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NOVEMBER 2026

DRONE WAR GETS PERSONAL

ORBITAL DATA CENTRES

MAKING GA SAFER

THE AI EDITION

INTELLIGENCE TAKES FLIGHT

FROM GA TO SPACEFLIGHT – HOW AI IS RESHAPING OUR SECTOR

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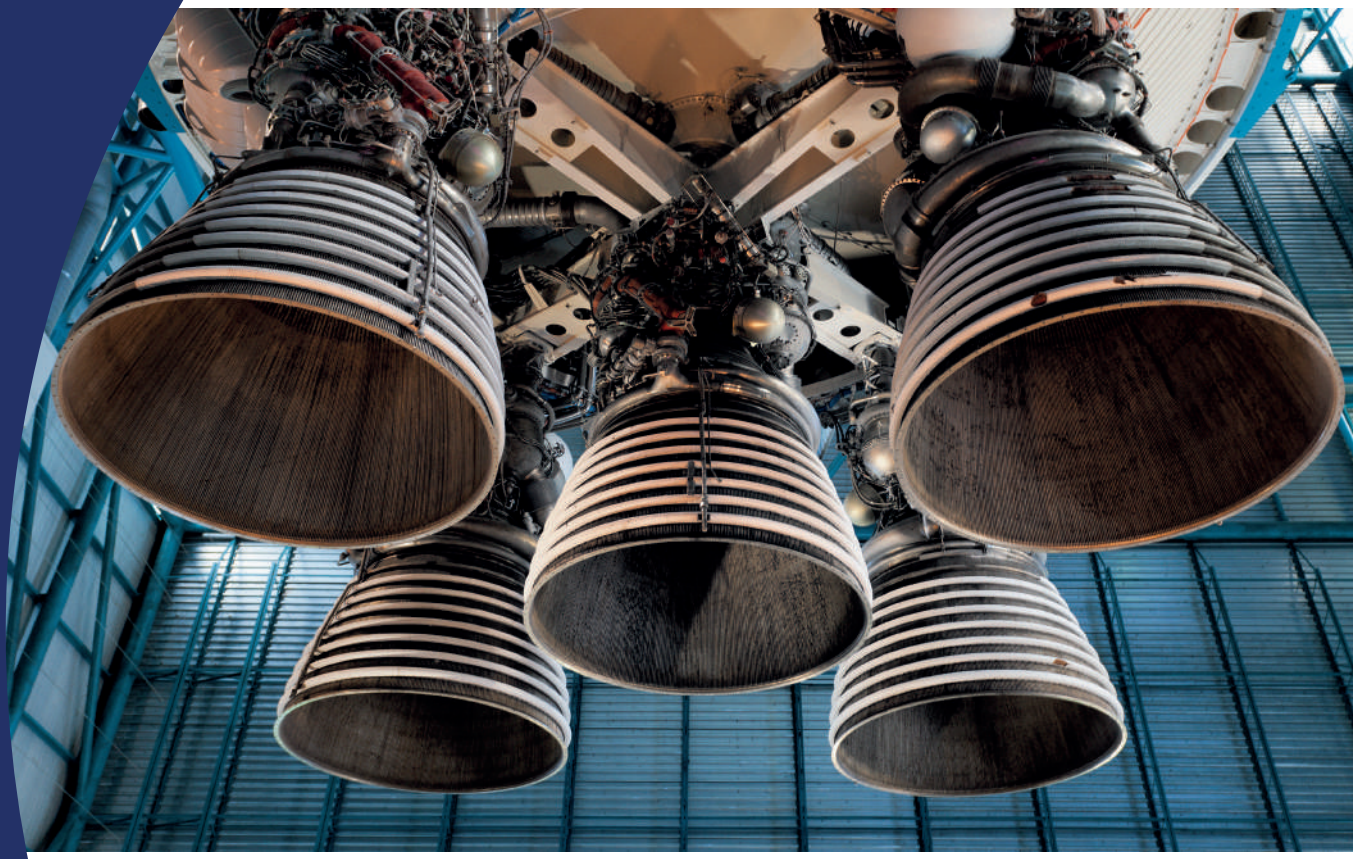

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AEROSPACE

Volume 53 Number 10
November 2026

EDITORIAL

How will AI reshape aerospace?

The breakneck speed at which humanity is either rushing to a Utopian singularity or an AI apocalypse (depending on who you listen to) makes judging the progress or likely impact of the AI revolution extremely difficult. Yet in fields, such as maths and health, AI's claimed breakthroughs are coming so swiftly that experts and scientists are having trouble keeping up. How, then, might AI reshape aerospace, aviation and space?

There are already clues as people experiment with these new tools. Houthi insurgents reportedly used Claude AI to help adjust and enhance missile accuracy, with multiple agents being used, working on separate parts of the problem, bypassing the LLM's guardrails. Other, more benign, public tests have seen AI used to build 3D models of ships using freely available LIDAR scans from space or create a home-built passive radar by detecting faint reflections of aircraft from broadcast transmitters.

Yet it may be wise not to overhype the potential. The previous information age, ushered by computer technology in the 1980s, did not lead to lives of leisure for white collar workers – but paradoxically barely moved productivity statistics. As some tasks got easier or jobs disappeared, new tasks, such as emails, virtual meetings and social media expanded to fill the time available. As one Nobel Laureate put it: "You can see the computer age everywhere but in the productivity statistics."

Moreover, with its reliance on complex systems engineering on which lives depend, the aerospace sector has much justification in being cautious about 'vibe coded' apps where the inner workings of software are not known. Certification and verification to ensure safety will, thus, remain key.

With its 160-year history of being at the forefront of aeronautics, the Society will be looking at AI in more depth with learned specialist papers in 2027. Do look out for them but, in the meantime, this issue of *AEROSPACE* will be a useful primer on the coming revolution.

For more on the strategic opportunities and challenges surrounding AI in aerospace scan the QR code to read an article by the RAeS' Head of External Affairs, Jonathan Clare.

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AEROSPACE is published by the Royal Aeronautical Society (RAeS). Unless specifically attributed, no material in *AEROSPACE* shall be taken to represent the opinion of the RAeS. Reproduction of material used in this publication is not permitted without the written consent of the Editor-in-Chief.

Printed and Distributed by Buxton Press Limited.

2026 *AEROSPACE* subscription rates: Non-members, £248 (10% agency discount)

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ISSN 2052-451X

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Front cover: From GA to spaceflight, artificial intelligence is set to transform the aerospace sector as we know it. (AI generated image)

AEROSPACE INSIGHT

Additional content is available to view online at: aerosociety.com/aerospaceinsight
Including: Running out of runway – an arresting approach, Loss of signal: Can the UK fight on when satellites go dark? Supersonic salesman – demoing the Bombardier Global 800, The big questions shaping flight simulation in 2026, Space ambush, Aerospace Down Under – ICAS Congress 2026.

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AEROSPACE APP

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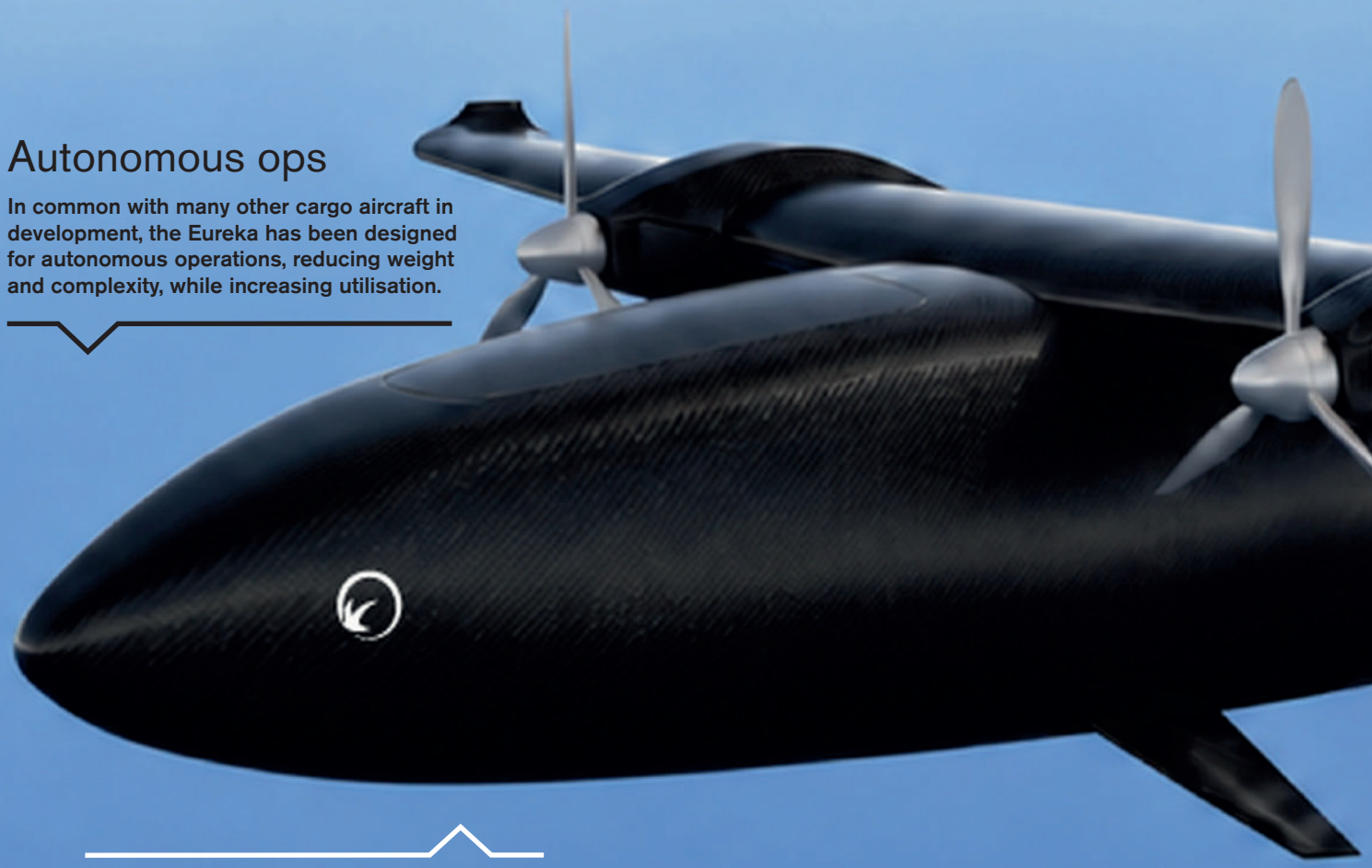
Blueprint

Aspera Industries Eureka

Crew: None
Payload: 2,200lb
Power plant: Twin propeller, type undisclosed (TBC)
Range: 1,200 miles



Autonomous ops

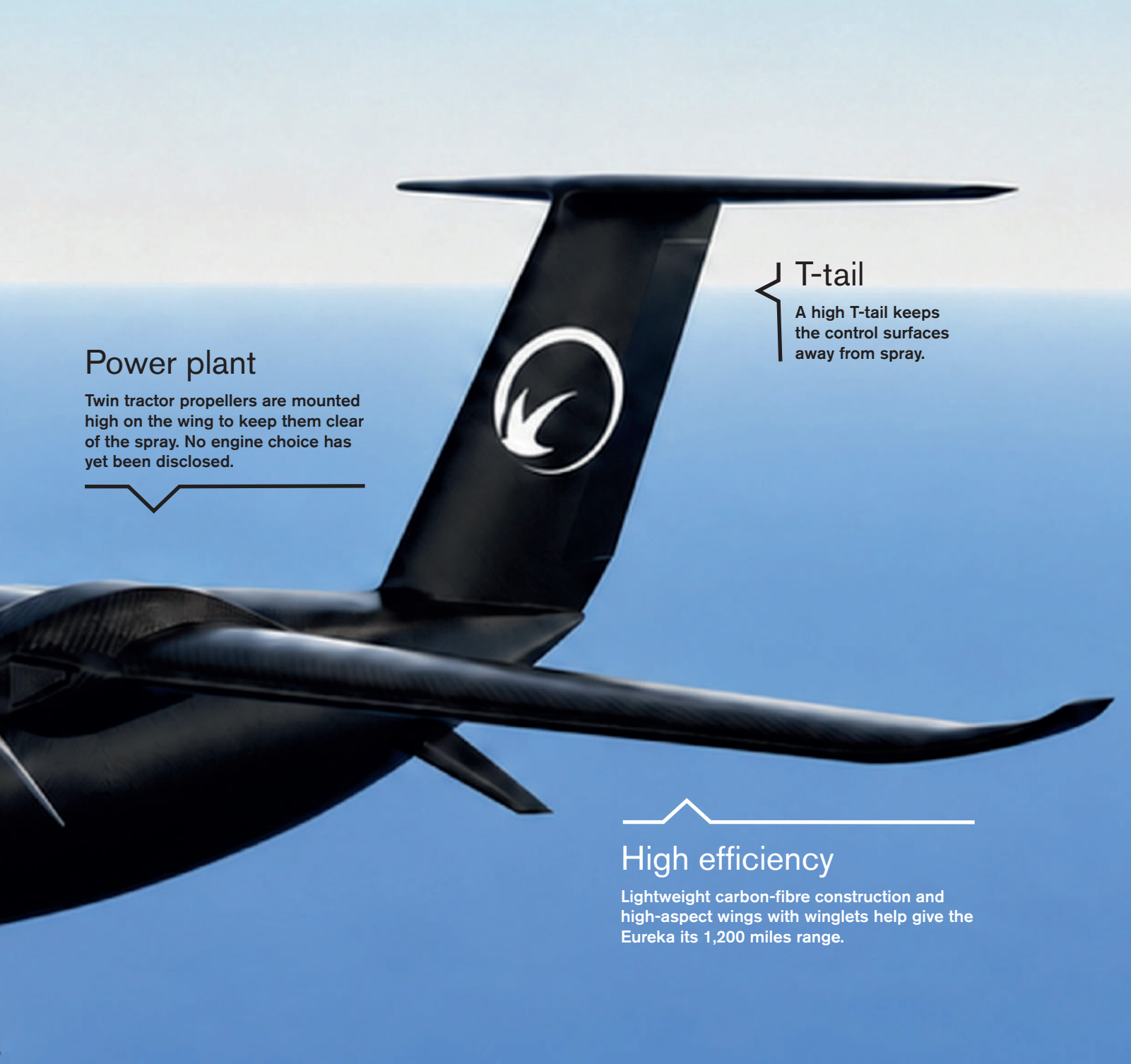
In common with many other cargo aircraft in development, the Eureka has been designed for autonomous operations, reducing weight and complexity, while increasing utilisation.

Stepless fuselage

A smooth stepless hull cuts drag in the air, while an all-composite construction reduces weight. With no conventional wheeled undercarriage, the cargo bay is built to enable dockside loading.

Retractable hydrofoils

Twin retractable hydrofoils, fore and aft, allow the aircraft to skim over the water and keep the fuselage clear of the water. Once in the air, they retract, cutting down on drag.



AEROSPACE

Hydrofoil cargo drone

From India's Bengaluru-based Aspera Industries comes the Eureka cargo UAV – designed to operate off water and halve the cost of logistics from £1.20 per tonne mile to 60p at scale. With a 2,200lb payload and a 2,200lb range, Eureka swaps the traditional stepped boat hull of a seaplane for retractable hydrofoils – making for much reduced drag in flight. The company has so far received $750,000 in seed funding – with a subscale prototype undergoing water tests. As well as India, Aspera says it will initially focus on New Zealand, Australia and Southeast Asia, targeting logistics providers, freight forwarders and military operators as its first customers.

Radome

AIR TRANSPORT

AI speeding up turnaround could save airlines £33bn

Research by AI airport turnaround company, Assaia reveals that one in five flights across Europe and North America arrived late in the first quarter of 2026 due to delays on the ground, with the average turnaround taking 11 minutes longer than planned. Its 2026 *Turnaround Report* found the average turnarounds ran 11.1min over schedule – the seventh consecutive quarter of overruns – with the lost time swallowing around 6% of stand capacity at airports. Comparing 125,000 AI-monitored turnarounds at eight airports against 1.5m at 20 others, Assaia found overruns 36% shorter where AI was watching the apron (7.3min versus 11.4min). Eliminating the 11min gap, it claims, could save airlines worldwide more than £33bn.

AEROSPACE

Heroic flydubai captain foils 9/11-style terror plot



Social Media

On 30 September, a flydubai Captain, Smit Machchhar saved more than 170 people on board his Boeing 737 MAX 8, when his co-pilot attempted to overpower him with an emergency crash axe on a flight between Dubai and Tel Aviv. Battling serious wounds, Capt Machchhar managed to open the cockpit door, allowing fellow passengers to overpower his attacker and pull the aircraft out of dive. In the dive, the aircraft reached Mach .97-.99 - which was enough to damage the rudder. The aircraft was landed safely in Tabuk, Saudi Arabia, by two off-duty pilots. The attacker's plan was reportedly to crash into an airport terminal at Tel Aviv during the Yom Kippur holiday.

SPACEFLIGHT

Russian sat closes to within 0.5km of ICEYE SAR satellite



A Russian military satellite has been caught tailgating a Western SAR radar spacecraft whose imagery is used by Ukraine. Tracking firm, LeoLabs reported that Kosmos 2612 – one of a batch launched from Plesetsk in April – closed from more than 320km to around 0.km of US-registered ICEYE-X36 in less than a day on 16 October, having spent weeks matching its orbital plane and altitude, in what was described as 'non-consensual proximity operations.' (See Securing Space, p 46).

DEFENCE

Starshield speeds throttled for Ukraine

An international dispute has broken out after speed limits of the military version of SpaceX's Starlink satcoms system, Starshield, were artificially lowered for Ukrainian users. The slowdown, which affected Ukraine's long-range strike drones and Shahed interceptors, came after White House pressure on Kyiv to curtail strikes on Russia's oil and diesel infrastructure. Ukrainian President, Volodymyr Zelenskyy claimed that the US had deliberately throttled Starlink to send a 'message' to him. However, there was confusion over responsibility, with *The Wall Street Journal* reporting that Elon Musk took the decision to slow Starshield after speaking with President Trump. Meanwhile, US Secretary of State, Marco Rubio claimed that Ukraine only had access to the civil Starlink system.

NEWS IN BRIEF

Heart Aerospace has received a £2.1m grant from the FAA to advance development of a hybrid-electric propulsion system for its planned ES-36 regional aircraft. The funding forms part of the regulator's Continuous Lower Energy, Emissions and Noise (CLEEN) programme and will support Heart's HYPER (Hybrid Propulsion Environmental Readiness) project.

Airbus has released its Global Services Forecast, which the company sees doubling in size to £314bn in the next 20 years and growing by 3.8% a year. The fastest growing segment is Digital & Connectivity which will triple to £20bn by 2045. Meanwhile, some 2.44 million extra aerospace professionals will be needed, breaking down into 730,000 maintenance technicians, 660,000 pilots and 1,050,000 cabin crew.

Saab handed over the first GlobalEye AEW&C aircraft to the Swedish Air Force on 15 October. The type will replace the two Saab 340-based S-100 Argus Erieyes, which Sweden donated to Ukraine in 2024. Sweden has ordered three GlobalEye aircraft.

German rocket start-up, HyImpulse received its UK Launch Operator Licence on 1 October. The firm is now working to complete the necessary pre-launch approvals and, "based on the current assessment of these remaining activities with the CAA and the seasonal weather conditions at SaxaVord Spaceport during autumn and winter," plans to launch its SR75 sub-orbital launch vehicle from SaxaVord Spaceport in Scotland in spring 2027.

Utah-based Wasatch Aero, which is developing the two-seat SD3 light aircraft, has announced plans to create a four-seat, twin-turboprop aircraft, designed for multi-engine flight training. Power for the SD6 will come from two 148shp Turbo Tech turbine engines, with the company stating an anticipated 200kt cruise speed, while burning just 12 to 14 US gal per hour. The aircraft is being developed to take

DEFENCE

Boeing wins US Navy F/A-XX deal


Boeing

On 29 September it was announced that Boeing had been selected by the US Navy to produce its sixth-generation F/A-XX combat aircraft, intended to replace the service's fleet of F/A-18 Super Hornets. Boeing said the fighter "will revolutionise advancements in open mission systems architecture, advanced mission systems and operational reach and capacity." With the F/A-XX award and the USAF F-47, Boeing is now developing sixth-generation fighters for both the US Navy and USAF.

AEROSPACE

Drone flies almost 50 miles on a lithium-sulphur battery

Australian battery manufacturer, Li-S Energy has conducted a test flight with a 16ft-wingspan drone that stayed aloft for almost two hours and flew 47 miles, powered by a single 382w/h lithium-sulphur (Li-S) battery pack linked to perovskite solar cells. The company says the VTOL Aerospace Pegasus drone landed with power in reserve and emphasises that "alternative battery chemistries are one step closer to routine commercial aviation." Li-S batteries promise lightweight and higher-energy density than lithium-ion cells but issues with thermal management and cell lifespan have historically meant they have been unsuitable for aviation purposes. Li-S Energy has, therefore, designed a specialised battery management system for aerospace applications.

GENERAL AVIATION

FAA halts single-pilot Citation ops

The US FAA has halted single-pilot operations in a swathe of legacy Cessna Citation bizjets. In a six-page notice, the regulator cited safety concerns and a 2024 review that "revealed widespread non-compliance with the exemptions," first granted in 1984. It also found that two-pilot-certified Citations flown solo suffered around twice the accident rate of single-pilot-certified models. Affected types include the 500 Citation and Citation I, 550 Citation II and Bravo, S550 Citation S/II, 552 Navy T-47A and 560 Citation V, Ultra, Encore and Encore+ – a total of some 1,250 US-registered aircraft. However, CitationJet and Mustang owners are unaffected. Industry and operator groups, AOPA and NBAA are pressing for a rethink of the decision.

AIR TRANSPORT

A350F makes first flight


Airbus

Airbus' new widebody A350F freighter made its maiden flight on 29 September from the company's flight test centre in Toulouse, France. The first of two prototypes flew for 4 hours 10 minutes reaching an altitude of 25,000ft, marking the start of an expected nine-month flight test campaign.

advantage of the FAA's MOSAIC rules, which expand certification options for light-sport aircraft.

The Women in Aviation and Aerospace (WiAA) Charter's 2026 report found that aviation has one of the UK's widest gender pay gaps, reaching 53% – more than four times the national average of 13% and second only to Premier League football among the sectors examined. The report also revealed that women are still under-represented in technical, operational and leadership roles within the sector.

Japan Airlines (JAL) has ordered up to 26 Embraer E190-E2 aircraft to replace the E170s and E190s operated by its J-AIR regional subsidiary. The order includes 16 firm aircraft and 10 options, with deliveries scheduled to begin in fiscal year 2029.

During the Conservative Party Conference in October, party leader, Kemi Badenoch pledged to invest £10bn in a defence system inspired by Israel's Iron Dome air defence system, if it wins the next general election. Dubbed the 'Britannia Shield', the system would consist of new advanced radar systems and upgraded command and control systems, along with new interceptor missiles and counter-drone capabilities. (see Last Word, p 62)

SpaceX's Starship 14 mission launched on 28 September, reaching orbit for the first time and launching 26 Starlink V3 satellites. An unexpected shutdown of one of the six RVac engines saw the decision to press on with the trip, with Starship flying for 3 hours and 9 minutes instead of the original planned 10 hours. It completed just two orbits instead of the planned six, before splashing down in the Pacific Ocean.

Following the fatal crash of an Elixir light aircraft at the manufacturer's facility in Rochefort, France on 1 October, EASA issued an emergency directive to ground the entire fleet of 60 aircraft in five countries. BEA had found the left flap separated from the wing.

Radome

GENERAL AVIATION

Aerobatic firm creates dedicated aerial firefighter



Game Composites

Game Composites GB2 single-engined air tanker (SEAT) performed its maiden flight from Louise Thaden Field in Bentonville, Arkansas on 23 September. Designed and test-flown by Philipp Steinbach, the GB2 is described as the first purpose-built firefighting aircraft developed in the US. The company, which was co-founded by Steinbach and Stuart Walton of the Walmart dynasty, produces the GB1 competition aerobatic aircraft but created the GB2 as a cost-effective and safe aerial firefighter. With a 6,050lb empty weight and an MTOW of 19,000lb, the two-seater has been designed to carry 1,200 US gal of dispersant and 400 US gal of fuel.

DEFENCE

Terror threat against RAF Fairford sees B-1s leave

Around a dozen USAF B-1B bombers forward-deployed at RAF Fairford in support of Operation Epic Fury left the base to return to the US on 4 October. The move came following the arrest and release of five British nationals close to the base on suspicion of explosive offences a few day earlier. Two further men, including a dual British/Iranian national, were later arrested and also briefly bailed. A 6-mile radius area of restricted airspace has also been established around the base up to an altitude of 9,500ft. On 12 October, British PM, Andy Burnham accused Iran's Islamic Revolutionary Guard Corps (IRGC) of directing a suspected plot targeting the base. He described the incident as "highly likely to have been co-ordinated in Iran [and] almost certainly directed by Iran's IRGC."

AIR TRANSPORT

BA to roll out A380 cabin refurbishment

British Airways has unveiled a cabin refit for its 12-strong Airbus A380 fleet that will create "the world's largest business class deck," with 106 Club Suite lie-flat seats filling the entire upper deck across four zones. Every cabin gets new seats and interiors, with the other three cabins sharing the main deck. The reconfigured aircraft will seat 417 – 52 fewer than today – but premium seats rise from 166 to 202, while First Class shrinks from 14 suites to 12. Collins Aerospace supplies the First and Club Suites, with Recaro fitting premium economy and economy. BA says each aircraft's refit involves more than 35,000 individual parts, including redesigned galleys and stairways. The programme will run into 2028.

AEROSPACE



HyLight

Airship fleet to check powerlines

French autonomous airship developer, HyLight has raised £11m to scale up and industrialise its fleet of AI-enabled, hydrogen-powered airships to help inspect critical national infrastructure. The four 39ft-long HyLighter vehicles have already spent more than 750 hours inspecting thousands of miles of rail lines, power lines and gas pipelines. HyLight now plans to increase the fleet to 15, while expanding its automated AI-powered data analysis capabilities.

NEWS IN BRIEF

Yakovlev's Irkutsk Aviation Plant has begun construction of a shortened variant of the MC-21-310 airliner. The MC-21-210 will share the same wings, engine and cockpit as the larger variant but sacrifice payload for range. Expected to carry 140-150 passengers, the new variant is scheduled to make its first flight in August 2028. The second prototype of the all-Russian MC-21 – which substitutes Western components that became unavailable after sanctions with Russian-made elements – is now undergoing tests of its Aviadvigatel PD-14 engines.

Air France has shared the results of a large-scale contrail trial programme, covering almost 4,300 commercial flights operated over the North Atlantic between February and April of this year. The study found that 3% of flights accounted for 25% of the total climate impact associated with contrails. Using weather data, the researchers identified 130 flights with a high potential for climate impact, calculated alternative flight paths and rerouted them, reducing their contrail climate impact by 57% and avoiding the equivalent to 22,000t of CO^2.

Lockheed Martin has unveiled a new lower-cost interceptor missile for use against hypersonic and advanced missile threats. Based on the existing PAC-3, the new PAC-3 Edge is pitched at the US Army's Future Interceptor competition, with the company saying it will begin testing the missile in 2027 to prepare for rapid deployment by 2031 if selected.

On 28 September, NASA announced plans to fly Boeing's Starliner spacecraft on an uncrewed test flight to the ISS in either December or January but confirmed it has no plans to fly astronauts aboard the ship until mid-2028.

Vertical Aerospace opened a new aircraft assembly centre at Cotswold Airport (the former RAF Kemble) on 24 September. Situated alongside its Flight Test Centre, the newly built 60,000ft^2 facility will be used to assemble both production Valo aircraft and the firm's new hybrid-electric demonstrator – the latter

AEROSPACE

NASA teases return of the SR-71 Blackbird

In mid-September, NASA Administrator, Jared Isaacman cryptically teased plans for a new high- and fast-flying X-plane, showing a head-on illustration that looked very similar to the Mach 3 Lockheed SR-71 Blackbird, that last flew some 27 years ago. To add to the mystery, shortly after, *Aviation Week's* Steve Trimble reported that the SR-71 that had been on display at NASA's Armstrong Flight Research Center Museum at Ames for years had mysteriously gone missing in May – with retired engineers being approached about a secret restart. Isaacman has been vocal about the need to rebuild NASA's X-plane fleet and get "back in the business of flying high and fast again."

SPACEFLIGHT

UK's first national space debris removal mission



ClearSpace has been selected by the UK Space Agency (UKSA) to lead the UK's first nationally commissioned space debris removal mission. The UK Active Debris Removal mission (UK ADR) – planned for 2029 – will remove two UK-registered defunct satellites from low Earth orbit, demonstrating the ability to approach, capture and safely remove objects that were not designed for servicing.

DEFENCE



First medevac by drone

Ukrainian forces have made military history with the first combat medical evacuation of a wounded soldier by drone. The evacuation, in the Kupiansk sector of Kharkiv, saw an heavily injured soldier of the 30th Mechanized Brigade airlifted to safety by a heavy-lift hexacopter UAV.

AIR TRANSPORT

Saudia pilot killed and A320 destroyed in Riyadh

An airliner belonging to Saudi Arabian carrier, Saudia was destroyed during a Houthi missile attack on Riyadh's King Khalid International Airport on 8 October. The pilot of the aircraft, reportedly an A320, was among those killed during the attack by Yemen-based Houthi rebels. A series of follow-on raids over the coming days claimed the lives of 17 individuals and injured more than 300. Saudi forces hit back at Sanaa Airport in the rebel-held Yemeni capital as the Houthis warned airlines to avoid the area. Meanwhile, on 12 October, Riyadh Air announced the suspension of its flagship Riyadh to London and Manchester flights.

being a conversion of the battery-powered VA-1X that flew at this year's Farnborough International Airshow. Vertical plans to produce more than 25 Valos per year in the facility.

California-based Stratolaunch has acquired a Boeing 777-200ER to expand its fleet of carrier aircraft supporting the Talon-A autonomous, reusable, air-launched hypersonic flight test platforms. It joins the company's existing Boeing 747 and the unique Roc at its base in Mojave where it is being modified to launch the Talon-A from below its fuselage.

Bangladeshi national carrier, Biman Bangladesh Airlines has signed a firm order for four Airbus A350-900 widebody airliners and six A321neo single-aisle aircraft. The order is part of the Dhaka-based airline's fleet modernisation strategy and its ambition to expand its international network.

In an interview with French newspaper, *Les Echos* on 11 October, French Air and Space Force Chief of Staff, Gen Jérôme Bellanger, confirmed that the nation was accelerating plans to develop an independently designed sixth-generation fighter. The announcement came after the collapse of the Franco-German FCAS/SCAF programme with Germany, with France now pursuing a new type, designated the *Avion de Combat du Futur* (ACF). Bellanger suggested a proof-of-concept aircraft could fly in 2027, with work on an operational prototype to begin in 2029.

UK company, Skyrora has successfully completed a 45-second static hot-fire test of a scaled-down version of its Skyrora XL orbital launch vehicle. The test was conducted at Machrihanish spaceport on the west coast of Scotland.

A joint order for 50 De Havilland Canada DHC-515 firefighting aircraft is expected to be announced during the Canada-European Union (EU) summit in Montreal on 29-30 October. The details were revealed by *Politico Europe,* which claims sight of a draft speech to be given at the event. The DHC-515 has already been ordered by Croatia, France, Greece, Italy, Portugal and Spain, as well as Canada.

Radome

AIR TRANSPORT



Triple digit order for Avolon

Dublin-based aircraft financing giant, Avolon has placed a further firm order with Airbus. This latest purchase consists of 35 A330-900 and 75 A320neo family aircraft and takes its total order of the type to 114 and 650 respectively. It also announced a firm order for 140 Boeing 737 MAX aircraft, taking its entire firm aircraft orders to 749 across both OEMs.

GENERAL AVIATION

CAA report sets out approach to eVTOL noise

The UK CAA Civil Aviation Authority has published *Civil Aviation Publication: Managing Noise from Emerging Aviation Technology (CAP3304),* examining how noise from drones and eVTOLs could be assessed and managed. It highlights how they "may create different patterns of noise exposure from conventional aviation" because of their propulsion methods but also the likelihood of them operating closer to homes. It identifies priorities, including noise assessment, appropriate operating procedures and community engagement, as well as the systematic collection of data. The CAA warns that their acoustic character could prove more annoying than other noise sources at comparable levels.

DEFENCE

Europe studies strategic airlift options

The EU-funded European Defence Agency (EDA) has conducted a study of options for sustaining the continent's ability to transport outsized (100t plus) cargo by air. *The European System for Outsized Cargo Airlift (ESOCA)* study, published on 8 September as part of the Strategic Air Transport for Outsized Cargo (SATOC) project, identified the two most feasible options as a major modernisation programme for the Antonov An-124 fleet or the development of an entirely new aircraft to replace the three Boeing C-17s in use with NATO's Strategic Airlift Capability at Pápa Air Base, Hungary. Europe currently has access to five ageing An-124s run through NATO's Strategic Airlift International Solution (SALIS) agreement with Antonov Logistics.

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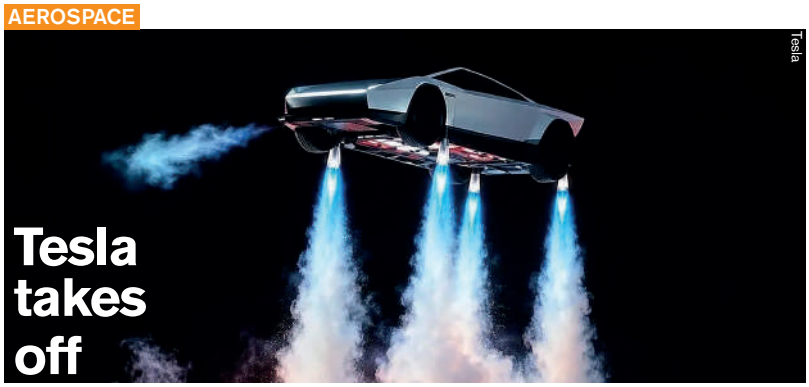


On 15 October, SpaceX engineers teamed up with Tesla to unveil a thruster-equipped sportscar. Two separate live stunts saw the new Roadster remotely driven up a U-ramp, flip over in the air, then land safely using its cold-gas thrusters – while another one saw it jump into the air with thrusters, roll 360° over vehicles and land on the other side. The stunt, based on SpaceX's thruster technology, saw the car tested for a year in secret using NASA-style lunar drop rigs before the live demonstration.

NEWS IN BRIEF

On 20 October, the US FAA awarded type certification to the much-delayed Boeing 737 MAX 10 during a visit by US Transportation Secretary, Sean Duffy to Boeing's Everett plant. Duffy said the certification followed "extensive safety reviews." Airlines have ordered nearly 1,500 MAX 10s, the largest in the MAX family, with around 31% of Boeing's outstanding 737 backlog for a jet originally launched in 2017 and due to begin deliveries in 2020.

Romanian Airbus A220 operator, Animawings has filed for insolvency, citing technical issues which have seen part of its fleet grounded. As part of a restructuring, the airline will dispose of the six A220s it has leased since 2024.

The UK MoD and QinetiQ has jointly launched Project Safari, opening up access to UK test and evaluation facilities for SMEs. By removing barriers to UK sites, the project aims to help new capabilities move from development to deployment quicker.

On 19 October, JAXA's Mars Moons Exploration (MMX) mission launched on board an H3-24L rocket. It will see a probe attempt to land on Phobos and return a sample to Earth.

ON THE MOVE

Vittorio Lorenzo Della Bella will replace Nathalie Tarnaud Laude as CEO of ATR from 1 November.

General Dynamics President, Danny Deep will take over as CEO on 1 January when Phebe Novakovic steps down after 13 years in the role.

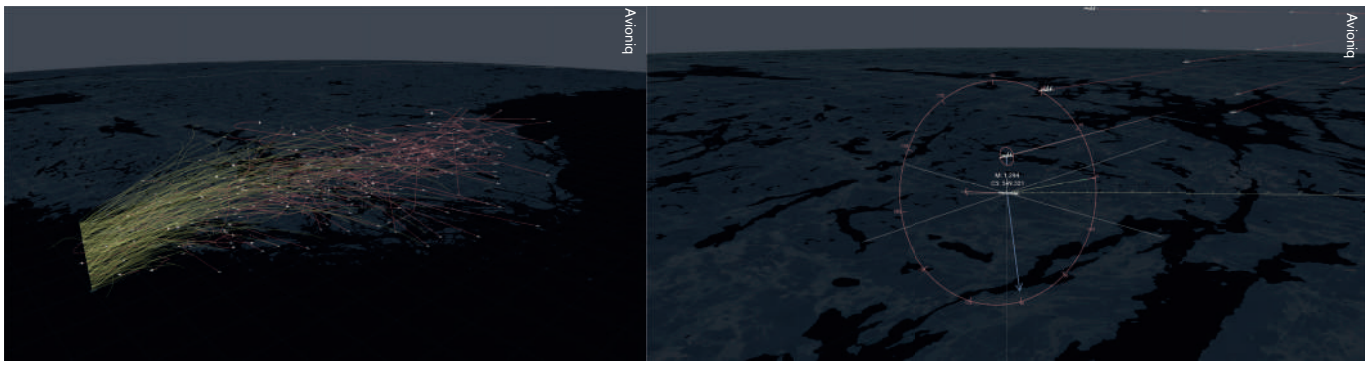
GA manufacturer, Tecnam has appointed Giovanni Pascale Langer as its CEO. He replaces his father, Paolo Pascale Langer, who assumes the position of President. His grandfather, Luigi, founded the company in 1986.

Matthias Spohr, previously Managing Director of Lufthansa Aviation Training, has joined Eurowings as Chief Operating Officer.

News Analysis

AI to hone the nugget's edge

Tim Robinson FRAeS



Left: A simulation of missiles shot from different heights (missile flight path tracked in yellow) against a hostile aircraft (aircraft flight path tracked in red). Right: close up – a missile is followed through its path (again tracked in yellow) against a targeted hostile aircraft part of a larger squadron (tracked in red).

In September the USAF announced that it would badge some 1,500 new pilots in fiscal year 2026 – a goal it has been chasing after to fill empty cockpits. Yet USAF Chief of Staff, Gen Ken Wilsbach named the tougher problem: "The challenge will be absorbing all those into line cockpits." How, then, can these rookies gain experience and knowledge quicker?

Some half a century ago, over the hostile skies of Vietnam, the USAF and US Navy found out the hard way what happens when perishable fighter pilot skills are left to wither and decay and new pilots entered combat without the right skills. The result was Red Flag and Top Gun respectively, with the former designed to provide simulated combat experience from the first ten missions. Survive those initial missions, and a pilot's chances of survival increase exponentially.

Today after more than 20 years of COIN operations against enemies without effective air forces, the problem has re-emerged. Air-to-air combat has been neglected by Western air forces, while threats, especially in the air defence and electromagnetic spectrum, have evolved and multiplied. With the geopolitical situation deteriorating fast, there is no time to be lost in getting fighter pilots trained for the front line.

However, this time around, rookie fighter pilots may have extra assistance of a synthetic kind, thanks to Avioniq – a company founded by two former Swedish AF fighter pilots. Mikael Grev, a Gripen pilot, who for 17 years wrote code at night, co-founded Avioniq in 2016 with his former squadron commander Stefan Wilson, and says: "We did AI before AI was cool."

One of its software products, Rattlesnaq, uses AI to give a 100hr 'newbie' pilot the situational awareness of a 1,000hr veteran aviator. Rattlesnaq is already operational on an unnamed Western type and uses high-fidelity models of threat missiles, weapons systems and radars to produce a vastly more accurate threat and EW display that is the equivalent of years of real-world knowledge. Running hundreds of missile simulations a second on the aircraft's own processors, it draws a continuously updated volume of sky in which the pilot cannot be shot down. Instead of the generic range rings and book numbers of enemy missiles, Rattlesnaq is able to provide a dynamic and highly granular picture of the battlespace – allowing the pilot to ignore invalid threats, react to the most dangerous ones and employ their weapons more effectively, increasing their situational awareness.

This is not just new symbology on a horizontal situational display – when Sweden's FOI defence research agency tested it, Grev says, BVR effectiveness rose by 200-300% "just by switching out the software on exactly the same aircraft." This decision support tool was trialled by BAE Systems in a Typhoon simulator last year. Avioniq calls its approach 'verifiable AI' where the small 'nuggets' of machine learning on narrow questions, each checkable, can be glued together. An appropriate analogy and name for AI that is designed to help turn fighter pilot nuggets into veteran aces as part of a wider team.

'Playing football without a ball'

The same models of high-fidelity missiles, aircraft and threats also power Haimdall – a beyong visual range (BVR) air combat training tool. Today, says Avioniq, when BVR training is undertaken it is similar to a football player kicking an invisible ball in the direction of the opposition's goal. It's "like playing football without a ball," says Grev, adding: "The first time you are going to hear a missile approach warner is when there is a real incoming missile, because nobody actually orders a training system for it that works."

Though today's instrumented ranges are a far cry from the hand-waving dogfight debriefs of yore and 'who shot who,' the issue of validating a virtual kill still remains. However, with high-fidelity threat modelling and tracking, Haimdall makes sure that every simulated missile shot in a live exercise settles who really killed whom. The result is more realistic and worthwhile training in this skill – one that is increasingly in focus given the lethality of long-range AAMs, as seen in Ukraine and the 2025 India-Pakistan aerial clash.

Summary

While these sorts of AI decision-support and training tools have, undoubtedly, applications and crossovers into autonomous CCAs, Avioniq is keen to stress that the age of the fighter pilot is not yet over. Air combat is "the easy bit," Grev says. Instead, rules of engagement, sovereignty and not starting the next war are the hard part, and no generalist AI is close. Wilson concurs, noting the end of the fighter pilot "might be, but not now," adding "Verifiable AI is a step on the way, but we are not there, maybe within the next 30 years."

By the Numbers

Understanding the world of Aerospace through data

AI takes the controls

How far has artificial intelligence spread through aerospace and defence? The latest surveys, budgets and company programmes in numbers.



RAeS/AI

Pushing the Envelope

Exploring advances on the leading edge of aerospace



Robert Coppinger

Biomimicry from the maple seed

Over the course of history, many aerospace projects have taken their inspiration from nature, from drag reducing shark skin riblets to winglets.

Now, researchers at the Singapore University of Technology and Design (SUTD) have taken biomimicry one step further and combined different lessons from very different species.

The researchers have created a single wing drone that takes inspiration from both the maple seed's principle of lift and birds' ability to fold their wings in flight. Another 'twin-wing' version could fly for more than an hour.

"I really like the efficiency and the sophistication of the maple seed," said Dr Shaohui Foong, a professor in engineering product development at SUTD. "The seed itself does not actually look very impressive, but it has a lot of engineering to it. For example, most of the seed is actually designed to generate lift."

Seeds take to the AIR

Foong has been the principal investigator for the SUTD Aerial Innovation Research (AIR) Laboratory. His team is exploring different methods of energy efficient flight and what he calls "multi-domain locomotion."

The single wing approach sees a flat, thin, asymmetrical wing – like a maple seed – spun, enabling it to be controlled for stable flight. In one of their papers, Foong and his researchers describe two systems for folding the wing in-flight: passive and active.

The passive system uses the centrifugal force from the spinning to unfold the wing, overcoming the restoring force of a coil spring. When the rotation speed slows, the spring's restoring force retracts the wing.

The active system uses an actuator to unfold and retract the wing.

Foldable Rotary Origami Wing

The researchers call one of their drones the Foldable Rotary Origami Wing (FROW) and according to Foong this active wingspan control, origami, offers better power efficiency and manoeuvrability. He sees these spinning wings as more energy efficient than the popular quadcopters, saying: "A quadcopter... has two rotors spinning in two different directions and they sort of cancel [each other out]. So you are effectively wasting energy. Here we actually utilise the spinning motion to its maximum advantage."

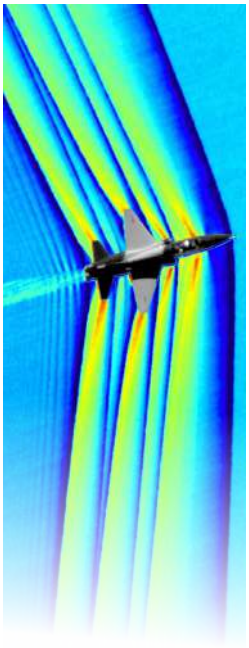
With the twin-wing actuated system, the wing can be extended and retracted independently of the rotation speed. While retracting the wing reduces the efficiency, Foong points out that this has the advantage of allowing the drone to access areas that would be inaccessible to other drones of a similar size.

While his team has achieved more than an hour of flight for one version, Foong thinks that endurance could be increased. They have been able to put a camera on a twin-wing variant and obtain useful images during what the researchers call 'omni-dimensional' surveillance.

The spinning can also create a useful optical illusion. Using a single strip of light emitting diodes, the SUTD researchers have used the illusion of persistence of vision. This is where the eye retains an image briefly and a light's repetition creates the illusion of a stable, stationary image for the viewer.

The use of a single-wing variant can also be applied to the capability of multi-domain locomotion. Foong envisages a maple seed like one-wing drone falling and landing on water, with the asymmetric wing becoming a sail. He and his researchers are also working on drones with an air and ground locomotion capability using just two propellers.

Mother nature has spent billions of years solving problems with energy efficient solutions – the machines that they inspire could be as strange as the strangest creatures that inhabit the Earth.



> THE SINGLE WING APPROACH SEES A FLAT, THIN, ASYMMETRICAL WING – LIKE A MAPLE SEED – SPUN, ENABLING IT TO BE CONTROLLED FOR STABLE FLIGHT

Transmission

ONLINE

The future of space

Response to 'As part of World Space Week, we explore the trends, innovations and challenges expected to shape the future of space and the opportunities that lie ahead for industry, academia and governments alike.'[1]

Marcin Podlasiak The future of space will not be shaped only by what we can launch, but also by how we rethink the materials and systems inside those missions. That is one of the questions I am exploring with OrbitHemp Lab: whether bio-based materials can find a role in the next generation of space infrastructure. As a designer and space outsider, I am especially interested in where unconventional ideas can open a new path.

When space goes dark

Response to 'From navigation and communications to intelligence gathering, satellites are deeply embedded in modern defence operations. What if those systems go dark?'[2]

Chris Bigwood FRAeS I found this a particularly interesting article, particularly the section that said: "Potential adversaries possess a spectrum of capabilities capable of interfering with space-enabled systems, including electronic warfare, cyber operations and jamming, directed-energy technologies, co-orbital systems and direct-ascent anti-satellite weaponry." I wonder, how advanced are we beyond what is in the media already?

Lawrence Ott FRAeS When GPS is compromised, the systems that maintain navigation, timing and comms continuity become mission-critical. Resilient, multi-sensor architectures are the future of assured positioning – especially as contested environments become the norm.

Shape of things to come



Response to 'Future of aerodynamics to be discussed at the RAeS Aerodynamics Conference on 16-17 November.'[3]

Harry Simpson It is definitely a career highlight to date to see the test I led last year at the European Wind Tunnel (ETW) on the front cover of the Royal Aeronautical Society's *AEROSPACE* magazine! Thanks Joe Coppin for providing such a photogenic model. Andrew Rae has pulled together a great article on challenges in aerodynamics, which we will be discussing in more detail at the conference. One such challenge is in predicting the aerodynamics of potential future configurations, such as the blended wing body concept. The SWiFT test at ETW last year made key progress in understanding the fundamental behaviour of these concepts at high Reynolds numbers. Future wing and airframe configurations feature in the ultra-efficient technology roadmap section of the ATI's Engineering Growth strategy document.

Doug Greenwell This will be a very useful event. RAeS President-Elect, Andrew Rae has raised some important challenges for the future of aerodynamics in the UK, which, to my mind, need to be addressed pretty urgently. I will be talking about measurement in the 'Measurement and modelling of complex flows' session.

Future flight sims

Response to 'What will be the flight simulation and training technology needed for the future flight decks of 2050?'[4]

Shannon Torres One piece I would add to the 2050 list is training that builds resilience alongside technical skill. Simulators are already good at rehearsing a failure. The next step is scenarios that help pilots recognise and manage stress, fatigue and cognitive overload in the moment, with debriefs that treat that as a trainable skill rather than a weakness.

Amir Khosh MRAeS Thanks to the RAeS team for hosting such a great Flight Simulation Conference. I really enjoyed the discussions and the opportunity to contribute alongside so many people from across the flight simulation community. Looking forward to next year!

Adaptive Capacity

Response to 'Mark Greenfield's article on Adaptive Capacity in pilot performance asks what happens when the plan stops working.'[5]

Christian Gleave FRAeS Can decision-making be augmented by technology? The role of a human and AI, especially in a crisis, is the same – to cross-check and verify actions. Augmenting a stressful environment with logically-reasoned options seems to be sensible mitigation to poor decision-making on both sides of the HMI algorithm.

Mark Greenfield FRAeS Automation and AI, undoubtedly, have the potential to augment decision-making, reduce workload and, importantly, help pilots recognise deteriorating situations earlier. However, there is an interesting paradox here. Automation may reduce the demands on a pilot during normal operations, while potentially making it harder to respond effectively when things do not go to plan. The critical issue is whether the technology genuinely preserves Adaptive Capacity or simply reduces the opportunities to exercise it. I think the real opportunity for AI is in recognising eroding margins and helping pilots make better, earlier decisions, rather than just taking more decisions away from them.

Steven Green FRAeS "Automation may reduce the demands on a pilot during normal operations, while potentially making it harder to respond effectively when things do not go to plan." I think this is a pivotal statement – also keep in mind that margins often need to be adjusted, as well as protected. What role does rationality play in adjusting margins? What about experience or instinct?

Mark Greenfield FRAeS Safeguarding margins does not mean treating them as fixed. Pilots must continually reassess them as circumstances change. Recognising when a margin is no longer adequate, and acting early enough to restore it, is a central expression of Adaptive Capacity. Rationality, experience and instinct are complementary, but are not equally accessible under pressure. Experience helps us recognise problems, rational judgement helps evaluate options, while trained instinct can provide an immediate response when startle compromises deliberate thinking. Of course, experience can also breed complacency, and instinct can be wrong!

Alexander Robinson There is a powerful theme in this article. The discussion around Adaptive Capacity highlights a challenge facing modern aircrew development. Mission success is not defined solely by aircraft handling. Increasingly, it depends on the ability to synthesise information, prioritise tasks, manage systems and make decisions while maintaining situational awareness under pressure. Developing those cognitive skills early and reinforcing them through integrated training environments that progressively increase complexity, may be just as important as teaching flying techniques themselves. The aircraft is the platform – the objective is building the cognitive capacity behind it.

Aerosociety Lates Quiz



Response to 'The fourth annual Aerosociety Lates Quiz was a success, with much hilarity over the 'is it a cheese or is it a flying machine' round as usual. We also asked AI to combine two aeroplanes to make a future Red Arrow!'

Mark Piesing 'Cheese or a flying machine' – what a round that was!

Guy Gratton It was tremendous fun – delighted that I was able to make it.

Sam Wise Not convinced by the AI round but more than made up for by the outstanding cheese course!

LETTERS

Evolution of Airborne Early Warning

I was interested enough in Paul Robinson's report in the October edition of *AEROSPACE*, on the Weybridge branch's lecture given by Prof Simon Watts, titled 'Early Warning Radar', to do some research into Airborne Early Warning (AEW).

In doing so, I discovered an article in the December 1983 edition of *AEROSPACE*, written by Wg Cdr David Greenway, titled 'AEW Shackleton Operations'.

This provided images of the aircraft that delivered AEW during the Cold War, including the Soviet Tupolev Tu-126 *Moss* (illustrated) and the US Navy's Grumman Hawkeye.

In particular, Wg Cdr Greenway – who was Officer Commanding 8 (AEW) Sqn – told the story of how the Avro Shackleton was brought back into service in the AEW role.

During my career, I worked for Plessey Radar in Addlestone in the 1970s, albeit in the Secondary Surveillance Radar (SSR) products section, as Chief Systems Engineer for several sites. We put SSR systems into sites in Eastern Europe, the Persian Gulf states, Central and South America and at Luton and Jersey airports.


US Navy

However, as Wg Cdr Greenway points out, because the Earth's surface is curved – and radar only works in straight lines – a ground-based radar will only detect approaching enemy aircraft flying at low level when it is too late to take any defensive action. His case for AEW in his article was very well put.

Ian Macfarlane MRAeS

"We asked AI..."


Tim Robinson/RAeS

Response to 'Aircraft designers – look away now! For the quiz we asked AI to merge two aircraft types to create a future Red Arrows mount.'

@Rotorfocus That was not even the worst of them!

@carlossnaps Did somebody describe a Red Arrows Hawk to an AI over the phone?

@AhamadNooh Oh wow, that hits in all the wrong places.

@CommandDevTeam It is not a million miles away from British Aerospace P.1233-1 Saba from the late '80s.

@Tim_Reid79 Is that the Boeing SkyFox?

@Glovergreen It is a Hawkhog.

@gevrekian_plane This is the A-10's long-lost cousin that A-10 does not want to talk about.

@SFbirding Where does the undercarriage go? The gun positioning blocks the nose gear and the underwing stores block the main gear. Although – to be fair – it is more symmetrical than most AI aircraft, which makes a pleasant change.

Germany in GCAP?

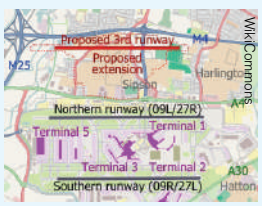
Response to 'As some warn that Britain's next-generation Tempest stealth jet faces years of delays if Germany is brought on board as a full partner, is it worth remembering that the core aircraft is only part of the GCAP systems of systems approach? Are there potential opportunities for new partners in combat cloud network, CCAs, etc?'

@eddaniel9464819 Which is exactly the role Germany has just rejected with FCAS. Reportedly 20-30% of the airframe plus leadership on the cloud, drones, etc – which is way more than GCAP can afford to give them.

@BeakerBate The only benefit I can see would be Helsing's involvement for its AI agents and CCA.

@MaxGoldingDa Germany's beef with France was workshare on the aircraft itself. Even if Germany could join as a Combat Cloud or CCA partner, they would have less than they left the French partnership for.

Heathrow's third runway

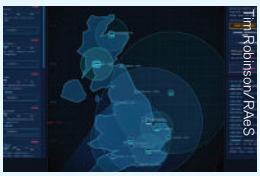


Response to 'PM refuses to endorse third runway at London Heathrow.'

@SpeedBirdEU Or we could just build a new airport where one does not sit in the hold for 20 minutes?

@JonA2i If a third runway is hard, imagine how much more difficult a new airport West of London would be? Wisley and Greenham Common were the great missed opportunities.

Britannia Shield


Tim Robinson/RAeS

Response to 'Earlier this year I 'vibe-coded' a UK air defence war game 2026-2040 in AI showing possible options/procurement (assumed % of GDP as per NATO goals). I might have to revisit it now with a £10bn Britannia Shield option.'

@paul_tremelling It will be a good exercise to model the potential outcomes of a £10bn injection into IAMD – and probably more complex than modelling the current (checks notes) nothing much. If one were good at defence one would be good across all pillars of IAMD.

@ArgusPlatformAI If you do decide to revisit the coding, I would advise you to log every assumption next to the budget line so readers can see what moved the end result. After all, spend levels get the headlines, but stockpile depth and reload rates usually decide how air defence options hold up.

Space is a drag

Response to 'DSTL Chief Scientist notes that satellites in LEO could be affected by geomagnetic storms.'[1]

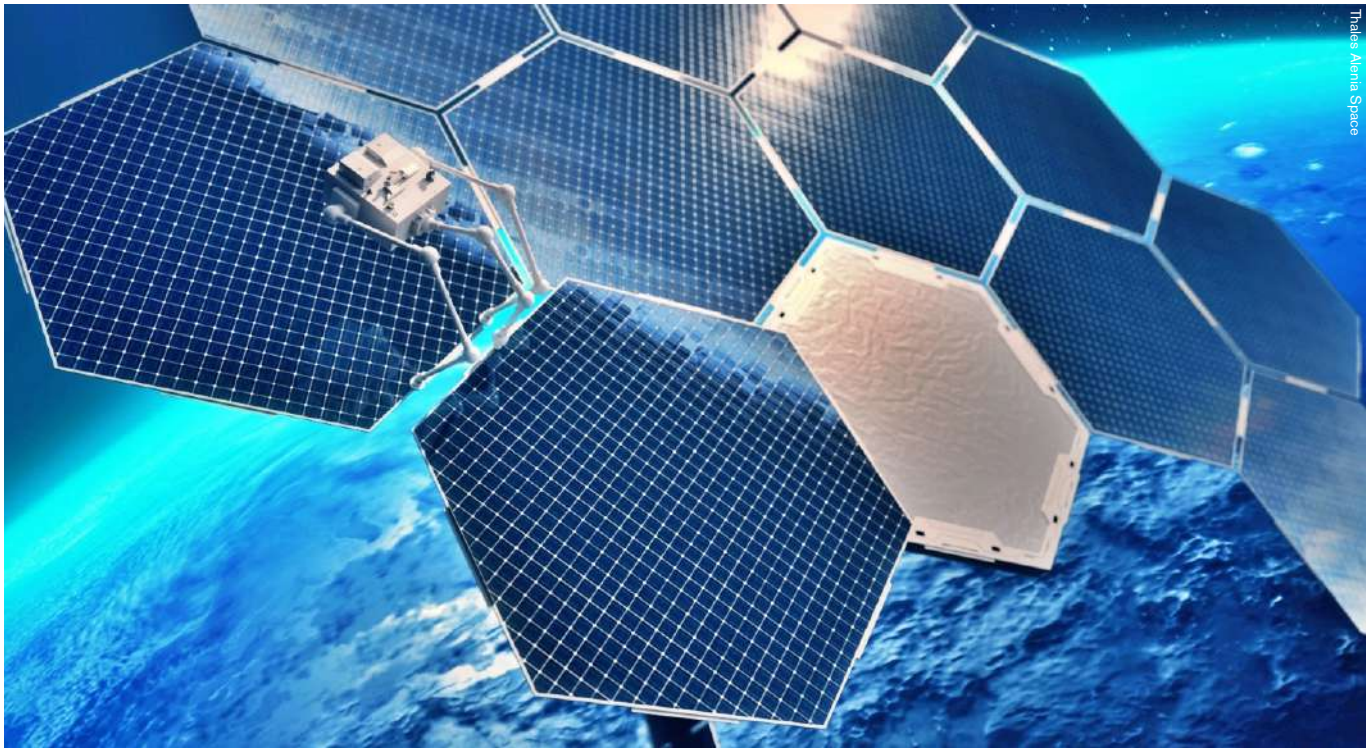
@CMETracker1 The main storm risk is drag. The upper atmosphere heats, swells and slows low satellites.

Deputy Editor wins Air Pilots Award

AEROSPACE Deputy Editor, Stephen Bridgewater FRAeS has been awarded the 2026 Hugh Field Memorial Award for Aviation Journalism by the Honourable Company of Air Pilots (HCAP). Presented "for an outstanding contribution to the promotion or public awareness of aviation," the award is named after prominent British aviation journalist, editor and test pilot, Hugh Field. After leaving journalism, Field managed public affairs for British Aerospace, successfully promoting the BAe 146 programme, and served as the Master of the Guild of Air Pilots and Air Navigators (GAPAN) – now HCAP – from 1980 to 1981.

The award was presented at the Guildhall in the City of London on 22 October. *AEROSPACE* Editor-in-Chief, Tim Robinson FRAeS received the award in 2020.

(1) aerosociety.com/news/securing-space/
(2) aerosociety.com/news/loss-of-signal-can-the-uk-fight-on-when-satellites-go-dark/
(3) aerosociety.com/news/go-with-the-flow-the-future-of-aerodynamics/
(4) aerosociety.com/news/the-big-questions-shaping-flight-simulation-in-2026/
(5) aerosociety.com/news/when-the-plan-stops-working/



Powering tomorrow

Are orbital data centres all hype or the next infrastructure revolution? Dr **ADAM E WHITE** FRAeS, from the RAeS Space Group, explores the challenges.

Data centres are now some of the most important infrastructures of the 21st Century. Invisible to most of us, they power AI, cloud storage, banking and streaming, and increasingly rank alongside roads and power stations as critical national infrastructure. What were niche facilities in the 2000s are now strategic assets underpinning modern economies.

That shift has sped up sharply over the last five years, driven by generative AI. Training and running large language models takes enormous computing power, and demand for data centre capacity has surged as a result. Governments and industry are now grappling with the consequences: data centres need cheap power, cooling, land and increasingly scarce grid capacity. Analysts expect global electricity use from data centres to more than double over the next decade as AI workloads grow, from around 415TWh today to roughly 945TWh by 2030 – comparable to Japan's entire electricity consumption.

This backdrop has pushed a once science fiction idea into serious commercial investment: orbital data centres (ODCs) – computing facilities in space rather than on Earth. Instead of warehouses full of server racks, hardware sits aboard large spacecraft in orbit, powered by solar arrays and linked to the ground via high-capacity networks.

The idea of 'compute from space' dates back decades – to at least the 1980s – but only recently has it moved from theory to commercial proposal. Several organisations are now seriously examining whether computing infrastructure can be deployed beyond the atmosphere – raising the question: are ODCs a genuine economic opportunity or simply the latest example of space industry hype?

Taking the headlines

ODCs have attracted growing media attention over the past two years, largely down to the combined growth of the commercial space sector and the rapid rise of AI. Much of that traces back – directly or indirectly – to Elon Musk and SpaceX. In a February 2026 podcast, Musk claimed: "In 36 months, the cheapest place to put AI will be in space." That January, SpaceX had filed a Federal Communications Commission (FCC) application for an "ODC System" of up to 1m satellites between roughly 500km and 2,000km altitude, and by June had released its AI1 design concept, built on Starlink's technology.

▲ Thales Alenia Space's orbital data centre concept forms part of its (Advanced Space Cloud for European Net zero emission and Data sovereignty) feasibility study. It features modular hexagonal solar panels and robotic assembly systems with findings suggesting such space-based infrastructure could potentially reach operational scale around 2036 and target up to a gigawatt of capacity before 2050.

Launch costs were historically an almost insurmountable barrier to putting significant computing infrastructure in space. However, SpaceX's reusable launch vehicles have cut those costs dramatically, encouraging entrepreneurs to revisit ideas once considered economically impossible. Declining launch costs, rising demand for computing power, energy concerns and growing confidence in large-scale space infrastructure are all converging at once.

Several other companies and government-backed initiatives are now exploring orbital computing platforms, mostly well-funded US start-ups, such as Starcloud, Orbital and Cowboy Space Corporation (formerly Aetherflux). In June 2026, Orbital filed further plans with the FCC for 100,000 satellites, while Starcloud has already flown a high-end NVIDIA AI GPU in orbit. Activity is not confined to the US, though. In the EU, the ASCEND (Advanced Space Cloud for European Net zero emission and Data sovereignty) project helps lead the co-ordinated EU effort, and some companies have also demonstrated AI computing with AI chips in space, such as D-Orbit.

China has also rapidly emerged as one of the leading nations pursuing ODCs, taking a co-ordinated, state-backed approach rather than relying on start-ups. In 2026 it announced a space-based AI computing programme spanning satellite manufacturers, AI firms, chipmakers and launch providers.

The technical challenges

Are ODCs technically possible? In a sense, it has already been done – a satellite is essentially a computer with a payload attached. However, building one at scale presents formidable engineering challenges.

The most obvious challenge is getting the hardware to space. Modern data centres contain thousands of servers plus extensive networking, cooling and power distribution equipment. Even with future heavy-lift vehicles, moving that much equipment into space will remain expensive and complex.

Conventional server hardware is not designed for launch environments either. Components must survive intense vibration, acoustic loading and acceleration during ascent, so equipment may need redesigning or ruggedising, adding cost.

Cooling may be the single greatest technical challenge. On Earth, data centres lean on air conditioning, liquid cooling loops and the atmosphere itself to shed waste heat.

In space there is no atmosphere to dump heat into, so orbital facilities must radiate it away instead – needing radiator surfaces spanning hundreds or thousands of square metres.

Space being cold is beside the point – with no surrounding medium to absorb heat, cooling in orbit is often harder than on the ground, not easier. As computational density rises, thermal management gets more critical.

> SUCCESS MAY NOT HINGE ON OUT-PERFORMING GROUND-BASED FACILITIES ACROSS THE BOARD, BUT ON OFFERING CAPABILITIES UNIQUE ENOUGH TO JUSTIFY THE COST

Electronics in orbit are exposed to ionising radiation from solar activity, cosmic rays and particles trapped in Earth's magnetosphere. This radiation can cause temporary upsets, corrupt data, degrade components and shorten operational life. Radiation-hardened electronics are routinely flown on spacecraft but lag behind commercial hardware on performance and cost far more. Future ODCs will likely need sophisticated fault-tolerant architectures to stay reliable under constant radiation exposure.

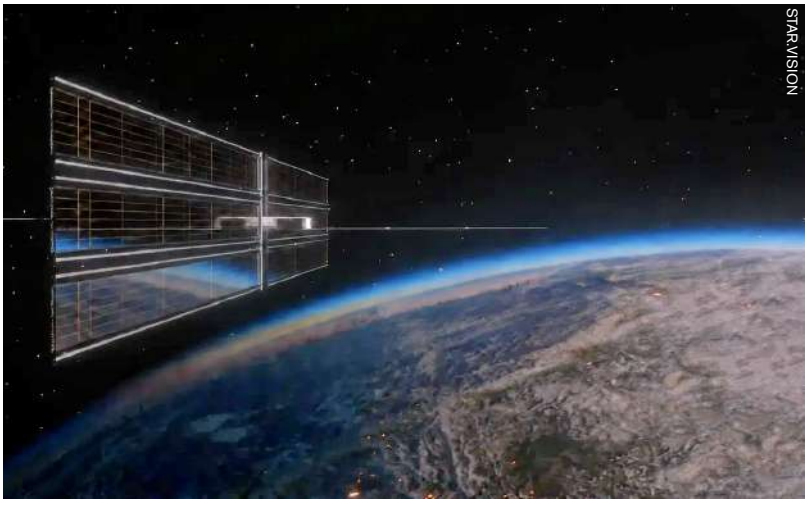
Terrestrial data centres require continuous maintenance: failed components are swapped out within hours and upgrades happen routinely and at scale. An orbital facility offers no such luxury. Designers would need extensive redundancy, autonomous fault management and possibly robotic servicing. Future spacecraft may eventually swap failed modules, but that technology remains immature.

The mismatch is fundamental: modern data centres assume frequent hardware replacement to keep up with advances in chip technology, while spacecraft are traditionally built to run for years with minimal intervention.

A data centre is only useful if people can reach it quickly. Orbital facilities would need extremely high-capacity links capable of moving vast data volumes between space and Earth. Radio frequency alone may not suffice, pushing reliance towards optical communications. Such laser communications are advancing fast, but globally available, low-latency connectivity is still a significant challenge.

Making it practical

Even if the technical barriers can be overcome at scale, economics are likely to determine whether ODCs ultimately succeed. Their financial model differs fundamentally from that of terrestrial data centres.



▼ In total, 1,080 G3 satellites will form part of China's 'Space String' computing constellation. Proposed by STAR.VISION, it is envisioned to provide space-based orbital AI and computing infrastructure via laser communication links to form an orbital supercomputer. Initial launches are planned starting in late 2027.



Kepler


Orbital

ODCs require substantially higher upfront capital investment, but this is offset by significantly lower operating costs over their lifetime. In effect, orbital data centres shift much of the expenditure from ongoing operational costs to upfront capital expenditure.

Launch costs have fallen dramatically, but they are still orders of magnitude higher than moving equipment by road or rail.

A terrestrial data centre can be built using mature supply chains, standard construction and commercially available hardware. Every kilogram launched into orbit carries a substantial cost premium – and space-qualified hardware adds further to the bill. The economic case rests on orbital facilities offering advantages unique enough to justify the expense.

Space remains a high-risk environment. Launch failures, spacecraft malfunctions, radiation damage and orbital debris introduce risks terrestrial operators rarely face, and insurance premiums could become a significant operating cost.

Perhaps the most important economic challenge is also the most easily overlooked: terrestrial data centres are not standing still. Advanced liquid cooling, small modular nuclear reactors, renewable integration and increasingly efficient processors are all improving ground-based economics. ODCs must compete not against today's infrastructure, but against the ground infrastructure of the 2030s and beyond.

The growing congestion of low Earth orbit (LEO) adds further operational and economic challenges. Operators must meet stringent debris mitigation rules while maintaining robust collision avoidance – and even then, collisions and further debris remain a real concern, risking disruption to other spacecraft and adding to long-term orbital hazards.

Large ODC constellations would also worsen the impact of existing large satellite constellations on astronomy – more bright streaks across optical observations, more potential radio-frequency interference with sensitive observatories. Low-reflectivity designs and careful spectrum management can help, but balancing commercial ambition against the night sky will not be easy.

ODCs will also need reliable end-of-life disposal, including dedicated deorbiting capability – adding further cost and complexity across the system's life cycle.

▲ Left: Axiom Space and Kepler Comunications plan to offer two ODC 'nodes' that will be used to process data from Earth-observation satellites, using complex AI and machine-learning algorithms.

Right: A conceptual rendering of an ODC, developed by the US-startup Orbital. It will use space-based solar power and passive radiative cooling to process AI workloads. The first test mission, featuring NVIDIA chips, is planned for 2027.


Cowboy Space Corporation

◀ Founded in 2024 by Baiju Bhatt, Cowboy Space Corporaton initially focused on beaming power from space to Earth using lasers but has now pivoted to developing ODC and launch vehicles designed to integrate data centre payloads directly into rocket upper stages.

▶ Starcloud and NVIDIA plan to build a 5-gigawatt ODC and have contracted space construction company Rendezvous Robotics to assemble it in orbit.

The regulatory landscape

Space regulators have spent decades licensing satellites, not orbital industrial estates full of processors and communications equipment. ODCs sit at the intersection of space operations, telecommunications and digital infrastructure – regulatory territory that existing frameworks were never designed to cover. As with most new technology, it is outrunning the regulatory environment, and governments may eventually need new frameworks blending space law, telecommunications regulation and digital infrastructure governance.

Operators would need radio spectrum, orbital resources and international links, facing scrutiny over cyber-security, data sovereignty, export controls and handling of sensitive information. Working out which laws even apply to data processed in orbit may prove surprisingly complex.

There is a broader policy challenge too: large computing constellations could add to congestion in valuable orbital regimes, raising concerns around long-term space sustainability. Regulators are already grappling with existing satellite constellations; ODCs would add another layer of complexity.

Where does the future of AI lay?

ODCs sit in an intriguing spot between visionary ambition, engineering reality and, above all, economics.

The concept has genuine advantages: continuous solar power, physical isolation, reduced dependence on terrestrial infrastructure and resilience against certain kinds of disruption – but the challenges are just as real.

Launch costs, thermal management, maintenance complexity, communications constraints and economic uncertainty are formidable obstacles. On balance, this is currently a finely poised case, not a clear-cut one.


CASC

▲ A Long March 2D rocket lifts off from Jiuquan in May 2025 carring satellites for China's Three-Body Computing Constellation. The programme will see 2,800 satellites use high-speed 100Gbps inter-satellite laser communications to perform 1,000 peta operations per second (POPS). The units will harness space's cold vacuum to assist with natural thermal cooling for its dense processing workloads.


Rendezvous Robotics

Near term outlook

In the near term, ODCs will not replace terrestrial facilities. Ground-based infrastructure remains far more economical, easier to maintain and better suited to most computing workloads.

As launch costs keep falling and orbital infrastructure matures, the idea will edge closer to reality – though whether it becomes a transformative industry or stays a niche application depends on technology still emerging. Given SpaceX's continued ambition for large-scale ODCs, alongside others chasing the same goal, this author would not rule it out.

Perhaps a more plausible mid-term future is a hybrid model: not a replacement for data centres on the ground, but an extension of the wider global and now (Planetary-and-beyond) digital infrastructure ecosystem. Specialised applications – Earth observation processing, defence systems, satellite network management, high-value scientific computing – may increasingly move into orbit, cutting bandwidth needs by processing data closer to its source. Other tasks, such as large batch processing jobs (training a large language model, for instance), do not need high-availability low-latency communications so may be better suited for ODCs.

Success may not hinge on outperforming ground-based facilities across the board, but on offering capabilities unique enough to justify the cost.

For aerospace professionals, one thing is clear: the debate is not about whether computing at scale can be placed in orbit anymore. It is about which computing tasks belong there.

Freight expectations

With AI in aerospace evolving at pace, **DOMINIC WARD** looks at its use in air cargo operations.



◀ Fully digital cargo is one step closer with AI-freight ops integration.

As AI continues to shape our lives, one way in which we as consumers have been impacted by the technology – consciously or subconsciously – is the way it interacts within air cargo operations.

On 8 October, *Air Cargo News* reported that AI-related shipments have driven an increase in air freight. Trade across materials that enable AI "drove 42% of goods trade growth in 2025," it said, "and this share rose to 76% during the first quarter of 2026, according to WTO and OECD [Organisation for Economic Co-operation and Development] analysis."

Curiously, however, despite carrying AI-enabled products, the air freight industry itself is still trying to assess how best to utilise the technology across its own operations.

In March 2026, IATA took a step forward by announcing AI initiatives to support air cargo – which included launching an "AI Subject Matter Expert (AI SME), a mobile and web-based application that helps operational teams quickly find information in IATA cargo and safety publications by asking questions in plain language."

IATA also launched the Air Cargo AI Excellence Hub, which it said will "[bring] together airlines, ground handlers, freight forwarders, technology providers and regulators to support the orderly integration of AI in air cargo."

At the time, IATA's Global Head of Cargo, Brendan Sullivan, said: "The scope for AI to accelerate air cargo's digital transformation is enormous. Together, these initiatives will help to make the most of AI's potential with an industry adoption that is consistent, interoperable and aligned with global aviation standards. Importantly, we will learn from these initiatives to identify additional areas where standards, technological innovation and collaborative development can enable safer, smarter and more efficient operations."

Early adoption

That said, the use of AI in cargo operations has been present for a few years – before IATA's assessments of how best to aid its implementation.

In May 2023, Etihad Cargo announced it was implementing Singapore-based Speedcargo Technology's Amplifi, Cargo Eye and Assemble products following a successful trial period – two years after the carrier entered into a proof-of-concept agreement with the tech firm. Etihad said at the time that the products would "boost efficiency, digitise and standardise cargo handling across Etihad Cargo's network, and enhance service levels for the carrier's customers and partners."

In 2025, Lufthansa Cargo rolled out AI across its shipment booking system, allowing for a simplified,



> WHILE AI CAN EXPEDITE PROCESSES, IT STILL RELIES ON THE FUNDAMENTAL ELEMENTS TO BE COMPLETED BY A HUMAN AND TO BE CORRECT – OTHERWISE THE SYSTEM CANNOT PERFORM OPTIMALLY

▼ AI can optimise an aircraft's loading and unloading – allowing for shorter turnaround times and more freight to be carried per sector.



streamlined process. Then, in June 2026, Taiwan-based China Airlines launched an AI customer service platform aimed at giving "cargo owners and shipping agents... around-the-clock support."

By September 2026, Ethiopian Cargo announced a partnership with another Singapore-based tech firm, CargoAi, to power its digital booking platform.

AI, then, has been around in air cargo operations for longer than some may realise.

Optimis-AI-tion

For carriers, however, AI performs more functions than purely that of a chat bot for customer service. Instead, it can take duties typically performed manually by humans and process the results at pace.

Through AI software, operators can perform functions such as demand forecasting, cargo condition checking and capacity management – leading to optimised service levels on the ramp and in the warehouse.

Optimisation is not just limited to the ground, however. Flight planning also benefits from AI by monitoring and assessing airspace closures and restrictions, weather or any other matter that would disrupt operations – alongside AI solutions fitted to individual airframes for in-flight systems monitoring and fault detection. All of this leads to better visibility for cargo handlers. Providing a snapshot overview of where a pallet is, its condition, location and arrival time can expedite loading and unloading processes, leading to shorter turnaround times and the ability to carry more freight.

Limitations

Despite its varying range of benefits, AI still only works when there is a human-in-the-loop element applied – and freight operations are no exception.

New York JFK-based DelEx Air Cargo explained in a post on its LinkedIn page how the basics of air cargo still apply, saying: "A shipment still needs accurate paperwork. Cargo still needs to meet airline and TSA requirements. Labels, weights, dimensions, consignee details and commodity descriptions still need to be correct. Cutoff times still need to be followed.

"AI can support the process, but it cannot fix a shipment that was poorly prepared from the start.

"That is why human review, compliance knowledge and hands-on coordination remain critical in air freight."

While AI can expedite processes, it still relies on the fundamental elements to be completed by a human and to be correct – otherwise the system cannot perform optimally.

Freight logistics software company, WiseTech Global, suggested in a blog post on its website that AI's use across air cargo starts with a "single source of truth," adding "for AI to deliver meaningful results, it needs access to accurate, timely and trusted information. But in air cargo, shipment data is often created, managed and exchanged by multiple parties across different systems. Information can be duplicated, manually re-entered, translated and reconciled throughout a shipment's lifecycle, creating inconsistencies that reduce efficiency and limit opportunities for automation."

The industry has been using electronic Air Waybills (eAWB) for several years. An eAWB is a digital replacement for the traditional paper waybill, meaning operators no longer have a need to print, handle or archive material – "simplifying the air cargo process," in the words of IATA.

Taking this one step further, in January 2026 IATA rolled out its ONE Record platform – which it says is "one step closer to digital cargo." ONE Record, says IATA, is an "API-based [Application Programming Interface] standard designed to enable seamless, transparent and event-driven data sharing across all air cargo stakeholders."

It adds the technical standard is composed of:

- A common data model for air cargo that facilitates data integration with existing and new data services.
- An API specification that details how airlines and their partners can easily connect their systems with each other.
- A security specification that ensures data privacy and confidentiality for all parties.

While ONE Record takes the eAWBs of yore one step further, crucially it sets the foundations for the future of digital cargo. Said IATA: "ONE Record creates the foundation for true digital air cargo where airlines, their partners and service providers can develop collaborative and automated digital services and welcome a new generation of digital savvy air cargo innovators."

Cargo – connected

Elias Hatzigeorgiou, WiseTech Global Senior Product Manager, explained in a blog post how the future of AI in air cargo operations is not necessarily governed by who will adopt AI systems first, but who creates platforms which can deliver trusted information.

Hatzigeorgiou thinks ONE Record is a great starting position: "Standards like ONE Record provide the digital foundation for the future of AI in air cargo.

"By establishing a common data language and enabling a single source of truth across the supply chain, the industry is unlocking new opportunities for automation, intelligence and collaboration. This is a critical step toward a more connected, agile and resilient air cargo ecosystem."

AI, then, has the potential to shape and streamline the way in which the air cargo sector operates – but needs widespread support and adoption to deliver. No longer *avant garde*, it is now in a transitional phase to deliver real-world results.

A world with truly digital cargo is almost upon us.



The human in the loop

As AI moves deeper into air warfare, a human operator is often presented as the ultimate safeguard – but, as **LUCA LEONE** FRAeS, Vice-Chair of the RAeS C3 Specialist Group, and **MATT POWLSON**, CEO of BlueWorks Engineering, explore, a human who cannot independently challenge the machine may add delay while creating false assurance.

Picture the scene. An air-defence operator is presented with a recommended response to a fast-closing threat. The system has already fused the sensor data, classified the contact, assessed the risk and selected an engagement option. The operator has seconds to approve or reject it.

They approve

Formally, a human has remained in the loop – but did the operator assess the evidence and make the decision, or simply validate a conclusion reached by the machine? If their intervention delayed the response without improving it, did the human safeguard increase safety or reduce it?

The comforting promise of human control

The phrase 'human-in-the-loop' is often used to suggest that militaries can exploit the speed, scale and analytical power of AI while retaining human judgement as the final safeguard. Yet it



▶ Operators who rarely disagree may either be working with an exceptionally accurate tool or may have stopped forming an independent view entirely.

◥ In February, a US air strike hit a primary school in Iran, killing more than 150 people. Public reporting suggests that outdated targeting data contributed to the strike.


USAF


Iranian Red Crescent


USAF

is an architectural description, not evidence that meaningful judgement has taken place.

The same challenge arises across safety-critical systems that use AI to interpret information, recommend actions or operate within human-defined constraints. AI, automation and autonomy are not interchangeable, but each can alter what the human sees, when they are expected to intervene and how much genuine discretion they retain.

Human involvement is not cost-free. In operations conducted at machine speed, requiring approval introduces delay. That delay is justified where the operator adds context, detects error or considers consequences the system cannot, but if the operator routinely accepts the recommendation or cannot assess it independently within the available time, the human may add latency without adding safety. The choice is not simply between human and machine control. Human control can sit at different points: approving each action, setting objectives and constraints, determining rules of engagement, supervising performance or deciding when autonomy may be used. The relevant question is where human judgement adds positive value – and whether that contribution has been demonstrated under realistic conditions.

For policymakers, the critical question is not simply whether a human remains in the chain, but whether that human retains genuine, demonstrable control over the outcome.

The human fallback

The most dangerous form of skill fade is not simply that an operator becomes less capable. It is when the operator, the organisation and the wider system continue to operate on the assumption that the capability remains reliably available.

As automated systems appear more capable and reliable, humans perform fewer of the underlying tasks themselves. They may remain trained, qualified and formally responsible for intervention, but have little opportunity to practise taking control under realistic conditions. Their declared competence can, therefore, remain unchanged while the practical skills needed to intervene gradually atrophy.

Human intervention is most likely to be required when the situation is complex, ambiguous or outside the system's expected operating envelope. The operator may, therefore, need to understand a rapidly changing situation, rebuild situational awareness and act precisely when the task is hardest.

The loss of Air France Flight 447 remains a warning from civil aviation. When the aircraft's automation disengaged, the pilots struggled to diagnose the situation and respond appropriately. This particular accident is commonly cited in discussions of the 'out-of-the-loop' performance problem: human supervisors can experience difficulty in rebuilding situational awareness and resuming effective control after prolonged reliance on automation.

It should not be reduced to a single cause, but it shows why the effectiveness of a human fallback cannot be assumed.

Skills normally progress from conscious recall, through repeated practice, to rapid and largely automatic performance.

When a task is rarely performed, that process can reverse. An experienced operator may still remember the procedure but no longer execute it effectively under pressure.

This creates an important distinction between three forms of competence:

- Declared competence: what qualifications, training records and procedures say the operator can do.
- Demonstrated competence: what the operator can achieve during realistic testing.
- Recoverable competence: what the operator can do immediately when a changing situation demands intervention.

Only the third provides a credible operational fallback, because at the pace and complexity of modern air warfare the operator may have only seconds to understand the situation, challenge the machine's judgement and act effectively.

The risk is, therefore, not merely skill fade, but latent skill fade: a hidden gap between assumed and actual capability. Doctrine, safety cases and rules of engagement may continue to rely on the human as the final safeguard while the ability to perform that role quietly erodes. The organisation may, only when it is needed, discover that the protection expected of the human fallback no longer exists.

From oversight to habitual approval

Even where an operator retains the skill to intervene, meaningful oversight can fail if they have become conditioned not to use it.

Automation bias is the tendency to favour recommendations from automated systems even where contradictory information is available. The risk is likely to grow as AI systems become more capable, reliable and embedded in routine decision-making.

If a machine provides hundreds of correct recommendations, the operator learns that approval is usually the quickest and safest response – and may consciously or unconsciously begin to doubt the need to intervene. Independent scrutiny becomes confirmation; confirmation becomes habit.

The human remains formally in the loop but may be doing little more than completing the machine's workflow. This creates three distinct levels of involvement:

- Authorisation: the operator approves the action.
- Verification: the operator checks the recommendation against the available evidence.
- Judgement: the operator forms an independent view and is genuinely capable of disagreeing.

A final approval may demonstrate only the first. System design can shape the operator's behaviour as much as the underlying algorithm. A display that presents one course of action prominently while placing uncertainty, rejected alternatives or conflicting evidence out of view is not simply informing the operator. It is framing the decision and steering the human towards agreement. The more polished and persuasive the recommendation, the greater the risk that confidence of presentation is mistaken for confidence of evidence.

The consequences of getting this wrong can be devastating. On 28 February 2026, a US strike hit the Shajareh Tayyebeh Primary School in Minab, Iran, killing more than 150 people, most of them children. Public reporting suggests that outdated targeting data contributed to the strike. Advanced AI tools were being used across the wider campaign, although their role in this specific decision has not yet been publicly established.

The reference is not to claim that AI alone caused the tragedy but rather demonstrate that faster decision-making can also accelerate the consequences of bad information. If data is stale, absent, wrongly classified or insufficiently challenged, speed does not make the decision safer. Nor does human approval provide meaningful protection if the operator assumes that the underlying information has already been checked. In those circumstances, an old error can pass through a modern system with greater speed and greater apparent authority.

Trust must, therefore, be calibrated and earned, rather than maximised. Interfaces should, by design, expose the system's evidence, confidence, uncertainty and missing information. Training and operating culture must also support challenges, rather than treat disagreement as operator delay, inefficiency or error.

The challenge for systems assurance is proving that the operator is not merely present but retains the agency to recognise when the machine may be wrong and to stop or redirect it.

The dependency spiral

Skill atrophy and habitual approval are not separate risks but may actually reinforce one another.

As the machine becomes more reliable, the operator has fewer reasons to question its recommendations and fewer opportunities to perform the underlying task independently. Reduced scrutiny leads to reduced practice, weakening competence and confidence. As confidence in human judgement falls, reliance on the machine grows further. The result is a dependency spiral:

High machine reliability ▶ habitual approval ▶ reduced independent practice ▶ skill atrophy ▶ greater dependence on the machine ▶ still less willingness to challenge it.

This creates a difficult assurance problem. The system may appear to perform well precisely while the human contribution is deteriorating. High approval rates, rapid decisions and few interventions can be read as evidence that the human-machine team is working effectively. The same indicators may also show that the operator is becoming passive.



▼ The interior of General Atomics Aeronautical Systems Block 50 Ground Control Station, used for piloting uncrewed aerial vehicles such as the MQ-9 Reaper





Reliable Robotics

▲ The cockpit of Reliable Robotics' Cessna 208B Caravan during its first uncrewed, remotely-supervised flight at Hollister Municipal Airport in California in 2023. The aircraft can taxi, take off, fly, and land autonomously while supervised by a remote pilot on the ground

An operator who rarely disagrees may be working with an exceptionally accurate tool, or may have stopped forming an independent view. An operator who never takes control may have no need to do so, or may no longer be ready when the situation demands it.

The human safeguard can, therefore, erode while every visible indicator appears positive. The central assurance question is not simply whether human control exists at a particular moment, but whether the design, training and operation of the system preserve that control over time.



Designing and demonstrating meaningful human control

Meaningful control must be designed into the system before it can be tested. However, that does not mean a human should remain in every immediate decision loop by default.

Where an operator is expected to provide oversight, the interface must supply the evidence, uncertainty and alternatives needed to form an independent view.

The wider system must preserve relevant skills, allow sufficient time and give the operator practical authority to intervene. That contribution must be real and demonstrable under the appropriate conditions.

There will also be situations in which human approval adds delay without adding judgement, safety or operational value. If the operator cannot assess the recommendation within the time available, routinely approves it without scrutiny, or is less reliable than the automated system at that task, retaining the approval step may make the system worse rather than safer.

The allocation of control should, therefore, be task-specific and decided in context. It should reflect comparative human and machine performance, the time available, the clarity of the operating envelope and the severity, visibility and reversibility of error. Human control may be better placed outside the immediate loop: in setting objectives and constraints, authorising deployment, establishing rules of engagement, supervising performance and deciding when autonomy may be used.

Moving the human out of an immediate decision does not remove human responsibility. Accountability must remain clearly assigned to those commanders, operators, designers and institutions across the system's life cycle.

Neither humans nor machines are infallible. The relevant comparison is not between a perfect human and an imperfect algorithm, but between their real performance, individually and together, under operational conditions.

That allocation must then be tested across realistic workloads, time pressures, stale or manipulated data, and confidently incorrect recommendations. Assurance should examine model accuracy and decision speed, but also missed interventions, unnecessary delay, quality of judgement, skill retention and the consequences of both human and machine error.

The aim is not to prove that a human was purely present. It is to demonstrate that responsibility has been placed where it improves the performance, safety and accountability of the system as a whole.

The human must be able to change the outcome

Human involvement is not automatically a safeguard, just as autonomy is not automatically unsafe. Either may improve or degrade performance depending on the task, system design and operational context.

'Human-in-the-loop' should, therefore, no longer be treated as the default answer. Where humans are retained in the immediate loop, they must have the competence, independence and authority to change the outcome.

Where they cannot add positive value, we should be prepared to redesign the relationship or, where the evidence supports it, remove them from that immediate decision.

The test is not whether control is labelled human or machine. It is whether the system, as a whole, is safer, more effective and genuinely accountable.

Post-certification learning for AI systems

Artificial intelligence systems that are intended to provide an equivalent – or better – level of safety to that of a human pilot are on the cusp of being certified in aircraft, with the expectation that they will enhance aviation safety by reducing/eliminating pilot errors. **ROBERT JOSLIN** FRAeS, Associate Professor at Embry-Riddle Aeronautical University reports.

In its Roadmap for *Artificial Intelligence Safety Assurance*, the Federal Aviation Administration's (FAA) definition of AI encompasses "implementations of fixed and deterministic algorithms" – Learned AI – and "implementations that continue to change through learning in the operational environment" – Learning AI.

The bulk of aircraft certification ground and flight tests involve rigid predetermined scripted scenarios and manoeuvres in a controlled environment, which can be easily learned by an AI system through deterministic algorithms. The final stage in the certification process for civil or military aircraft, called Function & Reliability Testing or Operational Test & Evaluations respectively, is anticipated to be when AI systems will be afforded an opportunity to learn in a dynamic unpredictable operational environment.

However, in its current form, this operational testing is short in duration and, therefore, not exhaustive enough to involve all potential environments and situations. Consequently, the AI learning period will have to continue once the aircraft is fielded and conducting real-world operations in uncertain environments and unforeseen situations.


Joby Aviation

▲ In September 2026, Joby Aviation flew an AI-equipped Cessna Caravan autonomously (with a safety pilot onboard) across the US to demonstrate the maturity of its technology.

Environmental uncertainty

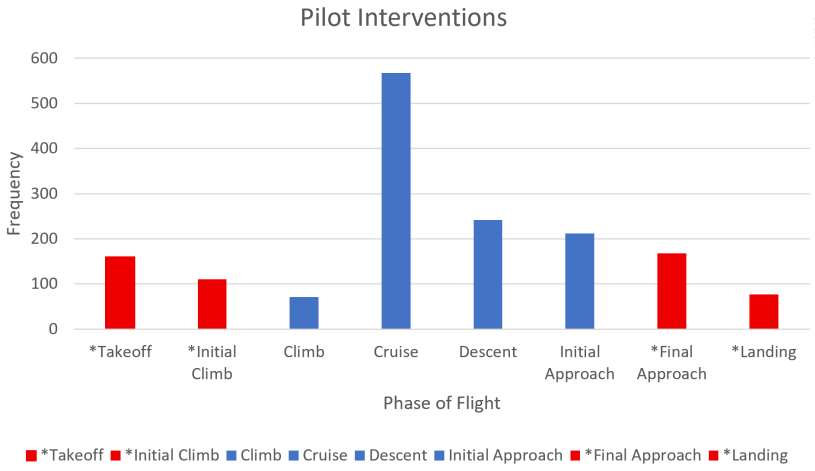
An uncertain environment is when there is a lack of information about the environment that results in uncertainty about the outcome, for instance consequences, as well as uncertainty about the probability of a certain situation occurring in that environment.

An unforeseeable situation is one that could not have been reasonably expected to be anticipated or known about beforehand. Reasonably expected means the reasonable expectation of a person who has the pertinent knowledge, competency, skills and expertise to evaluate a given condition or situation.

One indication of gaps in the design and/or performance of simple or complex automated systems, such as AI, is when threats have to be mitigated by pilot interventions exercising human judgement, creativity or practical intelligence. Pilot interventions are most often required when:

- The automation has not been designed to accommodate a certain contingency
- The automation has been designed for a contingency but is malfunctioning
- The automation is working according to the design but is ineffective; or
- When encountering uncertain unforeseen situations.

Evidence of these pilot interventions in fielded AI systems can be extracted from the voluntary anonymous safety reports submitted to the NASA



Via author

▲ Two of ASRS' codes for flight crew actions are "overrode automation" and "overcame equipment problem." This chart, provided by the author, shows results from his search query into reports containing these codes. Critical phases of flight are denoted by red bars.

Aviation Safety Reporting System (ASRS), which has codes for specific flight crew actions – two of which are "overrode automation" and "overcame equipment problem." A query for reports indicating one or both of these actions to mitigate an in-flight threat from current automation/equipment during a Part 121 air carrier flight yielded over 1,600 reports in just the last five years, of which 515 were during a critical phase of flight.

Lessons learned

The Flight Deck Automation Working Group established by the FAA Performance-Based Aviation Rulemaking Committee (PARC) and Commercial Aviation Safety Team (CAST) concluded that the aviation safety system relies on pilots mitigating safety and operational risks on a frequent basis. In that light, and coupled with the ASRS data, all indications are that pilots will continue to be relied on to mitigate threats, at least during the initial learning period for AI aircraft systems.

A rich source of lessons learned (precursors to accidents) to be taught to the AI during its learning period can be expected to be documented in the first-person narratives provided in voluntary safety reporting systems, such as ASRS and the European Co-ordination Centre for Accident and Incident Systems. Consequently, analysis of these voluntary safety reports for pilot interventions during the post-certification AI maturing process should provide a proactive method for identifying learning gaps in AI-driven automated systems prior to precipitating an accident or otherwise identifying functions or tasks that may still need to be fulfilled by pilots.

No.4

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Ukrainian Ministry of Defence

Goodbye to all that

The sci-fi concept of a 'killer drone' programmed to hunt you down may be closer than we think. **SOPHIE SOMERVILLE ROBERTS** considers the psychology of both the hunters and hunted.

After four years of war in Ukraine, the commentary has caught up with much of the battlefield's materiel change. It has, quite rightly, focused heavily on the rise of the first-person view (FPV) drone; a recent Royal United Services Institute (RUSI) report estimates that drones account for 60-70% of damaged or destroyed Russian military systems – with Ukrainian officials reporting that FPVs now inflict 60% of Russian army losses, while the country has the capacity to produce more than eight million FPV drones annually.

The hobbyist toy of yesteryear has become one of the dominant killers on the modern battlefield.

The consequences are being covered in ever finer detail, but what is less well covered is the implications of this change: the psychology and mental wellbeing of the people who have to live under, operate and adapt to the FPV drone. sIt is, of course, a complex issue, and due to the scope of the question, this article will focus on one proposition: that UAVs, and specifically FPVs, are opening a second front on psychological stamina (that is, the capacity of a force, government and public to absorb sustained psychological cost without breaking).

Put simply, this article will not ask whether NATO could win a high-intensity war, but instead whether it could *sustain* one.

State vs Rate

Most discussion measures a battlefield state: who holds ground, which force has the advantage or which system prevails at a given moment. However, drone warfare increasingly turns on rate: how quickly those conditions can change. In Ukraine, that rate of change is increasingly decisive.

The decisive issue in drone warfare is not simply whether a force is dominant, but how long it can remain so before that advantage is countered. A new

▲ No longer the hobbyist toy, the FPV drone has become a dominant killer on the modern battlefield. Ukraine's DOT-Chain Defence IT system enables units to independently select from more than 180 FPV drone models supplied by 40 manufacturers. In the first four months of DOT-Chain Defence's operation, more than 100,000 FPV drones were delivered to the military.

system enters the fight, prompting a countermeasure; that countermeasure is then met by another technical or tactical adaptation, and the iteration race is set. RUSI's work on wire-spooled FPVs and terminal guidance shows this clearly, with both emerging on the battlefield to overcome the electronic-warfare defences which had made earlier systems less effective. The adaptation cycle is, therefore, not an occasional interruption to the war but an integral part of it.

Research organisation RAND's work on Ukraine makes the broader point. Battlefield advantage now lies not simply in possessing the better technology, but in how quickly a force can capture, apply and institutionalise the lessons produced by its use.

The psychological consequence of rapid rate change is more significant than it may first appear. Military training is meant to produce more than technical competence; it is also meant to develop character, particularly personal agency, which is emphasised across military syllabi. A sense of agency gives soldiers a practical belief that, through experience, judgement and learned routines, they can do something to improve their own and their unit's chances of survival.

Yet in a battlefield defined by rapid iteration, that relationship begins to break down. The problem is not that a soldier loses their skills, but that those skills lose their predictive value. Lessons about how to move, when to shelter, how long a vehicle can remain exposed or what the sound of the sky means may stop transferring before they can settle into routine. Experience does not become confidence but rather another thing to recheck.

This matters because perceived control and coping efficacy are associated with better psychological outcomes after combat exposure. Conversely, when a threat is experienced as persistently uncontrollable, the result can be heightened anxiety, passivity and a reduced willingness to act. The direct research on this exact drone-warfare condition is not yet there, but the implication of existing research is clear: a force that cannot bank survival knowledge may struggle not only with physical risk, but with the erosion of its sense of agency beneath it.

This is the tyranny of iteration.

The hunted

With this broader picture of the modern battlefield established, we can return to the soldier under the drone – because theirs is the experience being broadcast.

Much of the public image of warfare has been collective. From Renaissance paintings of massed armies, through the shared danger of shellfire in the trenches, to embedded helmet-camera footage from Afghanistan, it has often shown a team offering shared risk and mutual support.



Ukrainian MoD

▲ It can be psychologically challenging for an operator to watch, process and act upon the footage received.

> THE DECISIVE ISSUE IN DRONE WARFARE IS NOT SIMPLY WHETHER A FORCE IS DOMINANT, BUT HOW LONG IT CAN REMAIN SO BEFORE THAT ADVANTAGE IS COUNTERED

FPV strike footage from Ukraine can present the opposite image. Circulated widely across social media, it often reduces war to the final moments of a lone soldier.

The bitter irony is that, off-camera, the drone war is the opposite of lonely. In Vovchansk, Ukrainian soldiers trapped in the ruins of a factory survived not through individual cleverness, but because a whole, fragile system kept operating around them. Food, water, batteries, ammunition and medicine were dropped in by friendly drones because roads and evacuation routes had become too dangerous to use. Men took turns watching through holes in the walls, reinforcing their positions and caring for the wounded. Commanders, watching friendly drone feeds from the rear, directed them by radio.

Surviving under a drone canopy is intensely collective, down to the unit level. Where fibre-optic FPVs are resistant to radio-frequency jamming, the remaining countermeasures are often physical and shared, with teams combining small-arms fire or even running to cut fibre-optic cable with scissors to down drones. Survival, much like combat, is a team sport.

Yet this is the one thing the camera rarely shows. FPVs are designed to film their strikes, and their mass use has created an equally vast archive of footage. This visual economy favours isolation over cohesion – not through an intent to mislead, but because the camera records the point of impact more readily than



▲ In 2025, Ukraine's Ministry of Defence said it recorded 819,737 video-confirmed strikes through its Army of Drones Bonus system.

the system that makes survival possible. The visual space forming a generation's picture of war is, thus, skewed towards its loneliest fraction.

This matters particularly for Gen Z. They are the first cohort to meet war in the same feeds where they meet friends, fashion, politics, celebrity gossip and personal journeys.

In an earlier *AEROSPACE* article on whether Gen Z would fight in a hypothetical WW3 (November 2025), I argued that the generation is not intrinsically anti-service. It is, however, high-agency, sceptical and unusually willing to test the claims made to it.

On the same platforms as drone footage sits the familiar discourse that Gen Z is lonely, economically cheated and operating under a broken social contract. The combination is a near-perfect breeding ground for 'why me?' thinking.

Why should an individual accept exceptional risk if the public contract behind that risk appears frayed, the cause is unclear and the image of war is a near certain, lonely and violent death?

For an air force, or indeed any service, already trying to recruit a sceptical cohort, this is a recruiting headwind hiding in plain sight.

The hunter

Now turn the camera around. At the other end of the FPV feed is a person whose experience of war is also increasingly shaped by the FPV drone.

It is tempting to confuse drone warfare with remote warfare and, therefore, with 'safer' warfare.

> "THAT PRESSURE WILL GROW AS SIMILAR TOOLS MOVE BEYOND SORTING DATA TOWARDS TARGET RECOGNIT-ION AND, POTENTIALLY, BIOMETRIC IDENTIFICA-TION

Yet this mental shortcut, much like physical shortcuts, leaves out a lot of ground. The human cost of war is not removed by the rise of FPV drones; it is redistributed.

First, the FPV operator is not always distant from the battlefield. Unlike a Reaper crew operating from Nevada, FPV crews often work close to the front, sometimes only a few kilometres from enemy positions. Their signals can expose them, their launch sites are targeted, and their role has become sufficiently important that drone crews are targets in their own right.

Russia's Rubicon unit, for example, has reportedly targeted Ukrainian drone capabilities; one report claimed it killed up to 70% of a Ukrainian brigade's drone operators in a single week.

This danger matters because drone warfare is not creating a small specialist niche, but an ever-larger cadre of people who must be trained, deployed and replaced.

Ukraine says it trained more than 5,000 uncrewed-system operators in 2025 alone, alongside a growing network of certified training centres.

However, alongside the physical exposure sits a second burden: the image itself.

In 2025, Ukraine's Ministry of Defence said it recorded 819,737 video-confirmed strikes through its Army of Drones Bonus system, with footage submitted for verification and points allocated to units on that basis. This does not mean that every operator watched 819,737 deaths, nor that every confirmed strike caused a casualty. However, it does show the scale at which combat is now recorded, reviewed and made administratively useful.

Research into remotely piloted aircraft crews suggests that screen-mediated killing is not psychologically simple. It does not show that all drone operators are traumatised, nor does it allow a direct comparison between US Reaper crews and Ukrainian FPV pilots, but it does challenge the comfortable assumption that physical distance makes lethal action emotionally distant.

FPV operators do not necessarily have the same days-long 'dwell time' as Reaper crews – but they do guide a platform through its final approach, often with a clear live feed right up to impact. It would be a mistake to claim we already know that this creates greater moral injury (we do not) but it is reasonable to say that it keeps the operator visually close to the consequences of their actions at the very point Western militaries are trying to scale such roles.

This is the flaw in the promise of bloodless, uncrewed warfare. Uncrewed, remote and autonomous are not interchangeable terms, but each can shift work and responsibility rather than eliminate it. Uncrewed systems can reduce some physical risks, and they may preserve lives that would otherwise be lost in a vehicle, trench or cockpit.

However, they can also create a force in which





Ukrainian Ministry of Defence

▲ A still image of video footage from a Ukrainian FPV drone as it closes to explosively destroy a Russian Orlan UAV.

▼ A Russian Msta-S self-propelled howitzer in the sights of a FPV drone belonging to the Ukrainian military's 109th Territorial Defense Brigade.


109th Territorial Defense Brigade

more people are required to operate, analyse, verify and authorise violence, often while carrying both the physical danger of a forward position and the psychological burden of watching the result.

There is a public dimension too. One political promise attached to remote and autonomous warfare is that it might soften body-bag politics and protect the public consent on which any Western war depends.

Yet, a psychological casualty is harder to honour than a coffin, and if the hidden cost eventually surfaces in veterans' wards, a public told that this warfare was clean may feel deceived.

In a war of sustained attrition, that delayed reckoning could prove more corrosive to consent than the visible casualties remote and uncrewed systems were meant to reduce.

The temptation of the machine

The obvious answer to the operator's burden is more autonomy. If a small number of people cannot watch, identify, track and strike quickly enough, then let the machine do more of the watching.

There is a real military logic to this. The British Army describes ASGARD as a digital targeting system that uses AI and novel communications networks to provide rapid targeting and decision support, reducing the time needed to see, decide and strike. That pressure will grow as similar tools move beyond sorting data towards target recognition and, potentially, biometric identification, including facial recognition. However, this does not remove the human cost of remote killing.

The psychological difficulty for an operator is not simply the amount of footage they must process. It is the fact that they are asked to act upon it. An algorithm may recommend a target, but it cannot take on the moral weight of a decision to strike. If a human remains in the loop, that person still carries responsibility for what follows. If no human has meaningful control, responsibility becomes harder to locate, not easier to discharge.

The danger is that AI reduces the operator's agency without relieving them of that responsibility. A person who has time to investigate, challenge and refuse a recommendation is making a judgement. A person given seconds to approve it is doing something closer to ratifying a process they cannot properly see or understand.

This is not an argument against systems such as ASGARD, nor a claim that every autonomous or semi-autonomous system breaches international humanitarian law. The law does not require a human to press a particular button in every circumstance, but it does require distinction, feasible precautions and proportionality. More fundamentally, however, a system cannot be said to preserve human judgement merely because a human name remains attached to its output.

This is the real temptation of the machine: not that it will make war impersonal, but that it will allow institutions to tell themselves that the human cost has gone away. It has not. The operator may be physically removed from the strike, and increasingly removed from the process that produces it, but they remain the person asked to live with its result.

The answer is not to reject automation, but to make retained human judgement a design requirement: time to interrogate, authority to refuse, and clear ownership of the decision.

That is where the tyranny of iteration becomes something more troubling than a technical contest. As surveillance and target-recognition systems are folded into the kill chain, and as biometric identification – including facial recognition – moves from possibility towards practice, war begins to depart from the forms through which soldiers, civilians and governments have learnt to understand it.

The danger is not simply that the technology will outpace the law, but that the rush to adapt before an adversary does will outpace the judgement, doctrine and democratic consent needed to govern it. We may end up building a field whose costs we cannot yet see: one in which fighters are asked to carry responsibility for decisions they cannot properly interrogate, while non-fighters lose confidence that violence is being controlled at all.

That is the risk of the machine's promise: not a cleaner war, but an unknown one – built faster than we can understand it, govern it or meaningfully choose it.



Digital skies

Uncrewed systems have transformed warfare. Simulation is changing how those systems are built, trained and deployed, and, as **ANDY FAWKES** MRAeS of the Flight Simulation Specialist Group writes, the boundary between the digital environment and the battlefield is increasingly dissolving.

In 1951, US psychologist, Paul Fitts posed a question that engineers and aviators still wrestle with: what should humans do, and what should machines do? Writing for the US National Research Council on aviation, he reserved judgement in novel situations, flexibility and inductive reasoning for humans, while assigning machines speed, consistency and routine processing. Grounded in the human-factors knowledge of its time, his framework has held broadly stable ever since.

In the inaugural issue of *Wired* magazine in January 1993, sci-fi author, Bruce Sterling visited a simulation facility at Fort Knox, Kentucky and watched soldiers fight wars they would never physically enter. He spoke with Col Jack Thorpe, the Defense Advanced Research Projects Agency (DARPA) Programme Manager behind SIMNET, a 1980s' networked simulation system. Thorpe's vision for its successor was clear: simulate before building, train before deploying and generate capability in the digital environment when needed rather than stockpiling it in the physical world. Sterling left with questions that remain unanswered today. When training and war merge, what happens to the professions, institutions and standards built around that boundary? Who certifies an operator who never encountered the scenarios that shaped the system? Who is accountable when autonomy produces behaviour its designers did not anticipate?

Furthermore, if a machine's behaviour is already decided before any human professional is ever involved, what is left for them to shape? Both Fitts and Sterling described the same arc – and we are still on it.

The laboratory no nation chose

Since 2022, necessity has made Ukraine warfare's most intensive testing ground for uncrewed systems.

▲ The USAF has a goal of fielding 500 operational CCAs by 2032, with an eventual planned total fleet in excess of 1,000 aircraft. Prime contractors are Anduril Industries with its FQ-44A Fury and General Atomics Aeronautical Systems with the FQ-42A Vengeance (illustrated).

At the Army of Drones event in Kyiv in January 2026, President Zelenskyy reported that drones were responsible for more than 80% of strikes on Russian targets, including personnel. Ukraine recorded 819,737 video-confirmed drone strikes in 2025.

By mid-July 2026, that tally had already passed one million verified hits for the year, according to Ukraine's Defence Ministry, with drones now accounting for around 90% of confirmed hits on Russian forces.

Euromaidan Press reported that more than 9,000 Ukrainian drones flew daily by early 2026, generating terabytes of operational data. In March, Defence Minister, Mykhailo Fedorov, announced that allied AI developers would gain access, though questions of priority and control remained. Nevertheless, by August, the UK had secured formal access to Ukraine's Avengers AI Labs and combat footage.

"Today, Ukraine has a unique array of battlefield data that is not found anywhere else in the world," Fedorov wrote. "These are millions of annotated frames collected during tens of thousands of combat flights." A live conflict had become a training ground for the next generation of autonomous systems.

The operational effect is stark. "Autonomy is the single most impactful defence technology of this century," Yaroslav Azhnyuk, co-founder of Ukrainian autonomy developer, The Fourth Law, told *IEEE Spectrum*. "The moment this happens, you shift from a manpower challenge to a production challenge, which is much more manageable."

Autonomy modules costing about $50, retrofitted to first-person view (FPV) drones, can raise inexperienced users' strike success rates fourfold compared with direct operator control.

That change alters the economics, as well as the tactics. Better software raises the effectiveness of cheap, existing airframes without a new platform or a long acquisition cycle, and lowers the experience an operator needs, moving part of their skill into the system itself.

Ukraine demonstrates how autonomy changes tactical execution. The US and Israel's 2026 war with Iran has showed the same compression at the level of intelligence and targeting. The US military's Maven Smart System, developed by Palantir Technologies, combined intelligence and moved targets through the strike process.

"The AI machine is making recommendations for what to target, which is actually much quicker in some ways than the speed of thought," Craig Jones, a Newcastle University expert on kill chains, told *The Guardian*. "So, you have got scale and you have got speed."

Before AI integration, targeting cells processed fewer than 100 targets a day. Computer vision lifted that to 1,000. After large language models (LLMs) joined a US National Geospatial-Intelligence Agency official put the figure at 5,000. These are operational facts, not forecasts.

> TRADITIONAL SIMULATION TRAINS PEOPLE. AI-ENABLED SIMULATION TRAINS MACHINES

Simulate before you build

Thorpe's proposition has quietly become the organising principle of UAS development. Using Duality AI's Falcon digital-twin platform, the US Army trained the AI for its AiTDR counter-drone system entirely in simulation, before any physical hardware existed.

Designed to protect crews aboard the XM30 infantry fighting vehicle, the approach allowed the Army "to train and test the AiTDR model in complex conditions, explore varied drone detection scenarios and validate potential solutions in simulation before the physical hardware is even ready for field testing," said Duality AI Chief Product Officer, Michael Taylor.

Shield AI's acquisition of simulation company, Aechelon, in early 2026, alongside a fundraising round that valued the combined business at $12.7bn, shows where industry sees value. Capability is now "shaped in software, trained in simulation and improved through use," said Chief Executive, Gary Steele. New Zealand's Ministry of Defence reached a similar conclusion in its February 2026 Long-term Insights Briefing: "Military success will be increasingly defined, not by platforms and capabilities, but by the software that operates and connects them."

This reverses a familiar order. The aircraft no longer necessarily arrives first. Designers can build, test and refine its behaviour before the hardware exists, making the platform a physical expression of a capability developed in the digital environment. The US Department of War's January 2026 *AI Acceleration Strategy* makes the point more starkly. One priority programme is named Ender's Foundry, after Orson Scott Card's novel in which a simulated final exercise proves to have been a real war. The name reflects how far the boundary between rehearsal and combat may already be dissolving, for human and machine trainees alike.

Collaborative Combat Aircraft (CCAs) show the simulate-first principle in practice. The USAF selected Anduril's FQ-44A Fury and General Atomics' FQ-42A Dark Merlin in June for low-rate production,

▼ In October 2026, a USAF F-22 Raptor pilot successfully directed an Anduril Industries FQ-44A Fury CCA from the cockpit for the first time as an 'airborne quarterback.'



Anduril Industries





▲ Left: A US Army soldier assembles a Vanilla UAS during April's Fleet Experimentation 2026 exercise in Florida.

Right: Boeing's MQ-28 Ghost Bat has undergone tens of thousands of digital testing compared to physical flight testing.

with the first phase expected to cover 150 aircraft. By September 2025, Boeing's MQ-28 Ghost Bat had logged 150 hours of physical flight testing against more than 20,000 hours of digital testing. These programmes pair human pilots with autonomous uncrewed aircraft. The US Navy, meanwhile, is pursuing a more independent strike UCAV than the cheaper USAF wingman. In either case, the human becomes the decision-maker within a mixed team, not the platform's sole authority.

The digital environment does more than prepare that team for a mission. It shapes the mission, the machine's responses and the range of choices later presented to its human partner. Traditional simulation trains people. AI-enabled simulation trains machines. The operator may never encounter the scenarios that formed an autonomous system's behaviour. How aerospace closes that gap may define human-machine teaming in military aviation.

The loop that never stops

There was once a time when developers tested a system in simulation, handed it to operators, then folded operational lessons into the next design cycle over months or years.

Now, combat data can flow directly into AI retraining pipelines without human review at every stage. Ukraine's decision to share battlefield data makes the change visible. The physical world supplies data to the digital one, which produces improved systems for deployment back into combat.

That loop now closes in days. Scout AI co-founder, Collin Otis, told Booz Allen Ventures bluntly: "When the adversary figures something out... we are able to be agile, train overnight, deploy something." Systems are already being retrained between missions.

Russia's newest jet-powered Shaheds, produced at a rate of about 3,000 a month, allow remote retargeting in flight rather than following a fixed route. Monthly attack numbers rose from 350 in June to 2,800 by August. Neither development amounts to autonomous learning during a sortie, but together they sharpen the next question: what happens when you remove the human relay and an aircraft decides mid-flight that its simulation no longer applies?

That same compression reaches the humans directing individual engagements, not just the machines being retrained. The pressure on operators became clear during a September 2025 training rotation at Fort Irwin, California. Lt Col Mat Scott, Commander of the 82nd Airborne Division's 504th Parachute Infantry Regiment, said his unit detected 399 targets but could not engage them. The unit logged tanks, radars and command centres, then left them untouched because its fire apparatus and cognitive capacity could not handle the volume. They had, in Scott's words, "left a lot on the table." Fitts warned in 1951 that "both men and machines are likely to break down or become unstable if overloaded." Fort Irwin confirmed it 74 years later.

David Leslie, Professor of Ethics, Technology and Society at the Digital Environment Research Institute, Queen Mary University of London, calls one consequence "cognitive off-loading." Operators may feel detached from a strike because a machine performed the analysis. "These systems produce a set of options for human decision-makers," he told *The Guardian*, "but they have got a much narrower time band... to evaluate the recommendation."

The decision remains nominally theirs while the conditions for genuine judgement erode. Continuous reliance on AI may also weaken planning, situational awareness and professional judgement, the skills needed when a system fails or goes offline.

The UK MoD's *Future Operating Environments 2040*, published in March 2026, charts the institutional path. "If AI verifiably outperforms humans," it states, "the shift from human-in-the-loop to human-on-the-loop will extend onward to human-starting-the-loop. In some circumstances it may even reach a position of human-out-of-the-loop." It also warns that swarms, AI decision support and autonomous weapons "could overmatch human control over pre-conflict escalation management."

The distinction matters. A person who approves an option at machine speed may remain formally responsible without exercising meaningful control. Moving farther from the loop makes that tension harder to ignore, particularly when several autonomous systems interact and no operator can follow every decision. Nor is cognition the only bottleneck. Apparent autonomy rests on a

> CONTINUOUS RELIANCE ON AI MAY ALSO WEAKEN PLANNING, SITUATIONAL AWARENESS AND PROFESSIONAL JUDGEMENT, THE SKILLS NEEDED WHEN A SYSTEM FAILS OR GOES OFFLINE

largely unseen human system: people manufacture components, assemble and arm aircraft, replace batteries, load software, maintain communications and recover damaged equipment. Supporting 9,000 daily sorties requires that workforce to prepare platforms as fast as forces consume them, often while exposed to attack. Autonomy may reduce the labour at the point of engagement, but it redistributes much of it into production, maintenance and logistics.

The new military doctrine writers

Emelia Probasco, a former US Navy fire-control officer, noted in Katrina Manson's March 2026 *Wired* account of Project Maven that its users still receive no formal training comparable to the month-long schoolhouse for AEGIS weapons-system operators. "If you are going to be making lethal decisions through engagement," she said, "soldiers should be trained as if it were a weapons system." Institutions must, she added, "fund the adulting tasks." The training gap she describes has yet to close.

The consequences extend beyond operator competence. Engineers who design the digital environments for autonomous-system training are also making doctrinal choices. Decisions about target priorities, ambiguous signals and escalation in contested airspace enter the training environment and shape behaviour in the field. They may look like technical parameters and thresholds during development, but on operations they govern what the system notices, ignores or recommends.

New Zealand's MoD argues that "human accountability, and adherence to international law, must be built into the system design." As decision cycles compress, it adds, "de-escalatory and explanatory functions must be embedded in the system design to ensure humans retain appropriate control in autonomous decision-making processes."



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▼ A person who approves an option at machine speed may remain formally responsible without exercising meaningful control.

Yet if these design choices amount to rules of engagement, who reviews or authorises them? A commander cannot use a capability responsibly – or recognise when an adversary has deceived it – without knowing the assumptions built into its training and the conditions under which its performance degrades.

Fitts warned that engineers and human scientists worked "in almost complete insulation from one another," producing systems that burdened operators in unforeseen ways. Today, Silicon Valley increasingly supplies the architects – and increasingly the infrastructure too: connectivity, data relay and positioning depend on commercial providers, such as Starlink and Amazon whose choices about access, price and continuity carry operational consequences no procurement contract can fully predict. Alexander Karp, summarising his book, *The Technological Republic* on X in April 2026, framed the issue directly: "The question is not whether AI weapons will be built; it is who will build them and for what purpose."

In December 2024, a UN General Assembly resolution on lethal autonomous weapons systems passed by 166 votes. Russia was one of only three opponents; the US voted in favour, although it has resisted a binding treaty through the Convention on Certain Conventional Weapons.

Governments cannot agree where to draw the line. Who draws it in digital environments, training parameters and code remains unclear. So does whether military advantage will override any agreed limits.

Questions for the profession

In 1993, Sterling asked what kind of profession and institution could survive once training and operations became indistinguishable. That question is no longer theoretical. Kate Bondar, a research fellow at the Center for Strategic and International Studies, told *IEEE Spectrum* that: "Humans will still be in the loop for some years, simply because there are so many unpredictable situations when you need an intervention." Many in aerospace and defence share that view. However, the direction of travel, from Fitts in 1951 through Thorpe in 1993 to the battlefields of Ukraine and Iran today, is consistent and accelerating – and the boundaries are shifting faster than the institutions built to govern them.

The Royal Aeronautical Society spans this whole challenge: civil and military, platform and system, crewed and uncrewed. Its members design these aircraft, train their operators and help set professional standards. The Society is, therefore, well placed to define what certification should mean for a simulation-shaped system. The aerospace profession must establish how these new digital skies are governed and hold itself accountable for what its uncrewed systems do.

Push the button

How AI is set to make GA pilots safer

As AI continues to find it into the cockpit **STEPHEN BRIDGEWATER** FRAeS speaks to two companies that are aiming to make piloting safer and simpler than ever before.

In the late 1990s, NASA developed Highway in the Sky (HITS), a guidance system that projected a virtual flight path for General Aviation (GA) pilots to follow. Although the technology was ahead of its time, it influenced modern synthetic vision systems and foreshadowed today's increasingly autonomous aircraft. A quarter of a decade on, several organisations have picked up the baton, using AI to make NASA's dream a modern-day reality.

Fatal consequences

Mark Groden founded El Segundo, California-based Skyryse a decade ago as his "life's work," explaining to *AEROSPACE* that "I was tragically exposed to GA fatality at a relatively young age – a loss of control in flight, a stalled aircraft and three generations were lost in one accident."

He started looking at the statistics and was shocked at the regularity of such crashes. Today, the top causes of fatal aviation accidents are very understood, with more than 70% of crashes attributed to 'pilot error'. "I do not believe it is pilot 'error,'" Groden offers, "it is that pilots' workload in the cockpit is incredibly high. These incidents are generally controlled flight into terrain (CFIT) and poor management of emergency situations, such as engine failures."

The company's first project was Skyryse One, which began life as a Robinson R66 helicopter. Even building a bespoke fly-by-wire system only scratched the surface of the project as the team soon discovered that, with the exception of the engine, everything needed to be updated, adapted or changed "from the FADEC system to knobs to control the strobes."

"A modern airliner needs a room of boxes in order to support its fly-by-wire" he continues, "but that room is bigger than our entire aircraft. So, we had to build the system ourselves, miniaturise it



Skyryse

▼ SkyOS is now deployed on both rotary and fixed-wing platforms. Groden says the pilot always has the ability to override the system by simply grabbing the controls.

and rewrite the 1.3m lines of code needed to run everything from air data to digital engine control and localisation and control of what you see on the touchscreens. We ended up having to produce the touchscreen displays and four-axis control stick in-house as well."

Airhart

Meanwhile, Nate Thuli is President of Airhart Aeronautics, a Los Angeles-based company which also aims to make personal aviation simpler, safer, more accessible and more human-centred.

Getting to this stage has not been easy for either company. Thuli explains that the first problem Airhart experienced was the design of existing autopilot servos, which necessitated a new in-house design in order to achieve what was needed. Next was the avionics and then the interfaces: "We realised that needed a three phase, deconstructed approach and we could not just jump straight to the finish line and develop the clean sheet aircraft that the Airhart team set out to do that from the outset."

"Our Phase One offering is an avionics refit, which we are offering as an STC [Supplementary Type Certificate] modification. "At first glance it is a panoramic slab of glass with two of the largest and brightest displays in GA, but when you look deeper it is an incredibly intuitive user interface [UI] that simplifies the pilot's interaction with the aircraft." Thuli describes the new cockpit as "a complete, vertically integrated, completely self-contained avionics system" adding that "a traditional autopilot system is not context-aware."

"A standard autopilot has around 17 different interaction modes, but in redesigning the system we have simplified it to just two, namely are you navigating to a constraint, or are you navigating to a flight plan?"

Priced at less than $50,000, including installation – which Thuli claims takes "around a day" – the Airhart system is competitively priced against competing avionics systems that do not offer the benefits of AI.

Airhart's focus is now on further automation of GA via 'Phase Two' of the programme, which will introduce what Thuli refers to as "a fly-by-wire, simplified flight control system," and has already been test flown aboard a Sling TSI Light Sport Aircraft (LSA).

The company's ultimate goal is 'Phase Three', which will see a clean sheet aircraft brought to market "coupling context-aware avionics with a fly by wire system that reimagines the relationship between operator and aircraft."

Airhart plans to fly the prototype by the end of 2028 and while not being drawn on specifics of the airframe, Thuli confirmed it could be operated within FAA Part 22 regulations as part of the FAA's new Modernization of Special Airworthiness Certification (MOSAIC) legislation.

SkyOS

The pilot interacts with the Skyryse One helicopter via an operating system called SkyOS. "It is essentially a user interface of two touchscreens that gives you access to all the capabilities of the aircraft, but also affords some level of automation," explains Groden. "By way of example, a pilot does not need to chase three layers into sub-menus to find a tripped circuit breaker. If it is obvious that the POH [pilot's operating handbook] says 'just flip the circuit breaker back', well then, the system is going to do that for you."

The same applies in critical situations such as a drop in engine power. "With the [conventional] R66, if you have a drop in main rotor RPM, you have 1.8

◣ SkyOS employed aboard the SkyryseOne helicopter. The system replaces the conventional cyclic and collective with a single controller and provides a completely digital cockpit.

◢ The Airhart UI fitted to a Sling Light Sport Aircraft. Both companies plan to use triplex full authority fly-by-wire systems and electromechanical actuators to replace the aircraft's mechanical controls, but these needed to be built from scratch to meet FAA Part 25 requirements with a 'ten to the minus nine' level of reliability at a GA price point.





seconds to drop the main rotor pitch – if you do not do that, the main rotor stalls and it is unrecoverable," Groden reveals. "With SkyOS, the system will detect an RPM drop and automatically change the pitch of the blades so as to keep them spinning. From there, the dynamic envelope protection system just redefines your safe flight envelope and if requested by the pilot – simply by swiping down a button on screen – initiates an autorotation."

Groden also points out that "autorotation landings are considered so dangerous that the FAA does not even ask pilots to do last part of the manoeuvre (flaring and setting down onto the ground) during your exam. With SkyOS it is as simple as choosing your parking space."

"We want to make the aviate side easy so that a pilot can focus on the higher-level decision making, navigating and communicating" Groden says. "SkyOS gives the pilot the capacity to look for a landing spot, ensure it is not being used by kids playing soccer and avoid power lines and cables."

While SkyOS was initially designed for the helicopter market it is also being rolled out to fixed-wing types via an STC, however Groden revealed that the company was in discussions with an as-yet unnamed OEM about integrating the technology on the assembly line via a full Type Certificate.

The system also reduces "thousands of component parts with about a dozen" – in turn reducing weight and increasing available space and range. "We have a product fit right the way up to business jets," Groden continues.

Gentle nudges

Meanwhile, the Airhart system is designed to give pilots a series of 'gentle nudges' when required, something that starts even before you have climbed aboard. "You can load your flight plan a few days before the trip," Thuli explains. "The system is not just aware of your destination but also your experience and currency – so it might, for example, suggest that 'hey, you have not done a GPS approach in a little while – you are current and legal – but if you have the time here is a refresher to help you make sure you are prepared for the flight.'"

There is a maxim in aviation that pilots need to aviate, navigate and communicate in that order. In times of high workload, communicating with ATC can often drop down the pilot's priority list but both Airhart and Skyryse have a solution for this.

Thuli explains: "Climbing away, ATC might say something like 'turn left onto 270, climb to 3,000ft and change to approach on 127.45' and the Airhart Assist will provide a live transcript of the call to save the pilot having to note it down on a kneepad. The system listens and transcribes all radio calls, but it specifically flags up when your aircraft is being spoken to. Then, with the touch of a button on the stick, the pilot can acknowledge and make it all happen."

Skyryse's SkyOS has a similar system, which includes what Groden refers to as "an AI copilot" called Skyler. "Skyler is in the cockpit with you and is constantly listening to the radio. It gives a transcription on screen of all calls, highlighting ones directed at your tail number. It will then suggest an action for the pilot to approve or reject – and once confirmed it passes the details to the SkyOS to implement the action."

Continuing our imaginary flight, Thuli explains what might happen when a pilot reaches their destination: "Once again the UI provides nudges such as 'hey, this runway is narrower than what you are used to, so maybe flare a little bit sooner?' Back on the ground, the automation does not stop when you put the aeroplane in the hangar – this is where intervention without closing the training loop can erode away at pilot competency. The UI is monitoring at all times and can provide an informed debrief of the flight, suggesting ways to improve on the next sortie. It really is just like having a competent safety pilot or flight instructor sitting over your shoulder at all times."

> "WE HAD TO BUILD THE SYSTEM OURSELVES, MINIATURISE IT AND REWRITE THE 1.3M LINES OF CODE NEEDED TO RUN EVERYTHING FROM AIR DATA TO DIGITAL ENGINE CONTROL"

▼ Airhart's system is available as an STC modification and can be installed in around a day. Phase 2 will also be available as an STC for LSA types, but Airhart envisages it eventually being certified to FAA Part 23 standards and available for OEMs to build into their designs at the factory. It expects the system to be available in mid-2027.





Training path

This begs the question of whether this new generation of aircraft need a new generation training syllabus. "Yes, dramatically!" Groden replies emphatically. "In the US, the FAA is already moving in that direction with what it calls Simplified Vehicle Operations (SVO), which came out as part of MOSAIC legislation."

MOSAIC specifically outlines how aeroplanes, helicopters and future vertical lift aircraft equipped with SVO systems like SkyOS or the Airhart UI may only require 20 hours of pilot training. "We anticipate changes to the manoeuvres that a student pilot will need to learn," explains Groden. "Do you need to practice a stall if the aeroplane physically cannot stall any longer because you have a triplex fly-by-wire system that keeps you safely inside the envelope?"

Automotive crossover

There is a precedent here in the automotive industry, where cars have become increasingly automated and simple to drive. "We need to be careful to avoid automation for the sake of automation though," Thuli cautions, citing the modern car's propensity to bury options in submenus within the main screen. "Many modern cars with large displays require mental capacity to tap through menus and pages to adjust a vent rather than just twisting a knob. A lot of new tech is taking the human out of the loop – but at Airhart we have been through a very deliberate thought exercise with every user interface to improve it with the human in the loop in mind."

Another problem with the interactive screens in modern cars is that reaching out and finding buttons while keeping your eyes on the road can be difficult. "That is in a relatively static benign environment" emphasises Thuli, "it can be much more difficult in a manoeuvring aeroplane, especially in turbulence." To counter this, the Airhart UI has been developed with a very intentional ergonomics. "The physical stick – which we call Airhart Assist – is your primary interface with both the aircraft and the avionics," says Thuli.

Optionally autonomous

With incredible levels of autonomy now possible, why did these companies not completely automate flight? "We could have done so," Groden confirms, "but we for Skyryse One wanted to put the pilot more firmly in control."

However, the level of autonomy available has not gone unnoticed by the military and in June of this year Skyryse announced a partnership with Robinson Helicopter Company to integrate SkyOS into a fully uncrewed variant of the R66 for use as a CCA, ISR platform or for crewed-uncrewed teaming. Meanwhile, SkyOS has already been fitted to a Sikorsky Black Hawk helicopter and successfully test flown in 2025.

However, the difference between a SkyOS-equipped aircraft and other autonomous vehicles is that it can still be flown by a pilot when required. "Flight crew need rest, but aircraft do not," smiles Groden. "You can use that same Black Hawk to fly deliver supplies with nobody sitting in the cockpit, so it provides a tremendous force amplification opportunity."

Could this translate into the civilian world? "Absolutely," offers Groden. "One area we have been exploring is the uncrewed repositioning of business jets between paid charter flights. If you can do that without crew the value proposition is pretty significant."

The end of piloting as we know it?

All of which begs one final question – at what point does the pilot become redundant? "The concept of George Jetson getting into his flying car is pretty similar to the product vision that we are delivering," offers Groden. "The human operative will always be there, but the role of a pilot will evolve to something more akin to a high-level decision maker."

Thuli and Airhart see things differently. "If you want to get from the airport to downtown, that is a great use case for urban air mobility," he says, "but we are trying to solve the problem of the 500 mile trip. Do you load up the family car and drive, or do you take a commercial flight? We think that making flying your own aeroplane easier, safer and cheaper will create a third option.

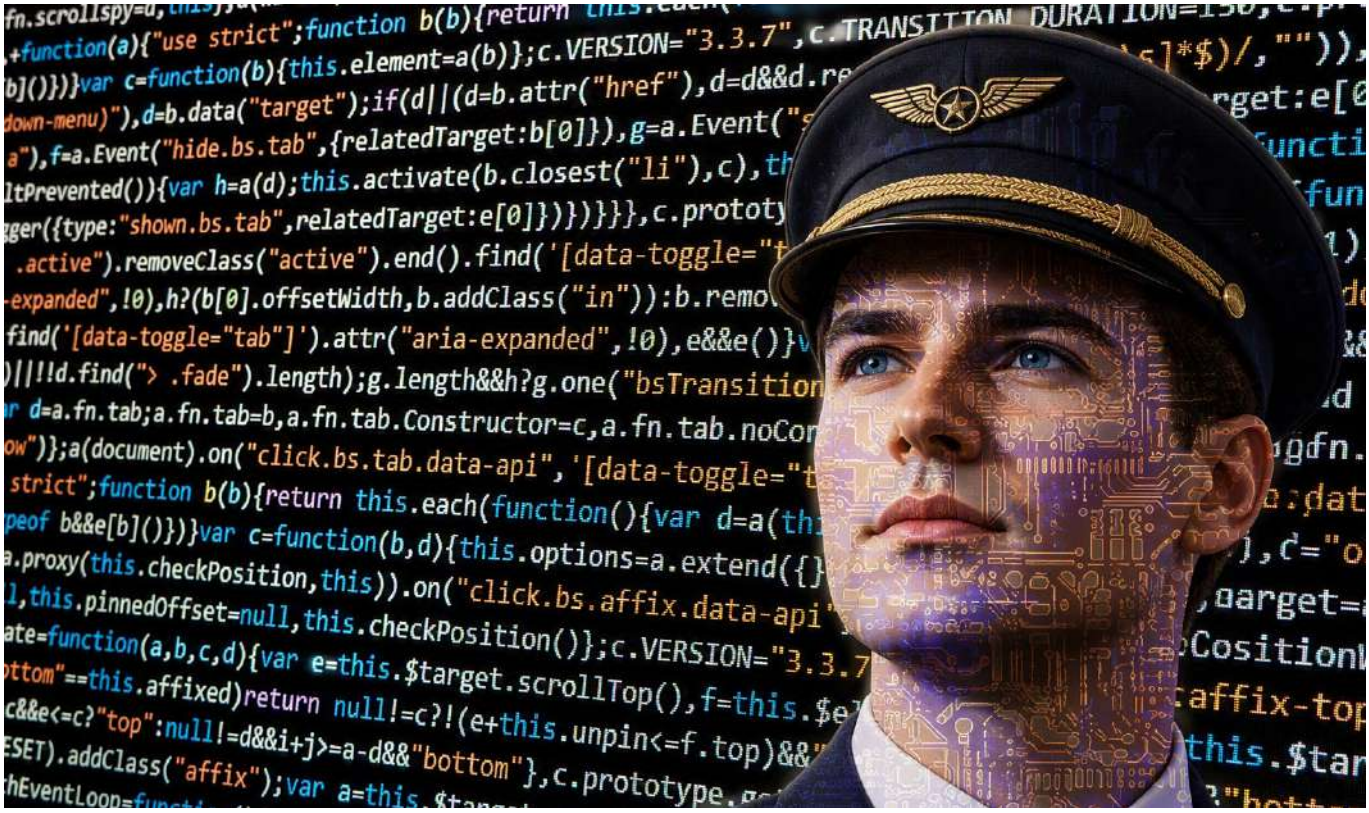
"The key to 'easier, safer and cheaper' is autonomy – but the really exciting part of simplified flight controls and fly-by-wire is that the system can live in the middle space, not fully disengaged but not fully on. It can live in the 'I want to actually enjoy flying' mode – like the 'sport' mode on a modern car – or it can live in the 'chill' mode where it is docile. This is not about removing the pilot from the cockpit, it is about removing the cockpit stress from the pilot," concludes Thuli.

▼ Below left: SkyOS was test flown aboard a Sikorsky Black Hawk helicopter in 2025. According to the company, the installation took just 91 days. According to Groden: "The pilot can simply swipe their finger down and land if the cockpit workload becomes really intense, which is especially in 'brownout' conditions." The company suggests that the system could also be used for other high-risk missions, such as aerial firefighting and crop spraying.

Below: SkyOS enables the pilot to use the touchscreen to do everything from engine start to an emergency autorotation. Both the Airhart and Skyryse systems also listen and transcribe all radio calls, specifically flagging up when your aircraft is being spoken to.


USAF


Skyryse



Can AI make better pilots?

Can AI improve flight training, or will it weaken proficiency? **RAUL BONADIA RODRIGUES** MRAeS and **FABIO PARO BELLAGAMBA** investigate.

Artificial intelligence is moving steadily into aviation. No longer the stuff of science fiction, it is now a practical layer of assistance, analysis and decision support.

On the flight deck, its promise is easy to understand. AI can process more data, faster and present options more clearly than a human pilot working under time pressure. It can also support diversion decisions, highlight operational threats, detect patterns in performance data and help training organisations tailor learning more precisely.

Aviation has learned many times before, often the hard way, that that any tool which makes flying easier can also make skills more fragile if it is introduced carelessly. The central question, then, is not whether AI belongs in pilot training. It is how to use it in ways that strengthen judgement, resilience and airmanship rather than quietly hollowing them out.

> “ANY TOOL WHICH MAKES FLYING EASIER CAN ALSO MAKE SKILLS MORE FRAGILE IF IT IS INTRODUCED CARELESSLY

Regulation and research

That question matters because the current regulatory and research landscapes already point in the same direction. EASA’s *Artificial Intelligence Concept Paper Issue 2* distinguishes between AI which enhances human capability and AI that operates in a more collaborative human-AI teaming mode under human oversight. Its message is not technological enthusiasm for its own sake. It is that trustworthy AI in aviation requires learning assurance, explainability, ethics-based assessment and clear human guidance.

The FAA, from a different angle, has reached a similar conclusion: the industry still lacks a settled method for AI safety assurance, even as designers seek to incorporate AI into aviation systems. In other words, the debate is no longer about whether AI is coming – it is about whether aviation can integrate it without losing control of what makes the human operator competent in the first place.

Virtual assistant

For pilot training, the first genuine opportunity is not replacement, but augmentation. Good instruction has always tried to reduce unnecessary cognitive clutter so that pilots can concentrate on what matters: recognising threats, prioritising actions, managing energy, communicating clearly and making sound decisions. AI can assist that process.

A recent interview study by Menig, Becker and Kleudgen[1] examined pilots using an AI-based Virtual Crew Assistant in a diversion scenario and found that workload was rated significantly lower when the assistance system was used. That is not a trivial result – in time-critical or information-rich situations, reducing workload can preserve mental bandwidth for higher-level judgement.

Used properly, this suggests AI can become a training partner for improving scenario management rather than merely a cockpit convenience. The gain is not that the machine makes 'decisions' better than the pilot; it is that it can help the pilot think more clearly when complexity rises.

▼ Aviation often frames new technologies as cockpit issues, but training outcomes are shaped by the entire system around the cockpit: syllabi, checking practices, simulator scenarios, instructor standardisation, operational philosophy and even the informal messages organisations send about what counts as 'good performance'.

What happens when the AI assistant is wrong?

However, workload reduction is not automatically a safety gain. Training has always involved a tension between support and dependency. If a pilot becomes accustomed to receiving perfectly structured options from an intelligent assistant, what happens when the assistant is wrong, unavailable or only partially helpful? That is where the concept of human-AI teaming becomes more useful than the older language of automation. Teaming implies roles, responsibilities, communication and the possibility of disagreement. Korentsides *et al*[2] argue that effective human-AI teamwork in the flight deck depends on trust, role clarity, task allocation and situation awareness. Those are not merely design issues; they are educational issues. If pilots are going to work with AI, they must be trained not only to use it, but to supervise it, challenge it and understand when not to rely on it. The training aim should therefore be disciplined scepticism, not passive acceptance.

(1) Menig, A., Becker, N. and Kleudgen, J.P. Investigating the role of an AI-based assistance system for the decision-making process of pilots: An interview study. *Transportation Research Procedia*, 2025, 88, pp167–175.
(2) Korentsides, J., Merwin, E.R., Berger, L., Laskey, L., Winter, S.R., Sobel, B. and Keebler, J.R. The use of artificial intelligence (AI) in the flight deck: Enhancing human-AI teamwork in aviation. *Journal of the Air Transport Research Society*, 2026, 6, 100099.


BAA

This has implications for what pilot proficiency actually means in an AI-enabled environment. For years, aviation training has been moving away from a narrow, event-based model towards competency-based and evidence-based approaches. ICAO's competency-based training framework is designed to help organisations address performance gaps by building training around observable capability rather than rote completion of manoeuvres.

EASA's *Evidence-Based Training* resources make the same broader point: the purpose of training is not simply to rehearse isolated events, but to develop and assess the overall capability of crews in line with competency-based principles. That philosophy is especially relevant to AI. If intelligent assistance enters pilot training, it should not be bolted on as another gadget to learn. It should be integrated into a competency framework that asks a more serious question: does this tool help produce better pilots, or merely better button-pushers?

The illusion of proficiency

The danger of getting this wrong is that AI can create an illusion of proficiency. A pilot may appear smooth, organised and efficient when supported by excellent prompts, recommendations and cross-checking from a digital assistant. However, some of that performance may belong to the machine rather than the human. That distinction matters. In pilot training, proficiency is not just the successful completion of a task. It is the internally developed ability to cope with uncertainty, ambiguity, novelty and degradation. Those qualities become most visible when conditions are imperfect. A training system that uses AI to produce polished performance without testing the pilot's independent understanding may create a generation of operators who look capable until the support disappears. That would not be progress. It would be the training equivalent of borrowed competence.[2]

This is why manual flying and flightpath management remain so important. FAA *Advisory Circular* 120-123 frames flightpath management as a unifying framework for operations and training, explicitly including manual flight operations, managing automated systems, pilot monitoring and energy management. That list is revealing. It does not treat manual flying and automation management as opposites. Rather, it treats them as mutually reinforcing elements of competent flightpath control.

In practical terms, that means pilot training for an AI-assisted future should protect manual and cognitive fundamentals rather than assume they can be safely outsourced. The more capable our support systems become, the more intentional we may need to be in preserving the foundations that let a pilot recover when support is degraded.

Research on manual flight performance strengthens that argument. Sun *et al* [7] proposed a competency-based assessment method for pilots' manual flight performance during instrument flight training, built around observable behaviours and measurable assessment indices. The value of that work is not simply technical. It points to a wider principle: if training wishes to remain credible in increasingly digital environments, it must still assess what the pilot actually does, how often key behaviours appear and how reliably those behaviours hold up.

> THE DEBATE IS NO LONGER ABOUT WHETHER AI IS COMING – IT IS ABOUT WHETHER AVIATION CAN INTEGRATE IT WITHOUT LOSING CONTROL OF WHAT MAKES THE HUMAN OPERATOR COMPETENT IN THE FIRST PLACE

AI may help analyse performance data more effectively, but it should not erase the need to measure hands-on competence. In fact, the growth of AI probably makes such measurement more important, because it becomes easier to confuse system-supported success with human mastery.

AI as a force multiplier

There is, however, a more constructive way to view AI in education. Rather than seeing it as a threat to proficiency, training organisations can treat it as a force multiplier for better instructional design. Ramanjaneyulu *et al*[3] argue that digital competence in aviation training must include technical skill, critical evaluation, ethical practice and adaptive expertise in safety-critical contexts.

That is an important shift. In this view, digital literacy is not merely the ability to operate software. It includes the judgement to evaluate outputs, detect limitations and respond appropriately when technology behaves unexpectedly. For pilot training, that means AI should become part of the curriculum not only as a tool, but as an object of critical understanding. Pilots should learn how AI reaches or supports a recommendation, where the data may be weak, what biases may exist and what signs suggest the output should be questioned.

This educational dimension is especially



▲ Human instruction or Human-AI Teaming in pilot training – what can AI improve without weakening proficiency?



(3) Ramanjaneyulu, S., Jalandharachari, A.S., Bindhani, S., Kasodhan, P., Harish, D. and Murthy, B.R., Integrating digital competency into aviation training: An auditable inputs–processes–outcomes framework. *Journal of the Air Transport Research Society*, 2026, 6, 100104.
(4) Kabashkin, I., Misnevs, B. and Zervina, O., Artificial intelligence in aviation: New professionals for new technologies. *Applied Sciences*, 2023, 13, (21), 11660.



Stephen Bridgewater/RAeS

important because current aviation curricula have not always kept pace with technological ambition. Kabashkin, Misnevs and Zervina[4] examined aviation engineering bachelor's programmes and found limited focus on AI and machine-learning competencies, with greater emphasis on more foundational digital skills.

While their study addressed engineering education rather than pilot training directly, the lesson still applies. Aviation institutions often declare their intention to modernise faster than they redesign what they teach. In the pilot domain, that gap could become particularly risky. If operators introduce AI-enabled systems into training or line operations before instructors and trainees possess a structured understanding of human-AI collaboration, the result may be superficial adoption without real competence. That is precisely the kind of mismatch that safety-critical industries should avoid.

Call for caution

Another reason to proceed carefully is that AI in aviation is expanding faster than assurance methods. Yiu *et al*[5] reviewed 175 studies on AI and aviation safety and concluded that the field shows strong promise, but still requires explainable AI, certification frameworks, hybrid intelligence design and more robust datasets for generalisation.

Their conclusions are directly relevant to training – if the broader safety community is still working out how to assure the reliability and trustworthiness of AI, then pilot instruction should not present AI outputs as inherently authoritative. Instead, training should normalise a healthier relationship: AI as a powerful but fallible contributor to safe performance.

Instructors have long taught pilots to challenge weather interpretations, FMS entries and even each other's assumptions. AI outputs should be treated with the same disciplined professionalism.

This is where human factors becomes decisive. Kirwan's work on human-AI teaming in aviation[6] argues that principles and policy statements are not enough; what is needed is a structured set of human-factors requirements spanning areas from human-centred design to organisational readiness.

That phrase, 'organisational readiness', deserves attention. Aviation often frames new technologies as cockpit issues, but training outcomes are shaped by the entire system around the cockpit: syllabi, checking practices, simulator scenarios, instructor standardisation, operational philosophy and even the informal messages organisations send about what counts as 'good performance'. If an operator values smooth AI-enabled execution more than evidence of deep understanding, the training system will drift accordingly. The true challenge is therefore cultural as much as technical.

Four principles

A sensible training philosophy for human-AI teaming would rest on four principles.

First, AI should be used to widen understanding, not to hide complexity. Good systems should make relevant information clearer, but they should also help pilots understand why a recommendation appears.

Secondly, training should preserve periodic unsupported performance. Pilots need opportunities to manage scenarios without intelligent assistance so that baseline competence remains visible and trainable.

Thirdly, assessment should separate assisted from unassisted performance wherever possible. If we do not know which part of success belongs to the pilot, we do not truly know what has been learned.

Fourthly, instructors should be prepared to teach AI scepticism as a normal professional skill, just as they teach cross-checking, monitoring and threat management. These are not anti-technology principles. They are the conditions under which technology strengthens rather than weakens the human operator.

> TRUSTWORTHY AI IN AVIATION REQUIRES LEARNING ASSURANCE, EXPLAIN-ABILITY, ETHICS-BASED ASSESSMENT AND CLEAR HUMAN GUIDANCE

Pilot training has always adapted to new tools. Radio navigation, glass cockpits, flight management systems and increasingly capable automation all changed what it meant to be proficient. AI will do the same, but its effect may be deeper because it touches judgement itself. That makes the educational response more consequential. The aim should not be to preserve an idealised past in which pilots do everything alone, nor to embrace a future in which machines quietly become the real thinkers in the system. The aim should be to build pilots whose judgement is sharpened by AI, not substituted by it; whose workload is reduced without losing mental discipline; and whose proficiency remains anchored in observable, resilient performance.

If aviation can hold to that standard, rather than a threat to airmanship, human-AI teaming in pilot training may become one of the best tools available for renewing it.

▼ AI has the potential to revolutionise training in both civilian and military cockpits.



USAF

(5) Yiu CY, Li W-C, Ng KKH, *et al*, Enhancing aviation safety with artificial intelligence: a systematic literature review on recent advances, challenges and future perspectives. *Advanced Engineering Informatics*, Vol 71, Part B, April 2026, Article number 104378.
(6) Kirwan, B., Human factors requirements for human-AI teaming in aviation. *Future Transportation*, 2025, 5, (2), p42.
(7) Sun H, Zhou X, Zhang P *et al*. Competency-based assessment of pilots' manual flight performance during instrument training. *Cogn Tech Work 25*, p345-35

AI frontier world models the future for defence

Why contested environments demand frontier world models at the edge. LLMs will never close the loop fast enough

Defence environments are becoming increasingly difficult places for conventional AI to operate. GNSS jamming and spoofing are commonplace across the battlefield, communications can be degraded or denied, terrain and visibility change. Autonomous systems are being deployed further from human operators, for longer periods and alongside larger numbers of other assets.

The difficulty is that much of today's AI works best when the world it encounters remains reasonably close to the world represented in it its training data. This is not necessarily a problem for narrowly defined tasks such as identifying objects in a camera feed. But physical autonomy in contested environments asks something more difficult of AI. A machine moving through the real world has to maintain an understanding of where it is, what has changed and what it should do next, even when its information is incomplete.

Stanhope AI has built its approach around this idea. The UK sovereign frontier AI company develops cognitive AI for autonomous systems, building on more than 20 years of neuroscience research at UCL. Its core model, Petra, is based on 'Active Inference'. Rather than asking a neural network to learn every useful relationship from training data, Petra begins with an explicit model of the physical world, where things are, how they might move, what belongs to the agent rather than its environment, and how certain it is about what it currently believes.

Using only onboard sensors, Petra continually updates that model as the platform moves, which becomes particularly important in GNSS-denied environments. Many current UAS remain highly dependent on satellite navigation, whereas Petra allows the platform to build and maintain an estimate of its own position from onboard observations.

Some features of the terrain provide more useful information for localisation than others. A distinctive ridgeline, watercourse junction or treeline boundary can help the system refine its estimate of where it is, while less distinctive parts of the landscape contribute relatively little. Petra can retain and update these salient features within its world model, using them to continually refine both its position and its confidence in that estimate. If the available information is insufficient, the agent can seek observations that reduce uncertainty while continuing towards its mission objective.



Autonomous navigation and optimal route selection.

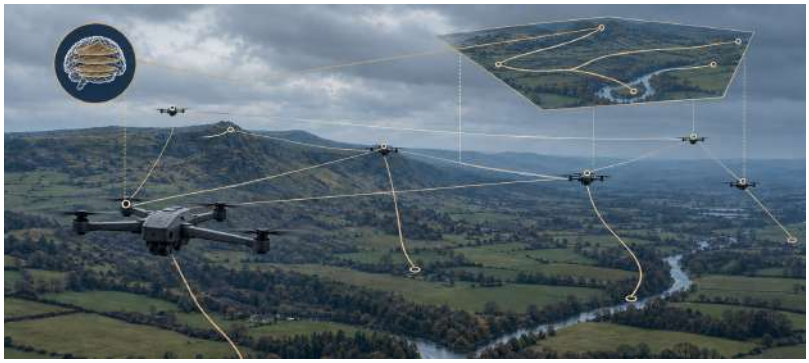
Why does defence need a new generation of AI models?

The current AI paradigm creates a practical problem for defence, because building capability around large training datasets assumes that the relevant data can be collected, labelled and incorporated into a model before it is needed. This is unrealistic in the face of new threats, unfamiliar operating environments or when there is simply not enough representative data available in advance. Retraining also carries a cost - it requires another cycle of data collection, model development, testing and assurance when a change in theatre, mission, or operating conditions occur. At defence timescales, this can make adaptation slow exactly where the operational requirement is quick response.

There is also the problem of confidence. Conventional models can produce an answer without providing a useful account of how uncertain that answer is. As AI takes on a greater role in autonomous decision-making, knowing when a system is uncertain becomes essential. The same is true of explainability - if a model is difficult to interrogate, assurance, accountability and compliance with the law of armed conflict become harder. And finally, much of the recent

progress in AI has been enabled by very large amounts of compute and infrastructure. These resource-heavy requirements are incompatible with the tactical edge, where power, bandwidth and connectivity are constrained.

Petra's core reasoning does not depend on an LLM or large-scale remote compute. Its world model architecture contains approximately



Autonomous collaboration and adaptive task sharing.

10million adaptive parameters, with current prototypes operating on NVIDIA Jetson Orin Nano hardware at around 18W and a pathway towards Raspberry Pi-class compute below 15W.

Why is on-device AI processing becoming more important for defence and aerospace organisations?

One problem with scaling autonomy is that adding more platforms can also mean adding more demands on the operator. Human attention is finite, and a fleet offers limited advantage if every asset still requires someone to interpret what it is seeing and decide what to do next.

On-device AI begins to close the gap between the amount of information a fleet can generate and the attention a human operator can give it. By moving more interpretation and decision-making onto the individual asset, the operator no longer has to remain in the loop for every adjustment or observation. With Petra, each platform can maintain its own understanding of the mission and surroundings, updating it locally as new observations arrive. Where communications are available, useful information can be exchanged across the team without making that connection a prerequisite for continued operation. Less data needs to be transmitted, and critical functions can continue when communications disappear.

Why are adaptability and reasoning becoming increasingly important for defence AI applications?

As autonomous systems move from carrying out individual functions to executing a mission, the different aspects of autonomy must integrate. Recognising an object, estimating position and controlling movement are useful capabilities, but none is sufficient in isolation. Perception has to connect with what the system has observed before, what it expected to observe, what it is trying to achieve and what action is now appropriate.

When several autonomous assets are operating together, they need to coordinate actions and share information without requiring every decision to pass back to a central operator. Active Inference brings these relationships into the same architecture. What an agent observes can modify its understanding of the situation, and that revised understanding can alter what it does.

For Petra, the same principle can extend across a team of drones. Individual assets can investigate different parts of an environment and contribute what they observe to the team's developing picture. Stanhope has already demonstrated Petra integration within a swarming UAS architecture, providing a proof point for operation within a wider system-of-systems environment.

This is an important distinction between automation and autonomy. Automation executes the plan it's been given, whereas greater autonomy requires a system to recognise when the situation has changed enough that the plan should adapt with it.

Where can Stanhope AI help?

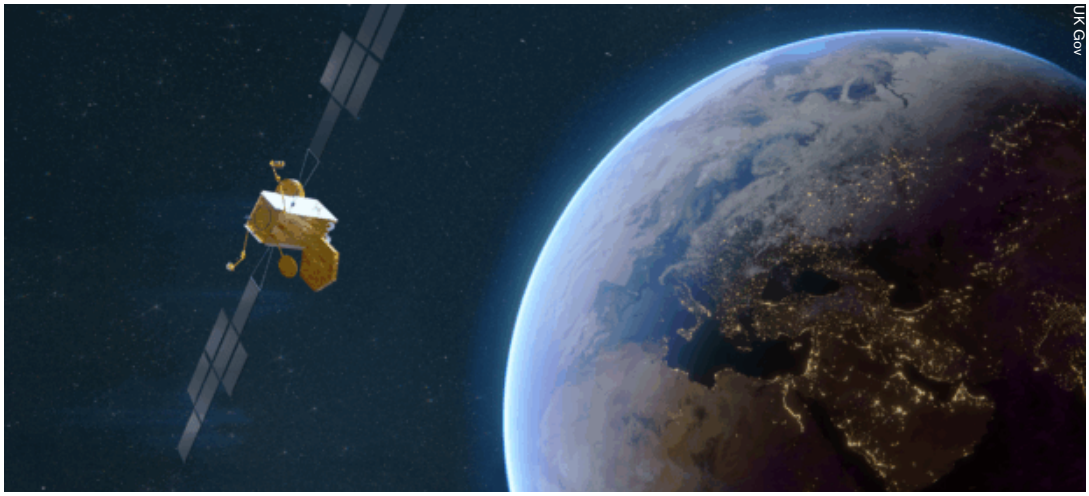
Stanhope AI provides Petra, a cognitive AI software stack designed to bring autonomous decision-making directly onto physical platforms. Petra is platform-agnostic and integrates through an open, standards-based SDK across air, maritime and ground systems.

The immediate operational focus is collaborative recce swarm and counter UAS operating in adverse and GNSS and comms denied environments. Petra has already been integrated and tested on four air and ground platforms and looking to extend to fixed wing. Stanhope is testing across mixed UK land and inland-water and sandy environments in day and night conditions.

Petra's core IP and software are UK-owned and UK-developed, with no dependency on overseas infrastructure for core operation. While GNSS-denied localisation is a core application, the same architecture supports adaptive mission planning and mid-mission re-tasking, target-relative search and collaborative decision-making.

For defence users, this means existing systems can be given greater autonomy without becoming more dependent on centralised infrastructure or continuous operator control.

To find out more and discuss how Petra could bring cognitive AI to your platforms; please contact info@stanhopeai.com.



Securing space

With space now becoming critical (inter)national infrastructure on which our daily lives depend, the challenge has now moved from exploiting space, to assuring it. **TIM ROBINSON** FRAeS and **STEPHEN BRIDGEWATER** FRAeS report from the 2026 RAeS President's Conference.

On 29-30 September the Royal Aeronautical Society hosted the 2026 President's Conference, Assured Space at its HQ in London. Coming hot on the heels of a new UK *Space Strategy*, and an upcoming vertical launch from SaxaVord, Scotland, the two-day event arrived at a topical time. With high-level speakers and panellists from industry, government, academia, and the military, the conference theme was a far wider than traditional 'access to space' or sovereignty, taking in topics such as sustainability and the space careers pipeline – making for a fascinating and insightful forum that considered assured space in a holistic and multifaceted way. Let's take a look at just some of the highlights.

Opening the conference, RAeS President Prof Malcolm Macdonald FRAeS noted that in 1866, the year of the Society's foundation, the SS *Great Eastern* laid the first transatlantic telegraph cable – the beginning of a global communication network that shrank the world. Fast forward 160 years and, while terrestrial data links are still important, much has moved to orbit, where the ultimate high ground connects, senses, locates and provides timing for our modern technological civilisation which we take for granted. Macdonald set the theme for the two days: Assured Space is "the ability to sustain the full space value chain so that essential outcomes continue despite failure, disruption or attack" – and the test is "continuity of outcomes, not activity."

From the UK perspective, he noted that while the past two decades had seen Britain active in producing "strategies, reviews and reforms," the UK's problem "has not been ambition or achievement. It has been continuity." This theme would be revisited in the conference with discussion about the new UK *Space Strategy* – released earlier in September.

Meanwhile, a video message from the UK Space Minister, Baroness Lloyd, highlighted the huge economic stakes of assuring space: a £19bn sector, with some £450bn of economic activity (almost a fifth of UK GDP), dependent on satellite services.

▲ A selection award for the £6bn UK MoD Skynet milsatcom is imminent.

▼ Below left to right: NATO Deputy Allied Commander Europe ACM Johnny Stringer joined via video.

Nick Earl FRAeS, from Safran UK, laid out the industrial capability.

Assuring the space skills and career pipeline was also a theme of the conference.









▲▲ Dr Alice Bunn FRAeS highlighted SDA as potentially the biggest opportunity for the UK from its new *Space Strategy*.

▲ RAeS President Prof Malcolm Macdonald FRAeS opened the conference.

Contested space every day

Giving a keynote video from SHAPE HQ in Mons, Belgium, was ACM Johnny Stringer, Deputy Supreme Allied Commander Europe, NATO – marking a significant shift in how civil and military space power is now becoming merged. As one delegate quipped during a networking break: "Ten years ago, ESA officials would cover their ears if you mentioned military space." As this conference was to confirm – those days are now over.

Stringer noted that the post-Cold War and Global War on Terror (GWOT) era where satcoms and GPS always worked – and space was seen as "free goods" – were over. Instead, he said that "we are contested in space every day" – adding that while Western Europe had avoided war so far "[he] would argue that we are not at peace" – a situation highlighted by a recent arson attack on a Starlink ground station in Poland.

The importance of this conference in generating debate was also highlighted by ACM Stringer who, as well as satcom, ISR, PNT and missile warning, included industrial capacity, raw materials, financing as well as "informed societal and political engagement" on space control as part of assured space. For any remaining holdouts who were hoping that space would remain a civil domain of peace, Stringer said "that ship has sailed," NATO itself is building up its space power muscles with its next defence planning cycle, which for the first time will include space capability targets – and the alliance ran its first 'Red Flag' style space-centred exercise at the end of 2025.

Procuring through the rear-view mirror?

Meanwhile, the UK's military space acquisition plans came into question in the next panel session 'Towards Assurance' – with AM (rtd) Andrew Turner FRAeS, CEO Saibre Capital, telling the conference: "We are procuring through the rear-view mirror." Turner noted that, just as the UK has committed billions to owning and operating the military ISTARI spy sat and Skynet hardware, the world had moved on to "capability as a service." The US, not short of funding for military space, was leading this charge – for example with the US Space Force buying imagery through its Global Data Marketplace. Turner also noted the disconnect between Whitehall and the money markets in the City – where one did not understand the other.

However, does assured space mean owning the hardware? Fellow panellist Matt Wood of EarthDaily observed that 'sovereignty,' barely mentioned couple of years ago, has now become the hottest topic. Yet this has already shifted from sovereign-built, sovereign-launched systems, which few nations can afford, to the most important aspect: sovereign control of data flows.

While the next panel considered space as dual use, a morning presentation from Martin Gilmore, Chief Technologist, AWE, provided lessons from a purely defence perspective – the strategic nuclear deterrent and the UK's own warhead and re-entry capabilities. While the UK is working on an updated Trident warhead in Astraea, Gilmore explained how the previous Chevaline programme – to increase the penetration capability of the Polaris missile – had been an outstanding technical success but a budgetary and schedule failure. With the UK nuclear deterrent also closely tied to the US, Gilmore also noted that an effective partnership "is not the opposite of sovereignty."

The following panel considered the inherent nature of dual-use of space – with Anthony Baker of SatVu, noting that its infrared satellites, built to monitor pollution and energy waste, also pick out the thermal signatures of drone factories, rockets about to launch and nuclear plants – defence applications thus come built in. Michael O'Callaghan FRAeS, of Airbus Defence and Space, reminded the audience that dual use was not a new concept, and in fact there were lots of previous military/civil projects, such as TopSat, to learn from.

Control of space

One of the first day's most eye-opening panels came in on Dynamic Space Operations and how military space is moving from 'static fortresses' to 'manoeuvre warfare' – led by the US, China and Russia. At first glance this may seem counterintuitive – how can satellites whizzing above our heads and thousands of miles an hour, be 'static'? However, launched with carefully optimised levels of reserve fuel to change orbit, and on highly predictable paths, any unplanned engine burns (to avoid space debris or hostile satellites getting up close) quickly burn up their fuel and shorten their operational lives. Space manoeuvre was already here with a Chinese satellite in 2025 making burns that used up "six years of normal GEO station-keeping in one go."







An audience with Meganne

A particular highlight of the conference for many was the fireside chat featuring ESA Reserve Astronaut, Dr Meganne Christian FRAeS. Dr Christian discussed her route from a material scientist specialising in hydrogen storage and graphene to joining the ESA programme and her focus on In-Space Servicing, Assembly and Manufacturing (ISAM). By taking advantage of the space-based manufacturing in microgravity, Dr Christian discussed how mankind can create superior crystal growth, leading to higher-quality semiconductors and pharmaceutical formulations with lower viscosity allowing for easier injection. She also expressed an eagerness to synthesise high-quality graphene on the ISS to reduce structural defects.

Predictable orbits also make for easy targets. Gabriel Elefteriu FRAeS, AstroAnalytica and the Council on Geostrategy, revealed that an open-source study in the Chinese *Journal of Systems Engineering* had simulated how 99 'hunter' satellites could intercept 1,400 Starlinks within 12 hours.

One way around this, to increase deterrence in space and project space power, was refuelling of satellites. OrbitFab's Jacob Geer made the deterrence case for refuelling: if the adversary knows you can top up, "it changes the way they think." Elefteriu went further – dynamic space operations should not just be having the fuel or DeltaV to avoid hostile satellites but also hold the adversary's high-value assets at risk too.

Congested and contested

If hostile action was one threat to assured space services and capabilities, another panel considered accidental and natural challenges to sustainability. Dstl's Chief Scientist for Space Weather, Prof Gemma Attrill, observed how with 60,000-100,000 satellites predicted in orbit by 2030, LEO is getting "congested and contested" and the Sun has a vote. Space weather, in the form of intense geomagnetic storms, had already caused havoc in 2022 – and the next event was a matter of "when, not if" (see 'The solar storm of the century is overdue. Are we ready for it? *AEROSPACE*, Aug/Sep 2026).

Meanwhile, with increasingly frequency of satellite launches and deorbiting of LEO satellites, pollutants were being injected directly into the stratosphere at a dizzying rate, where they lingered for two to three years instead of weeks, said UCL's Prof Eloise Marais. Even well-intentioned attempts to build sustainable spacecraft in the form of wooden satellites, where the structure would burn up, still deposited carbon into the upper atmosphere.

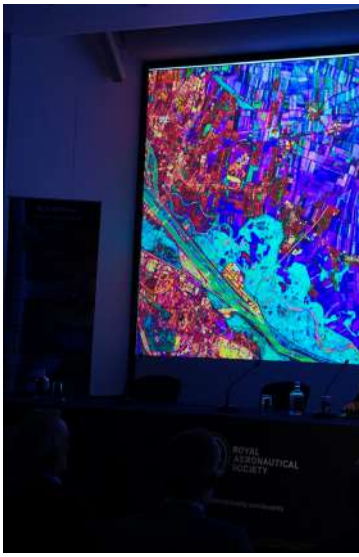
Eutelsat OneWeb's Pablo Minhuijon Pallas gave the satellite operators perspective on this. Manual conjunction coordination "is not possible any more" with industry relying on automated alerts and warnings. However, outside the basic Newtonian problem of large numbers of objects spinning around a planet with the potential to hit each other, Pallas also lamented international standards: "At the most basic end of the problem, you have the fact that there is a fundamental lack of transparency and development standards. When it comes to coordinating with other operators, there is no real clear ways of doing it. Many times, there are not shared platforms to do so."

'Here is our day'

Just two-weeks into to her new role as Co-Director of the UK Space Agency, the conference also heard from Dr Alice Bunn FRAeS in a fireside chat. Despite the swallowing up of the UK Space Agency by the UK Department for Science, Innovation and Technology (DSIT), Bunn was upbeat about the move, saying that it benefited the Space Agency to be in a "heavyweight department." Moreover, and echoing comments both in the official conference presentations and in the networking breaks, with its new *Space Strategy*, the UK government was putting its 'hands off' market-led approach to space behind it with a focused one government civil/military approach. Bunn laid out her takeaways as three Ps – Priorities, and the courage to deliver them, Procurement and Partnerships – and concluded of the new *Space Strategy* and its opportunities for the UK: "Here is our day."

Space as the new sea lanes

In his keynote presentation to open the second day of the conference AM Mark Flewin, the RAF's Air & Space Commander, drew parallels between assured space and assured access to sea lines of communication: "For centuries Britain's security and prosperity depended upon our ability to move people, goods and military power across the world's oceans. We did not need to own every sea lane, but we did need to be confident that, when required, our ships could sail, our trade could flow, our forces could move and – when that freedom was threatened – we had the capability, the tactics and the means to protect it."



All images: Alex Bielinski/RAeS unless stated otherwise.

Flewin proffered that Britain has now reached that same point in the space domain. "The question is no longer can we put satellites on orbit," he suggested, "it is whether, when our nation needs space, space will work."

Flewin explained that the UK needs options to protect its systems in space, to preserve its freedom of action and, where necessary, the "lawful options to impose cost on those seeking to deny us that freedom."

The UK *Space Strategy* rightly places significant emphasis on industrial capability, resilient supply chains and the ability to turn innovation into operational effect. Flewin was followed onto the stage by Nick Earl FRAeS, VP and National Executive of Safran UK, who explored the industrial and technological requirements necessary to transform strategic space ambitions into dependable and resilient capabilities.

People are CNI

The first panel session of the second day was moderated by the RAeS' Head of Education, Skills & Diversity, Nick Davis, and looked at the role of people as part of our Critical National Infrastructure (CNI). Joined by Philippa Davies FRAeS (Founder of Uplifted Leaders and Mission Lead at the Satellite Applications Catapult) and Vice Chair of the RAeS Next Generation Board, Joe Palmer MRAeS, the panel emphasised that assured space ultimately depends on people. Panellists argued for stronger links between government, industry and academia, more flexible learning pathways and better mechanisms for retaining expertise and translating research into operational capability.

Academia as a critical enabler, innovator and amplifier in the space sector was also the subject of a panel discussion moderated by Jason Maroothynaden FRAeS from the RAeS Space Specialist Group. He was joined on stage by Prof Kate Robson- Brown, VP for Research, Innovation and Impact at UCD, Dr Paul Bate – Professor in Practice at the Surrey Space Institute and Dave Moody FRAeS, Director of the North East Space Skills and Technology Centre (NESSTC) to discuss how academia can play a role in space collaboration and bridge the talent gap.

A fascinating session investigated how space can be an innovation engine and amplifier, creating technologies that spin out into other sectors. Simon Brown of the Met Office kicked off by highlighting the growing economic and operational value of Earth observation and space weather data, noting their importance to government, defence and climate resilience.

Dr Miranda Turvey, Principal Scientist for Technologies and Techniques for Timing at Dstl, highlighted the importance of resilient timing systems in an era of GPS jamming and spoofing. She described a range of alternative timing technologies that could provide assured services without full dependence on GNSS and argued that resilience, rather than absolute precision, should be the UK's guiding principle.

Prof Srinivasan Keshav of the University of Cambridge outlined the TESSERA (short for Temporal Embeddings of Surface Spectra for Earth Representation and Analysis) project, which uses AI to make vast volumes of Earth observation data more accessible to scientists, policymakers and conservationists. By identifying patterns within satellite imagery without requiring extensive labelled datasets, TESSERA demonstrates how advanced analytics could broaden the value of space-derived information. "We wish we knew how it works," Prof Keshav told the audience with a smile, "but like ChatGPT it just does!"

Beyond mission success

The second afternoon began with a panel moderated by Sue Kee, Head of Space Applications at the UK CAA, asking where the space sector goes next. It is already transitioning from a bespoke, mission unique craft and Kee was joined by two entrepreneurs – Rafel Jorda Siquier, CEO of Open Cosmos and Dr Peter Mendham, Founder and CTO of Bright Ascension – to discuss the move to an industrialised domain with higher launch cadence, larger scale production and a need for standardisation.

Throughout the conference there had been a repeated call for UK space sovereignty, but Siquier cautioned against "narrow sovereignty," advocating for "resilience through interoperability and diverse, international supply chains to avoid single points of failure."

Summary

If the first era of military space was about access and the second was about exploitation, we are now entering a third era of assurance. Space is no longer simply a domain of future opportunity; it has become part of the infrastructure of modern life. It supports communications, navigation, financial transactions, environmental monitoring, emergency services and defence operations. At the same time, space is becoming more congested, more competitive and certainly more contested. Nations must therefore assure access, services, effect and, ultimately, operational advantage

The 2026 RAeS President's Conference could not have occurred at a more relevant time. With the announcement of the UK *Space Strategy*, the US revealing it owned a 'space-based' weapon, the news of a RAF satellite jamming capability and the increasing levels of GNSS denial and cyberwarfare there was much to debate. Speaking to delegates at the event, many praised the technical content, quality of speakers and the in-person networking opportunities provided at this forum.

In its 160th year, the Society once again found itself of the heart of aerospace discussion asking the important questions of the era.

▼ Below: By fusing temporal imaging from space with AI, the Cambridge University's TESSARA was democratising Earth Observation.



For the full conference report please scan the QR code to visit the *AEROSPACE* Insight blog on our website.

RAeS HQ, LONDON
MONDAY 23 NOVEMBER 2026

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- High-consequence Infectious Disease retrieval: lessons from the South Atlantic

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Afterburner

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Diary

12 November 2026

Berlin-Brandenburg Branch: Cross Disciplinary Propulsion Research at DLR – Enabling a Competitive and Sustainable Aviation Future

Prof Dr Florian Herbst, Director, Institute Propulsion Technology, Rolls-Royce Deutschland, Eschenweg 1, 15827 Blankenfelde-Mahlow-Dahlewitz, Germany

The unique Dornier D328 UpLift is operated by the German Aerospace Center (DLR) as a flying research and test platform investigating innovative aviation technologies of the future, such as synthetic fuels or hydrogen. On 12 November, Prof Dr Florian Herbst, Director, Institute Propulsion Technology, Rolls-Royce Deutschland, will speak at the Berlin-Brandenburg Branch about the cross disciplinary propulsion research undertaken at the DLR. DLR

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– From our President

"Every profession depends upon people who preserve hard-won knowledge, question established practice and help others to advance beyond it."

– From our Chief Executive Officer

"There is an opportunity here for Skills England, the UK Civil Aviation Authority, educators and employers to work together on something genuinely practical."

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Message from RAeS

OUR PRESIDENT

Malcolm Macdonald



> Every profession depends upon people who preserve hard-won knowledge, question established practice and help others to advance beyond it



▲ Addressing the New Fellows' Reception at No.4 Hamilton Place on 29 September. Jonathan C Clare/RAeS

Last month, I wrote about the publication of the UK government's new *Space Strategy* and the challenge of turning ambition into durable capability. My President's Conference brought that challenge into sharper focus. As RAF Air and Space Commander, AM Mark Flewin, put it: "The first era of military space was about access. The second was about exploitation. The era we are now entering is about assurance: assuring access, assuring services, assuring effects and, ultimately, assuring operational advantage."

The conference (see *Securing Space*, p.46) did more than reinforce the importance of assurance; it clarified what delivery requires. Assurance is not secured by agreeing with the argument, but by accepting responsibility and acting on it. No nation can – or should – reproduce every part of the space value chain. Collaboration is credible only when roles are understood, dependencies are visible and partners know what they can reliably expect from one another: interdependence without overdependence. Equally, innovation must travel the difficult distance from demonstration to product, certification, integrated service and long-term support. A promising technology is not yet an assured capability.

Martin Gilmore, Chief Technologist at AWE, offered a deceptively simple test of credibility: connect purpose, evidence, interfaces and people across generations. Each element matters. Purpose without evidence is assertion; evidence without effective interfaces remains isolated. Neither produces enduring capability without people who possess the judgement, experience and professional confidence to bring the system together. Our challenge is not merely to recognise those connections but to sustain them under pressure.

The same thought shaped my remarks at our New Fellows' Reception on the evening before the conference. Fellowship rightly recognises achievement, but it is not a destination. Every profession depends upon people who preserve hard-won knowledge, question established practice and help others to advance beyond it. What we inherit from previous generations fulfils its purpose when we test it, strengthen it and pass it on.

That responsibility belongs not only to Fellows, but to every member of our Society. Membership is more than a credential or a collection of benefits; it is an opportunity to strengthen the profession.

We can mentor someone, contribute to a Branch or Specialist Group, share expertise, support professional registration or open a door that was once opened for us. Professional community is, therefore, integral to assurance. Resilient systems depend upon more than robust hardware and diversified supply chains. They need people who can recognise failure, exercise judgement, challenge assumptions and restore capability when plans no longer fit events. Investment in skills, professional standards and trusted networks is not an adjunct to technical assurance. It is part of the system itself.



▲ The inaugural Clyde Aerospace Early Careers Network took place in October, supported by the Prestwick Branch and was attended by President Malcolm Macdonald. Via Malcolm Macdonald/RAeS

My thanks go to the Society team whose work made Space Week possible, and to every speaker, panellist, moderator and delegate who contributed so openly. The value of the week lay not in producing easy agreement, but in bringing different parts of the community together to test assumptions, expose dependencies and identify where action is still required. That is precisely the kind of constructive challenge a learned society should provide.

That principle was put into practice in October at the inaugural event of the Clyde Aerospace Early Careers Network, established with the generous support of the Prestwick Branch. The sell-out gathering brought together participants from all four Glasgow universities and beyond, giving the Society a new and visible presence in a city with a strong aerospace heritage. More importantly, it created a place where early-career members can build relationships across institutional and disciplinary boundaries. I congratulate and thank the network's committee. An idea becomes valuable only when people turn it into action; their energy, persistence and leadership made this network happen.

That momentum continues. I met the Dublin Branch on 28 October, and on 10 November I will support the launch of a new Branch in the North East of England, extending the Society's presence into another important aerospace community. On 9 November, our Honours, Medals and Awards Ceremony will celebrate outstanding achievement, innovation and distinguished service across aviation, aerospace and space. These occasions differ in scale and purpose, but each reflects the same truth: professional communities become stronger when people choose to participate in them.

OUR CHIEF EXECUTIVE OFFICER

David Edwards



> There is an opportunity here for Skills England, the UK Civil Aviation Authority, educators and employers to work together on something genuinely practical

The day after returning from Australia and New Zealand, I moderated the International Federation of Airworthiness Summit at Mercedes Benz World at Brooklands, the ancestral home of Vickers. The entire discussion was about the shortage of licensed aircraft engineers.

It was a familiar conversation. Disturbingly familiar. The Royal Aeronautical Society was warning about the shortage as far back as 1999. Yet more than a quarter of a century later, we are still holding conferences, commissioning studies and mapping vacancies as though we have only just discovered the problem.

The pandemic, undoubtedly, made matters worse, accelerating retirements, and Brexit had an additional impact in the UK, but they did not cause this shortage. Blaming them risks excusing decades of failure to develop a sustainable pipeline of skilled engineers. The consequences are now impossible to ignore. Airlines and maintenance organisations compete for an increasingly scarce workforce. Succession planning, especially in the GA sector, is virtually non-existent. Experienced engineers command salaries that would have seemed extraordinary only a few years ago, and while that is good news for those whose expertise is finally being properly valued, it is a serious challenge for an industry that depends upon a reliable supply of qualified people. We are equally familiar with the obstacles. Training is expensive, licensing takes time and apprentices need experienced engineers to supervise and mentor them. Those same engineers are already stretched meeting operational demands. Simply calling for more apprenticeships does not address the capacity required to turn apprentices into licensed professionals.

My recent visit to Australia offered a useful reminder that our established systems are not the only possible systems. Australia's Civil Aviation Safety Authority has pursued more flexible approaches to licensing, including modular pathways and opportunities for self-study. None of this means compromising safety. It means asking whether there are different ways of demonstrating the same competence. That is a conversation we must be prepared to have here in the UK, and wider. Regulation must protect standards, but it should not be beyond examination. Nor should we confuse the length of a training pathway with the quality of the engineer emerging from it.

There is an opportunity here for Skills England, the UK Civil Aviation Authority, educators and employers to work together on something genuinely practical. We need to expand training capacity, make mentoring viable, improve routes to licensing and give young people a credible route into an exceptionally rewarding profession in a way that works with today's expectations. However, the industry must also accept responsibility. We cannot expect the government to solve a problem that employers have spent decades identifying without collectively investing in the answer. Public policy can help remove obstacles and support access; industry needs to build and fund the capacity. Above all, we need to change the question. We know there is a shortage. We know why the current system struggles to correct it. Another survey telling us where the vacancies are will not train a single additional licensed engineer.

The question is no longer whether we can describe the problem accurately. It is whether we are prepared to do something different. If we are still describing the same shortages in another ten years, we should probably stop calling them shortages and start calling them choices.



▲ The inaugural International Federation of Airworthiness Senior Aviation Leaders Summit at Brooklands. Via International Federation of Airworthiness



▲ Meeting students at the RAeS and AIAA Ice-Breaker Session during ICAS 2026. Via RAeS Australia Division



▲ The 35th Congress of the International Council of the Aeronautical Sciences in Sydney. Via RAeS Australia Division

Obituary

DR GRAHAM ROOD



FRAeS
1940-2026

Graham Rood was born in Surrey and attended a grammar school in Epsom before being selected at 17 for an apprenticeship at the Royal Aircraft Establishment (RAE) at Farnborough. After completing the apprenticeship – a much sought-after and world-renowned initiation into the world of aeronautical science and technology – and obtaining a degree in Engineering, Graham achieved more academic achievements before joining the Ministry of Defence's Inspection Directorate, where he worked closely with industry, including aero engine companies. This role was both interesting and deeply satisfying, but his thirst for hands-on engineering led him to the Royal Signals and Radar Establishment at Christchurch, where he worked on mobile power systems for the Army.

Returning to RAE, he became immersed in tackling cockpit noise – a problem that threatened to make communication impossible in low-flying jets. With defence priorities in the RAF switching increasingly to a new generation of 'below the radar' front-line strike aircraft, this was a major challenge. Determined to find solutions, Graham worked on developing advanced helmets and noise-cancellation systems. His role as a Flight Observer in fast jets allowed him to test and refine these innovations first-hand. His expertise and dedication saw him rise to become Head of the Acoustics and Vibration Section within the Man-Machine Integration Department.

After formally retiring, Graham became a support team leader for classic car rallies which took him all over the world. However, his passion for aviation and engineering remained undiminished and he soon became involved with the Farnborough Air Sciences Trust (FAST), where he became a Trustee and, subsequently, with a small team of volunteer specialists, the FAST Curator. This involved the monumental task of saving a vast archive, comprising photographs, reports and records that were at risk of being lost and forgotten, along with prototype and early evaluation examples of equipment of every description – from laser and electro-optical sensors to airborne cameras and radios and space items. This huge collection is unique as it concentrates on the scientific innovation, testing and evaluation of defence equipment from the earliest days of pioneer flying to comparatively recent times under what evolved from RAE through the Defence Research Agency to QinetiQ.

Graham's curatorial work, subsequently, expanded to include the work carried out in RAE outstations and associated Establishments, such as Bedford and Boscombe Down. He developed close relations with MoD and QinetiQ, as well as a host of other organisations, including the Science Museum and the Royal Aeronautical Society among others. His output has included countless lectures, articles and specialist books.

Thanks to Graham's efforts, future generations will be able to access and learn from the 100 years of pioneering technical and scientific work of the Royal Aircraft Establishment.

Sir Donald Spiers Hon FRAeS
President 1995-1996

FROM THE ARCHIVE



As Boeing is awarded the contract for the US Navy's future FA-XX sixth-generation fighter (see p.7), it is worth looking back 100 years to 3 November 2026 when the prototype Boeing F2B first flew. The US Navy would order 32 examples, with deliveries beginning in January 1928. The type was assigned to fighter squadron VF-1B and others to bomber squadron VF-2B, both based at NAS North Island in California and operating from the carrier USS *Saratoga*. The comanding officer of VF-2B, Lt DW 'Tommy' Tomlinson created the US Navy's first aerobatic team (illustrated) using three F2Bs, which flew in 1928 and 1929. While officially called 'Three Sea Hawks,' the team were more commonly referred to as the 'Suicide Trio' by virtue of their tied together aerobatics and inverted flight. US Navy

Aerosociety Lates

QUIZ AND FILM NIGHTS

The Aerosociety Lates events returned on 25 September with the fourth annual Aviation Quiz. Written and hosted by *AEROSPACE* Deputy Editor, Steve Bridgewater, the quiz included the usual rounds of aviation current affairs, as well as a geography round (in which he described places that shared their names with well-known aircraft).

Hilarity ensued over a new round that involved quizzers trying to identify the two aircraft that AI had merged to create a future Red Arrows mount and the evening finished with the ever-popular 'Is it a type of aeroplane or a variety of cheese?' round. There were prizes galore this year, kindly sponsored by Intercontinental Hotels, Corgi, the RAF Club and Runway 25, Ben Griffiths and Michael Pryce.

An Aerosociety Lates film night also concluded the President's Conference (see p46) on 30 September, featuring a showing of the *In the Shadow of the Moon* documentary about the Apollo space programme. The night featured a Q&A with its producer, Chris Riley, and aviation artist, Martin Impey – the latter painting live as the film played.



▶ "We asked AI to merge two famous aeroplanes to create a new mount for the Red Arrows." Tim Robinson/RAeS



▶ The 2026 Aerosociety Lates Quiz winners were team 'Martin Baker Tie Sweatshop', comprised of Andy Leather FRAeS, Sam Leather MRAeS, Chris Grutke, Tony Osborne and Sam Wise. Tim Robinson/RAeS

Membership applications, upgrades and Professional Registration

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Don't miss the final closing date this year on 17 November!

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Diary

EVENTS

3 November
Loughborough Branch: Effyn Richards Lecture 2026 – E-7 Wedgetail
Gp Cpt Alexandra Hyatt MBE MEng MA CEng MCMI MRAeS RAF
Lecture Room U005, Brockington Building, Loughborough University, Margaret Keay Road, Loughborough LE11 3TU

4 November
Weybridge Branch: Glider G-IZII Accident – What Happened?
TBC
Brooklands Museum, Brooklands Museum, Weybridge, Surrey KT13 0QN

4 November
Careers in Aerospace and Aviation Live 2026 London
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

4-5 November
Advanced Engineering 2026
NEC Birmingham, Pendigo Way, Marston Green, Birmingham B40 1NT

4 November
RAeS Greener By Design Webinar: Hydrogen – Contrails and Contrail mitigation for fuel cell aircraft
Tim Wittmann, Fluid/Hydromechanical & Thermal Development Engineer, Airbus
Online

5 November
Munich Branch: The future of satellite navigation – where are we going?
Cécile Deprez, Researcher Next-Generation GNSS, DLR Institute of Communications & Navigation
TUM Department of Aerospace and Geodesy, Magistrale, Lise-Meitner-Straße, Garching, 9 85521 Ottobrunn, Germany

6 November
RAeS Light Aircraft Design Conference 2026
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

9 November
Honours, Medals and Awards Ceremony 2026
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

9 November
DGLR Lecture (supported by the Berlin-Brandenburg Branch): Cross Disciplinary Propulsion Research at DLR – Enabling a Competitive and Sustainable Aviation Future
Dr Roland Wilhelm FRAeS
Hall MA004, Mathematics Building, Straße des 17, Juni 136, 10623 Berlin-Bezirk Charlottenburg-Wilmersdorf, Germany

9 November
Prestwick Branch: Maintaining Legacy with the Red Arrows
Sqn Ldr Andy King
Ayr Campus, University of the West of Scotland, University Avenue, Ayr KA8 0SX

10 November
Farnborough Branch: Roger Green Lecture 2026: From Human Factors to Safety Intelligence – 25 Years on the Front Line of Aviation Safety
Bob Simmons FRAeS, Co-Founder Baines Simmons
Farnborough College of Technology, Boundary Road, Farnborough GU14 6SB

10 November
Southend Branch: Southend Airport over the years
Roger Campbell, RAeS Southend Branch Chair, former Southend Airport Director and Senior Air Traffic Controller
Holiday Inn Southend, Eastwoodbury Crescent, Southend-on-Sea SS2 6XG

11 November
RAeS Greener By Design Webinar: SAF mandates/linkage with EU/ETS/financial implications
Jonathon Counsell, Group Sustainability Director, International Airports Group
Online

11 November
Chester Branch: RAF Heritage Team
Sqn Ldr Rick Lipscomb RAF
Broughton Wings Sports Club, Chester Road, Broughton CH4 0NQ

11 November
Preston Branch: Young Persons Network Mini Lecture Competition
TBC

11 November
Brough Branch: 'CLASSIFIED' – Beaumanor during the Cold War
John William Day (ret'd)
Cottingham Parks Golf & Leisure Club, Woodhill Way, Cottingham HU16 5SW

12 November
Berlin-Brandenburg Branch: Cross Disciplinary Propulsion Research at DLR – Enabling a Competitive and Sustainable Aviation Future
Prof Dr Florian Herbst, Director, Institute Propulsion Technology
Rolls-Royce Deutschland, Eschenweg 1, 15827 Blankenfelde-Mahlow-Dahlewitz, Germany

12 November
Bristol Branch: The Great Engineering Pub Quiz
The Eldon House Pub, 6 Lower Clifton Hill, Clifton, Bristol BS8 1BT

14 November
Munich Branch: Messerchmitt Lecture and 35th Anniversary Event: Curating Aircraft Collections
Nina Hadaway, RAF Museum and Dr Robert Kluge, Deutsches Museum
Deutsches Museum Flugwerft, Schleißheim, Effnerstraße 18 85764 Oberschleißheim, Germany

16 November
RAeS Lanchester Named Lecture 2026
John Harvey FRAeS, University of Cambridge
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

16-17 November
RAeS Aerodynamics Conference 2026
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

17 November
RAeS Sopwith Named Lecture 2026
TBC

17 November
Loughborough Branch: What Formula 1 can teach about aerospace – and what it can't
Dr Mark Robinson, Head of Engineering Aston Martin Performance Technology (Special Projects)
Lecture Room U005, Brockington Building, Loughborough University, Margaret Keay Road, Loughborough LE11 3TU

18 November
RAeS Greener By Design Webinar: Bridging Asia's UCO supply to Europe's SAF
Grazvydas Bajoras, Director, iFuel Ltd
Online

18 November
Medway Branch: Sextant to Sat Nav Part 2
Peter Griffith
Holcombe Hockey Club, Curtis Way, Rochester, Kent ME1 2TQ

19 November
Birmingham, Wolverhampton and Cosford Branch: Overview of the EE Lightning
Sqn Ldr Dennis Brooks and Richard Norris
Cockerell Room B1, SAFRAN Aerospace Wolverhampton, Stafford Road, Wolverhampton WV10 7EH

19 November
Manchester Branch: Jetopetra
Dr Andrei Evulet, President, CEO, CTO, Jetoptera
Lecture Theatre B, Roscoe Building, University of Manchester M13 9PL

23 November
RAeS Aerospace Medicine Group Annual Symposium 2026
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

23 November
Stewart Memorial Named Lecture 2026
Dr Peter Hodkinson FRAeS
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

24 November
Gloucester and Cheltenham Branch: Aircraft Electrification, Past, Present and Future
John Collins, Advanced Technology Engineering Manager, GE Aerospace
GE Aerospace, Bishops Cleeve, Cheltenham GL52 8SF

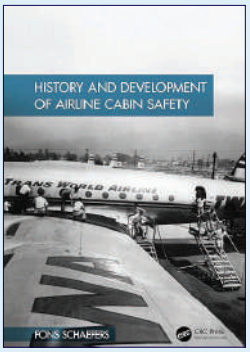
Book Reviews

CABIN SAFETY

History and Development of Airline Cabin Safety

Fons Schaefers

CRC Press, 2025, 350pp, £124.09 (Hardback), £119.84 (eBook). This book is available for loan via the National Aerospace Library.



Fons Schaefers' work is a masterful forensic review of the development of cabin safety from the outset of commercial flight to the present day. Schaefers draws on a long career in cabin safety – with both aircraft manufacturer and airline – and supplements this with wide in-depth research, in particular from North America, where so many of the innovations and regulations have originated.

The author structures the book by interleaving chapters covering distinct chronological phases of cabin safety development with chapters on specific subjects, such as regulatory frameworks, evacuations and the cabin professional. The phases of development start with the pioneering years through to WW2, then a first wave of development taking credit for wartime technology developments to 1953. The second heavily accident-driven wave runs to 1972, then a third wave, including 16 seats to 1996.

The chapter on developments since 1997 brings the reader up-to-date on issues, such as turbulence, cabin air quality and brace position. The last time-based chapter, titled *Future Developments*, reviews issues of the day, such as cabin baggage challenges, rather than issues of the future, for example the use of AI to guide passengers to the right exits.

A wide range of aircraft accidents involving cabin safety are documented. Those most significant for driving change are given close attention, such as the 1983 Air Canada DC-9 in-flight fire and landing in Cincinnati and the 1985 British Airtours 737 fire and evacuation in Manchester. Schaefers notes that most of our learning is from accidents and that it is a pity we could not be more proactive identifying issues before the harm is done.

The book is largely factual, though Schaefers is happy to state his view, for example, that locking overhead bins look very difficult to implement, or that cabin safety cards add little value with a better approach being to make procedures and equipment use intuitive. It is difficult to argue as his assertions are presented unemotionally and supported by evidence. Schaefers does, however, steer clear of making recommendations, which would have been of interest but maybe inconsistent with the documentary style of the book.

The book is well illustrated with period documents, pictures and data. The wide referencing and extensive index enable the book to be used as a reference encyclopaedia on cabin safety. The author structures and signposts clearly and includes upfront abstracts, enabling a straight read or a sampling by area of interest. This original and thematic approach to aviation history enables a key commercial flight imperative to be thoroughly and engagingly presented. Schaefers' approach is quite unique and may remain so given the skill and dedication required to research and document such a topic over a century.

Christopher Gibbs FRAeS

COUNCIL ELECTIONS 2027

Help shape the future of the Royal Aeronautical Society

The Royal Aeronautical Society is seeking nominations from members who would like to contribute to the future direction of the Society by serving on Council.

Council represents the views of the membership and the aerospace, aviation and space professions, providing advice, insight and challenge to help the Society achieve its strategic objectives.

We welcome nominations from members across all sectors, disciplines, backgrounds and career stages who are passionate about supporting the aerospace community and the Society's charitable objectives.

To stand for election, candidates must submit a nomination supported by one proposer and two seconders who are Members or Fellows of the Society.

Voting is open to eligible members of the Society.
Visit: **https://www.mi-nomination.com/raes2027**

Nominations close at 23:59 GMT on 29 January 2027.

Elections

FELLOWS

Thomas Breckenridge
Timothy Chibs
Letcher 'Lee' Collins III
Tim Eldridge
Aun Jafari
Christine McGee
Richard Milne
Mark Radcliffe
Paul Rowley
Andreas Schenk
Athanasios Synodinos
Paul Tedman
John Vincent
Andy Wilson

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Reuben Arkwright
Wai Kei AuYeung
Biswajit Bhowmick
Matt Edgson
Michael Footitt
Peter Hambrook
Ewan Hamilton
James Harvey
Martin Hawley
Jelle Hieminga
Shane Isaacson
Ansel James
Chandrakantha Karunaratne
Alison Kearney
Dionysios Klaoudatos
John Norsworthy
Devendran Sanjeevekumar
Jack Williams

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Jack Harding
Benjamin Payne
Mohammed Sirhan Pullambalavan
Katrina Rigby
Connor Wilson

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Greg Harper
Ellie Harris
Mateo Jarvis
Lizzie Li
Talal Malik
Paolo Moncada
Taniya Singakkutti Arachchige

STUDENT AFFILIATE

Darragh Hoare

WITH REGRET

The Royal Aeronautical Society announces, with regret, the death of the following members:

Air Cdre Norman Bonnor FRAeS 87
Capt Terry Buckland FRAeS 77
Prof George Done FRAeS CEng 90
Paul Lederman ARAeS 84
Ma'som Bin Mahadi MRAeS CEng 71
James O'Farrell MRAeS 79
Dr Graham Rood FRAeS CEng 86

2027 MEMBERSHIP SUBSCRIPTIONS

Membership Grade	2027 Subscription Rate
Fellow or Companion	£441
Fellow or Companion – 20% Discount	£352
Member	£298
Member – 20% Discount	£239
Associate Member	£185
Associate	£169
E-Associate	£60
Affiliate	£153
Student Affiliate	£57
Apprentice Affiliate	£0
Baseline Rate	£153

Administration Fees

Application Fee – Fellow or Companion	£187
Application Fee – All other grades	£93
Transfer Fee – All grades	£69

Notes

(1) CPIH Rate: Average 12 months to July 2026 - 3.4%
(2) 2027 Membership Subscriptions increase is proposed at 3.4%
(3) 2027 Membership Subscriptions increased are rounded up/down to nearest £.
(4) Members who have reached normal retirement age in 2027 are entitled to pay subscriptions at the Baseline Rate.
(5) Members who will be retiring during the course of the year can apply for the 20% discount on their subscriptions. Note – if the 20% discount takes the subscription below the Baseline Rate, the Baseline Rate will apply.
(6) Members have the option to pay their subscriptions by Direct Debit either in one sum in January 2027 or in ten monthly instalments from January 2027.
(7) 2027 Application and Transfer fees as shown left:

2027 Engineering Council Registration Fees

Registration Level	Entry Fee	Annual Fee	Annual Fee (Reduced)
Chartered Engineer (CEng)	£66.37	£51.03	£23.08
Incorporated Engineer (IEng)	£56.03	£41.97	£19.22
Engineering Technician (EngTech)	£22.97	£24.06	£11.01
Interim Registration	£18.24	£18.24	£18.24

New Member Spotlight

DARISHA L VIDRINE

Name: Darisha L Vidrine

Grade: Member

Age: 44

Location: South Louisiana, US

Job title: Systems Engineering Doctoral Student, author and aviation safety advocate



What inspired you into aerospace? I was inspired into aerospace by my ten-year career in aviation supply chain in 2006 at PHI Aviation in Lafayette, Louisiana. In this role, I was responsible for procurement and inventory management of aircraft parts for the Sikorsky S-76 A and C model helicopter fleet programme of 42 aircraft, as well as ten Leonardo AW139 aircraft. This role inspired me to pursue my education at Embry-Riddle Aeronautical University, where I completed the AS and BSc in Aviation Business Administration, MSc in Engineering Management and MSc in Systems Engineering. This inspiration continued to grow during my one-year Aviation Safety Automation internship with NASA Langley Research Center. I served as a volunteer Aviation Safety Team Representative with the FAA for the past four years and earned my FAA Part 107 Remote Pilot Certificate in January 2025.

What's the best thing about your current role? The best thing about my current role as a Doctoral Student in the Department of Systems Engineering at Colorado State University is that I get to be a part of high-impact engineering research on advanced and emerging technology in aerospace. This work allows me to explore complex systems, stakeholder interactions and help develop frameworks that will guide the future of aeronautical decision-making.

What made you join the RAeS? After a decade in the aviation industry, I spent several years as a stay-at-home parent while continuing my education. Now, as I return to my career while pursuing a PhD in Systems Engineering, I wanted to join a society that recognises the full scope of my journey. The Royal Aeronautical Society offered exactly that, along with a global community that shares my commitment to advancing aerospace.

What do you hope to get out of your registration with the RAeS? As a member of the RAeS, I look forward to taking part in thoughtful intellectual dialogue, collaborating on projects and contributing to aviation and aerospace policy and engineering papers with other engineers and researchers worldwide.

What three items would you take with you to the space station? The first item I would bring is my personalised Pandora charm bracelet. Each cube holds a photo of my children, spouse and the people closest to my heart, and wearing it would feel like carrying my whole support system with me. The second item would be my Embry-Riddle Aeronautical University alumni lapel pin. Finally, I would bring a Colorado State University pennant to show pride in my current college.

Who is your biggest inspiration? My biggest personal inspiration was my grandmother, Mary Mazella Tolliver, who passed away in 2022 at the age of 83. She raised me from a very young age and became my legal guardian when I was 12 years old. She was a mother of eight who was a supportive caregiver, housekeeper, mill worker and seamstress. She was the most admirable and selfless person I have ever known, and she passed down wisdom on the value of hard work, patience and persistence.

Piece of advice for someone looking to enter your field? Expand your horizons by being open to opportunities beyond your local community, especially if the options close to home are limited. Some of the most important experiences in my journey came from stepping outside my comfort zone and pursuing opportunities I would not have found if I had stayed in one place. Do not be afraid to network. It can feel intimidating at first, but many people in this field are genuinely happy to offer guidance. Above all, remember why this work matters. Technical skill is essential, but the engineers who make the greatest impact are the ones who never lose sight of the people their solutions are meant to serve.

The Last Word

COMMENTARY FROM
Professor Keith Hayward
FRAeS



Britannia shield – Running to catch up

"There is a need to upgrade the UK Ground Based Air Defence (GBAD) capability to counter the increasing range of threats, including cruise missiles, unmanned air vehicles and attack helicopters," – not a requirement issued by the next Conservative Minister for Defence for the 'Britannia Shield' protecting us from all manner of aerial threats, but one put out by Lord 'Willy' Bach, Minister for Defence Procurement in May 2003[1].

The clue is in the absence of a ballistic missile attack in the requirement, mightily adding to the problems posed to a defence and its cost. Israel's Iron Dome is the prototype, and until shortages hit home, Kiev has mitigated Russian attacks. Meanwhile the US has experienced Iranian attacks on its bases around the Gulf. All of these events have focused European minds on meeting a comparable multi-missile attack.

Domes do not come cheap

In the UK, the Conservative opposition party has raised the ante by proposing a £10bn 'Britannia Shield'. Details are sparce but it was clear that the additional spend on GBAD would be spread out over a decade. Defence against cheap drones and albeit more costly ballistic missiles is expensive. Ukraine has developed and manufactured relatively cheap defensive systems, but high-altitude interceptors are of a different magnitude. A Patriot battery costs £824m, with some £518m of that the missile load. Relatively cheaper systems are, or soon will be, available but the cost would soon eat into £10bn, let alone £1bn a year.

However, any increase in British spend on GBAD would help. The £1bn plus in the current planning round will not buy much in the way of area defence. Since 2003, UK GBAD has been better organised and modernised, but other weapons have had greater priority. The active bits have been predominantly short-range equipment such as Sky Sabre and CUAS weapons. In 2025 we saw a commitment to longer range weapons, but we still await the full details from the *Defence Investment Plan* for any further upgrades. My guess is that improved GBAD will get a mention, which might lead to a more generous commitment.

Better a Brussels Dome than a Britannia Shield

As my fellow veteran analyst, Trevor Taylor, notes: the UK's GBAD effort is already firmly attached to a European system. This makes eminent sense as the UK has a comforting distance from the likely source of threat. A European GBAD would need a layered and integrated network-based system. The UK could then add to a regional coverage. It would be better still if the system was based on local and dependably sourced kit which could also be replenished in quantity.

Europe relies on the US and, politically sensitive, Israel for some of its sharp end weaponry, such as Germany's Arrow 3 system, able to counter ballistic missile threats outside the atmosphere. Even given a fair wind from the White House, the problem is that the lead time to make a difference is very long indeed. There is a mightily long queue for existing kit to replace the rapidly diminishing supplies of Patriots and other missiles; developing a locally sourced alternative will take even longer. Europe will have to run to catch up with an investment that should have been made a decade ago.

More detail fewer slogans

The announcement of a 'Britannia Shield' (especially in its first manifestation as a 'Britannia Dome') was greeted by a storm of immediate scepticism. The Conservatives should certainly have thought through some of the details of their scheme – but the requirement for a better European GBAD system with a fully integrated British component is a compelling and necessary evolution of regional defence against the missile/drone threat.

"

THERE IS A MIGHTY LONG QUEUE FOR EXISTING KIT TO REPLACE THE RAPIDLY DIMINISHING SUPPLIES OF PATRIOTS AND OTHER MISSILES

[1] Note from Minister for Defence Procurement, 31 May 2003, National Archives, CAB164/2295

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