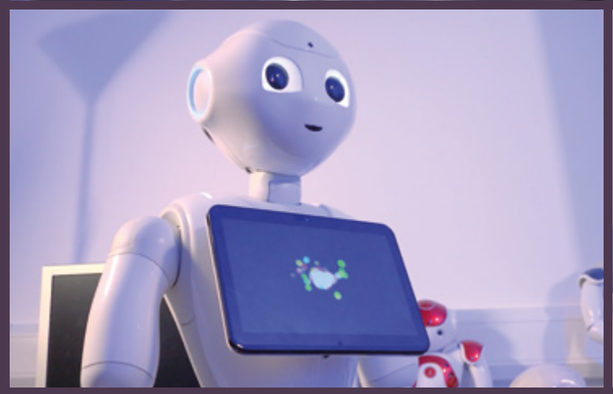
Pioneering future innovation







These stories are dedicated to projects that look beyond today's needs, paving the way for technologies that could redefine aspects of defence.

Many of these projects could also deliver results sooner than expected, like our work to help soldiers use everyday language to command autonomous vehicles. Instead of needing to be remotely piloted requiring complex software to plan waypoints and tasks, we've actually demonstrated how uncrewed vehicles can perform simple missions simply by being asked.

There are also future underwater digital networking advances, all built to NATO standards to allow interoperability across allies. We've shown how a combination of optical and acoustic data transmission can increase range and bandwidth of comms underwater, helping our customers quickly share intelligence and plan missions.

We also work closely with universities, where recent research into stealth ceramics promises unprecedented radar invisibility, offering new defensive strategies against sophisticated threats.

With our pioneering spirit, we are not just anticipating future needs; we are crafting the technologies that will define them. From autonomous vehicles navigating the unknown to adaptable networks resisting advanced electronic warfare, our projects capture the essence of innovative thought. We're creating systems that are smarter, faster, and more efficient, ensuring our defence capabilities are unmatched.

Ruth Nichols,
Head of Innovation

"With our pioneering spirit, we are not just anticipating future needs; we are crafting the technologies that will define them."

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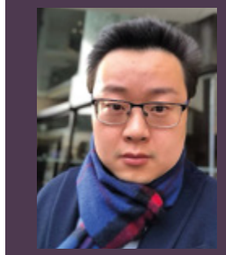
6G antennas as flexible, programmable AI command and control posts?



Professor Guo,
Head of Centre for Assured & Connected Autonomy and the Head of Human Machine Intelligence Group at Cranfield

Professor Guo is the Head of Centre for Assured & Connected Autonomy and the Head of Human Machine Intelligence Group at Cranfield. Here he describes a possible future use for 6G phone masts, which could put them at the centre of temporary military and crisis response operations around the globe.

The potential of 6G technology to transform military operations is truly fascinating. Imagine using phone masts, traditionally used for communication, as mobile centres for defence operations. These towers are no longer just about calls, texts and mobile data; they're also powerful computing hubs capable of handling complex tasks and coordinating military assets.

In the late '90s, telecom infrastructure was all about voice and text. Fast forward to today and 6G masts come with some seriously powerful computer processors and array antennas, given the massive amounts of data they need to coordinate between tens of thousands of devices simultaneously in "Internet of Battle Things". That gives them many of the requirements for an effective military command and control centre, particularly as they have such precise timing mechanisms, allowing them to judge the distance of all the assets they're in contact with – even triangulating direction if used with other masts.

To turn a 6G mast into a command centre, it could be as simple as uploading a purpose-built Large Language Model (LLM) designed to understand military requirements, mission planning and communications protocols. The mast itself already has the ability to communicate and the processing power required. Also, given that future mobile phone masts are potentially designed to be 'open' – they'd be potentially available to have a slice of their resources reprogrammed over-the-air. After a mission is complete, the LLM could even be deleted from the tower, leaving very little evidence it was ever there.

6G masts also boast super-fast communication and low latency, making them perfect as a source of edge intelligence for coordinating command and control applications and secure operations. Their processing power could even be used to analyse intelligence – perhaps the video and sensor feeds of hundreds of your devices – to make sense of a battlespace and calculate potential courses of action. Our early work in the civil sector is showcased here.

Of course, it's not all positive. This potential use is just as open to adversaries as it is to our allies, so it's vital we start looking at ways to protect our own masts, to keep our national interests safe while driving innovation.

While we need to tackle challenges like ethical use and data sovereignty, the benefits of improved coordination and operational agility make this a critical area for development. As 6G rolls out, how we use it into defence systems will be key to making the most of its potential while keeping ourselves safe.

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World's largest all-electric quadcopter flight

Carly,
Project Manager for STRIX

STRIX™ has made history as the largest all-electric quadcopter to take to the air.

STRIX has been uniquely designed to perform a range of autonomous missions without needing a runway, including attack helicopter 'loyal wingman' roles, air-to-ground strike, electronic warfare and intelligence, surveillance and reconnaissance. STRIX helps remove human crews from dull, dirty or dangerous conditions and frees up skilled personnel to focus on where they are needed most.

Given STRIX's unique design, with an 'X-Wing' layout and a 'tilt-body' configuration that pivots to take off vertically, it presents an entirely new aerodynamic challenge, but one that our core team of 20 was ready to tackle.

Carly, the project manager for STRIX set out our approach: "We worked with an amazing small business, Innovaero, who led on designing and building the physical structure. We at BAE Systems focused on the autonomous brain, electronics and flight dynamics. We had to develop a new form of an AI control system to handle all the complex airflows through propellers and across wings that we expected, which had to control eighteen different control actuators in a novel control scheme utilising engine speed, rapidly moving variable pitch propellers and aerodynamic control surfaces. This was the only way to handle the changes in airflow required for stable vertical and horizontal flight."

The extra effort needed to build something this novel is justified by the unique advantage it gives: being able to take off vertically while benefiting from fixed-wing lift in cruise, giving it endurance comparable to conventional aircraft, rather than the shorter flight times of conventional quadcopters or helicopters. This means that naval ships with less deck space can field an aircraft with a range predicted to be hundreds of miles.

The latest testing went entirely to plan and enabled the team to make further improvements to the AI flight model, as Carly explained: "The work to train the AI model really paid off, as the flight testing gave us lots of valuable data. We were able to track exactly how the flight system reacted to the physical movement of STRIX and make further improvements, so now that we've proven it can take off, hover and land, we're really looking forward to actually flying STRIX in fixed-wing mode between multiple waypoints."

"The work to train the AI model really paid off, as the flight testing gave us lots of valuable data."

Since its unveiling at the Avalon Airshow in 2023, STRIX has moved from concept to autonomous VTOL flight within two years, demonstrating BAE Systems Australia's ability to quickly conduct disruptive sovereign research and development at the speed of relevance.

STRIX draws on proven technologies, including those from BAE Systems' previous autonomous systems such as Herti and Taranis, as well as our current work with the Australian Army's M113 OCCV Programme and the MQ-28 Ghost Bat for the Royal Australian Air Force.

The focus will now move from airframe testing to the hybrid-electric propulsion system, which has been under development in parallel with the prototype.

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Developing a natural language interface for autonomous vehicles

While most UAS currently require human remote pilots, voice commands could soon help bring greater autonomy.

"The two tasks we've tested so far mirror common military needs: establishing a comms network and simple reconnaissance."

Every defence company, large and small, is talking about bringing AI and autonomy to the front line. But how do non-expert personnel actually command and control autonomous vehicles?

Right now there's no common solution, so that's why we are testing the use of Large Language Models (LLMs) such as ChatGPT to translate goals and commands given in ordinary English, just like talking to a human soldier, into actions that an autonomous vehicle can carry out.

So far, we've tested this on robots in laboratory conditions, verbally asking them to perform a variety of high-level tasks. There are lots of effective LLMs already available, so the focus of our work was on setting up an LLM for use with a robot and then experimenting. We trialled both simple wheeled robots with optical sensors, as well as flying drones with similar sensors and a 'mesh' radio networking system. We had to instruct the LLM on what capability and actions were available to it – moving the wheels, analysing images and accessing LiDAR (a kind of light-based RADAR) data for the ground robots, then flight functions and other sensor data for flying drones.

If you ask the robot to do something it wasn't equipped for – make a cup of tea, for example – then it would use the LLM to 'mentally' build a picture of that activity, check against its available capability, then tell you that was impossible (in this case as it had no way to pour a kettle). In a military scenario, the LLM would similarly know whether it could fly or drive, its available range, onboard sensors and other key capabilities.

Bashar, leading the project, explained what we've done so far: "The two tasks we've tested so far mirror common military needs: establishing a comms network and simple reconnaissance. We told our flying drones equipped with radios to fly in a pattern that gave maximum comms coverage to maintain a strong network, then at the same time find objects of interests to be relayed back to a human commander. Without having to explain in detail and use specialist language, the LLM worked out how to do this based on our simple order, then directed the drones to work as a group to spread out as far as they could while maintaining a strong comms signal. At the same time, the separate onboard 'guardrail' systems controlling obstacle avoidance and flight control made sure they didn't crash – the LLM only provided requests to those flight management systems and does not control them directly."

As Bashar set out, by separating the LLM from the onboard safety systems such as obstacle avoidance, we remove one of the greatest risks of an AI system – giving a trained AI model direct control over the sub-systems driving your vehicle. AI models make mistakes, as all they're doing is calculating probabilities and choosing the highest scoring course of action. Safety systems on the other hand are hard-wired to prevent dangerous actions - the same way your car might activate an emergency brake to stop you reversing into a wall. By keeping these systems separate we maintain safety.

Bashar gave further context: "There are some self-driving cars on the road today where the AI model is in direct control with no hard-wired, independent safety systems there to override its decisions. We've taken a very different approach of keeping the existing flight control and vehicle management systems in charge of flying, with the AI model only providing mission related requests for evaluation and implementation. If the AI tells the drone to fly to a certain location but there's an unexpected wall in the way, it'll still stop and ask the AI to calculate a new route to avoid that obstacle. It's a bit like your satnav telling you to turn right at the next junction, as you only follow that suggestion when the route is clear and it's safe to do so."

Another advantage of using LLMs to control assets is that it could act as a true force multiplier – a single human would be able to more easily direct multiple uncrewed vehicles to perform complex tasks.

The next step is to try this technique in our larger uncrewed platforms in development, such as the ATLAS uncrewed ground vehicle, Malloy's heavy lift UAVs and the P-24 autonomous boat.

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Drones you can verbally command

We are testing the use of Large Language Models to translate goals and commands given in ordinary English, into actions that an autonomous vehicle can carry out. Our vision is to brief uncrewed systems by voice alone.

Human: Perform a search of the area and flag any concerns

LLM: You've asked me to search the area. I will perform a 1km radius perimeter search and update your tactical map as I go. Is that correct?

Human: Yes

...

LLM: I've spotted an armed vehicle. Do you want me to take a closer look?

Human: Yes

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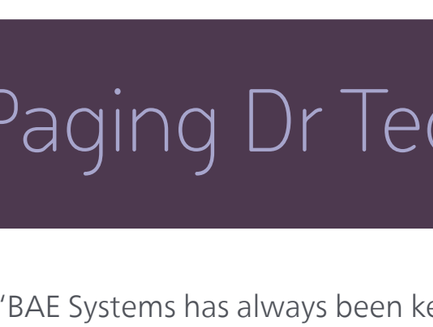
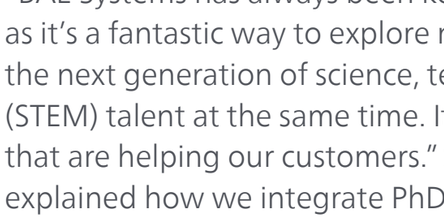
Paging Dr Tech

"BAE Systems has always been keen to support technology PhDs, as it's a fantastic way to explore new technology and help grow the next generation of science, technology, engineering and mathematics (STEM) talent at the same time. It's also led to some exciting applications that are helping our customers." Steve, our university partnering lead, explained how we integrate PhDs into our technology strategy in the UK.

As well as working with the EPSRC to support the PhDs financially, we hold an annual conference for PhD students to present their research to one another and to our wider organisation, which covers Digital Intelligence, land, sea, air and space domains. There's a prize for the best PhD presentation, as each university puts forward a student to take part in the competition. It's all about driving a vibrant community of students to engage with our company and defence and find new ways to apply their research.





Rebecca, the most recent winner, is developing specialist ceramics coatings that could change the radar signature of vehicles travelling at high speed, with potential stealth applications. Talking about working with BAE Systems, Rebecca said:

"I was really excited to work with BAE Systems on this PhD. As well as helping fund me, they also had some fantastic in-house specialists who could talk to me about applications in the real world. In the future, I'd love to continue researching materials that are applicable for space and defence applications."

Other finalists in the competition included:

Beth – multi-material 3D printing to make vibration control structures

Beth's PhD was about creating 'meta-materials' that can control vibration but add very little mass, as traditional damping materials tend to be heavy materials designed to absorb vibrations. This approach is particularly welcome in aircraft, where any weight reduction leads to improvements in efficiency and reductions in fuel use. This could also lead to quieter flights for passengers and crew, as well as quieter ships.

Fergus – energy harvesting

Fergus is looking to replace the pyrotechnics used in tracer ammunition with an LED, powered using a tiny generator that creates electricity from movement of the round when it's fired. The pyrotechnics currently used can degrade over time in storage, while generating energy to run an LED also gives you more flexibility in choosing when to activate the light, making it harder to detect a firing location.

Francesco – cobotic assembly

With more robotics in our manufacturing facilities, we need to find better ways for them to work together with people. Francesco's PhD focused on training robots to put themselves in the best and safest position to work alongside people, particularly where the robot was moving parts for a human to work on. He trained a deep neural network with input from a 3D camera in order to control the robot.

Adam – robotic inspection of marine materials

Adam's PhD looked at using robotically-controlled ultrasonic waves to inspect welds on maritime assets. Conventionally, x-ray imaging has been used, which means you need to move people away from the area for safety reasons to avoid exposure to radiation. Not only does using ultrasonic approach mean people can continue working while it's being used, but results are delivered in near-real-time while the robotic delivery helps ensure consistency.

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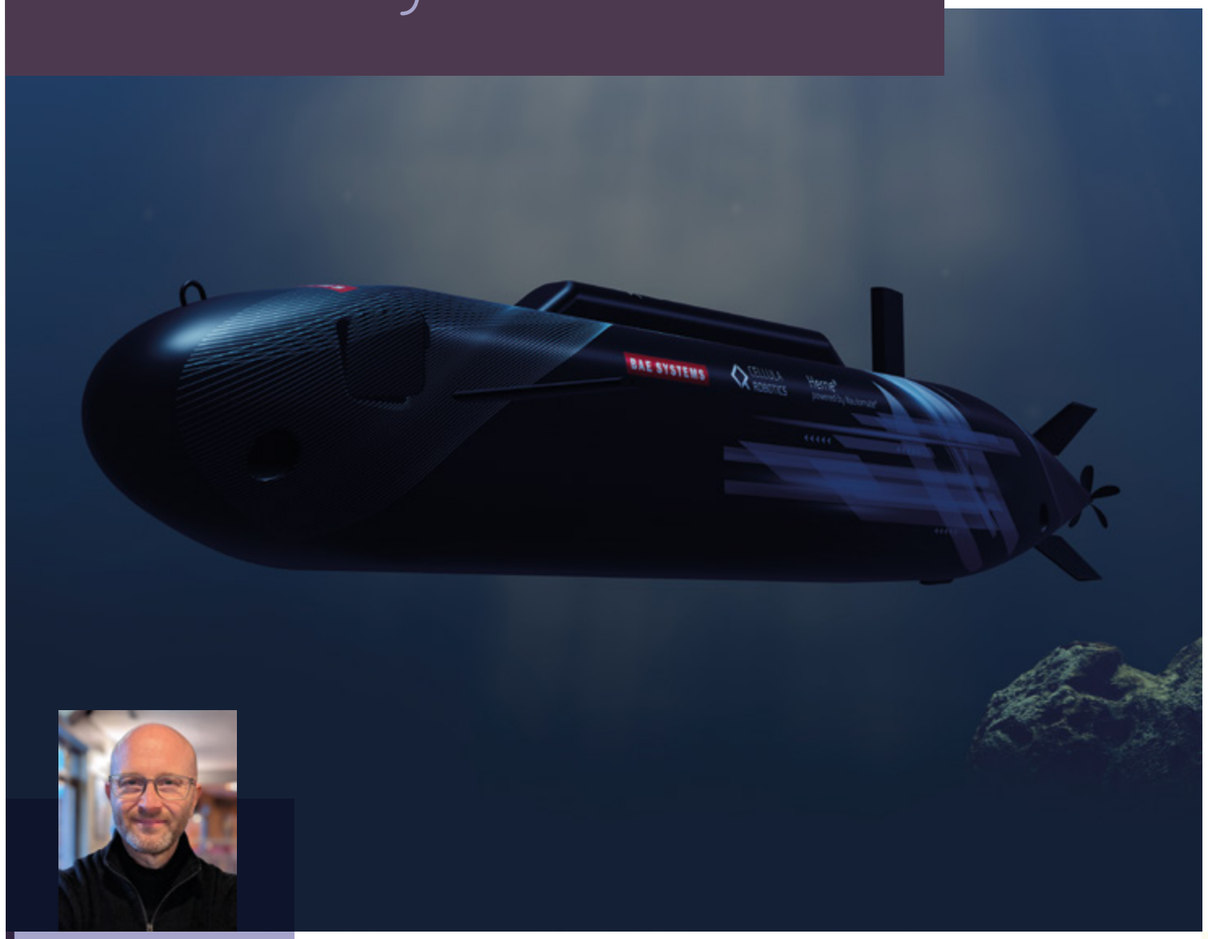
Underwater, no-one can hear your comms



Jason,
Lead for Underwater Communications

Or can they? We've trialled a new network designed for long-distance underwater communications.

Underwater communications have always been difficult. Radio frequency (RF) communication underwater is inefficient, water quickly absorbs optical signals and acoustics that are conventionally used for transferring data underwater are low bandwidth and give away your position.

We've now successfully tested a long-range underwater network that can use both acoustic and optical signals, meaning it can work with existing equipment and choose the best signal depending on range and bandwidth required.

The ability to switch between optical and acoustic signals is vital, as Jason, our Lead for Underwater Communications explained: "Imagine you have a fleet of uncrewed submarines, all moving at different speeds and directions to patrol a given area. They'll constantly be changing distance and direction in relation to one another, so optical will work when the sensors are facing each other and relatively close, whereas acoustic is lower bandwidth but works at any angle over longer range.

By making a mesh network that can switch seamlessly between the two, we maintain comms and maximise bandwidth at the same time, while building resilience."

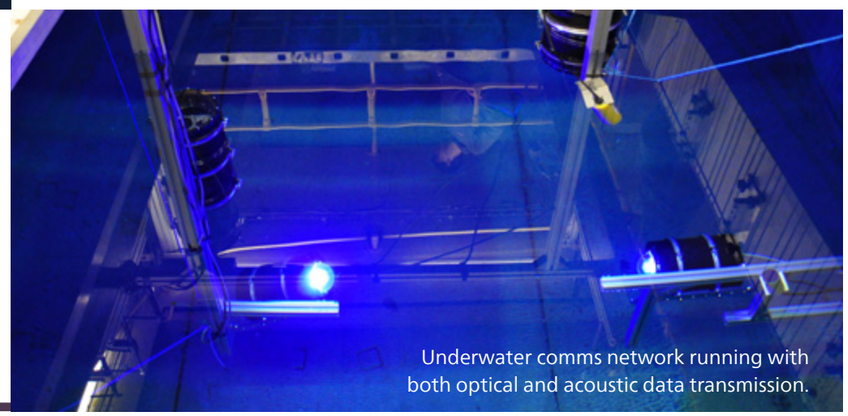
Imagine a mission where a fleet of autonomous subs is patrolling for enemies. If only one of your subs is close enough to detect the enemy, using our network it can inform other assets and the command team, establish the enemy position and call for a larger crewed vessel to intercept – all while keeping the suspected enemy under surveillance. You might also have a group of autonomous subs looking for sea mines, using sonar to scan the seabed. This generates a lot of data to transmit back to a mothership for analysis, so the ability to switch to higher-bandwidth optical comms will make the data transfer much quicker.

And the network doesn't only connect underwater assets. In our successful demonstration, we used a buoy floating on the surface to receive communications from underwater and then transmit RF signals to an air asset. This sent the signal on to a ground-based asset, showing that in the real-world you could quickly get data across all domains, including command HQ or government decision makers if required.

Jason was also keen to point out that this network would be interoperable: "In developing the network, we have ensured it can use the NATO network standard, JANUS, which specifies a protocol for underwater acoustic transmission between member forces. We are committed to working with our partners and helping our customers support their allies."

"In developing the network, we have ensured it can use the NATO network standard. We are committed to working with our partners and helping our customers support their allies."

The team behind the work.



Underwater comms network running with both optical and acoustic data transmission.

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Underwater communications network

We've now successfully tested a long-range underwater network that can use both acoustic and optical signals, meaning it can work with existing equipment and choose the best signal depending on range and bandwidth required.

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Concept for a space weather plasma observatory

Sophie,
Engineering Manager

Space weather can cause significant disruption to radio systems such as satellite communications and satellite navigation systems such as GPS, increasing risk to air traffic and potentially impacting economic activity, given society's increasing reliance on space services.

All space weather is driven by the Sun. However, whether technological systems are affected is dependent on the interaction between the solar wind, the magnetosphere and the ionosphere. This is poorly understood and currently difficult to predict, which is the reason for the European Space Agency's (ESA) 'M7' Plasma Observatory project.

BAE Systems has been selected for one of the early stages of this project, developing spacecraft designs for a mission to study the energetic plasmas that envelop the Earth. Space plasma occurs frequently in the Universe and this mission focuses on two key questions: how are particles energised in space plasmas, and what processes dominate energy transport and drive interactions between the different regions of Earth's magnetospheric system?

Plasma Observatory is a candidate for the M7 mission which will ultimately form part of ESA's fleet of science missions, which cover a wide range of ambitious space science themes. If selected from a shortlist of three missions, this study will lead to the realisation and launch of a seven-spacecraft mission that will transform our understanding of both fundamental plasma physics processes and the near-Earth plasma environment, and thereby provide insight into the science behind space weather.

During this early study phase, two different aerospace companies are undertaking parallel studies to ensure that a range of designs are considered. The initial stage of the project, which involves conducting a detailed analysis to produce a more comprehensive design for the mission, started in 2024 and will run until mid-2026, with the potential to continue if Plasma Observatory is chosen to be the next Medium-class mission.

If selected, the study will lead to the build and launch of the seven-spacecraft constellation, made up of one 'mother' spacecraft and six 'daughter' spacecraft. These will operate in a highly elliptical orbit (HEO), to explore the plasma environment around Earth.

This mission complements other ESA missions looking at the Sun-Earth interactions – answering important scientific questions and helping to keep life and technology safe from the effects of space weather. Indeed, it could lead to transformative advances in the field of space plasma physics, with implications on research fields that span from terrestrial space weather to our understanding of astrophysical plasmas in the rest of the galaxy and beyond.

This mission demonstrates our dual-use credentials and is just one example of where we are addressing civil space opportunities to support organisations such as ESA and the UK Space Agency. Through our highly skilled team, we are continuing to develop a full space capability as part of our objective to become a leading UK space prime.

BAE Systems has a long association with ESA. The missions we have worked on cover a huge range of science topics, helping to answer some important questions. Many of these missions operate in deep space and are supported with tracking, telemetry and command capabilities built by BAE Systems to receive data on Earth. Examples include Euclid, which is a space telescope exploring the composition and evolution of the dark universe, and the Jupiter Icy Moons Explorer (JUICE) which is on its eight-year journey from Earth to Callisto, Europa and Ganymede.

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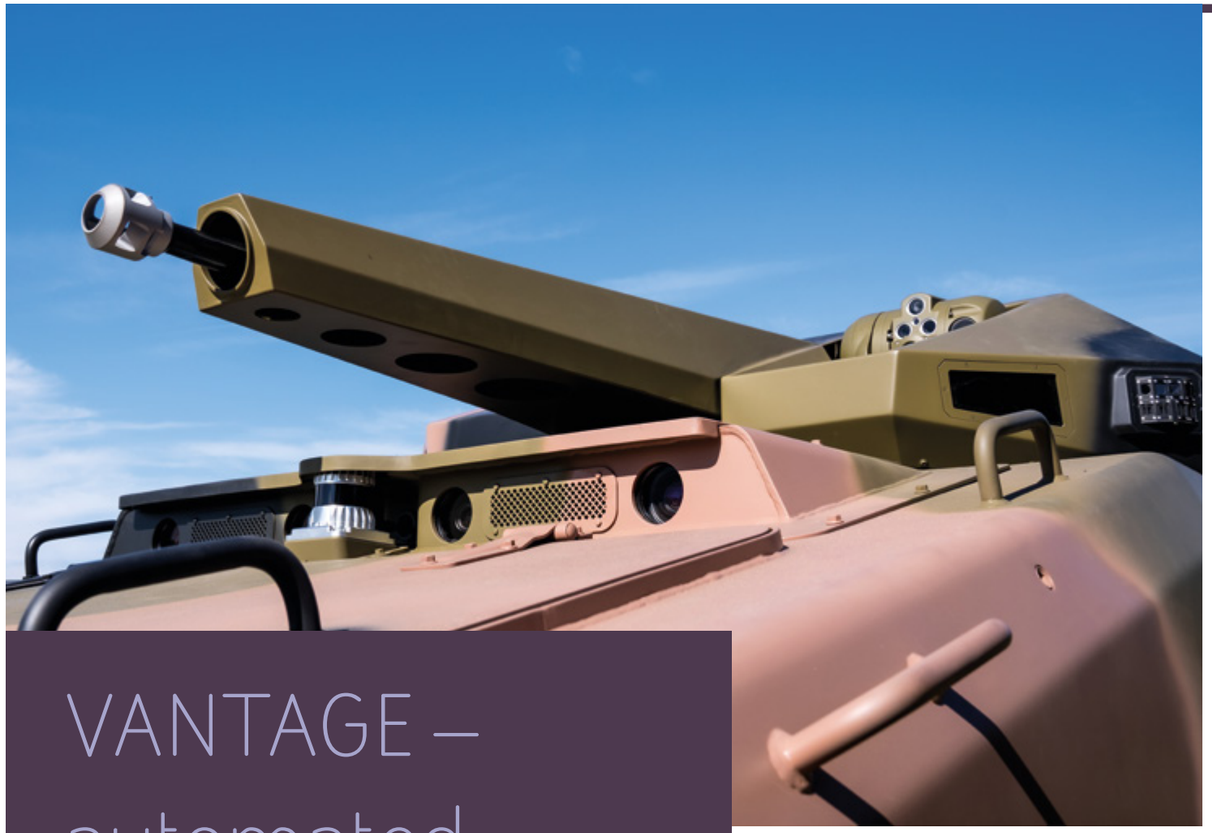
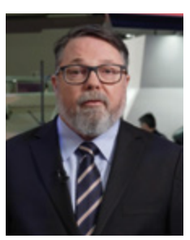


VANTAGE – automated turret takes people off the battlefield

How many uncrewed vehicles are actually autonomous as opposed to remotely operated? Our VANTAGE Automated Turret System (ATS) is designed to do everything apart from making the final decision on when to fire. It finds, identifies, tracks and prepares to fire, then requires human input to order engagement.



Paul,
Programme Manager
for Land Autonomy

VANTAGE is designed to be capable of autonomous operation from the ground up, so has no need to be adapted for people, such as not needing armour – although it could be added for greater survivability – or cooling. It fits on a standard vehicle 'azimuth' ring, which most combat vehicles use, as well as being less than 450mm high, so very low profile and therefore presenting a smaller target to enemies.

Paul, Programme Manager for Land Autonomy, explained: "With no need to adapt the vehicle and turret for people to sit inside, we've got a lot more flexibility over ammunition handling and storage. The only thing we really need to protect is the electronics, so the weight and space savings are huge over a standard turret. We can also more easily elevate the gun for engaging aerial targets, since the gun breech doesn't have to avoid people in a crew compartment."

Being automated using AI technologies, VANTAGE can also work with information that's beyond the comprehension of human senses. Its sensor system can not only see multi-spectral wavelengths invisible to the naked eye – in itself not unusual for a targeting system – but can also use that raw multi-spectral information to help identify the target. Most systems 'downgrade' that same information to make it understandable for human observers and in doing so remove information that could, for example, be used to detect camouflaged targets.

Paul set out how we intend VANTAGE to act as a force multiplier, allowing one person to manage several vehicles and a variety of payloads: "This means you can operate a larger force with your existing trained people.

"We're initially putting VANTAGE on our ATLAS uncrewed ground vehicle (UGV), which uses the evolved autonomous driving, navigation and perception technology developed and tested for the M113 Optionally Crewed Combat Vehicle with the Australian Army. This has already been proven to be able to follow waypoints while avoiding obstacles. We're also creating an intelligent target detection, tracking and classification system where VANTAGE automatically looks for targets in all directions at the same time, identifies them based on visual identity and multi-spectral signature, then presents to the operator to confirm the target identity and to approve or deny engagement."

We're working with a company based in Canada on the targeting system, Terrasense Analytics, which specialises in computer vision and AI deep learning to identify and track targets in cluttered environments and poor weather. They have built up highly accurate identification systems for military use, so can identify a range of military vehicles on land, sea and in the air.

In May 2025, we test fired the VANTAGE turret, integrated with a Slovenian Army Patria AMV in Slovenia. The turret performed very well in its first test firing, effectively engaging targets out to 750m, proving the various turret systems function as intended and offering confidence to potential customers that the highly automated, low profile design works using the 25mm cannon and can be scaled up to 30mm calibre if required.

VANTAGE is being designed in parallel with the ATLAS uncrewed ground vehicle, as this is likely to be its first role. VANTAGE is designed to work on any vehicle with a standard turret ring, or could even be deployed in-situ on a standard shipping container to act as perimeter or air defence.

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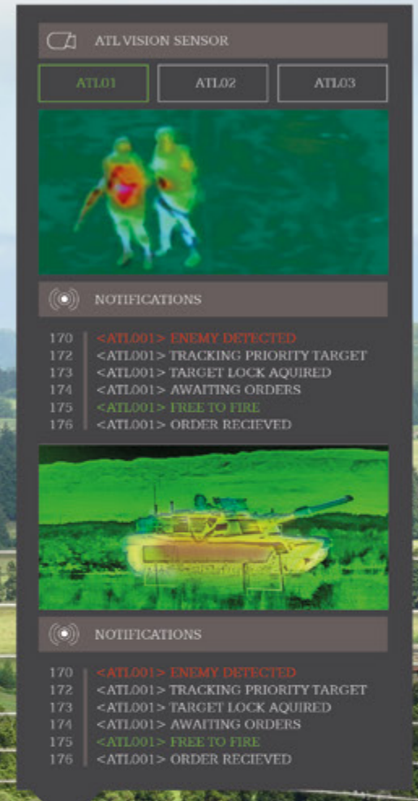
VANTAGE Automated Turret System (ATS)

The VANTAGE ATS also integrates the BAE Systems Australia passive Multi-Spectral Automatic Target Detection, Tracking and Classification System (ATTCS), delivering high levels of automated operation, reducing operator cognitive load, enabling one-to-many operation and reducing the probability of detection and the time to target engagement.



VANTAGE ATS is being designed to proactively search for potential targets, collecting and analysing information, which is presented to a human operator for decision-making.

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Adapting to electronic warfare at machine speed

Bashar,
Executive Scientist

In the modern battlespace, a drone you fly in the morning – or even your surveillance radar – can become useless by the afternoon, as your adversary adapts its electronic warfare (EW) to your radio frequency (RF) signal and degrades or blocks it.

Ordinarily, a highly specialised EW officer then has to manually adapt the comms signal or radar parameters, to try and make the enemy EW ineffective. The cycle continues, as the new signal is blocked in turn, often taking hours on either side to adapt.

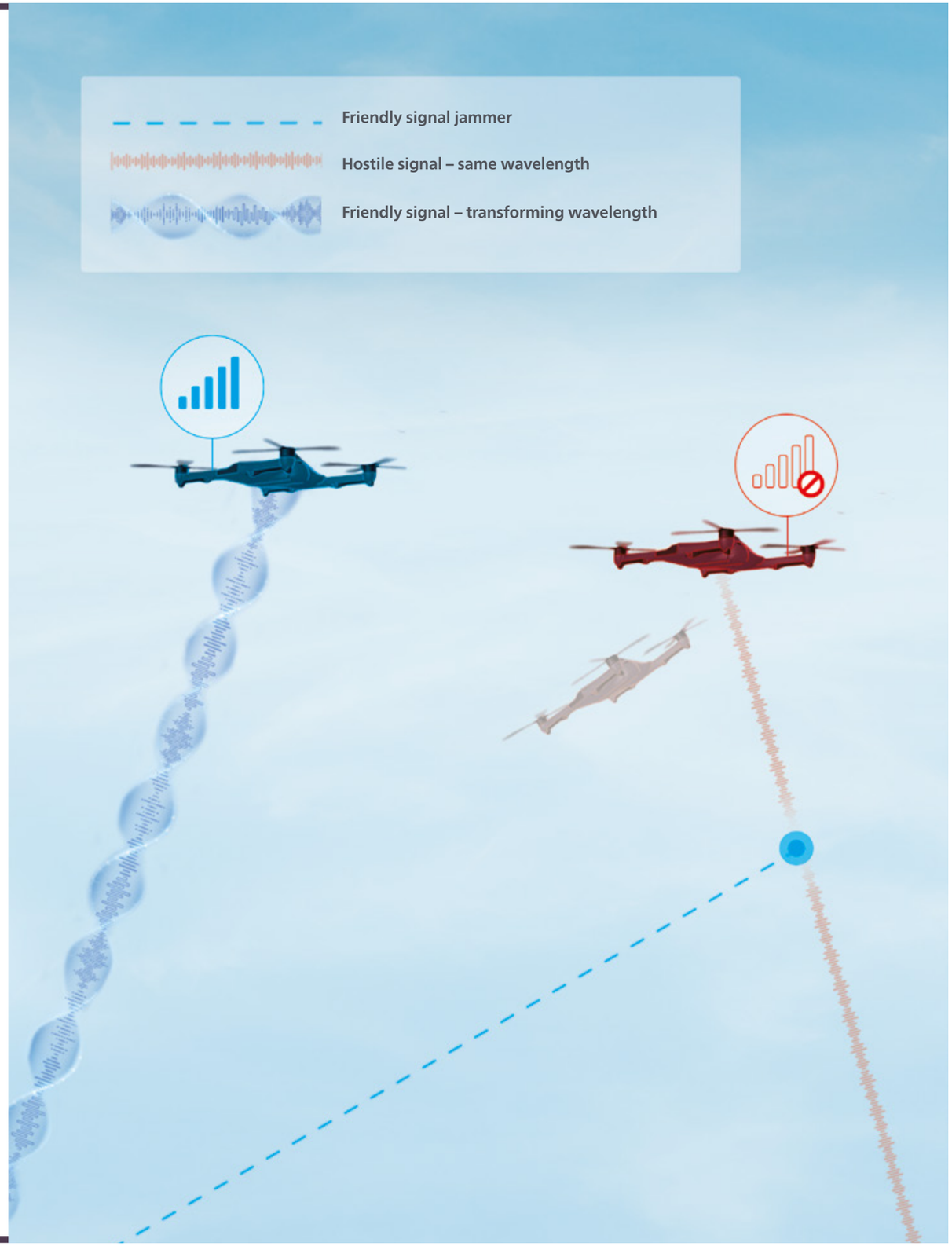
Now however, we have developed an AI technology that can automatically adapt our comms signals and sensors to counter enemy EW. It can also be used to power our own EW attack systems. We have combined this with a software defined radio that allows radio waves to be tuned to a variety of settings, meaning that our signals can be adapted much more quickly, allowing us to maintain communications and control of uncrewed vehicles or degrade the enemy's ability to do so.

Bashar, leading on this work, described how it could be used on operations: "We expect our customer's potential adversaries to be looking at this same problem, so unless we solve it first, our forces could effectively lose control of the RF spectrum at a tactical level, which would massively degrade their ability to fight. If we can build a superior AI-driven system, then they can enjoy much greater ability to get reconnaissance data from the frontline and maintain command and control of their assets as well as denying the enemy's ability to do the same."

The impact of this research goes well beyond maintaining communications to friendly forces, too. The same monitoring and analysis of enemy signals that allows you to jam or prevent jamming also allows you to identify each individual radio transmitter, whether that's a soldier's walkie talkie or a large radar antenna. Even between identical radios in the same factory batch, there are minute differences in the signal that act like a fingerprint.

While this fingerprinting has been possible for some time, it's previously been an intensive and specialist manual task typically requiring many hours, so was reserved for very high-value assets. Our recent improvements now mean it can be automated and done much faster, so it will be possible to build up a database of transmitters and track them over time. If a mobile radar that you detected four years ago in one region suddenly turns up somewhere else, you can use that knowledge to build a better intelligence picture of adversary movements and intentions.

The next step is to test this outside of the lab in more realistic environments.



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Efficiency through innovation

In defence, efficiency isn't just a goal – it's a necessity. Here we explore groundbreaking projects that help get the most out of every pound spent.

Innovation is helping us change the way we – and sometimes our customers – work to deliver greater protection and security.

In manufacturing, we're exploring an AI technique that reduces the time and energy required for manufacturing complex carbon fibre aircraft parts. This is part of our 'factory of the future' where environmental data is fed into artificially intelligent systems to make us more efficient.

Meanwhile, we're also finding new ways to make the hulls of naval ships not only use fuel more efficiently, but also remain more stable in rough seas. The same team is also using hydrogenated vegetable oil in place of diesel to run many of our forklift trucks and even in some of our small boats.

Efficiency is also about how we help maintain customer equipment. We're now actively trialling a new fatigue crack detection system that uses acoustic sensors in naval ships to detect even tiny cracks, invisible to the naked eye, and allows us to address them before they become serious, increasing overall ship uptime and potentially reducing the cost of maintenance.

Together, these stories highlight a clear relationship between innovation and efficiency, showing why we consider this a core part of our mission.

Pav Bhogal,
Head of Strategy, Maritime and Land

"These stories highlight a clear relationship between innovation and efficiency, showing why we consider this a core part of our mission."

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A small crack creates an acoustic signature, which is measured and triangulated by the sensors to determine location and severity.

Detecting crack damage for maximum ship uptime

Malcolm,
Engineering Manager

Every ship is designed to withstand massive strains during its lifetime, as it's subjected to huge waves and violent storms. All this strain leads to cracks, which is natural in any maritime structure. Ordinarily these are hard to detect before they become visible – or worse start to let in water.

We've now tested a form of acoustic monitoring that can detect even tiny cracks early, meaning they can be repaired or actively monitored before they cause further harm.

Malcolm, the Engineering Manager leading on this work, explained why cracks are such a difficult problem to solve: "The sea is a harsh environment for metal structures. Everything from oil rigs to offshore wind platforms develop cracks. On a ship, the first sign of a crack is usually when someone can see it or when small amounts of water get through. This often means that the crack is quite advanced and will require extensive repairs.

"If we detect cracks earlier and tell whether they are likely to lead to more serious problems, it can help reduce the effort required to repair them. Our trial suggests this is possible, so we're talking to customers now about installing the system on operational vessels."

Acoustic monitoring has been used on oil rigs and offshore wind turbines for years, but ships are much more complex structures, making it harder to decipher the acoustic signal of an active crack and localise it. To find a solution, we've been experimenting with a network of acoustic sensors, triangulating the signature of cracks as they occur and grow. By combining this acoustic picture with our knowledge of the ship structure from designing and building it, we've been able to assess the risk level of a crack and offer advice on mitigation.

The holy grail for this work is in deciding which cracks need corrective maintenance and which can safely be monitored, as Malcolm described: "Every ship will develop cracks as it ages, but you can't send it back to port every time you detect one. Instead, you need to build a picture of the cracks over time, track their severity and decide which to repair. If you can leave the repair until the next planned maintenance in port, you can keep the ship at sea as planned. Also, if you can stop it before it becomes severe, then you save time and resources in the long run."

"If we detect cracks earlier and tell whether they are likely to lead to more serious problems, it can help reduce the effort required to repair them."

To make even more use of the data, we're using a data fusion technique to overlay the acoustic crack data with weather and sea state information. This allows us to show how rougher sea states cause and accelerate crack damage, which then allows customers to include this as part of their forward planning – perhaps choosing to use more fuel in the short term to avoid inclement weather, knowing that it'll prevent further deterioration in cracks on board the ship.

To trial this approach, we fitted acoustic sensors to a Type 45 Destroyer for a long sea trial. In this initial test, the data was recorded and then analysed when the ship returned, but we are looking at an active datalink to share information in real-time.

Malcolm summed up our work on this: "This is all about saving customers money and increasing the time that ships stay at sea. When ships are planned for a lifetime of 35 years or more, this becomes critically important."

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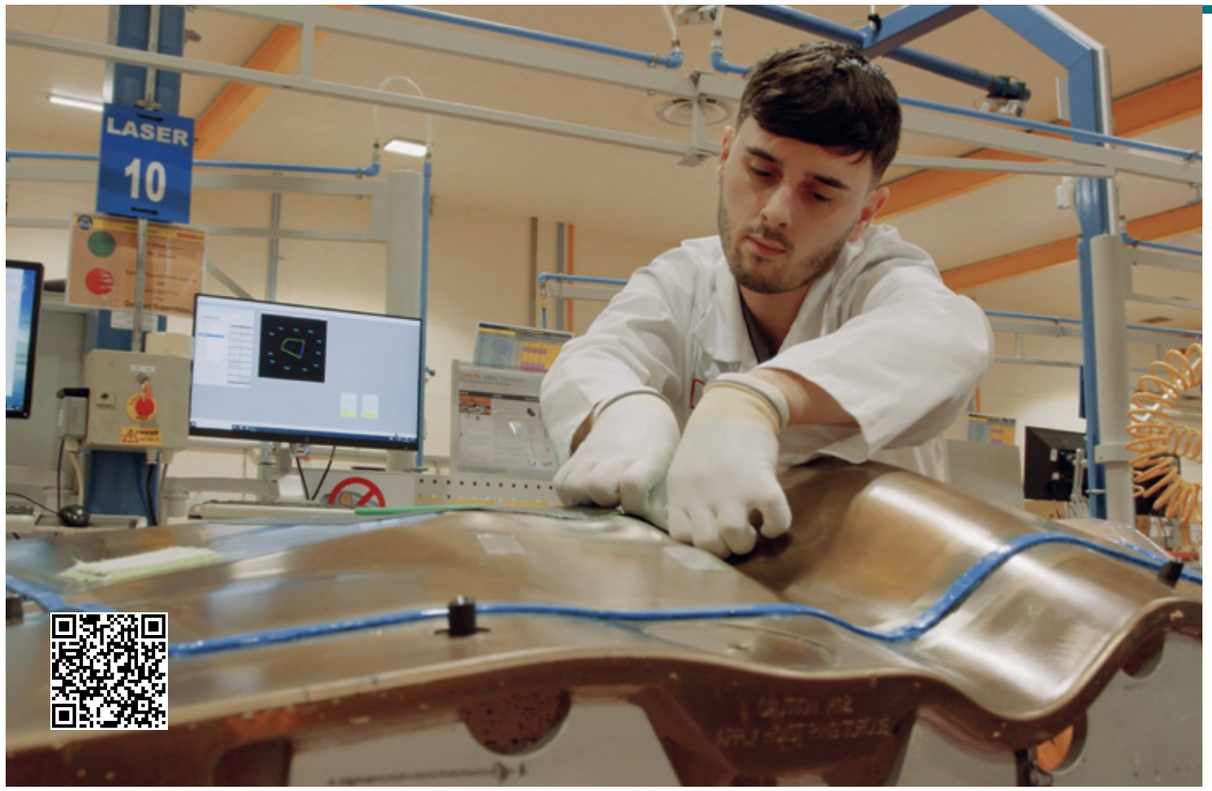


Carbon fibre 5D-Tetris?

Kamal,
Manufacturing Engineer

Carbon fibre material needs to be 'cooked' before it is ready to use, which gives it the tensile strength necessary for use as aircraft components.
To get the best performance, the temperature, duration and even the pressure the materials are cooked in need to be carefully controlled.

We're now combining the expertise of operators and the precision of data analysis with cutting-edge AI to speed up the process and make it significantly more efficient and more sustainable. To do this, we've worked with Digica, an AI-focused company based in Manchester and known for helping businesses unlock insights from their data.

Combining experience and data

The ovens we use are called 'autoclaves', which cure carbon fibre composites under exact pressure and temperature conditions. The challenge? Balancing high production demand and the quality we require, while reducing our impact on the environment. Filling the ovens is like arranging blocks in Tetris, as it's difficult to arrange the parts to make best use of the space. Operators have previously relied on sight and experience to arrange parts for curing and while this is highly effective, we wanted to explore AI and data techniques to take it to the next level.

As Kamal, Manufacturing Engineer on the project, put it: "This is like a game of 5D-Tetris on steroids – operators don't just have to arrange parts efficiently, but also need to account for part sizes, thermal mass (its ability to absorb, store and release heat), lengths of tooling and choices between autoclaves in order to figure out the most efficient option. We're now bringing together our experience and extensive data with an incredibly powerful AI tool to help solve this problem faster and more efficiently."

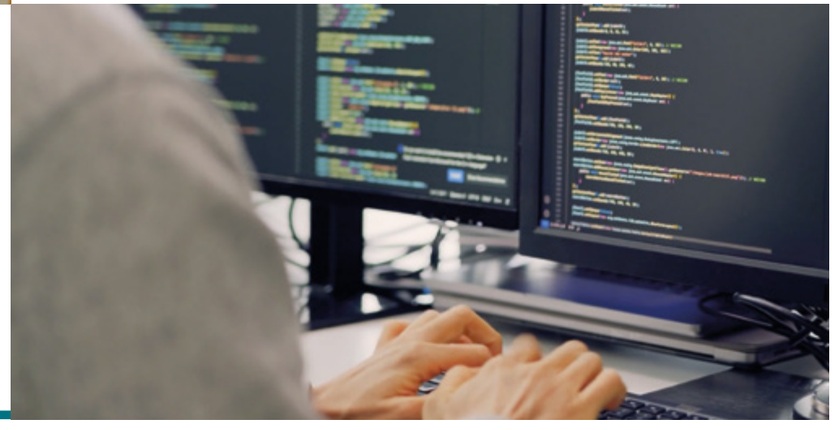
Digica began solving this challenge by comparing the operators' choices with data from sensors inside the autoclaves, which track how parts heat during curing. For the most part, operator intuition was correct, however the data highlighted opportunities for refinement. By applying an AI-based algorithm, Digica was able to identify packing strategies that reduce curing times while maintaining quality. These changes, when implemented, will not only streamline production, but also save energy, creating a more sustainable process.

Overcoming data challenges

Harnessing the potential of autoclave data wasn't straightforward, however, as Mike from Digica explained: "Autoclave sensor data was being stored purely for compliance checking and kept in a variety of formats and locations. To make this information actionable, our data scientists had to tackle complex transformations, structuring it into formats that could be analysed effectively."

Another hurdle was that autoclaves are different sizes and operate differently, so you can't apply the same approach to each one. Digica has now accurately modelled two very different autoclaves in our Samlesbury facility, with plans to extrapolate this to cover other sizes and shapes.

This initiative fits neatly into BAE Systems' broader digital transformation goals. Beyond improving processes, it leverages existing data to make new innovations. What was once unused information is now driving meaningful improvements in efficiency and operational excellence. It's also laying the foundation for the 'factory of the future,' where environmental data, such as factory temperature, can feed into intelligent systems for further refinements.



A smarter path forward

Kamal summed up: "Digica has helped show us how combining human expertise with AI can unlock efficiencies in even the most complex and traditional processes. For carbon fibre production, this means shorter cure times, reduced energy consumption and smarter packing strategies. For the industry at large, it's a blueprint for innovation that balances new technology with established expertise."

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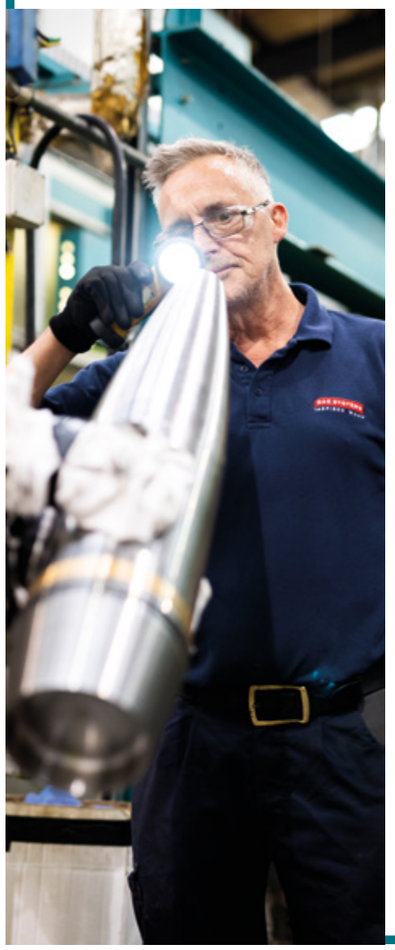
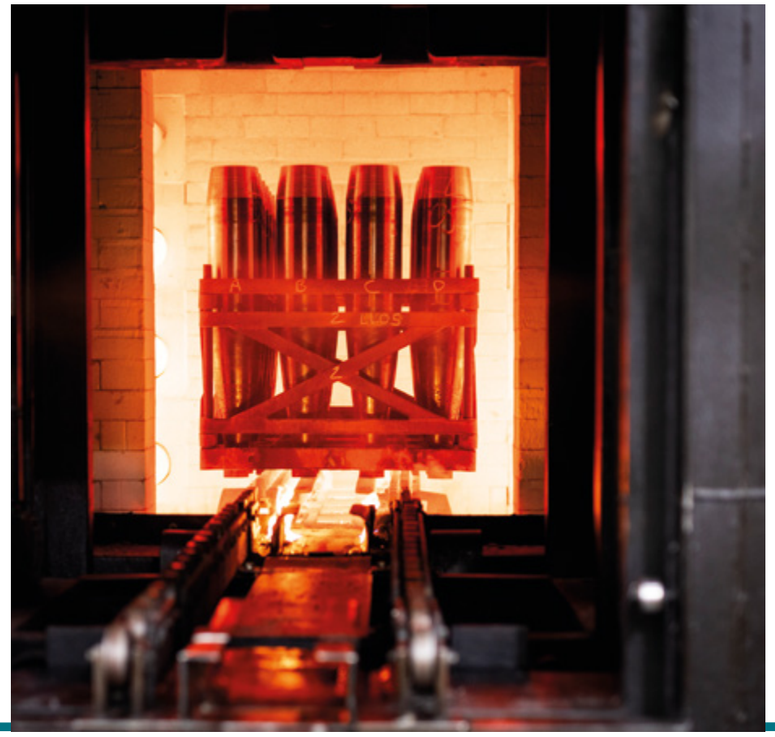
Major breakthroughs in UK munitions production



We have developed innovative new approaches in the production of energetics and propellants expected to strengthen supply chain resilience for the UK and its allies.



We have invested £8.5m in novel manufacturing methods over the past five years, which has led to significant breakthroughs in the creation of next generation explosives and propellants. The new methods will use continuous flow processing to synthesise explosive material and remove the need for Nitrocellulose and Nitroglycerine, which are in high demand across global supply chains, in propellant production.

As a result, we anticipate we will be able to produce sufficient explosives and propellants in the UK to meet UK Ministry of Defence and export requirements, with the initial phase of industrial capacity expected by the end of 2026.

Steve, Business Development Director, explained: "Our leap forward in synthetic energetics and propellant manufacture will strengthen the UK's supply chain resilience and support our ramp up of critical munitions production to meet growing demand in response to the increasingly uncertain world we're living in. It also supports economic growth through highly-skilled jobs and potential export opportunities."

A pilot has already demonstrated the technological breakthrough, producing the explosives in small nodes. This technology would remove the need for a large-scale explosive factory. The new propellant formulation and associated manufacturing process have been demonstrated across a wide range of products from small arms to large calibre munitions.

The new technologies are intended to require lower investment and would offer greatly reduced running costs while providing enhanced safety in manufacture due to the continuous process meaning there is less explosive in process at any given time.

As the primary producer of ammunition for the UK Ministry of Defence, we supply a range of munitions including small arms and artillery shells from sites across the UK, including in Cheshire, Monmouthshire and Tyne and Wear.

"Our leap forward in synthetic energetics and propellant manufacture will strengthen the UK's supply chain resilience and support our ramp up of critical munitions production to meet growing demand in response to the increasingly uncertain world we're living in."

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Maintaining defence manufacturing through climate change

We've all seen that extreme weather events are increasing in frequency and severity, so it's no surprise that we are taking steps to mitigate their impact on our facilities in the UK. Defence manufacturing is critical to national security, so it's important we reduce the chance of disruption by understanding the potential risk and preparing accordingly.

Submarine Academy for Skills and Knowledge.

Chris, part of the team leading this work at BAE Systems, set out the challenge: "Extreme rainfall, heat or strong winds have the potential to affect production. We have been using industry-leading tools to model the impact on our major sites, then site planning teams have used these to validate existing mitigations and identify specific changes to further reduce the potential impact.

"Our approach is designed to help make adapting to potential climate impacts more efficient. By identifying those impacts early, we can build mitigations, where possible, into existing maintenance and upgrade plans."

We have also used the tools to analyse sites for development and have actively ruled out those that present too high a risk. This will help us avoid areas of increased flooding and other natural hazards predicted over the coming decades.

We've been able to combine the scientific predictions with local site observations to mitigate against anticipated future impacts.

We've also changed designs for new buildings on existing sites to raise them further above ground level, upgraded the drainage facilities, taken steps to protect biodiversity and are reviewing building performance, with the aim of positioning our sites for predicted changes in weather.

Chris added that the approach could be applied to any of our customers' sites around the world: "These tools model the predicted impacts of climate change globally, so we're talking to our colleagues in Australia now about potential impacts on their facilities. Equally, we'd be happy to share this approach with our other customers and stakeholders."

"Our approach is designed to help make adapting to potential climate impacts more efficient."

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Innovation in shipbuilding – how is Line Zero moving the dial?

The Line Zero research and development facility in Australia is already improving build times for its six Hunter class frigates, while helping smaller businesses across the country upskill their people and improve how they do business.

But it's not an easy challenge, as Principal Technologist, Andrew, pointed out: "Building ships is a unique engineering challenge. Unlike the car industry, where you're trying to build maybe six different models a million times, in Tonsley we're trying to build a million different parts just six times."

Those millions of products each go into one of six Hunter class frigates, which are set to transform Australia's naval capability for decades. Andrew's team's job at Line Zero is to identify and develop the new technologies and techniques that will help build those ships more safely, faster and at an even higher quality.

Andrew described the breadth of the technology currently being rolled out: "Clearly we're learning from shipyards building Type 26 and derivatives in the UK and Canada as part of the Global Combat Ship Programme, but we're also developing our own new approaches. We're now bringing handheld optical and laser scanners into the workshops to map out the exact dimensions of parts and the compartments, analysing that data with machine learning tools to check instantly whether it's all to specification. We're now doing this earlier and more frequently during the build to get 'right-first-time', which is already saving a lot of time by avoiding re-work."

Advanced visualisation for management – the 'Anon' method

When you're building hundreds of thousands of parts, managing the supply chain and managing each aspect is highly complex. That's why we're now using visualisation tools that are used in gaming to visualise all that data to improve trawling through spreadsheets to find what you are looking for. This means that management can spot and fix delivery problems much quicker, whether that's yard layout and movements, our own production machines or progress on the overall programme.

Working with robots

We've been using robot welders to help build submarines for years, but we're now applying that technology to ship-building. In Tonsley, we also have flying inspection drones to get into hazardous and elevated spaces, that can systematically check areas of the ship that require significant safety measures for people to access.

Line Zero's aim is for robots to support people, as Andrew explained: "This is all about making our people the most effective and efficient they can be, so we start by looking at the job and then picking out the robotic technology that can help. One example is that before we handed over the robot welders to our manufacturing engineering colleagues, we validated the performance and workflow, explored how to share and process the data it collects and how this feeds into the overall quality report. In this case, it helps take away some of the physically difficult, repetitive and administrative parts of the job while making people more effective."

Digital parts tracking

The six Hunter class frigates will not be entirely identical, as even during the build programme some parts will receive upgrades between one ship and the next. Through Line Zero, we've created a digital parts tracking capability that will follow the ship throughout its life, so any future changes and upgrades can be recorded too. As Andrew explained: "Every ship will be slightly different, so we need to know exactly which parts are on which ship to help us maintain and sustain it effectively in the future. Say the third and fourth ship are going to different harbours for maintenance – we can make sure that those harbours receive the correct parts in advance to speed everything up as part of a digitally connected design to support system and supply chain".

Learning in the supply chain

Our Osborne shipyard uses more than 1,800 suppliers, many of them being small companies from Australia's diverse and capable SME Supply Chain. Line Zero is helping us not only bring new technology to those suppliers – such as equipping them with their own digital tracking that will help them with other customers too – but also helps us bring in great ideas from those small companies. Some of our suppliers also support the mining, resources and construction sectors, so they have some great innovations like connectivity, atmospheric monitoring and cabling methods that we can incorporate into shipbuilding. We're bringing these technologies to shipbuilding to help make the shipyard, and ultimately the ships, a great place to work and live for all of the people that are involved in the ships' life-cycle.

We've also been working closely with our suppliers to improve their cybersecurity, since adding them to our digital supply chain could otherwise increase our collective attack surface and vulnerability. These skills help strengthen our respective companies, our employees and to some extent the nation's cyber readiness.

Anika is an ambassador for STEM at local schools, as well as an engineer on the site.

Skills for the future

Line Zero has been great for recruiting young people into the workforce. One of our recent engineering graduates, Anika, explained why it's such a great place to work: "I get to work with some of the coolest new technology available, from robotic dogs that can patrol and inspect alongside our safety officers, through to virtual reality allowing us to visualise the ship before we build it, to help plan out the programme more effectively. I also get volunteer leave to visit local schools and encourage more students into engineering subjects."

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Artificial Intelligence-enabled hull design signals major performance improvements

Using AI to improve hull performance might not be new, but we might just be the first people to combine it with stability and sea-keeping performance.

One of the team working on AI-assisted hull formations.

Using HVO avoids the diesel smell small boats often generate.

Our research suggests this could allow us to significantly reduce the weight of future vessels, as well as make them more stable in rough seas and offer other advantages such as greater range and endurance.

Matt, the Engineering Manager looking after this programme, explained how this approach could make a difference: "We've been using AI to look at three areas that are really important in hull design: first reducing friction as it goes through the water; second its stability in difficult sea states; and third the impact of flooding – i.e. how the hull would respond to taking on water.

"By combining our AI tools to look at all three at once, we can optimise across these three very different metrics. Whereas for a racing yacht you're looking primarily at speed, we need to consider all three in quite a different way for naval vessels. We've been able to show that we may need fewer bulkheads – the metal panels separating different parts of the hull to control potential flooding – which could significantly reduce the weight of future vessels. Any reduction in weight then makes it easier to move and quieter, extending range and making the vessel harder to detect."

To build evidence to support our virtual AI design work, we've worked with the University of Southampton to build physical models of these new hullforms and test them in their specialist 138 metre-long wave tank. The AI-designed hulls performed as expected, even generating a much reduced 'wake' wave pattern behind the ship, which underlines the efficiency of the new shape.

Matt summed up our next steps: "We're now talking to customers about applying this to various naval and commercial designs, as our results have generated a lot of interest. Our results suggest that a 130m ship – representative of common naval vessels – could go an additional 1,000 miles using a hull designed this way, which is more than 10% additional range."

Replacing diesel with hydrogenated vegetable oil

Surprisingly, most diesel engines will run on hydrogenated vegetable oil (HVO) instead of diesel fuel without any changes required. We've been able to prove this in both our 10m Stormblade RIB and in a number of forklift trucks in the Glasgow boatyard.

Neil, our Head of Research and Technology for maritime applications, explained what this means: "We've known for a while that HVO should work just as well as diesel without causing the same environmental impacts. However, until now we haven't proven this in our own products. We've now shown in both RIBs and forklifts that not only was there no discernible impact on performance compared to diesel, but it also means you entirely avoid that unpleasant diesel smell. Now we've proven this works in smaller applications, we're determined to test it in larger vessels, so we're talking to our customers about making this happen."

HVO is made from either used vegetable cooking oil or in by-products from other processes. We've been using HVO created as a by-product from things like corn husks, so only waste-products are used in making the fuel.

While the production of HVO is relatively energy intensive, some suppliers use renewable energy to do this so that it still has a lower carbon footprint than fossil fuels.

Neil talked about our future plans: "We are also looking at fully synthetic fuels, which are made by taking carbon and hydrogen out of the atmosphere. This would reduce our carbon footprint even more, but these fuels are currently even more expensive and only available in limited quantities, so we need to wait for the technology to improve before considering them for a greater role. In the meantime, we've shown that HVO made entirely from waste-products can be just as effective as diesel."

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Entrepreneurial Development Programme: the secret sauce for innovation exploitation

Innovators will recognise the challenges of taking an idea from iteration to market. Bridging that gap between concept and product/fielded capability is one that vexes companies of all sizes, from start-ups to multi-nationals.

Saïd Business School.

But at BAE Systems, our Entrepreneurial Development Programme (EDP) is providing the skills, opportunities and network to ensure that innovation delivers real solutions into the hands of those on the front line.

We spoke to three EDP Alumni for their verdict on how the programme has helped them, the BAE Systems business and above all customers.

Natalie is Head of Integrated Systems, in Australia – Maritime. She joined the pilot programme in 2021. Natalie explains: "I was in our submarines business, in a delivery role, working within tight customer parameters. EDP opened my eyes to thinking really deeply about the current customer experience, and applying both process and technology innovation to the customer's problem, before the customer had necessarily identified the need themselves. For example, during our course we took an augmented reality helmet and comms systems for firefighting, but applied that into a ship environment. It's that understanding of taking an idea to the customer that is the difference between innovation and entrepreneurship."

Charlie is the System Design Authority for Maritime Services Autonomy. Charlie joined BAE Systems as a self-confessed 'middle aged STEM returner' having run his own business for over a decade. He says: "EDP allowed me to take all my skills and experience from running a business, and apply them to an established and complex organisation. It was during our first workshop session, however, that the penny really dropped. The conversations were much richer and deeper than I expected, exposing me to a diverse group of bright people doing incredible stuff. EDP provides that ability to look at a problem through the customer lens. One of the most important lessons I took away was the need for concise storytelling, to explain how an innovation solves the customer challenge."

Murray is the Chief of Staff to Julian Cracknell, BAE Systems' Chief Technology and Information Officer. He and Charlie were both in the 2022 EDP cohort, and he agrees with Charlie's assessment: "This programme drives a different mindset. It has the excitement of a graduate programme, but with a focus on the customer perspective. We have a history of building really cool stuff, but if there is no customer programme of record or strategic imperative, we could be wasting our time and resources."

At a time when novel capabilities can seem abundant, Murray makes an important distinction that EDP is not about idea generation per se: "The programme encourages a great way of thinking. It's not just about the innovation or capability, it's also about being disruptive in our processes and the way we work." As Charlie continues, that thinking isn't just limited to cohorts or alumni: "We're bringing those tools back into the workplace and sharing with colleagues, looking at problems in different ways. We have to have the courage to take ideas to customers in the right way, with the assurance and pedigree that we will be around in ten, 20, or even 40 years to maintain that capability."

Great ideas rarely arrive fully formed as a value proposition with a proven market. There can be an assumption that it's only the idea that matters. But through EDP, a swathe of great innovators and engineers are understanding and applying the entrepreneurship needed to turn innovations into genuinely viable opportunities for customers and BAE Systems. As Natalie summarises: "The company is already set-up to support taking ideas from innovation to the next level, it's the entrepreneurial skills acquired through EDP that help enable our people to develop those business cases and propositions for customers."

Murray goes further: "It's not about the projects or ventures that are generated by the teams on each EDP cohort, it's about creating and encouraging that culture of entrepreneurial thinking and ensuring a complete customer focus for our technology."

As customer needs evolve, so the opportunity for new technologies increases. Ensuring that the right technologies are developed alongside a sustainable business model and customer export potential remains a focus of industry. A focus that EDP is helping BAE Systems to meet head on.

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