PUSHING THE ENVELOPE AGAIN: PREVIEW OF THE TEMPEST

GPS-Denied Navigation

HIL Vital to Testing

AVIATAR Explained

ELB and ETL Advances

COVER IMAGE:
Tempest concept against a blue sky

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Welcome to Aerospace Innovations!

We are delighted to be launching Aerospace Innovations, an exciting new publication for senior and middle management aerospace engineers, airline technical staff and pilots working in the commercial aviation, aerospace and defence industries.

Technological developments and innovations in the aerospace and defence industries continue to progress and evolve, particularly in areas such as AI, ML and digital twinning, which will have an increasing impact on productivity, sustainability and industry performance.

Brought to you by Neil Walker and Simon Barker, we have experienced industry journalists covering the latest innovations, emerging technologies and solutions impacting the evolution of the aerospace and defence industries, including avionics, connectivity, testing, operations, sustainability, MRO and the eVTOL/UAM sectors. Aerospace Innovations magazine is published quarterly, in both print and digital formats, and aims to covers all the technological advances being developed, tested, and applied to commercial, military, rotary wing and business aircraft.

In our packed first edition, we explore the development of the Tempest - the latest in advanced, seemingly out of this world technologies that promises to produce the 6th generation fighter jet for the UK and its partners by 2035.

We also cover solutions for GPS-denied Navigation, Advances in Enhanced Flight Vision Systems (EFVS), Hardware-in-the-Loop (HIL) Testing, Wireless Quick Access Recorders (WQAR), Turbulence Mitigation Solutions, Contrail Reduction Software, ETL and ELB Advances, and developments with the AVIATAR platform.

We hope you enjoy reading this first issue of Aerospace Innovations magazine and find it to be informative and engaging.

Meantime, we do hope to meet many of you at the Farnborough International Air Show 2024 (July 22-26).

Best wishes,

Neil Walker & Simon Barker Publishers

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Airbus and Boeing Enter Separate Agreements with Spirit AeroSystems

Boeing and Airbus SE have announced they have entered into separate definitive agreements to acquire Spirit AeroSystems.

Boeing's merger is an all-stock transaction at an equity value of approximately $4.7 billion, or $37.25 per share. The total transaction value is approximately $8.3 billion, including Spirit's last reported net debt.

Boeing's acquisition of Spirit will include substantially all Boeing-related commercial operations, as well as additional commercial, defense and aftermarket operations. As part of the transaction, Boeing will work with Spirit to ensure the continuity of operations supporting Spirit's customers and programs it acquires, including working with the U.S. Department of Defense and Spirit defense customers regarding defense and security missions.

The Airbus SE agreement is in relation to a potential acquisition of major activities related to Airbus, notably the production of A350 fuselage sections in Kinston, North Carolina, U.S., and St. Nazaire, France; of the A220's wings and mid-fuselage in Belfast, Northern Ireland, and Casablanca, Morocco; as well as of the A220 pylons in Wichita, Kansas, U.S.

With this agreement, Airbus aims to ensure stability of supply for its commercial aircraft programmes through a more sustainable way forward, both operationally and financially, for the various Airbus work packages that Spirit AeroSystems is responsible for today ✍

Bangladeshi C-130J fleet reaches full strength with Marshall's support

Marshall has delivered the last of five C-130J Super Hercules aircraft to the Bangladesh Air Force (BAF), marking a key moment in the nation's long-term investment in sovereign airlift capacity.

Representatives from the Bangladesh High Commission in London and the BAF joined the Marshall team at the company's headquarters in Cambridge yesterday to formally celebrate the handover of the final aircraft.

Marshall's multi-million pound programme to upgrade and enhance the BAF C-130J fleet originated in 2018 and 2019, following the acquisition of the aircraft from the UK Ministry of Defence. The most substantial work packages have included decommissioning the aircraft from their previous service within the UK Royal Air Force's fleet, while integrating state-of-the-art avionics and installing capability enhancements including passenger transport and survival equipment.

While all five aircraft are now in active service with the BAF, Marshall is scheduled to deliver further modifications in the near future. Marshall will

also continue to support the BAF with a range of technical services including global engineering support, supply chain and logistics management, spare parts procurement and provision of training. ✍

HK Express Selects ULTRAMAIN® ELB™

HK Express Airways (HK Express), a Hong Kong based low-cost carrier, has selected Ultramain Systems ULTRAMAIN ELB electronic cabin and technical logbook software. HK Express operates a growing fleet Airbus A320 and A321 series aircraft, with a current fleet size of 34 aircraft.

The introduction of ULTRAMAIN ELB to their Airbus fleet will enable HK Express to capture real-time paperless data as work is accomplished. This does not only reduce the paper process but also provides improved operational visibility and reliability. Auto-collecting accurate data during the maintenance process is critical for effective corrective actions.

In addition to providing immediate global visibility of Tech & Cabin actions in ELB, and HK Express's Maintenance System, ULTRAMAIN ELB auto enforces many aspects of the defect identification and resolution process that paper systems cannot. Human induced variability is eliminated because ELB guides users to uniform defect classifications thereby providing on-device decision support directly

to pilots and engineers. With real-time visibility into maintenance operations, HK Express will lower maintenance cost, increase aircraft utilization and reduce deferral rates.

Alan Tang, Director, Maintenance and Engineering said, "We are excited to integrate ULTRAMAIN ELB into our fleet, marking a significant step towards enhancing our operational efficiency and reliability." He added, "This advanced electronic logbook software aligns with our commitment to leveraging innovative technology to streamline our processes and reduce our environmental footprint. We anticipate that ULTRAMAIN ELB will greatly improve our maintenance operations, providing real-time data capture and seamless defect management, ultimately leading to improved service for our passengers and a more sustainable operation." ✍

Viasat to Deliver Secure Broadband SATCOM on Airbus' C295 MPA Fleet for Spanish MoD

Viasat Inc, a global leader in satellite communications, today announced that it is expanding its work with Airbus Defence and Space to provide its secure, flexible broadband Ku- and Ka-band airborne technology for the Airbus C295 Maritime Patrol Aircraft (MPA) that have been acquired by the Spanish Ministry of Defence (MoD).

Viasat and Airbus Defence and Space will collaborate on the integration of Viasat's dual-band (Ku/Ka) broadband terminal, the GAT-5530, into the Spanish C295 MPA fleet to provide a highly flexible, multi-band and multi-orbit, broadband SATCOM capability to support missions utilizing the sovereign, next-generation SpainSat NG satellites.

The integrated Viasat GAT-5530 terminal will deliver secure, reliable satellite connectivity to the Airbus C295 MPA aircraft, enhancing the Spanish military's capabilities with resilient broadband SATCOM to support sovereign national security mission needs – including expanded command and control (C2) and intelligence, surveillance, and reconnaissance (ISR) applications.

Arajet Takes Delivery of its 10th Boeing 737 MAX as Carrier Expands International Routes

Arajet's 10th Boeing 737 MAX arrived today in Santo Domingo, Dominican Republic as the airline continues to grow its fuel-efficient fleet. This 737-8 delivery through a lessor supports Arajet's growth strategy throughout the Americas as the airline plans to more than double its routes in the next few years.

"This tenth aircraft is unique, not only because it has a special Dominican ribbon painted on the fuselage, but because it will increase the number of connections we make with the continent. We are reaffirming our commitment to democratize the skies and be able to connect all our countries with the lowest possible prices," said Victor Pacheco Méndez, CEO and founder of Arajet.

Since launching in 2022, Arajet has grown its all-737 MAX fleet to serve 23 destinations in 16 countries, including Canada, Mexico and Argentina.

With 737-8 jets that can fly up to 3,500 nautical miles, the airline operates some of the longest routes in the region - efficiently connecting the Caribbean to North and South America.

Sirius Aviation AG and BMW Group Designworks Unveil Revolutionary Hydrogen-Powered Business Jets

Sirius Aviation AG, an innovative leader in aviation, proudly unveils two revolutionary hydrogen-powered luxury business jets, the Sirius CEO-JET and the Sirius Adventure Jet. Developed in collaboration with BMW Group Designworks, these groundbreaking aircrafts aim to transform private air travel with eco-friendly alternatives, substantially reducing CO_2 emissions.

The global debut occurred on June 20, 2024 at the MOVE Expo in London, the world's premier tech mobility event. Sirius Aviation AG's Founder and CEO, Alexey Popov led the presentation alongside industry leader and design partner BMW Group Designworks, showcasing the innovative jets' cutting-edge features, upscale design, and premiering the official promotional video.

"The launch of the Sirius CEO-JET and Adventure Jet represents a major milestone in our mission to revolutionize air travel with sustainable solutions," said Alexey Popov, Sirius Aviation AG CEO. "The CEO-JET offers an eco-friendly option for business travel, while the Adventure Jet opens new horizons for global tourism and exploration."

The Sirius CEO-JET, the world's first hydrogen-powered private jet marks a new era in sustainable business aviation. This elegant, state-of-the-art aircraft seamlessly integrates advanced technology with unparalleled customization, and eco-friendly modern luxury.

French Army's NH90 for Special Forces has started flight testing

Airbus Helicopters has launched the flight test campaign for the prototype of the NH90 Standard 2. This standard is one of the latest NH90 configurations and is being developed specifically for the French Army Aviation, to support special forces operations. The French Ministry for Armed Forces has ordered a total of 18 NH90s in the Standard 2 configuration. Flight testing will continue until the end of the year in accordance with the schedule agreed with the French Armament General Directorate (Direction Générale de l'Armement).

The Standard 2 configuration includes the integration of the Safran Euroflir 410 electro-optical system, a new digital map generator, installation for a third crew member and new enlarged rear sliding windows able to accommodate self-protection guns.

The tests will validate the design of the new configuration. The prototype of the NH90 Standard 2 has also been equipped with mechanical and electrical provisions dedicated to the Distributed Aperture System (DAS) and a new generation Helmet Mounted Sight Digital Display (HMSD-DD) in the view of a future integration at a later stage. These systems will improve the special forces capabilities to operate in highly demanding conditions.

Intelsat Inflight Service Launches on Condor's New Airbus Fleet

Intelsat, operator of the world's largest integrated satellite and terrestrial network, launched high-speed, reliable inflight connectivity service on the first of more than 40 new Condor Airlines' Airbus narrowbody aircraft following an agreement that includes factory installation by Airbus.

"Intelsat's 2Ku service will deliver streaming-quality connectivity for passengers even in busy European airspace," said Dave Bijur, Senior Vice President of Commercial Aviation. "The factory installation means that Condor will be able to get the new Airbus planes in service faster and passengers will enjoy the reliable and proven Intelsat inflight connectivity."

German-based Condor will have 2Ku connectivity on 43 Airbus A320neo and A321neo aircraft immediately upon delivery from the manufacturer. The installations will be completed under Airbus' High-Bandwidth Connectivity Service program. Condor earlier this month started revenue service with the first A320neo with the remaining 42 aircraft planned for delivery through the end of 2028. 2Ku is designed to operate not just on today's high-throughput Geostationary (GEO) satellites but on Intelsat's fleet of new software-defined satellites that will enter service in 2026.

AirAsia renews its confidence in NAVBLUE, signing for a suite of solutions to improve flight operations, and becomes the first Mission+ FLIGHT customer in Malaysia

AirAsia (AXM), the leading low-cost airline in South-East Asia, the largest by fleet size and destinations, has signed an agreement for N-Flight Planning, Mission+ FLIGHT and Flysmart+, three state-of-the-art NAVBLUE solutions which will help the airline digitalise and enhance its flight operations. Air Asia was also part of the Early Adopter Program with Mission+, providing feedback during the development and testing phase as NAVBLUE continues to innovate its next generation platform.

N-Flight Planning, NAVBLUE's award-winning flight planning solution, has been chosen by AirAsia based on its track record of being one of the safest, most efficient and optimised flight planning applications on the market. The scalability and customisability of N-Flight Planning makes it the ideal choice for AirAsia with its multiple bases of operations throughout the region, each with its own unique operational requirements and scale.

Mission+, NAVBLUE's Electronic Flight Assistant (EFA), optimises the pilot's journey from preparation to closure of a flight: this EFA gathers all the information pilots need in one single application on a globe-centric display and reduces their workload, streamlining the flow of information between ground and onboard systems. AirAsia has selected Mission+ FLIGHT, a module of Mission+ for mission management providing briefing packages, flight follow-up and reporting capabilities to pilots.

Flysmart+ continues to help the airline to optimise aircraft performance and Weight & Balance calculations, and to ease access to electronic documentation. It is also interfaced with Mission+, allowing quick access to mission information, time savings, and reduced risk of errors.

Will Space Be The Final Frontier For ALN?

The Aviation Logistics Network (ALN) global logistics service provider to the Aerospace Industry has formally announced the formation of a dedicated division within the network to serve the needs of the growing Space sector.

The specialist offshoot from ALN will be called Space Logistics Network (SLN) and will provide bespoke services aimed at solving the challenges in the transportation and logistical supply chain for those companies developing low earth orbit satellites as well as those organisations developing spaceports for launch services who may require logistical support.

Ralph Perkins Managing Director of ALN said, "The idea is not a totally new one as ALN has in fact been fulfilling the needs of several space pioneers over the years through its global partners. However the idea of combining the various skill sets within ALN to form a dedicated vertical to our Space client's signals ALN commitment to continue to be at the cutting edge of both Space & Aerospace Transportation and Logistics"

"With the global space economy set to reach $1 trillion by 2040 through a combination of the continued commercialisation of space linked to a reduction in launch costs, allied to smaller and more cost effective Low Earth Orbit (LEO) satellites. Predictions of up to 40,000 being launched over the next decade will lead to a demand for specialists in this area and we believe the time is now right to look to the future and extend our reach further into this area ".
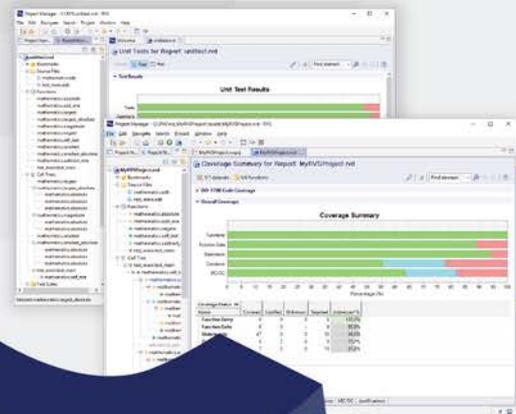
United Now Texts Live Radar Maps and Uses AI to Keep Travelers Informed During Weather Delays

United now texts customers links to local, live radar maps during weather delays, as part of its industry-leading effort to give travelers as much real-time information as possible about their trip, especially if things don't go as planned. For the past few years, the airline has used dedicated teams to write and send text messages to customers that give near-instantaneous details about a given flight – everything from gate changes and boarding times to more specifics regarding aircraft swaps, crew rescheduling and weather events – and the teams now use generative artificial intelligence (gen AI) tools to assist in giving more travelers real-time updates during flight delays.

United's latest innovation – real-time radar maps – can help customers understand how inclement weather in one part of the country can impact a flight elsewhere. United is the first and only U.S. airline currently providing its customers these kinds of specific messages, and the airline is sending them with assistance from gen AI tools.

"With more people traveling this summer than ever, we wanted to give our customers an easier way to stay connected to real-time information about their flight and texting was the simplest solution," said Jason Birnbaum, United's Chief Information Officer. "We know customers appreciate transparency and by combining innovative technology-enabled tools with people power, we can give more people, even more in-the-moment details about their flight."

Lufthansa Technik selects Thales for the Pegasus program

Lufthansa Technik has selected Thales for the audio/radio communication system of Germany's next-generation Signal Intelligence Surveillance and Reconnaissance aircraft. The program is led by German sensor solutions specialist HENSOLDT.

Thales will supply its last generation of secured audio/radio management system capable of managing the communications of the flight deck and operators both internally and externally to the aircraft.

This system features full compliance with German military requirements, the highest level of security, and significant weight savings, as well as enhanced reliability compared to traditional technologies.

"Lufthansa Technik's and Thales Aerospace Communications' engineering teams have worked very closely to develop the most adapted audio/radio management system for this program. Together we have come up with a highly efficient system that enables the aircraft to fulfill very demanding missions. This new contract confirms our market leadership in terms of audio/radio management systems for missionized single intelligence platforms." Nicolas Bonleux, Executive Vice-President, Thales Aerospace Communications.

Thales obtains the first Design Verification Report for a complete drone system ever granted by EASA

Thales received the first full DVR ever granted by EASA to operate light UAS in medium risk, SAIL III. This DVR process set in place in April 2021 by the Agency aims at ensuring safe drone operations. Such a premiere strengthens the Group's position on emerging civil drone market and represents further progress towards the certification of the Thales UAS100 in the most demanding conditions.

Flying drones represents a tremendous opportunity to convey new missions and operate with lower environmental and economic costs.

However, uncontrolled flying objects could pose risks to air traffic as well as installations and people on the ground. The European Union Aviation Safety Agency (EASA) has defined a set of rules to guarantee the safety of drone operations, according to a risk based and proportional approach.

Turkish Airlines Orders Four More Boeing 777 Freighters

Boeing and Turkish Airlines today announced an order for four 777 Freighters to further strengthen the airline's position in the global air cargo market. With this order, Turkish Airlines will operate 12,777 Freighters.

"This new investment in expanding our cargo fleet underscores our commitment to meeting the growing global demand for air freight services," said Turkish Airlines Chief Cargo Officer Ali Türk. "The addition of these Boeing 777 Freighters will not only enhance our operational capabilities, but also serve as another step in our strategic vision to reach the top of air cargo sector worldwide while maintaining our leading position with our unparalleled service and efficiency for our customers across

the globe."

Turkish Airlines' purchase of additional 777 Freighters will help the carrier meet growing demand for freight services, driven by the rapid growth of e-commerce and the need for efficient and reliable transportation across the globe. The new freighters will enable Turkish Airlines to optimize its cargo operations, reduce costs and deliver goods to destinations worldwide on time.

easyJet to digitise onboard Aircraft Technical log to cut down on paper use and weight

easyJet is replacing weighty Paper Technical and Cabin Logs previously used by cabin crew, engineers, ground crew and flight crew with the new e-techlog system, ULTRAMAIN ELB, which will be rolled out across its 346-strong fleet of aircraft during 2025.

The move represents another way the airline is trying to reduce its operational waste, with the transition expected to save more than 300,000 sheets of paper from being printed and stored every year.

Additionally, the new e-techlog system will help streamline the

maintenance reporting process for flight crew, cabin crew and engineering – enabling easyJet to increase line maintenance productivity in the process.

David Morgan, Chief Operating Officer at easyJet, said, "Rolling out Ultramain's state-of-the-art technology across our fleet of aircraft will not only improve the reporting processes for our crew and engineering teams but will also see fewer delays on the ground, which will help further enhance the travel experience for our customers."

Eve Air Mobility Announces $94M New Equity to Support eVTOL Development

Eve Air Mobility, a global electric vertical take-off and landing (eVTOL) aircraft manufacturer and services provider, has announced $94M in new equity financing from multiple investors. The funding, which includes the issuance of new shares of common stock and warrants, includes participation from a diverse group of global industrial companies that include Embraer, Nidec and additional financial investors. The new funding strongly positions the company for future success and will support the continued development and manufacturing of the company's eVTOL.

"We appreciate the confidence that these investors are placing in Eve. The new equity, along with existing cash and credit lines, ensures Eve is well positioned as we continue to build momentum and advance in the development and manufacturing of our eVTOL," said Eduardo Couto, chief financial officer at Eve Air Mobility. "With the industry's largest pre-order book with letters of intent for 2,900 aircraft and strong program development partners, Eve has continued to demonstrate the opportunity that our company presents for both strategic and financial investors."

The Company entered into agreements, dated as of June 28, 2024, for the issuance and sale of 23,500,000 new shares of the Company's common stock at a purchase price of $4.00 per share, the exchange of certain warrants for shares of common stock, and the granting of warrants to certain investors. The private placement is expected to result in gross proceeds to Eve of $94 million, before deducting other offering expenses.

Electronic Warfare Pods To Protect U.S. Navy P-8a Poseidon Aircraft

BAE Systems received an $95 million contract from the U.S. Navy for advanced countermeasure pods to protect the P-8A Poseidon Multi-Mission Maritime Aircraft from missiles and other threats. The electronic warfare (EW) pod detects and counters inbound threats, protecting the Poseidon and its crews, and expanding the aircraft's operating range in contested environments.

"We're working closely with the U.S. Navy to deliver innovative solutions to protect this critical, high-value aircraft," said Don Davidson, director of Advanced Compact Electronic Warfare Solutions at BAE Systems. "We quickly prototyped a very capable system using proven technology to defend against air-to-air and surface-to-air guided threats."

BAE Systems' survivability pod provides early threat detection and effective countermeasures to protect U.S. and international high-value airborne assets. The system's flexible, open architecture design allows rapid and affordable modernization, is compatible with future threat-detection and decoy countermeasure capabilities, and can host third-party EW techniques.

Renewable Aviation Fuels Prepare For Take-Off In Australia

Aviation experts from the University of South Australia (UniSA) will work with their Chinese counterparts over the next two years to develop a sustainable aviation biofuel industry in both countries.

The collaboration, announced by Australia's Department of Foreign Affairs and Trade (DFAT), comes on the back of a $1.7 billion Federal Budget allocation to prioritise renewable fuels for the aviation industry over the next decade.

UniSA Aviation Professor Shane Zhang has been awarded a $230,000 National Foundation for Australia-China Relations grant to lead the project, exploring the commercial opportunities of using bio feedstock to replace conventional kerosene jet fuels with 'green' fuel.

Sustainable aviation fuels (SAFs) are still in their infancy, accounting for less than 1% of jet fuels worldwide, although the European Union (EU), Singapore, the US and UK are moving towards mandating SAFs within the next few years.

Prof Zhang says the Federal Government budget announcement follows the establishment of the Australia Jet Zero Council in 2023 to deliver net-zero aviation in Australia, supported by a $30 million funding injection.

"Sustainable aviation fuels can potentially cut carbon emissions by up to 80% and are essential if we are to achieve net-zero greenhouse gas emissions in Australia 2050," Prof Zhang says.

Saudi Low-Cost Airline Flyadeal Sets New Standard For Efficiency And Innovation By Selecting Amos

In an impactful step towards transforming maintenance and engineering operations, Swiss-AS proudly announces flyadeal's selection of AMOS Airline Edition as its premier maintenance and engineering software solution.

The selection of AMOS marks a significant milestone for flyadeal, setting new standards for efficiency and innovation. AMOS serves the airline as a central hub for managing maintenance operations, leveraging data-driven insights to optimize efficiency, ensure compliance, and drive innovation in aircraft maintenance practices.

flyadeal, Saudi Arabia's leading low-cost airline based in Jeddah with a model for simplicity and affordability, has entrusted Swiss-AS with the pivotal task of enhancing its maintenance operations. By selecting one solution from Lufthansa Technik's Digital Tech Ops Ecosytem – the AMOS Airline Edition software package – flyadeal is well-positioned to attain operational excellence and boost productivity with the digitalization of its Technical Operations.

Adacore Research Proves Novel Solution For "Security By Default."

In an age of increasing security breaches and cyberattacks, the need for robust and comprehensive security mechanisms within embedded real-time systems is paramount.

Through its research, AdaCore has demonstrated how combining memory-safe hardware with memory-safe software results in a mutualistic layered approach to security and increases the assurance of embedded real-time systems. More specifically, this research describes the development steps and subsequent evaluation of a security-hardened Ada runtime executing on Arm's Morello CHERI extended ISA microprocessor.

"As the UK's National Cyber Security Centre (NCSC) states, 'Secure by Default' is defined as 'technology which has the best security it can without you even knowing it's there or having to turn it on.' This principle served as the guiding philosophy of our research." Paul Butcher

The paper summarizes research and development into a 'Security by Default' approach to real-time embedded systems by leveraging the Arm Morello CHERI ISA extensions and a bare-metal security-enhanced Ada runtime. More specifically, a layered approach to security is described that demonstrates the benefits of memory-safe programming languages executing on memory-safe microprocessors.

Thales Aerospace Communications & Collins Aerospace Announce Aviator 700S Installation

Thales Aerospace Communications and Collins Aerospace have announced the first installation of Thales's AVIATOR 700S Inmarsat SwiftBroadband satellite communications system. Thales will provide the TSO'd A700S system to Collins Aerospace as part of a Collins' program to deliver communication and navigation systems for commercial aircraft.

The AVIATOR 700S Class 6, dual-channel system consists of a high-gain antenna, diplexer/low-noise amplifier, multi-channel high-power amplifier, and compact satellite data unit. Its' flexible and configurable architecture allows for secure aircraft domain segregation with priority for the Aircraft Control Domain (ACD) over the Aircraft Information Service Domain (AISD) and the Passenger Information & Entertainment Services domain (PIES). A700S is FANS 1/A-compliant, can handle multiple voice calls simultaneously, and meets all ARINC 781 specifications.

RTX's Collins Aerospace Awarded Survivable Airborne Operations Center Subcontract

Collins Aerospace, an RTX business, has been was awarded a multi-billion-dollar subcontract as part of a team led by SNC to design, develop and deliver systems and products for a new aircraft under the U.S. Air Force's Survivable Airborne Operations Center (SAOC) program.

The SAOC program delivers next-generation of the E-4B National Airborne Operations Center, providing top military leaders with a survivable aircraft to ensure performance of the National Military Command System.

Collins Aerospace is on contract to deliver multiple products from across the business.

"We're bringing together systems from across RTX to help the team deliver an advanced, survivable airborne operations center to the U.S. Air Force," said Conn Doherty, vice president and general manager, Strategic Solutions for Collins Aerospace. "Our collaboration with SNC leverages the best of our collective engineering and manufacturing expertise. This mission is especially urgent and our decades of experience designing for contested environments is critical to its success."
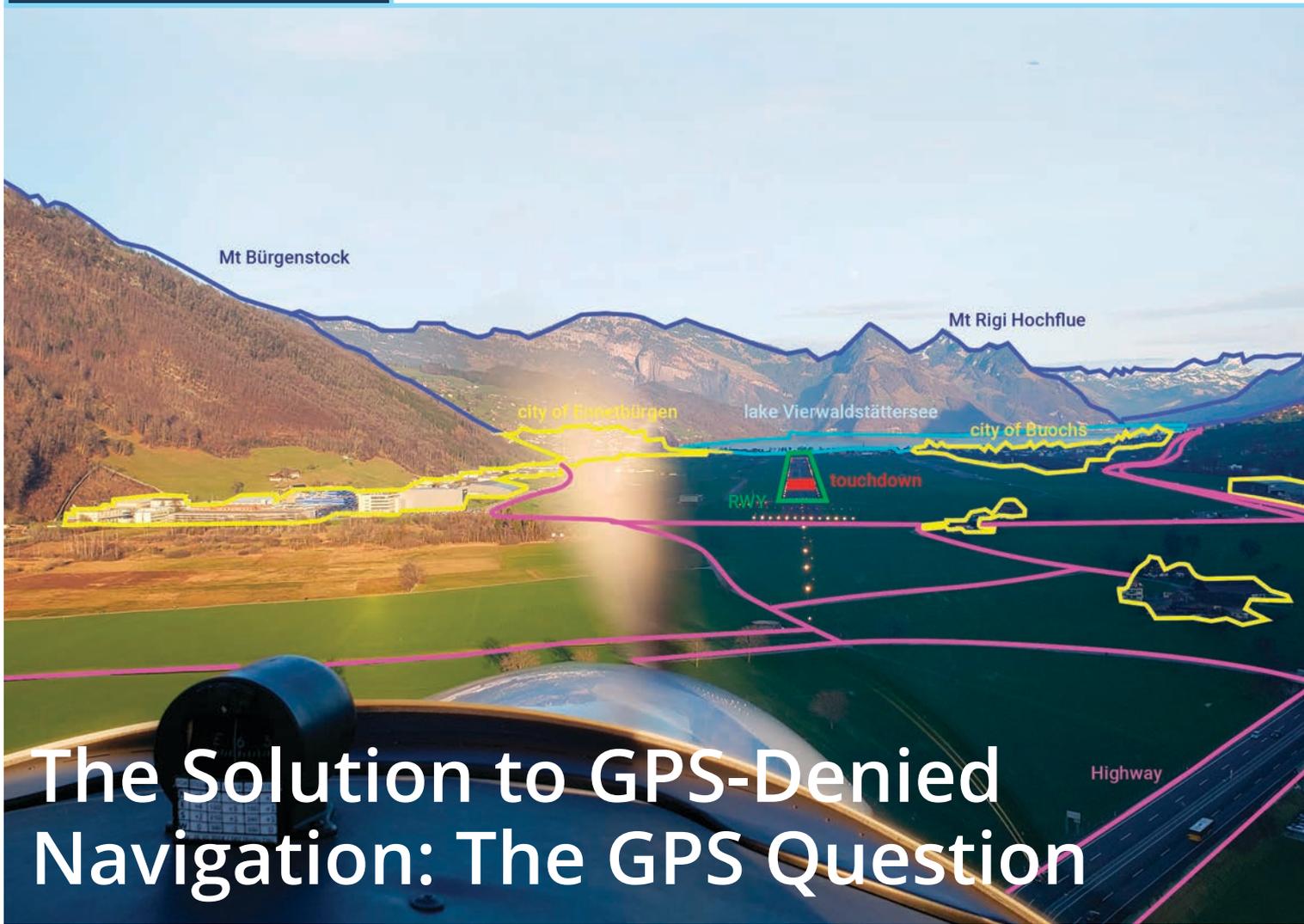
The Solution to GPS-Denied Navigation: The GPS Question

The world is over-reliant on GPS. And GPS is alarmingly vulnerable.

The daily fabric of life the Global Positioning System is threaded into is as unexpected as extensive. We count on GPS for financial transactions, cell phone networks, emergency services, even electrical grid function, and, among many other applications, of course, navigation.

But it is very fragile.

Dr. Todd E. Humphreys, Director of the UT Radionavigation Laboratory, puts it this way: "The problem is that the same transparency and predictability that have made civil GPS signals so wildly popular all across the globe give rise to a dangerous vulnerability. Transparency and predictability make the civil GPS signals easy to imitate — to counterfeit. The fact is that civil GPS signals are like Monopoly money: they have a detailed structure but no built-in protection against forgery."

And this forgery takes place big time. The scale of it can be seen at the website GPSJam — maps showing daily possible GPS interference.

The problem is now well-known:

- "Increased Russian GPS jamming hits signals in Baltics, Finland. Pilots in region forced to use alternative navigation systems" (March 2023)
- GPS jamming from Chinese military units in the South China Sea and the Philippine Sea (March 2023)
- "A 2019 report by a Washington, DC, think tank documented more than 10,000 cases of GPS interference in the last five years from Russia, including noting that Putin is intentionally spoofing his location and jamming GPS signals whenever he travels" (source)

- "The GPS interference has expanded on a scale that hasn't been seen before... What we're seeing now, since about a week ago, is GPS jamming bubbles covering hundreds if not thousands of kilometers around tactical Russian cities." (December 2022)
- "Ships have reported an increasing number of cases of significant GPS interference and jamming in recent months... the eastern and central Mediterranean Sea, the Persian Gulf, and multiple Chinese ports" (2020)
- Drug traffickers are spoofing government border drones on the US-Mexico border (2015)

An emergency backup for GPS was mandated by the United States in the 2018 National Timing and Resilience Security Act. This law demanded the development, construction, and operation of a

backup system within two years. Eleven systems were considered, but none have been chosen.

Meanwhile, solutions to the problem continue to be sought.

As a backup against the loss of GPS, Daedalean has developed its Visual Positioning System (VPS), which doesn't require any external infrastructure. A camera mounted under the aircraft can take a look at the ground and figure out where the aircraft is — just like a human looking out the window.

How does it work?

Visual positioning leverages two complementary processes for navigation: visual-based global localization and simultaneous localization and mapping (SLAM). The Visual Global Positioning System (VGPS) comprises the global localization, while the Visual Motion Unit (VMU) provides the SLAM functionality.

The VGPS matches position to global coordinates. For this, it needs a map — or, more accurately, a database of georeferenced landmarks — to match features, or elements of a landscape, against. The system estimates the 6D pose (position on the global WGS84 coordinates and orientation of the aircraft with respect to the Earth's surface). The system essentially says: "This is where I am, and this is where I am currently headed."

The VMU, on the other hand, calculates the distance and direction the aircraft has flown from a known starting point, enabling a consistent estimate of the aircraft's position and orientation. This method, however, inherently accumulates errors over time — a common issue in SLAM-based navigation systems used in small drones. To address this, our system constantly cross-verifies the VMU's estimated position with the VGPS's map of georeferenced landmarks.

Generally, the VPS performs more effectively at higher altitudes, ideally starting from 200m above the ground. The higher the altitude, the fewer the details seen, which leads to more stable visible features across different seasons, weather conditions, lighting conditions, environmental changes, etc. At 500m, you will primarily see roads, buildings, trees, whereas at 50m, you might only see a field of grass.

The advantage of the VPS is that it's a fusion of local (VMU) and global (VGPS) positioning, and it doesn't always require the latter to function. The VMU component does not need a pre-existing map, but rather, it constructs its own on-the-fly. Therefore, even if the aircraft descends to levels where minimal features are visible or occasionally leaves the pre-surveyed area for a short period of time, the VPS will continue to navigate.

Creating synthetic reference images. On the left: the 3d terrain mesh created using the altitude data of an area. On the right: the same mesh with the added satellite imagery. All done in the fisheye camera model, that is why everything is round.
(Copyright: Fabian's deck)

Nice touch: theoretically, VPS would also work on other planets. There is obviously no GPS on Mars but there are satellite images of the surface. (Copyright: NASA/JPL-Caltech/Univ. of Arizona)
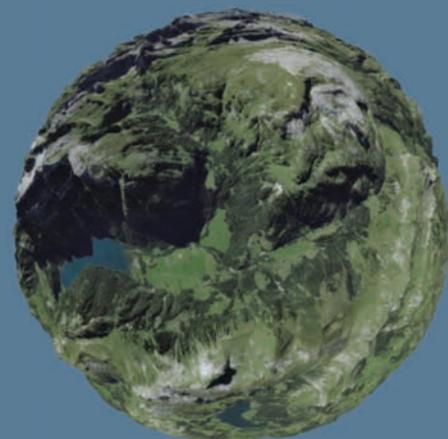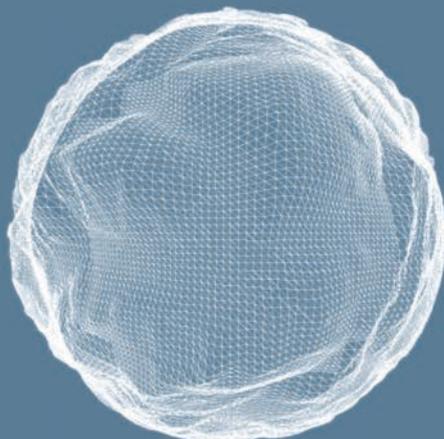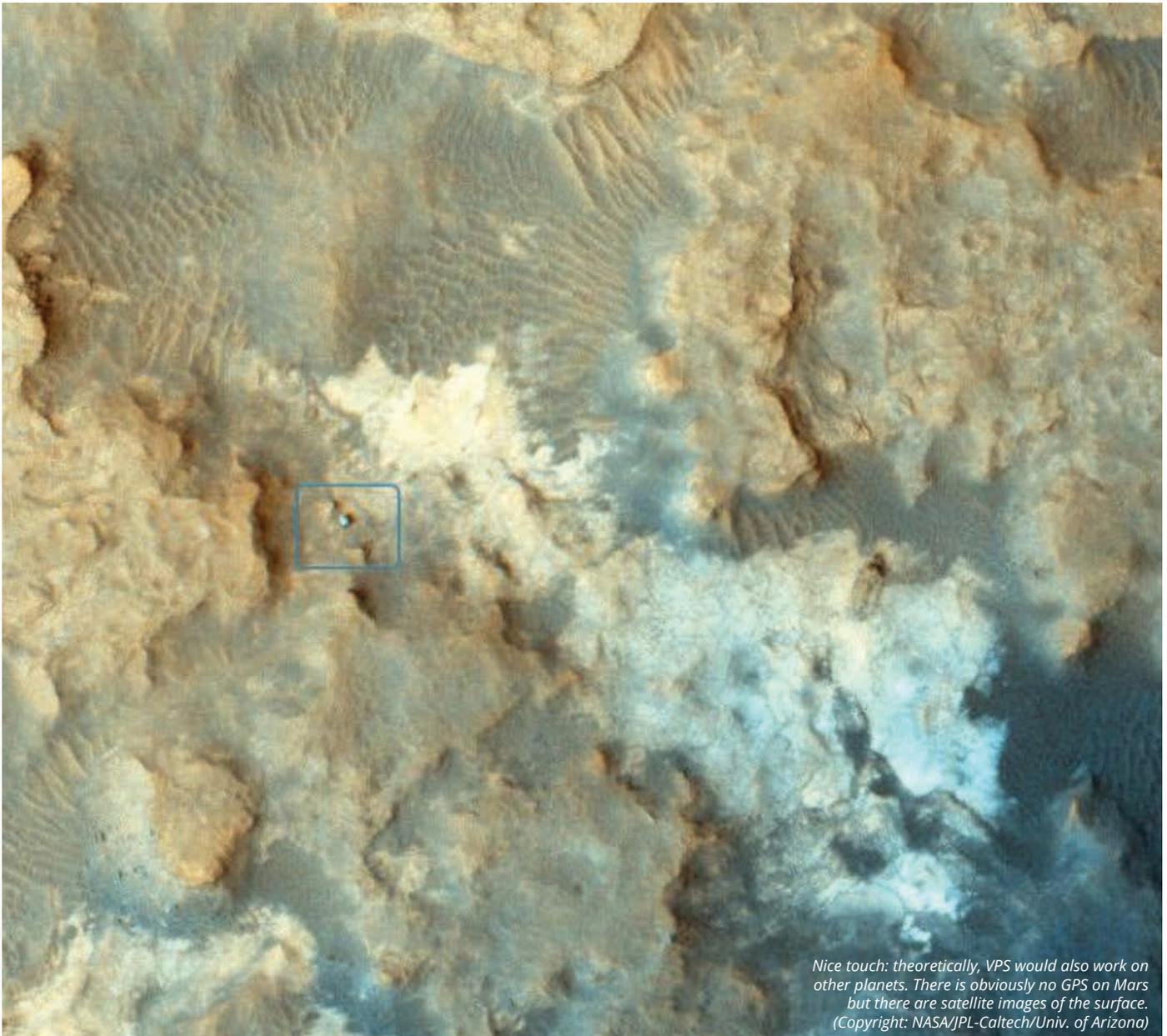
The VPS requires maps. Where do these maps come from?

Maps are created through survey flights with a reference GPS onboard, and then they are regularly updated and verified with data collected during normal operation. The map creation, update, and verification process follows the DO-200B standard. If the system is supposed only to work along fixed, known routes, it's relatively easy to collect sufficient survey data to build the maps (and afterward keep them up-to-date by using data collected during regular flights).

But flying survey flights can be cost-prohibitive or they simply might not have been flown for a given area. So Daedalean's VPS team is working on an alternative solution.

It is possible to create maps (sets of landscape features) from orthographic satellite imagery and terrain elevation data that already exist for many places around the world. Daedalean has developed a complete in-house system for rendering and map creation, which allows the use of third-party ground-truth terrain data. This requires some time to create the maps for the area, but it would, one day, make the VPS work out-of-the-box. No survey flights would be necessary then.

But maps generated from third-party data will only work well above approximately 200m above ground. They will work well for aircraft and heavy drones but not for small commercial and consumer drones, which are legally limited (by the FAA, EASA, the UK's CAA, and their counterparts in many other countries) to remain below 400 feet above the ground (120m).

How precise is it?

Overall, the system provides navigation data comparable to high-end inertial navigation systems (INS),

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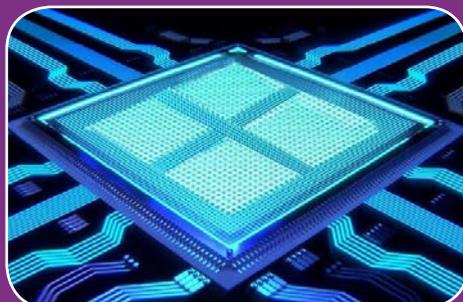
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A typical frame from the camera contains about 220 identifiable elements, and it only requires 15 from them (less than 10%) to localize. (Note: this is not what a pilot sees on the system display but reconstructed from the system's files)

Seeing is believing: A downward-facing camera, left, captures ground reality and feeds it into the VPS, while live mapping, upper right, compares position as shown by the system (black line) against GPS coordinates (green line), and differences are tracked, bottom right.

global navigation satellite systems (GNSS), and instrument landing systems (ILS): about 20 meters (horizontal position), and 15 meters (vertical position).

What's with low visibility?
Tests during nighttime, in limited visual conditions, or after drastic weather changes, such as after heavy snow, have been successful. Future development will include capability in low visibility, but it turns out that the system can function with as little as a 10% match with the map to localize itself.

Therefore, if there is at least some lighting below, or some features visible, the system can probably find its way. If the visibility is zero, so that no human pilot would see anything, or the terrain is completely featureless (say, if you fly over a completely white snow field in Antarctica or in the middle of a large desert), or without any lighting below whatsoever, then probably not. Also, the system is not going to work above water if there's no coast in sight.

What about the shelf life of the maps?
The system recognizes ground features, so since the Eiffel Tower hasn't changed much in 100 years, it's a very stable landmark. Manhattan skyscrapers would also work well since the skyline hasn't changed drastically during the last 20-50 years. But Dubai's skyline, on the other hand, keeps changing. After a year's absence, you will not recognize some once-familiar parts of the city.

But even in places such as Dubai, the VPS can operate effectively without constantly having to redo survey flights. The system can tolerate most changes, even with significant differences, as long as a minimum of approximately 10% of the landmarks match up with the original survey map. The reason is that the system looks at thousands of features, not just the major landmarks. So it is not important for every single feature to be recognized under all circumstances.

The same goes for flying in (snowy) winter with a map made in summer and vice versa.

Will VPS work even if GPS is not denied?
The answer is yes. The VPS is aimed at integrating with existing INS-/GNSS-based navigation systems, barometer data, and inertial measurements (IMU), as well as any kind of radar, lidar, or longwave infrared camera, while offering dissimilar capabilities such as operating in challenging conditions like fog, darkness, or cloud cover.

The vision solution
How could we live without GPS? The thought is unfathomable. For navigation aloft, one answer is a vision-based system, which can reliably operate independent of external infrastructure, including satellite-based navigation systems.

AerSale's AerAware 737 at twilight.
(Copyright: MocaPhotography@zoho.com/ AerSale)

Making Aviation Safer Through Enhanced Flight Vision Systems:

An Aerospace Innovations Roundtable

Enhanced Flight Vision Systems (EFVS) use infrared sensors installed on aircraft noses to create an infrared image of what's ahead outside, no matter what the weather and/or lighting environment.

By doing this, EFVS has made human flight far safer, as the images are then typically provided to the pilot using a wearable or cockpit-mounted display.

Yet the state of this technology is not set in stone. EFVS manufacturers such as AerSale and Universal Avionics are constantly innovating to make this technology more detailed, capable, and useful to pilots of all kinds.

Iso Nezaj is AerSale's Chief Product Development Officer. Dror Yahav is Chief Executive Officer of Universal Avionics. The two companies have banded together to create the AerAware EFVS, which relies on Universal Avionics' ClearVision EFVS

camera system.

In this Aerospace Innovations virtual roundtable, Nezaj and Yahav tell us where EFVS stands today, what it is currently providing to the aviation industry, and what is coming tomorrow.

Aerospace Innovations (AI): What is the history of your company's work in EFVS, and how did your products come about?

Iso Nezaj: At AerSale Inc., we specialise in developing Supplemental Type Certificates (STCs) to address various technical challenges and regulatory requirements faced by aircraft

operators. Our primary focus is to provide innovative solutions that enhance safety, performance and operating economics. Among our diverse range of products, AerAware, our dual Enhanced Flight Vision System (EFVS), stands out as a significant advancement in aviation technology.

Recognizing the need for better situational awareness during low-visibility conditions and improving energy management during all phases of flight, we partnered with Universal Avionics, an Elbit Systems company, and leveraged advanced technologies to create a state-of-the-art EFVS called ClearVision. This collaboration resulted in AerAware, the first-ever

A pilot's view through Universal Avionics' ClearVision EFVS camera system. (Copyright: Universal Avionics)
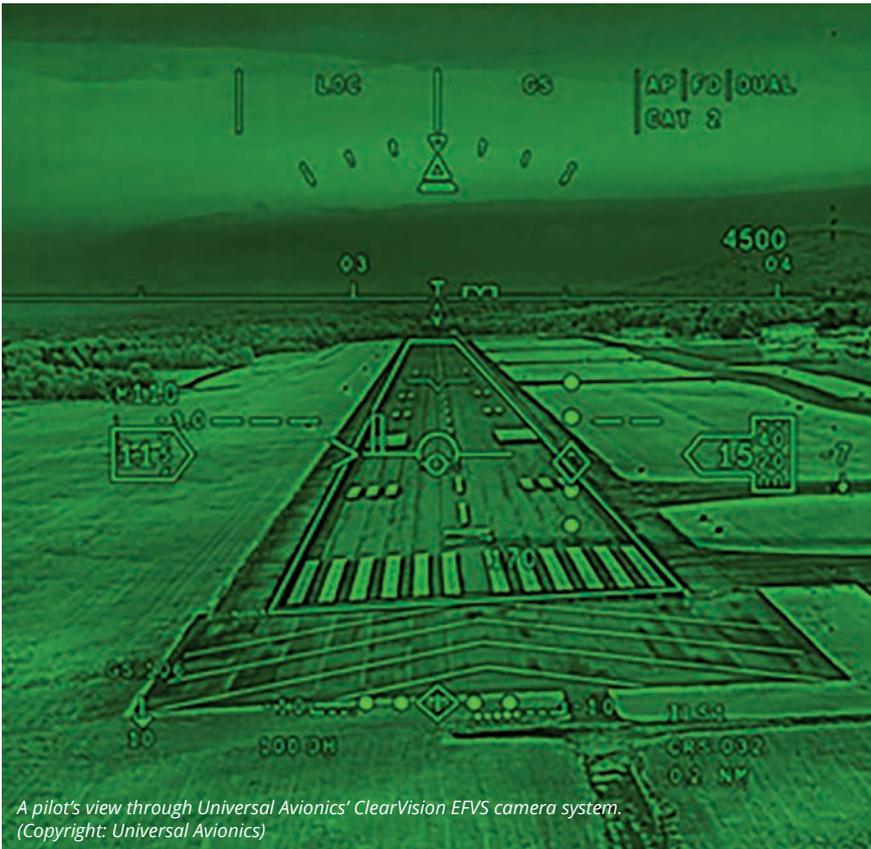
dual, head wearable display certified by the FAA for commercial operations while also achieving an industry leading 50% visual advantage — the highest certified by the FAA.

Dror Yahav: The ClearVision Enhanced Flight Vision System from Universal Avionics is a complete gate-to-gate visibility solution and the first wearable EFVS certified for the commercial aviation market. This innovative technology is inspired by EFVS technologies originally used in military operations, backed by generations of expertise from our parent company Elbit Systems Ltd., who has been developing enhanced vision systems since early 2000s when the FAA approved of operations.

The system is currently certified for the Boeing 737 under the AerAware brand, and will soon be available for King Air B200 and several other business jets. ClearVision supports the general aviation market by enhancing safety, operational effectiveness, supporting sustainability initiatives, and advancing future-forward markets such as Advanced Air Mobility and supersonic flight.

AI: What are the chief features and benefits that your products bring to pilots and non-military aircraft operators?

Dror Yahav: ClearVision brings advances in safety, efficiency, and

> ## "Advances in EFVS include improvements in sensor technology, image processing algorithms, and integration with other aircraft systems".
>
> **Iso Nezaj, AerSale's Chief Product Development Officer**

sustainability by combining enhanced visual imagery and primary flight display symbology into a single view, shared between operators.

This enhanced situational awareness has the highest visual advantage of any commercial aircraft EFVS on the market, providing dispatch and landing approach priority regardless of the destination airport's infrastructure. By mitigating traffic delays and allowing for alternate runways or approaches, seasonal weather-related disruptions, such as delays, diversions, and cancellations, are minimised. The result is continued operations and reduced costs, thanks to more efficient routing and lower fuel consumption.

Iso Nezaj: First, there's safety. Our EFVS provides pilots with the ability to control the aircraft's flight path and energy more precisely while remaining "heads-up" during approach and landing.

Next is improved energy management. This results in a more stabilised approach that minimises short/long landings, as well as a reduced risk of ground incidents such as hard landings, tail skid strikes, and runway incursions/excursions.

Third is enhanced situational awareness. Our EFVS delivers real-time visual information in poor visibility conditions, improving decision-making and reducing the risk of accidents. Additionally, a dual

With Universal Avionics' ClearVision EFVS camera system, a pilot has full situational awareness day or night. (Copyright: Universal Avionics)

"ClearVision provides complete situational awareness during all phases of flight, enabling pilots to see in low visibility situations".

Dror Yahav, Chief Executive Officer of Universal Avionics

system enables pilots to benefit from a shared mental model.

Then there's operational efficiency. Our EFVS reduces delays and diversions by allowing continued operations in adverse weather conditions. It enables pilots to continue an approach below published Decision Altitudes and Decision Heights, through touchdown and rollout on EFVS images alone.

AI: What are the components of an EFVS, and how is it installed and used in a modern aircraft?

Dror Yahav: EFVS is typically comprised of three primary components: An Enhanced Vision System (EVS) camera fastened to the radome of the aircraft, a computer typically installed in the avionics bay, and a Head-Up display in the cockpit used by the pilot to access the enhanced imagery.

ClearVision uses the EVS-5000 multispectral camera that combines visible light and longwave infrared

sensors to capture a comprehensive view outside the cockpit in low-visibility conditions. This information is combined with relevant EFVS symbology by the HUD computer, which is sent to the SkyLens head-wearable display (HWD) or SkyVis helmet-mounted display (HMD).

ClearVision is unique for being the first certified commercial solution that uses a HUD worn by the pilot, rather than fixed in the cockpit. Pilots wearing SkyLens can take advantage of both real-world EVS imagery, panoramic synthetic vision, and symbology in a 360-degree field of view for additional situational awareness during any phase of flight, stowing the HWD in a compartment when not in use.

AI: What are the stand-out features of the AerAware/ ClearVision EFVS?

Iso Nezaj: First, the EFVS-5000 camera includes a comprehensive network of four internal cameras as well as

*The wearable ClearVision EFVS camera system with SkyLens.
(Copyright: Universal Avionics)*

six sensors resulting in one perfectly fused picture, which enables pilots to overcome limited visibility conditions day and night. From visible light to longwave infrared (IR) this system captures multispectral imagery that goes beyond the limitations of the human eye. It reveals crucial details in low-visibility situations, ensuring pilots have a comprehensive view of the outside world.

Next comes Synthetic Vision image processing. It provides a computer-generated representation of the external environment, enhancing situational awareness by displaying virtual views of terrain, obstacles, runways, and other relevant features.

Then there's the Skylens Head Wearable Display (HWD). It offers the user a vast, immersive display that projects a complete view of

the aircraft's primary systems data alongside 3D synthetic vision. Yet this lightweight device provides superior see-through transmission in all weather conditions with unlimited field of view.

The HUD Computer Unit enhances and processes images from the EFVS camera and synthetic vision system for better clarity and usability. The Control Panel allows the pilot to interact with and adjust the system settings as required.

Worth noting: The streamlined EFVS installation process involves integrating these components into the aircraft's system, typically during scheduled maintenance. The post-production modification and installation requires 3 to 5 days and can be accomplished anywhere in the world with the support of our certified engineers.

AI: Let's get specific. How precisely does EFVS make flying safer?

Dror Yahav: Visibility through the windshield of an aircraft is quite limited, posing additional challenges in inclement weather and night operations, which decreases this visibility even further. In contrast, ClearVision provides complete situational awareness during all phases of flight, enabling pilots to see in low visibility situations.

Iso Nezaj: Our EFVS provides pilots with a 50% visual advantage over the naked eye, offering clear visuals of the runway environment, obstacles, and terrain in limited visibility conditions such as fog, rain, or darkness. This increased situational awareness helps pilots make informed decisions, avoid potential hazards, and ensure safer takeoff and landing operations.

Dror Yahav: As well, operators can stay one step ahead of the aircraft using real-time enhanced vision to prevent incursions during taxi operations with visibility of taxiways and ground operations. ClearVision also brings major safety improvements for helicopters, as the first time that civil helicopter pilots can leverage a helmet-mounted device for full awareness of terrain and obstacles, including cranes and antennas, while keeping focused on the external world during high-workload tasks.

AI: In general, what advances are being made in EFVS, and what will this mean to their users?

Iso Nezaj: Advances in EFVS include improvements in sensor technology, image processing algorithms, and integration with other aircraft systems. These advances result in higher resolution images, faster processing speeds, and more reliable performance. For users, this means greater situational awareness, enhanced safety, and the ability to operate in a wider range of weather conditions.

We are continuously innovating and

have several enhancements to our EFVS product in the pipeline. One of the benefits of the AerAware system being predominantly software is that we can continue to expand the capabilities of the system without replacing the hardware. These upcoming software enhancements will feature advanced imaging technologies, enhanced integration capabilities, and improved user interfaces, further pushing the boundaries of safety and efficiency in aviation.

Dror Yahav: An increasing number of airports are updating their lighting systems from incandescent to LED, meaning some EFVS camera systems lack the ability to properly detect runway lights. ClearVision's advanced multispectral camera detects these LED runway lights, assisting pilots during takeoff and landing. By adding new operational capabilities in a regulatory setting for approaches and landing, operators can land in lower prescribed minimums.

The ergonomic, wearable design of the SkyLens display benefits new applications by providing an unlimited field of view, which gives pilots the flexibility to turn their head and operate with panoramic synthetic vision (SVS) in addition to the symbology seen in a traditional HUD. Future innovations to SkyLens will include colour imagery for even more accurate visual information compared to the traditional green imagery.

AI: Will EFVS eventually become available to users of smaller aircraft, including private pilots?

Dror Yahav: Yes. One key benefit of ClearVision's head-wearable display is that it has a much smaller footprint in the cockpit compared to a fixed Head-Up display. Where a smaller aircraft might be limited by the size of a traditional HUD modification, ClearVision has the opportunity to make this innovative technology more widely available thanks to its smaller size and flexibility.

AI: What role can EFVS play in the operations of autonomous

Pilot wearing an AerAware EFVS headset. (Copyright: www.brentbundy.com/ AerSale)

An AerAware EFVS headset in the cockpit. (Copyright: AerSale)

and uncrewed aircraft, including drones?

Dror Yahav: EFVS is a key element in the future of autonomous vehicles, especially for those with visibility challenges, such as advanced air mobility in urban airspace and supersonic jets travelling at high speeds with virtually no natural vision from the cockpit. Image-based navigation provides the visual data needed for uncrewed aircraft operations. In emergency situations, a SkyLens HWD can be used to remotely pilot the aircraft, with the real-time information needed to operate safely and proactively make decisions, without putting lives at risk.

AI: Finally, what new EFVS products are coming to market soon?

Dror Yahav: Universal Avionics'

Aperture is the next step in bringing more connectivity and Artificial Intelligence capabilities to the cockpit. Aperture can process multiple video input sources and support four video outputs with zero latency. This means pilots and operators have shared information from even more visual camera and sensor sources, enhanced by content analysis and augmented reality in real time. This increases safety and improves decision-making for flight crews and mission specialists.

By James Careless

(Copyright: 2022 dSPACE GmbH)

HIL Testing Vital to Aerospace Innovation

With its use of artificial intelligence, real-time sensor tracking, and networked digital technology, the world of aerospace innovation is beyond the point where conventional flight testing will do. To ensure that all components work together as planned requires realistic testing on the ground, such as the Hardware-in-the-Loop (HIL) testing method.

"HIL testing is used in the development and testing of embedded systems," explained Dr.-Ing. Arne Brehmer, Senior Aerospace Manager at Vector, a provider of tools and services for testing aviation embedded systems such as Software Unit, Functional Software and Software Integration testing through to Component and System Integration test rigs. "Real signals from electronic control units are connected to a test system that simulates the complete environment of the control unit, sub-system or full system, including actuators, sensors, and loads. With HIL testing, you can easily conduct automatically thousands of possible test scenarios to fulfil the given test requirements and reach a high degree of test coverage."

In plain language, "HIL tricks an embedded system into thinking it is in an assembled product," said Noman Hussain. He is VP of Software and Strategic Business Development at Pickering Interfaces, a manufacturer of modular PXI (PCI extensions for Instrumentation) switching and simulation products primarily used in test and measurement. "To give you an example, in aviation we have an HIL testing model called Iron Bird. It is a ground-based test rig where an aircraft manufacturer can take all of the components, sensors, and systems used in an aircraft, assemble and connect them on the shop floor, and then use them to run realistic flight test scenarios."

Opal-RT Technologies is a provider of real-time test facilities for the aerospace industry. "The real-time nature of our system allows our customer to run the plant model discreetly in a real-time domain, so one minute of dynamics applied to the model is calculated in the same minute," said Mathieu Haineault, Account Manager in this company's Aerospace HIL testing division. "This allows a virtual software model to deliver electrical inputs/outputs, signals, and communications for interacting with a real device, which is normally a controller that we call a 'Device Under Test' (DUT). The cycle of receiving control signals from the DUT, calculating the reaction of the control signal, and sending back the new status (feedback) of the model is called a 'closed loop operation', which is the foundation of an HIL system."

"'Hardware in the Loop' is exactly as the name implies," concluded Francisco Flores, Business Development Manager for Aerospace and Defense at dSPACE, a provider of testing and validation solutions to many industries for over 30 years. "You put one piece of hardware — the actual controller under test — in a test bench and the rest of the system is simulated or emulated. This way you test your control software

algorithms to make sure that it is in fact working within the parameters of the established requirements. This will also allow the hardware to be tested beyond its prescribed limits in a lab environment."

A Testing Method for That Meets Many Needs
HIL testing successfully addresses four major areas of concern for the aerospace industry.

First, it provides a measurably reliable approach to testing aircraft systems on the ground. As such, HIL testing "increases system readiness before the completion of a new program," Haineault said. "It also provides the necessary data to create digital twins of aerospace systems to support continuous integration and update programs. Once validated, an HIL testing system can be used to develop and help validate new updates on an existing aeroplane."

Second, HIL testing helps aircraft manufacturers comply with government regulations, and document proof that they are doing so. "The development of embedded aircraft systems are regulated by standards like DO 178C or ARP 4754," said Dr.-Ing. Brehmer. "To comply with these standards and meet the low and high level system requirements rigorous testing is needed."

"As the complexities of avionics systems continue to evolve, the need to provide more sophisticated

> **"HIL tricks an embedded system into thinking it is in an assembled product."**
>
> **Noman Hussain. He is VP of Software and Strategic Business Development at Pickering Interfaces**

strategies and tooling to address the compliance will continue to grow," he added. "The networked aircraft will require the ability not only to ensure that a single LRU functions correctly, but also that they all function correctly when the entire system is brought together. This means that the ability to isolate components at a software unit level, as well as an LRU level while simulating the remaining interfaces, will be critical to achieving

Screen shot from Opal-RT Technologies Boeing 787 power system HIL test.

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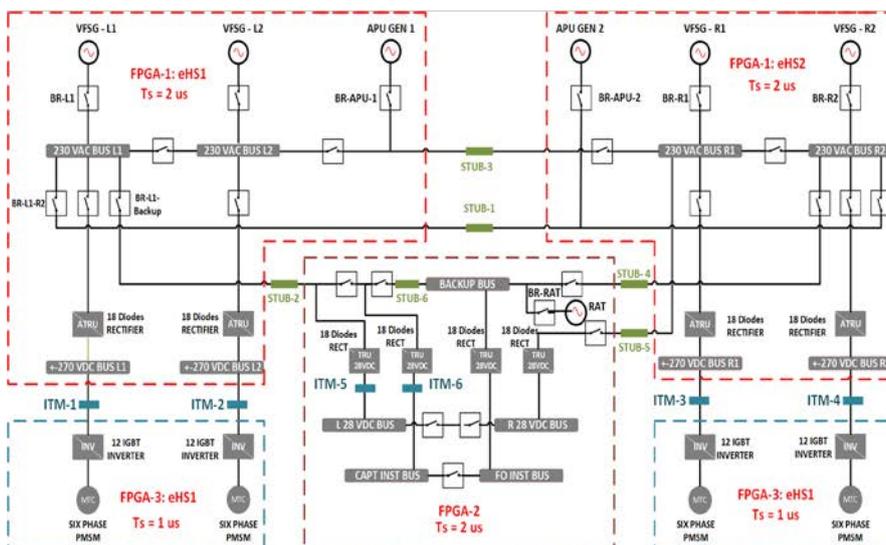
COUPLED CORES	FPGA INDEX	DECOUPLING INDEX
eHS1-eHS2	FPGA_0	STUB_1
		STUB_3
eHS1 -- eHS1	FPGA_0--FPGA1	STUB_2
eHS2--eHS2	FPGA_0--FPGA1	STUB_4
		STUB_5
eHS1--eHS2	FPGA_1	STUB_6
		ITM 5
		ITM6
eHS1 -- eHS_1	FPGA_0 -- FPGA_2	ITM1
eHS1 -- eHS_1		ITM2
eHS2 -- eHS_1		ITM3
eHS2 -- eHS_1		ITM4

Olaf Strumberg

MEA Boeing 787 Power system

A second screen shot from Opal-RT Technologies Boeing 787 power system HIL test.

(Copyright: Opal-RT Technologies)

Component	Amounts
18-Diodes Rectifier	10
12-IGBT Inverter	4
3-Ph Breakers	> 30
VF Synchronous Generator	7
6-PH PMS Motor	4
Cable Length	<10 meters

the quality requirements of the avionics industry."

Third, HIL testing is wonderfully practical. "For instance, products such as Linear Variable Differential Transformer (LVDT) transducers are used to control the flaps," Hussain said. "When you are sitting on the shop floor and you are moving the steering, you should be seeing flap movement. By doing this kind of action in an HIL testing environment, you have the freedom to create what I would like to call a 'really problematic aircraft' where you can simulate different kind of faults in that system, see what happens when they occur in the HIL test environment, and then develop fail safe/preventative mechanisms to make your product better before it ever leaves the ground."

Fourth, HIL testing allows an aircraft's entire suite of systems to be checked before it ever goes aloft. "In the world of aerospace — and I think that the FAA will most likely agree with me — the most important thing is to test an aircraft when the systems have been completed. For example, let's say that you're building a FADEC, which is a full authority digital engine control/ engine computer. The FAA would probably say, 'well, what we want to do is just test it when it is built and completed.' However, for manufacturers, that may prove to be too expensive and also requires a lot of hours. This is why HIL testing is so useful in aerospace manufacturing: It allows you to test within an environment where fault insertion and even testing critical paths can be done in a very safety conscious yet realistic environment."

The benefits of HIL testing don't stop here.

For instance, "HIL testing is usually fully automated and reproducible, hence it can be executed 24/7 in a lab environment," said Olaf Strumberg. He is He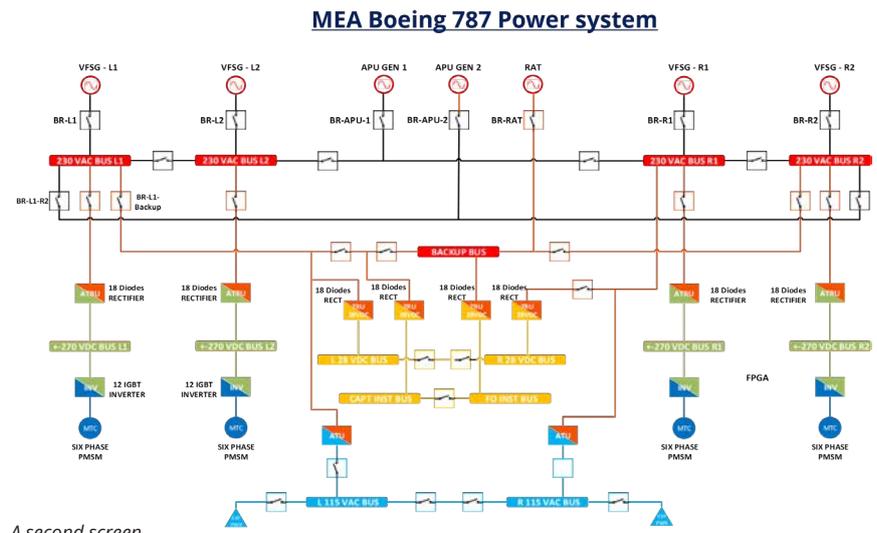ad of Engineering Center Verification & Validation Solutions at Elektrobit, a vendor of embedded and connected software products and services that employs HIL testing extensively for its automotive industry clients. "HIL testing is also easily scalable, allowing tests to be run in parallel across several testing setups, and is typically much more cost efficient than a real system test."

"The ability to automate and simulate these systems can greatly assist in reducing the overall effort, and hence implementation costs," Dr.-Ing. Brehmer agreed. As well, HIL testing allows Original Equipment Manufacturers (OEMs) to test their suppliers' equipment thoroughly," said Flores. "You can pit suppliers' products against each other, and see which ones work best to ensure the best possible combinations in the aircraft."

"Overall, the benefits of using HIL testing are massive," Hussain said. "The key benefit that we really talk about is the ability of HIL to create a truly realistic test environment. With HIL, you can do early validation of any of your equipment that's been created. Safety is another one because you can test different kinds

"Almost every single OEM out there is using it or considering starting to use it."

Francisco Flores, Business Development Manager for Aerospace and Defense at dSPACE

OP5707XG Real-Time Simulator by Opal-RT Technologies.

(Copyright: Opal-RT Technologies)

of scenarios on the shop floor, rather than in the air."

In Widespread Use, and Growing In Popularity

With all the benefits that HIL testing has to offer, it's not surprising that this method has taken the aerospace industry by storm.

"We are seeing more and more penetration of HIL testing across our industry," said Haineault. "Due to the high cost and engineering skills required to do physical flight testing, I would say that Aerospace has been one of the industries to grasp the full potential of [the] HIL system for many years, and its usage is still growing. This is mainly due to the high price of aeroplane development, the complexity of testing, and the really high cost of undetected errors."

"I will go as far as to say that almost every single OEM out there is using it or considering starting to use it," Flores said. "HIL testing is especially widely used right now by the many newcomers into the world of aviation, such as electric aircraft. HIL is popular because it's a good path to certification. You're able to prove a lot of concepts before starting to go into wide scale manufacturing and rapid deployment. After all, there's a lot of unknowns with respect to electric aircraft and their reliance on rechargeable batteries. Being able to test those batteries, and validate and verify that the battery management systems work properly using HIL guarantees that level of safety that the industry is looking for."

"In fact, HIL testing is becoming a standard throughout the entire aerospace industry, from suppliers and manufacturers of small general aviation aircrafts, eVTOLS to helicopters and large civil/military

aircrafts," said Dr.-Ing. Brehmer. "It is also a state-of-the-art method in automotive, railway, agriculture, telecoms, defence industry, and manufacturing systems' engineering," Strumberg noted.

As for the future? Dr.-Ing. Arne Brehmer expects that "the constant growth in aviation systems complexity will require more automated testing using HIL." At the same time, "tests on virtual platforms in software-only environments (SIL) will take a bigger share of project testing during the next couple of years depending on the availability of simulation models and the cost of computing performance," said Strumberg. "From the current perspective, SIL testing will not replace HIL testing in the upcoming years, as there will still be scenarios which require real hardware to fulfil specific testing requirements. This being said, one very important factor of parallel SIL and HIL testing will be the possibility to seamlessly exchange test cases, vectors and stimuli between these two complementary environments to ensure comparability between tests in software and

hardware environments."

"I think there's no limit to how far the aviation industry can go with HIL testing," Flores said; "especially given the introduction of AI into the aviation systems process. With AI, it's going to be very, very important for aviation companies to look at what the output is, how an AI system is making decisions and whether those decisions match the decisions made by a human being in the cockpit. I think that HIL will allow them to get those answers in a very safe environment, which will be initially in a lab, way before it is ready for flight testing."

By James Careless
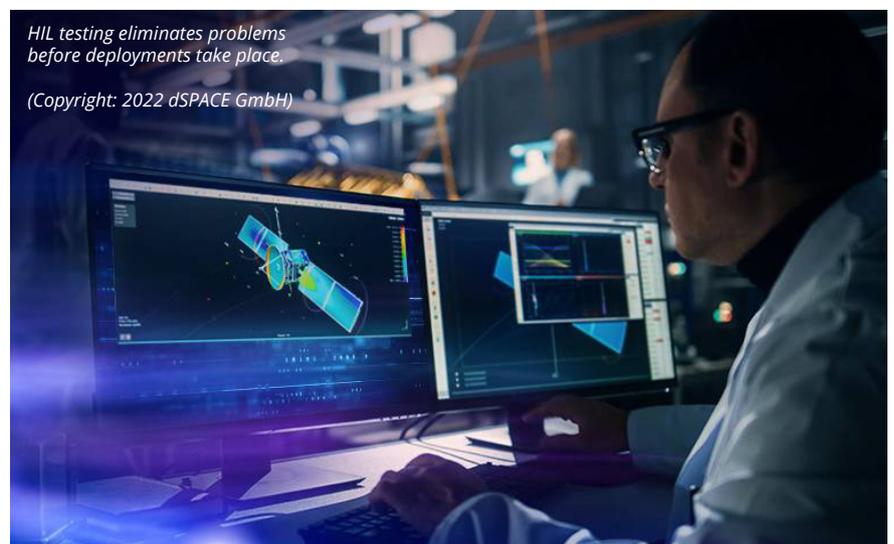
HIL testing eliminates problems before deployments take place.

(Copyright: 2022 dSPACE GmbH)

Redefining Aircraft Operational Data Strategies

Wireless has disrupted traditional Quick Access Recorders allowing airlines to have greater control over the on-board data. Alex Preston finds out how these multifunctional avionics platforms are transforming airline operations.

WQAR's are transforming operation control and flight technology management through the fast transmission, strong timeliness, and convenient extraction of onboard data.

In Coleridge's epic poem The Rime of the Ancient Mariner, the narrator bemoans "Water, water, every where, Nor any drop to drink." Fast forward to today's data-driven world, and our mariner could equally feel frustrated with the high volumes of low-density, unstructured data being generated annually.

During 2023, it was estimated that 120 zettabytes (ZB) of data were generated globally. This included sending and receiving about 347.3 billion emails every day, while Google processed over 20 petabytes of data per day – that's 40,000 search queries every second.

Our appetite for data looks sets to be unabated as it's expected that we'll generate over 180ZB of data by 2025.

And the world of aviation is not immune from this growth.

Data pipes
In a 2021 whitepaper, Collins Aerospace noted that with the advent — and increasing acceptance — of intelligent airplanes, aircraft and engine performance/health monitoring data have grown over time and now represent up to 80% of a new generation aircraft's Aircraft Communications Addressing and Reporting System (ACARS) data volume.

The report authors observed that engine and aircraft ACARS data has grown 25% to almost 75% between new and older generation aircraft, and that new generation aircraft generate four times the amount of ACARS data than their predecessors.

As airlines seek out greater safety improvements, Quick Access Recorders (QARs) have become an even more essential tool of a Flight Data Monitoring (FDM) platform.

If your aircraft have a digital flight-data recorder then it is quite possible for you to use downloads from that device for your FDM program. However, FDRs can be difficult to access and the requirement for a download unit (and specialised training) can make this option impracticable for daily (or even weekly) downloads.

An aircraft Quick Access Recorder (QAR), often regarded as a more intelligent version of the black box, is an onboard device that captures flight data from multiple aircraft systems and data buses, including the engine.

Traditional digital flight-data recorders have been seen to be difficult to access with the requirement for a download unit (and specialised training) often making this option impracticable for daily (or even weekly) downloads.

As Scott Chambers, Vice President, Sales & Marketing at FLYHT Aerospace explains, originally QARs were tape-based, (not suitable for regular downloads) before becoming optical. However, optical QARs have a reputation for poor reliability and slow downloads.

In these instances, personnel must regularly go to the aircraft to manually remove the recording media or access QAR ports. If connecting to a port, a cable is attached to download the required data and bring to a specific computer to transfer the data in the files for further flight data analysis (FDA). Under such conditions, velocity, or the fast rate at which data is received and (perhaps) acted on, is diminished. Additionally, as Chambers avows, during the retrieval of such media types, data can easily get lost or become corrupted.

The evolution to wireless overcomes these obstacles. A Wireless

Avionica's miniQAR records up to 6,000 hours of FOQA/FDM flight data and is flying in over 300 aircraft types worldwide. (Copyright: Avionica)

Quick Access Recorder (WQAR) is an onboard system that provides aircraft operators with a means to automatically transfer recorded flight data wirelessly, from the aircraft's onboard data acquisition unit to a ground-based Flight Data Analysis (FDA) system, after each flight, upon landing, without requiring an operator's manual intervention.

The first WQAR was designed, manufactured, and certified by Teledyne, who was the first company to introduce and patent cellular technology in 1999, as a viable means to transfer large volumes of data between the aircraft and the airline's ground network.

As Chambers notes, as WQARs allow you to get such data within minutes of the flight. "As safety programmes became mandated, the WQAR became more and more important because that data had to be as close to 100% as possible. And manually, you just can't get there."

To illustrate his point, Chambers highlights that China mandates WQAR.

Sunrise, sunset

Wireless delivery enables automated data transfer to and from the aircraft through existing cellular or Wi-Fi networks enabling FOQA/FDM programs. Ironically, this, believes Chamber, is the Achilles Heel of WQARs – cellular technology moves so fast.

Systems incorporating the 2G cellular network were first introduced in the late 1990s. "Anybody who adopted cellular technology in 2000/2001, is now at least three upgrades in – GPRS, 2G, 3G, some

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The base functionality of the avRDC MAX is to record ARINC 717 and up to 10 channels of ARINC 429 data. (Copyright: Avionica)

Top image: FLYHT's AFIRS Edge+ is a plug-in compatible 5G WQAR that can be installed overnight and is available at the cost of a 2G/3G WQAR repair or upgrade. (Copyright: FLYHT)

Bottom Image: AFIRS Edge serves as an Internet of Things (IoT) gateway on the aircraft ready to support new IoT sensor technologies as they are deployed. (Copyright: FLYHT)

may have even moved on to the LTE."

"The increase in connectivity speeds has allowed more data to be downloaded faster," says Scott Ridge, Vice President, Business Development at Avionica. "This helps ensure the data is available after every flight. The 2G/3G sunset has already occurred in many parts of the world. The sunset time is being driving by the cellular network providers, region by region. If an operator does not upgrade, their QAR would need to be downloaded manually. This would increase their labour cost and reduce the value of the data driven decisions."

The move to 4G/LTE has been occurring for several years, driven primarily by 3G shutdowns notes Teledyne. "The majority of 3G networks globally have already shut down, with a few still in the process of being decommissioned in 2024," a company spokesperson observes. "4G LTE radio technology is backward compatible with 3G/2G networks. While 2G networks are still in use today, most carriers are targeting shutdowns by 2025, although this varies by region."

According to Teledyne, 5G technology is often driven by performance hype and misconceptions about the near-term shutdown of 4G LTE. "We have been managing cellular technology evolution in our products since 1999. No cellular provider on the planet is announcing the shutdown of 4G LTE anytime soon," they state. "In fact, with over a billion IoT/Machine-to-Machine industrial devices relying on 4G LTE (including automobiles, security, fleet management, healthcare devices, agriculture, etc.), it is expected to continue well into the 2030s. Continued long-term support for 4G LTE is anticipated due to 3GPP standards, with cellular providers implementing Dynamic Spectrum Sharing (DSS), between 5G and 4G, and advanced 4T4R to 8T8R cell site technologies."

Addressing 5G performance, Teledyne says there are many misconceptions about actual 5G "throughput" performance. "Cellular technology is primarily driven by consumer demand, with a focus on high download speeds to allow greater subscriber capacity. However, upload speeds are typically slower and not symmetrical. For instance, when an airline "downloads" large data sets from the airplane, this is an upload from a network perspective and generally has less bandwidth. While this varies by region, comparisons between 4G LTE and 5G upload speeds show little difference in performance," the spokesperson remarks.

They add that, "Our current 4G LTE technology continues to meet the use cases for our customers. While early adoption of 5G should be evaluated carefully to avoid unnecessary expenses, it's important to note that 4G LTE will continue to be supported well into the 2030s. As we have done for over two decades, we are committed to ensuring seamless transitions and supporting our customers through these technological evolutions, including the introduction of our 5G-capable devices in 2025."

For many QAR options, upgrading requires a complete replacement of the unit. As Ridge explains, "For Avionica, with our modular design, it only requires replacing the cell module. Just four screws and some paperwork. For operators on the Avionica seamless plan, this technology upgrade is included in their subscription fee at no additional cost. Avionica also offers plug and play replacements for our competitor's offerings to allow upgrading to a wireless QAR for either manual or obsolete equipment."

All seems very well, but as Murray Skelton Vice President Business Development and Weather Solutions at FLYHT Aerospace points out, the problem with all cellular networks is that while most devices are compatible globally, not all the service providers and the owners of those networks, talk to each other.

5G WQAR UPGRADE INSTALLED IN 5 MINUTES

05 min

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AFIRS Edge+ is a 5G solution that plugs into existing WQAR provisions, enabling massive data harvesting

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"It's a challenge to try to pull that together," he says. "And that's something that we at FLYHT can solve by being able to provide a global service. We work with companies who can negotiate through global roaming on SIM cards, so you can overcome that problem."

Teledyne offers options for Teledyne-managed SIM Service or airlines can utilise existing cellular communication agreements.

Skelton continues. "If we take the QR part, it's just the ability to take a snapshot of data off the aircraft. That's what its purpose is. Its initial purpose was for flight safety, but It's gone way beyond that."

Volume and variety

He points to new aircraft, such as the Boeing 737 MAX family, 787s and Airbus Neo family and A350s, and the number of sensors they have is adding to the volume of data being generated. "That is why the WQAR is really coming into its own because cellular technology has grown so rapidly that moving gigabytes of data over cellular is nothing - it's minutes when previously it was hours and hours."

These data sets are so voluminous they require adequate storage capacities. As Ridge points out though, with wireless QARs, data storage onboard the aircraft is no longer an issue.

"Modern QARs boast increased data storage capacities, accommodating the extensive information generated by contemporary aircraft systems," says ATL Europe CEO, Peter Burden.

Writing on the company's website Burden says, "Capacity was very limited when QARs were first introduced, but they can now reach over 400 hours of flight data across multiple channels in more advanced devices."

Teledyne agrees, with a spokesperson stating that "Over the last 20 years, data storage has really kept up with the times. Years ago, single-level cell (SLC) drives were very reliable but also very pricey for the limited capacity they provided. Fast forward to today, and we've got multi-level cell (MLC) and triple-level

cell (TLC) drives, along with solid-state drives (SSDs) using 3D NAND technology, that offer much more storage at significantly lower costs. As an example, the cost per gigabyte of storage has dropped from around US$10 in the early 2000s to just a few cents today. We've seen huge jumps in storage density and reliability. Basically, we can store more data without worrying about running out of space."

Clean data caching

According to Ridge, Avionica's suite of data recording and transmission products are among the smallest and most capable systems on the market.

The miniQAR with the avCM cellular transmission module provides basic data capture and connectivity for an operator Flight Data Monitoring (FDM) of Flight Operations Quality Assurance (FOQA) analytics tools. This data can also be used for some basic maintenance analytics.

"When an operator wants data from even more systems to enhance their safety or maintenance analytics, the miniQAR is replaced by our avRDC (Remote Data Concentrator). The avRDC provides more inputs and outputs to connect to additional data buses," he says.

"When an operator wants additional functionality, such as an Aircraft Interface Device (AID), airborne data loading, onboard application hosting, or connection to additional communication channels, our avWiFi is added to the stack and the system becomes an aviONS, our onboard network server.

Ridge says that Avionica is differentiated in many areas. "Our small form factor allows for flexibility in installation location. This is critical in smaller aircraft or in crowded E&E bays and saves weight and therefore fuel. Our patent pending Enhanced Data Mode also allows installations with as little wiring as possible. These combine to allow very short installation times, saving the operator money. Our modular design allows for easy upgrades to allow more use cases to increase operator value as they progress on

Top image:The aviONS (Onboard Network Systems) aircraft data interfaces (e.g., ARINC 717, 429) can be used for both QAR functions and onboard data functions. (Copyright: Avionica)

Bottom Image: When paired with Avionica's miniQAR, the avCM enables wireless LTE capabilities (Copyright Avionica).

their connected aircraft journey."

Avionica has hundreds of customers, and its equipment is on thousands of aircraft worldwide. The equipment has been installed on everything from small business jets up to 747. This includes business jet fleet owners, cargo operators and many major airlines, such as Amelia by Regourd Aviation, Air Transat and JSX.

Teledyne's GroundLink® Comm+ system is an enhanced version of a WQAR. It automatically selects available LTE networks with automatic fallback to 3G when LTE is unavailable and supports the simultaneous use of up to two or four cellular radios (2,400 Mbit/s).

Teledyne's GroundLink® system provides airlines with additional functionalities that best meet their specific operational needs and goals. These additional features include a full suite of e-Enablement options such as AID+, to enhance EFB systems functionality by adding off-board communication, access to aircraft parameters, and data management

capability to EFB applications and crew devices; DataLink (ACARS over IP) – a cost-effective solution to send ACARS messages over cellular or broadband, and Broadband – in-flight connectivity enabling live data streaming, ACARS over IP and Internet access to EFB applications in all flight phases.

Over the last two decades Teledyne has grown to over 300 airlines worldwide with over 10K units in service. The types of operators are diverse – domestic and international passenger and cargo operators on single aisle (S/A) and long range (L/R) Boeing and Airbus airplanes represents the majority of installations, with various military installations as well.

FLYHT's Automated Flight Information Reporting System (AFIRS) Edge offers is engineered and designed as a state-of-the-art multi-channel WQAR with LTE/4G and 5G network availability. It also allows simultaneous Digital ACMS Recorder (DAR) and QAR recording.

The company recently introduced AFIRS Edge+™, a plug-in compatible 5G WQAR that can be installed overnight and is available at the cost of a 2G/3G WQAR repair or upgrade. It can also be used to replace 4G WQARs as 4G LTE technology begins to sunset in the late 2020s.

In January this year, FLYHT announced a multi-year design and manufacturing collaboration with One Stop Systems, for the AFIRS™ Edge family, including it's the new AFIRS Edge+.

Earlier this year, the flange version of the AFIRS Edge obtained an STC from Transport Canada for Airbus A320 aircraft. The achievement enables FLYHT to ship the Edge units to Canadian A320 customers while at the same time familiarising the Canadian STC into other jurisdictions to enable worldwide distribution.

Security measures

The evolution of WQARs has changed the security landscape around data retrieval and retention.

Writing in March 2024 Oracle's Sherry Tiao, Senior Manager, AI & Analytics defines big data as "data that contains greater variety, arriving in increasing volumes and with more velocity. This is also known as the three "Vs."

He writes that two more Vs have emerged over the past few years: value and veracity. "Data has intrinsic value. But it's of no use until that value is discovered. Equally important: How truthful is your data—and how much can you rely on it?"

Skelton agrees commenting that he thinks the value of the data more than anything is driving a lot of airlines wanting to have security capabilities.

"We ensure cyber resilience and protection of data/communications by following security policies and processes for all airborne and ground-based products," says Teledyne. "Our process is modelled after a variety of government and industry standards. In the past security was an afterthought, if at all. Today, cybersecurity is one of the first assessment in our engineering activities. Additionally, we perform our own STC applications and are required to demonstrate adequate security measure and controls to ensure there are no unauthorised interactions, or data access, between onboard devices and offboard networks."

Most QARs are one way communication devices that do not write to the aircraft, so cyber is not an issue, states Ridge. For multi-purpose devices that can write to the aircraft, the FAA has issued guidance. "Avionica's products meet these cyber requirements as needed," he affirms.

"For Avionica, once the data has been downloaded from the aircraft, it is securely stored in the Microsoft Azure cloud until it has been delivered to the end points requested by the operators."

Feature-rich future

In his online post, Oracle's Tiao writes that, "Big data makes it possible for you to gain more complete answers because you have more information. More complete answers mean more confidence in the data—which means a completely different approach to

tackling problems."

Teledyne says its WQAR has a long history of evolving to meet the dynamic needs of the aviation industry. "Since its introduction, we've consistently enhanced the functionality to go beyond simple data recording (QAR/DAR/ACMS) and wireless transfer from the Data Acquisition Unit to the ground. Years ago, we expanded the WQAR platform to include capabilities branded under Comm+. This evolution incorporated not only QAR/DAR/ACMS recording but also onboard Ethernet and Wireless Access Point functionalities, which enable diverse AISD onboard networking. These advancements facilitated essential services such as Aircraft Interface Device (AID) functionality for Electronic Flight Bags (EFBs), Avionics Data Loading, printing, ACARS messaging, IP Routing, etc. We will continue to invest in the future to meet our customers' needs."

Chambers and Skelton believe that the role of the WQAR is changing. What was once a data acquisition unit on the aircraft is becoming a data concentrator on the aircraft.

"Collecting and distribution of data is becoming its job, rather than just offloading data on the ground," extending to support EFBs.

"But it's what's happening with the data - real time," he emphases, using the example of AFIRS Edge which can perform the functions of an Aircraft Health Monitoring system as a WQAR, through its dual CPUs, and eight cores.

UK regional airline Loganair is using this capability to collect data from an airborne sensor, combine it with the Air Data computer, and then every day 120 seconds push out a weather message that says the aircraft is at this location, at this height, and this is the weather currently experienced.

"If you can imagine the CPU, the processing capability you have between ground-based systems with an airborne edge computer...the applications are pretty much endless." AI and predictive maintenance

Other possible applications include integration IoT sensors to monitor levels of potable water, control onboard temperature, check if cargo doors are open etc. Because its connected, because its wireless, the aircraft doesn't have to be inflight for the WQAR to continue to perform.

It's a sentiment shared by Ridge. "Although not all operators are taking full advantage of the capabilities, QARs have evolved to become simply a function of an onboard network system. As additional sensors and communication protocols evolve, these systems will need to continue to adapt to handle this additional inputs and outputs. Then the aircraft will become a true node in an operators IOT network, allowing real-time data and decision-making for the entire operation."

By Alex Preston

The GroundLink® Comm+ system offers automatic data exchange, leveraging 3G/4G/LTE cellular technology and IP Broadband connectivity to facilitate and accelerate data transfers between airborne systems and ground-based equipment, and to transfer critical data while in flight.
(Copyright: Teledyne)

Figure 1: Flight SQ321 heavily impacted by turbulence resulting in the death of one passenger and dozens of injuries. (Copyright: Stringer / REUTERS / picturedesk.com)

Turbulence Cancelling Technology for Turbulence-Free Flights of the Future

Atmospheric turbulence is an unsolved problem for aviation, affecting economics, safety and, above all, comfort and passenger trust. To date there has been no effective solution to this, apart from long detours or gritting your teeth and flying through.

Turbulence Cancelling was developed and successfully demonstrated 2021 in manned flight tests based on research at the TU Vienna. This system is available for purchase on a European high-performance ultralight aircraft from 2024. Further development projects to implement Turbulence Cancelling also in AAM and CS25 aircraft started in 2023.

Turbulence Impact on Aviation rising

Recent accidents show the heavy impact turbulence can have even on big airliner. A Boeing B777 of Singapore Airlines flight SQ321 experienced extreme turbulence resulting in negative g-force of -1.5 g leading to the death of one passenger and dozens of injuries. Only five days later a Boeing B787 of Qatar Airways flight QR017 hits turbulence resulting in twelve injured persons. While airlines do their best to avoid such events, rising turbulence levels will require more and more rerouting and more optimized forecasting to be able to deliver a positive flight experience and passenger trust. Unfortunately, every additional flight minute and every additional kg of flight mass increases fuel burn and thus CO2 emissions. In total, turbulence leads to about 10% of additional fuel requirement for air mobility, due to increased flight distance and flight time, inefficient flight logistics, and heavy and inefficient aircraft. As climate and aviation both take place in the atmosphere, there is a bidirectional influence of climate change leading to more frequent and stronger turbulence, and aviation responding with even higher flight emissions.

A different solution than rerouting to overcome the negative impact of turbulence is to actively counter the arising g-force by means of active flight control, also known as Turbulence Cancelling technology.
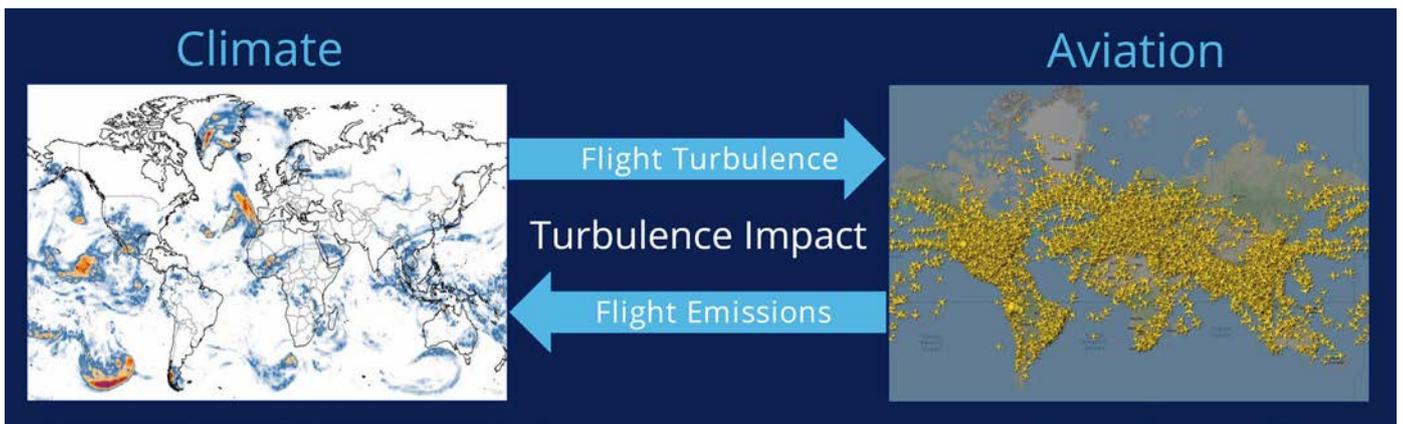
Figure 2: Bidirectional impact of Climate and Aviation in the Atmosphere.
(Copyright: Turbulence Solutions)

As most of the turbulence scenarios are rather comfort limiting than safety limiting - the last airliner that disintegrated in flight due to turbulence was the BOAC 911 - light counter-turbulence up to 0.5 g is already sufficient to cover most of the turbulence scenarios. Even in moderate to severe turbulence limited counter-turbulence of 0.5 g drastically improves the situation in the cabin, with the potential to alleviate light negative g-forces, which levitate unfastened passengers towards the ceiling, back to positive g-forces. In principle, even severe to extreme turbulence can be actively countered by advanced flight control, however, this requires large flight control authority and a guaranteed function, which significantly raises complexity and criticality compared to a limited authority assistance system, which is limited to 0.5g and can be turned off at all times.

In comparison, modern aircraft also fly straight through bad visibility conditions, such as clouds and fog, as they are equipped with systems to handle IMC conditions, without avoiding every cloud. Similarly, rising turbulence levels will lead to even more need for systems which enable to also cross turbulence fields without negative impact on aircraft, crew and passengers. Actual thunderstorms adding risks of lightning and hail - recently Austrian Airlines flight OS434 was heavily impacted by hail - will still be avoided. For the rest of turbulence scenarios Turbulence Cancelling systems can create a completely new quality of flight experience, especially in light aircraft, including Turboprops, Business Jets and eVTOLs (Advanced Air Mobility). Performance, safety, economy, planning security are just a few arguments in favor of implementing Turbulence Cancelling systems. The most important aspect given the rising turbulence levels is passenger comfort and trust, and the related operational efficiency of reliable and predictable air mobility.

How does Turbulence Cancelling work?

The patented system works similarly to the already established "Noise Cancelling". Based on targeted counter-deflections of control surfaces, the disruptive effects of turbulence, particularly focusing on the unpleasant vertical acceleration, can be reduced by more than 80%. Initial tests with a manned prototype in 2021 also confirmed these effects in practice with damping by approx. 60%. Through further development and refinement into a product ready for series production, which is available for purchase on a European high-performance ultralight aircraft from 2024, the dampening effect could be increased to approximately 80%. Instead of damping, we can already speak of cancelling.

For the upgrade a Turbulence Sensor is installed either on the aircraft nose or in front of the wings to measure the turbulence even before it hits the wing. Existing flap systems are extended by small and fast Turbulence Flaplets, which are capable of generating the required counter-turbulence. Depending on the available avionics system, a separate processing unit or an existing flight control unit can be used for the processing of the actual Turbulence Cancelling control logics.

Inventor and managing director of Turbulence Solutions, András Gálffy, explains that "aircraft that fly at low altitudes and are therefore exposed to thermal and orographic turbulence, such as gliders, sports aircraft and business aircraft with turboprop engines, can particularly benefit from Turbulence Cancelling. In the future, it should be possible to fly directly and reliably through turbulence while further increasing comfort."

"So-called eVTOL aircraft with wings (note: Electric Vertical Take-off and Landing), which will be used in the future as a cost-effective and fast air transport solution within cities or as air taxis on short-haul routes, are also extremely affected," adds András Gálffy. "Especially in urban areas, extreme turbulence arises. However, the sustainable use of the new flight services will largely depend on user acceptance. And this is supported above all by the feeling of safety, to which a turbulence-free flight contributes significantly".

But the use and capacity utilization of conventional aircraft also depends on the weather. "I often see that our aircraft remain on the ground when the weather indicates turbulence," explains Oliver Breiteneder, who,

Figure 3: Turbulence Cancelling Illustration.
(Copyright: Turbulence Solutions)
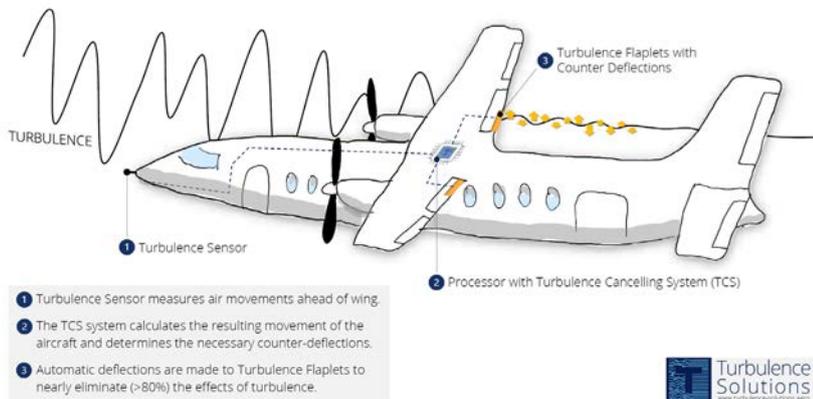
as president of flylinz – Flugschule Linz, has deep insight into the usage behavior of private pilots. "However, it is rarely the pilots themselves who are afraid of turbulence, but rather the passengers, often family members." Oliver Breiteneder expects that the utilization of those aircraft that are equipped with Turbulence Cancelling will increase significantly. "In our aircraft replacement and new investments, we will closely examine which models have Turbulence Cancelling available. That would be a decisive competitive advantage for us."

The technology works particularly effectively on fast aircraft with a broad airspeed envelope and on aircraft with low wing loading. "We therefore initially looked for contacts with manufacturers of high-performance ultralight aircraft," explains András Gálffy. "In the meantime, contacts have also been established with manufacturers of light aircraft and eVTOLs at international trade fairs, all of whom are impressed by the possibilities of our technology."

As one of the next steps, manufacturers of business jets and airlines who want to offer their passengers a special comfort experience and save the costs of turbulence-related detours will also be addressed. "We estimate that simply by avoiding detours around known turbulence zones, fuel savings

of around 3-5% are possible," explains András Gálffy. "Studies show that the total costs for turbulence-related detours and extra maintenance due to so-called high g-loads in global aviation are estimated at up to $ 3 billion." "By the way: our calculations show that gliders perform better in turbulent updrafts with our system. But that also means that in engine-powered aircraft the drag and thus the consumption decreases or the speed increases, what we could actually observe with the European ultralight aircraft."

Similar to the already established Noise Cancelling, targeted deflections of control surfaces - so-called "Turbulence Flaplets" - generate counter-oscillations that overlap with the turbulence-related movements and thus cancel them out. In aircraft with fly-by-wire controls, the control logic can be upgraded to include Turbulence Cancelling without having to install additional control surfaces. Furthermore, Turbulence Cancelling does not alleviate the pilot's maneuvering loads or interact with primary flight controls, such as aileron, elevator, and rudder. In contrast to the "Gust-Load-Alleviation" systems, Turbulence Cancelling focuses primarily on passenger comfort and not on reducing the weight of wing structures, i.e. focusing on continuous and daily turbulence loads and not the maximum or

limiting gust loads. In this context, the limited control authority of small flaplets is already sufficient to cover most turbulence scenarios for passenger comfort and trust, while Gust-Load-Alleviation needs to generate significantly higher g-forces when aiming for guaranteed alleviation of structure limiting gust loads. Future Turbulence Cancelling systems might be step-by-step expanded to raise complexity from limited-authority assistance systems focusing mainly on passenger comfort, up to full-authority fail-operational systems including alleviation of limiting gust loads in some decades in collaboration with leading industry partners. This development roadmap can be compared to the development from first low-complex flight instruments giving assistance to pilots in reduced visibility conditions, up to high-complex fail-operational navigation systems for intentionally entering instrumental flight conditions.

Figure 4: Turbulence Flaplet illustration and Turbulence Cancelling certification aspects. (Copyright:Turbulence Solutions)
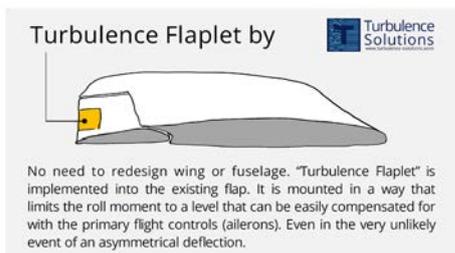
- "Limited by design"
  - Flaplet can only deflect +/- 15°
  - Flaplet size limits impact
- Assistance System
  - Fail-Safe, not Fail-Operational (yet)
  - Can be turned off at any moment during operation
- Pilot in control
  - Pilot can turn off system
  - Pilot can overpower system
- Monitoring of System States

When will Turbulence Cancelling be available?

Discussions are currently underway with several aircraft manufacturers. It is intended to start the series production process with maximum 2 – 3 at the same time. Inventor and managing director András Gálffy: "Ultralight aircraft have simple and therefore quickly implementable approval regulations combined with a high level of willingness to innovate. We therefore have focused initially on this area and have presented the first model available on the market at AERO Friedrichshafen 2024. Turbulence Cancelling is offered as an option for new aircraft, and on the other hand, retrofit kits (as part of STCs) are also planned for existing aircraft. "

At the same time, discussions are underway with several manufacturers of electrically powered air taxis (eVTOL). "These manufacturers are currently in very intense competition for certification. The first purely electric air taxi available on the market will certainly have advantages," explains Oliver Breiteneder. "However, paying passengers who regularly use this service will be crucial to the lasting success of this innovative and environmentally friendly transport solution. And that depends largely on trust in this new technology. In fact, we have a critical enabler technology for this new market.

"Surveys show that even in heavier and therefore more stable, large aircraft, around one quarter of all passenger struggle with discomfort due to turbulence. In the case of eVTOL, more than half of those surveyed are afraid of flying with these significantly lighter, partially autonomous aircraft in the future, even in light winds".

Considering the increasing turbulence occurrences and intensity also in the flight levels of jet aircraft, Turbulence Cancelling is becoming a very interesting solution also for Business Jets and Airliner.

Figure 5: The Team of Turbulence Solutions. (Copyright: Turbulence Solutions)

Company Information and Contacts

Turbulence Solutions GmbH was founded in 2018 to continue and market the research results, which DI András Gálffy developed at the TU Vienna in connection with turbulence. The company is still majority owned by András Gálffy. Co-partners are Oliver Breiteneder, MBA (Head of Market and Business Development) and Dr. Robert Mühlbacher (Head of Certification, Product and Quality Management).

All Turbulence Solutions employees share a passion for flying and are either already pilots or are in pilot training. The headquarters is in Vienna, the development center is located at the Aerospace Center in Baden.

DI András Gálffy: The inventor, researcher and founder of Turbulence Solutions GmbH. As part of his studies at the Vienna University of Technology, he carried out basic research on turbulence suppression and expanded the approach in his PhD studies. DI Gálffy teaches at the TU Vienna and at JOANNEUM Graz. He is a trained commercial and aerobatic pilot.

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Oliver Breiteneder, MBA: Head of market and business development, certified management consultant, President and CEO of flylinz - Linz flight school, Upper Austria. He brings decades of experience in top management, studied business administration and aviation management and lectured business-management and start-up at the Johannes Kepler University Linz (JKU) and at the University of Applied Sciences, Krems; He is holding a pilot license since 2003.

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Dr. Robert Mühlbacher: Head of Certification, Product and Quality Management; Experienced enterprise system architect and developer and lecturer at the WU Vienna. In his 35 years of professional experience, he has worked on many projects in various roles. Focused on aviation since 2018, started training to become a private pilot.

(Copyright: Shutterstock)

Nexus Lab's Advanced Approach To Contrail Mitigation

In an era where climate change poses one of the most pressing challenges, industries across the globe are innovating to mitigate their environmental footprint.

The aviation sector, a significant contributor to global greenhouse gas emissions, is under increasing scrutiny to adopt sustainable practices. While much of the focus has traditionally been on reducing carbon dioxide (CO_2) emissions, it is crucial to recognize that non-CO_2 impacts, such as contrails, are equally important. Nexus Lab is at the forefront of developing cutting-edge solutions to reduce the non-CO_2 impact of airlines by avoiding contrails.

Contrails, short for condensation trails, are artificial clouds formed by the water vapor emitted from aircraft engines at high altitudes. These trails persist in regions where the humidity is high enough and the temperature is cold enough. Although often perceived as harmless, contrails have a significant warming effect on the planet. They are five times more effective at trapping heat than CO_2 and represent 35% of aviation's direct impact on climate change. Due to their substantial impact, the European Union (EU) will implement new regulations starting January 2025, requiring airlines to monitor, verify, and report (MRV) their contrail impact. By the end of 2027, the EU could integrate non-CO_2 impact into the EU Emission Trading Scheme (ETS).

To address this urgent issue, Nexus Lab has developed software that allows airlines to reduce their contrail impact at almost zero cost. By combining massive quantities of satellite imagery, flight radar information, and meteorological data, Nexus Lab's Artificial Intelligence creates state-of-the-art predictions of when and where contrails are likely to form, similar to turbulence, icing, and storms. Dispatchers and pilots use this information to adjust the flight level or path during the pre-flight procedure, minimizing contrail formation.

Our solution leverages a combination of satellite images and advanced machine-learning techniques to detect and predict contrails. Specifically, we employ a pre-trained AI model based on a Convolutional Neural Network (CNN) with a custom U-net architecture. This model is trained on a large, manually labeled dataset comprising 450GB of contrail images from Google, ensuring robust detection capabilities.

Once contrails are detected, we match these contrail segments to specific flights using a proprietary matching algorithm. This validated contrail dataset is then enriched with meteorological data (e.g., humidity, temperature) and aircraft engine

data (e.g., emission rates). Using this comprehensive dataset, we train an AI classifier to predict zones where persistent contrail formation is likely.

To enhance prediction accuracy and evaluate the environmental impact, we incorporate several physical contrail simulation models: such as CoCIP (Contrail Cirrus Prediction model), developed by DLR, APCHEMM (Aircraft Plume Chemistry, Emissions, and Microphysics), created by MIT, and ACCFs (Algorithmic Climate Change Functions), developed by TU Delft/DLR.

By combining the AI predictions with physical model simulations, we identify the most accurate contrail formation points. The properties of these contrails are then detailed based on the physical models, significantly reducing false positive rates compared to using physical models alone. This integrated approach leverages the strengths of both AI and physical modeling, offering a cost-effective solution for airlines to minimize their contrail impact and comply with upcoming regulations.

Looking ahead, Nexus Lab aims to continuously refine and expand its contrail avoidance technology. Future developments include integrating real-time atmospheric data and enhancing machine learning algorithms to provide even more precise predictions. Collaboration with aviation industry stakeholders, regulatory bodies, and environmental organizations will be crucial in scaling the adoption of this technology globally.

In conclusion, as the aviation industry grapples with the dual challenges of growth and sustainability, innovative solutions like those developed by Nexus Lab are essential. By addressing both CO_2 and non-CO_2 impacts, Nexus Lab is helping to pave the way for a greener future in aviation. Our cutting-edge contrail avoidance technology not only meets regulatory demands but also drives the industry towards a more sustainable and environmentally responsible trajectory.

Ash Colour
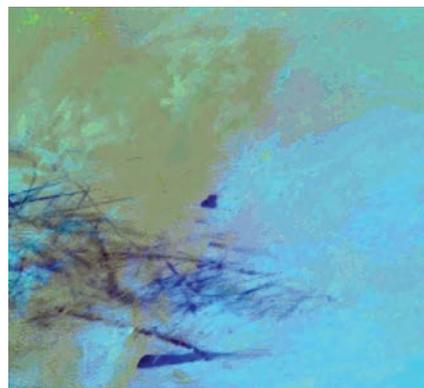
Detected Contrails
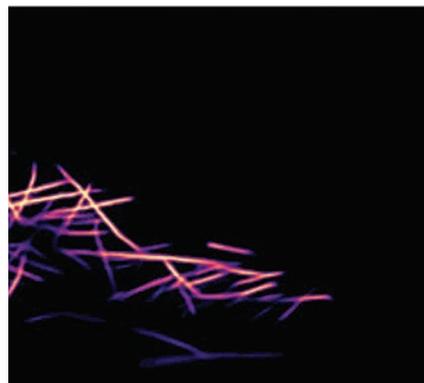
(All photos: Lufthansa Technik)

Time Is Everything

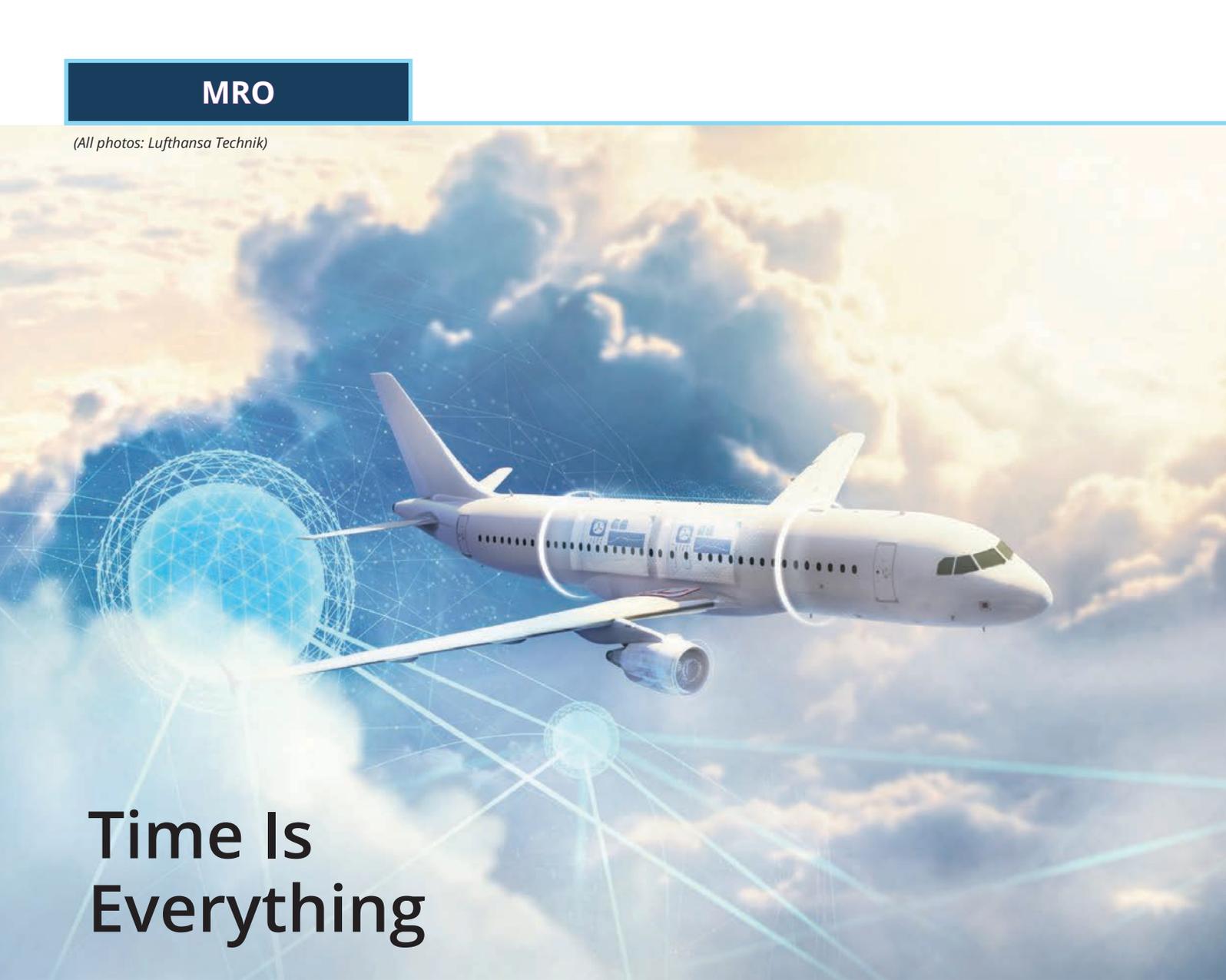A key element of airline operations is punctuality. If timekeeping is poor, it can be expensive in terms of reputational damage, passenger compensation payments and the knock on effects of delays to other flights, exacerbating the problem.

The answer is to be able to identify, predict, prevent and rectify problems as quickly as possible. However, this can be difficult to achieve without the use of data analysis.

One such solution is the AVIATAR, part of Lufthansa Technik's Digital Tech Ops Ecosystem , which was formed in early 2023 with the integration of AMOS MRO software from Swiss AviationSoftware (Swiss-AS) and digital records and asset management solutions from flydocs. Both companies are now 100% subsidiaries of Lufthansa Technik but with separate operations as well as collaboration between all three. In addition, Engineering Services complements the solutions offered by the Ecosystem. Data from these sources are incorporated into a number of AVIATAR modules that customers can assemble into a customised suite of applications closely tailored to their specific operations;

The latest development is the introduction, in April, of a new AVIATAR module called Reliability Solutions.

Dr. Jan Philipp Graesch, Product Lead Reliability Solutions, explains that, previously, it was not always possible to leverage all the available data assets, have a central data source (single-point-of-truth), easy collaboration between departments and to have the efficient, real-time creation of standard reports.

This is because a fault can be reported from a number of sources - technical logbook, pilot reports, messages from maintenance staff or directly from the aircraft, such as fault messages sent directly via the Aircraft Condition Monitoring System (ACMS). In addition, there are scheduled corrective actions and maintenance tasks. For pilot

It is important to include the hands on maintenance crews in the hangar. They can be forewarned of a problem and advise immediately when it is resolved.

Dr. Jan Philipp Graesch, Product Lead Reliability Solutions.

reports, these tend to have mistakes, especially the wrong ATA Chapter, while a mix of other languages and aviation English makes automatic analysis difficult.

Typically, the Technical Fleet Manager will oversee the resolution of problems with a Reliability Manager (RM) and a Systems Engineer (SE) but, he says, this can be a bit like a game of ping pong between the two. In addition, the

troubleshooters in the Maintenance Control Centre (MCC) of an airline may have to be in the loop.

The RM will highlight the problem and make it a case, passing it to the SE for root-cause analysis. Having received the results from the SE, the RM reports it to the authorities and copies in the SE, who then makes a recommendation of how to solve the problem and passes it to engineering for action. However, the result comes back to the RM for effectiveness analysis. Not only inefficient but different data is held separately.

Part of the reason for this complexity is that two separate tools were being used - one for Reliability Managers called Fleet Performance, with six airlines using it, and one for troubleshooters and engineers called Event Analytics, with 15 airlines and 2,500 aircraft.

To overcome these problems, the latest AVIATAR module, Reliability Solutions, was launched in April and not only merges these two tools but adds much more functionality. It currently covers Airbus and Boeing aircraft, along with some Key Performance Indicators (KPIs) of

Embraer and Bombardier types.

The first available application within Reliability Solutions is the Engineering Analytics Suite. More applications will be available this year, including reporting and case management for investigations and, like the first, are being developed jointly with partners and customers.

With the Engineering Analytics Suite, customised dashboards increase collaboration between user groups like Technical Fleet Managers, Reliability Managers, System Engineers, Maintenance Control Centre experts and troubleshooters. These can be easily adapted by adding alert and target levels, comments and changing the chart size as well as appearance. This is designed to promote dialogue on performance indicators and to empower users to collaborate and dive deeply into the data when required.

Aircraft messages and maintenance and engineering data are now collected and analysed using AI technology for natural language programming, which makes it possible to extract the technical aspects of a report while, if it is a new

Electronic Logbook information from AMOS or AVIATAR contains more data such as fuel uplift or the use of deicing.

(Copyright: Lufthansa Technik/ Christof Haake)

"In the Lufthansa Group, an important feature is the possibility to compare data between the different airlines - Lufthansa, SWISS, Austrian Airlines and Brussels Airlines."

Christian Haas, Lufthansa Group Process Architect Engineering

case, establishing a record for future reference. This is important as the outcome of the case will be flagged up if a similar problem arises in the future, providing direction to technical staff. Much of this uses AMOS, as it is really the single-point-of-truth. When the problem is solved, that data entry is available to everyone immediately. However, there is access to much more data than before, that can be brought in to solve a problem. For instance, Electronic Logbook information from AMOS or AVIATAR contains more data such as fuel uplift or the use of deicing.

The system can produce customised Reliability and Engineering dashboards, as well as introducing rules and automatic alert levels created by algorithms

developed through machine learning. This could be as simple as flagging up a missed Service Bulletin. If it produces a delay alert that is ignored, it is simple to see if the delay happened. Or, if the instruction is followed, perhaps for a temperature rise, then it is simple to see if the component change was effective and the temperature subsequently decreased. This can be done for a single aircraft or across the fleet. If there is a component exchange, there will also be workshop reports from Lufthansa Technik showing exactly what work was done.

Christian Haas, Lufthansa Group Process Architect Engineering, says the project started in 2018, with a request from the Technical Fleet Management to create a group overview of the

If a component like an APU shows a rise in temperature, it is simple to check if it drops again after a component exchange.

(Copyright: Lufthansa Technik/ Matthias Liebich)

The rest of the AVIATAR jigsaw

Reliability Solutions is just one of five solutions in AVIATAR. The others are Condition Monitoring, MRO Management, Predictive Health Analytics and Technical Logbook.

Condition Monitoring gathers data from various sources, including aircraft in flight, and displays it on a single screen or mobile device. It also provides flight schedules and ground time event information for each aircraft, including an annotation tool for notes and comments and an automated link to the Troubleshooting Manual and the Fault Isolation Manual.

MRO Management provides a complete overview of all maintenance activities for the whole fleet. There are three sub-modules:

- Monitoring includes an Event Dashboard which displays the most relevant KPIs, such as turnaround time, job card completion and milestone achievements to monitor the progress of items in work and spot problems. It is also possible to hold live video conference calls with customers during table inspections of components waiting to be repaired and to exchange files with them, avoiding travel.
- Sourcing is for all part and tool demands, bringing supplier and customer together. Searches can be made for part numbers, descriptions and alternative materials and filtered for certificates, condition or location. Quotations can be requested directly through the application.
- Accounting provides a complete overview of open invoices and finance related documents. Invoice copies, supplemental documentation and an automatically updated Excel overview can be downloaded directly.

Predictive Health Analytics combines engineering and data science to build use cases. With live data from the aircraft, behaviour of systems and components can be predicted during operation. It is customised to the specific needs of each airline customer to lower the costs of maintenance and avoid operational incidents, delays or AOGs.

The Technical Logbook offers prefilled text blocks and automated input masks that capture technical issues encountered during flight and on ground. It will work with any tablet, smartphone or desktop computer and provides pilots with access to aircraft status anywhere and anytime. Direct connection with AMOS or similar systems ensures maintenance is ready at the gate with the correct solution, reducing turnaround times and costs by up to 75%. The standardised data structure helps with trend analytics.

Customised dashboards increase collaboration between user groups like Technical Fleet Managers, Reliability Managers, System Engineers, Maintenance Control Centre experts and troubleshooters.
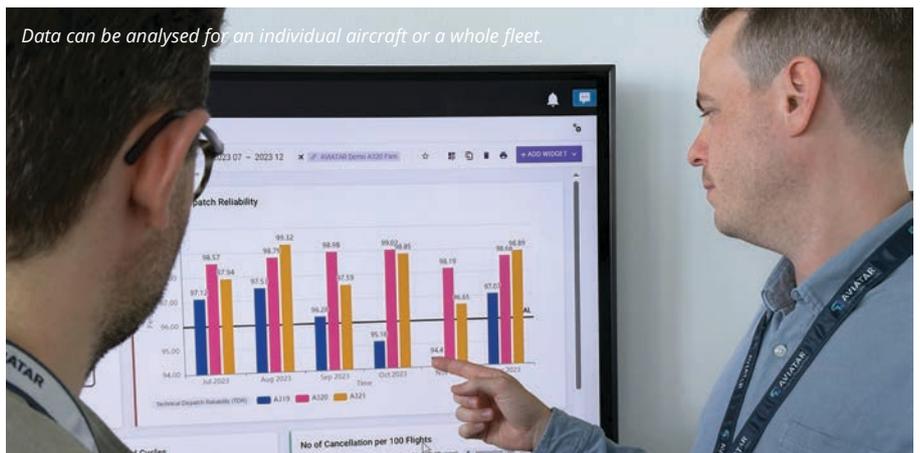
Data can be analysed for an individual aircraft or a whole fleet.

most important KPIs. This led to the joint development of Reliability Management on AVIATAR. As there were still some limitations there was a desire to replace the Weekly Report with an AVIATAR Dashboard, the app was developed further under the name Fleet Performance.

The biggest changes came with the decision to combine Fleet Performance and Event Analytics in the Engineering Analytics Suite. With this step, multiple new features have been introduced and are still on the roadmap, allowing the Monthly Reliability Report (authority report) to be replaced by another AVIATAR dashboard. Later this year, we hope to roll out the engineering investigations as well to have everything in one place.

He adds that, in the Lufthansa Group, an important feature is the possibility to compare data between the different airlines - Lufthansa, SWISS, Austrian Airlines and Brussels Airlines.

Graesch points out that, while workshop reports are available and the workshops use predictive data to help them, Reliability Solutions is currently configured to monitor

whole fleet. While bringing it down to component level could be possible, it will be a significant challenge due to the multiple layers of complexity that would be introduced - which defects, on what serial number, where was it worked on (airlines often use several repair shops), how is it acting? He says the research is ongoing.

Swiss-AS
As an example of collaboration between the Digital Ecosystem partners of Lufthansa Technik, late May saw Lufthansa Technik sign a five-year extension to its contract with Saudi Arabian low cost airline flyadeal for Aircraft Engineering Services. However, a new element was introduced with AMOS Airline

Edition software that will be hosted on AMOScloud, both from Swiss-AS. This is part of the airline's digital transformation to support a fleet of around 30 Airbus A320ceo/neo.

Aircraft Engineering Services will continue to deliver solutions such as maintenance programs and life-time status tracking but will also use AMOS for digital CAMO support. Meanwhile, flyadeal will use AMOS as a central hub for managing maintenance operations, including efficiency optimisation, ensuring regulatory compliance, an improving maintenance practices and in-depth reliability analysis of the entire fleet.

By Ian Harbison

There has already been a shift in acceptance by aviation authorities around the world. As momentum gathers, this will make it increasingly easier for airlines to introduce an ETL. (Copyright: NVable/ Christopher Wallace)

A Better Data Trail

Whether it's an electronic logbook or electronic tech log, the aviation industry agrees that these solutions are the future of avionics. Alex Preston looks at the motives behind this consensus.

The path towards the digitalisation of the cockpit is well-trodden. Collaboration between air and ground operatives has grown thanks to the greater affordability of intelligent solutions and the development of a connected ecosystem involving apps, services and documents.

As Reuben Mann, Director of Marketing at TrustFlight exhorts, "As technology develops, airlines must leverage these innovations to drive operational efficiency. It's an extremely competitive marketplace, and airlines need to develop competitive advantages to ensure they are performing better than their peers."

One area where this is at play, is with Electronic Logbooks (ETLs).

"In different regions of the world, different terminology may be used to describe the same thing," he says. "For example, in North America, we find Electronic Logbook (ELB) the dominant term. However, in the rest of the world, Electronic Tech Log (ETL) may be used to describe the solution. Both terms can be used interchangeably."

As Cameron Hood, CEO of NVable notes, "it is perfectly possible for solutions marketed as an ETL to fulfil the role of both ETL and ELB."

Such solutions cut across multiple disciplines and must meet best practices at every stage as Kessy Frech, Senior Lead Manager at SWISS-AS explains.

"There are three types of logbook on and around an aircraft," she says. "The electronic technical logbook is used to record and document the airworthiness status of the aircraft. Its main functions are maintenance tasks (defect handling) and releasing the aircraft into service. The electronic logbook, on the other hand, records all data relating to the aircraft in operation and is intended to be used in the cockpit by pilots to record events affecting the usual operation of the aircraft. Finally, the third logbook focuses on cabin requirements. The cabin logbook contains a layout of the aircraft to make it easier to locate any defective components. It is important that these three electronic logbooks are in constant communication with each other to ensure the smooth and timely handling of all operational aircraft requirements."

Whether electronic or paper, a copy of the ETL sector must be left on the ground prior to aircraft departure.

According to Frech, implementing an ETL solution is a game-changer. "Having operational requirements always documented, at your
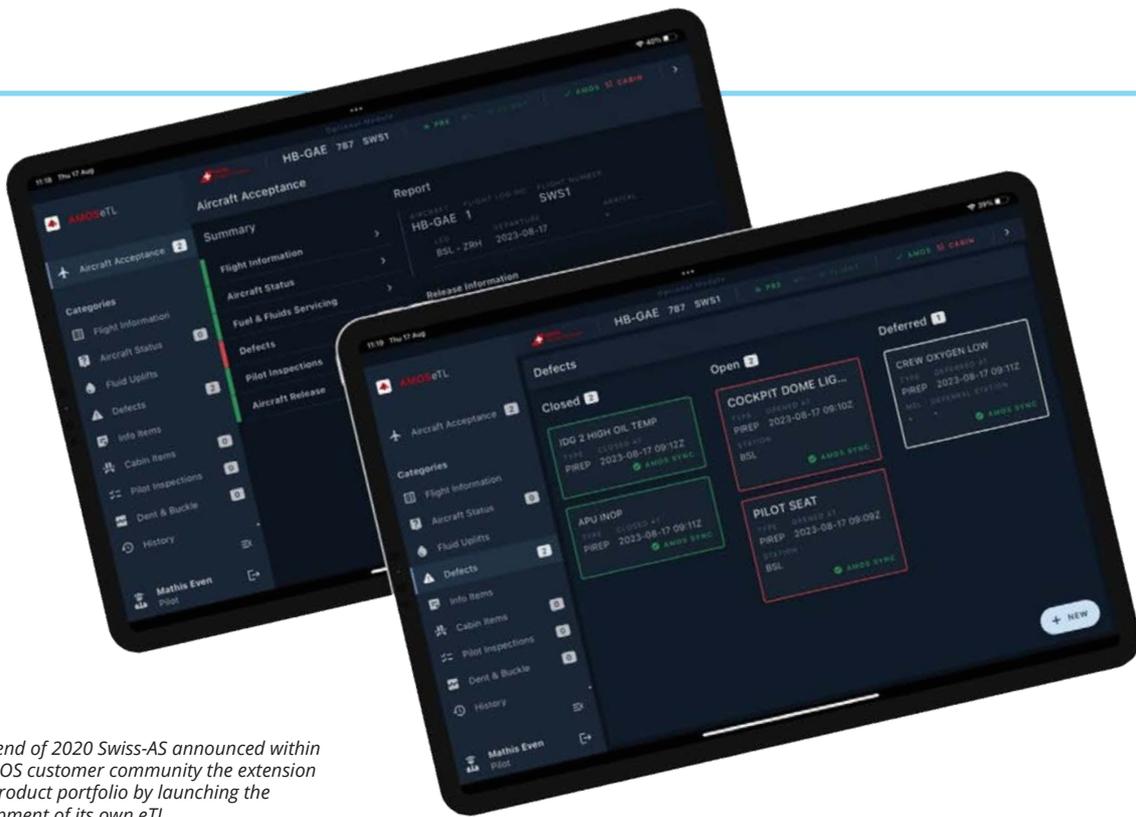
At the end of 2020 Swiss-AS announced within the AMOS customer community the extension of its product portfolio by launching the development of its own eTL. (Copyright: SWISS-AS)

fingertips, and using the automated system to evaluate suggestions improves the process by eliminating document loss, reducing the risk of communication errors and enabling smoother transmission of operationally essential elements."

Hood agrees. "Once an airline understands that they can easily view the real-time status of the entire fleet as well as explore the details of historic sectors and defects, they never want to return to using paper. It allows for general line planning efficiencies that were previously just

not possible.

"That, coupled with the fact that better quality data is being automatically fed into the maintenance planning system, is compelling."

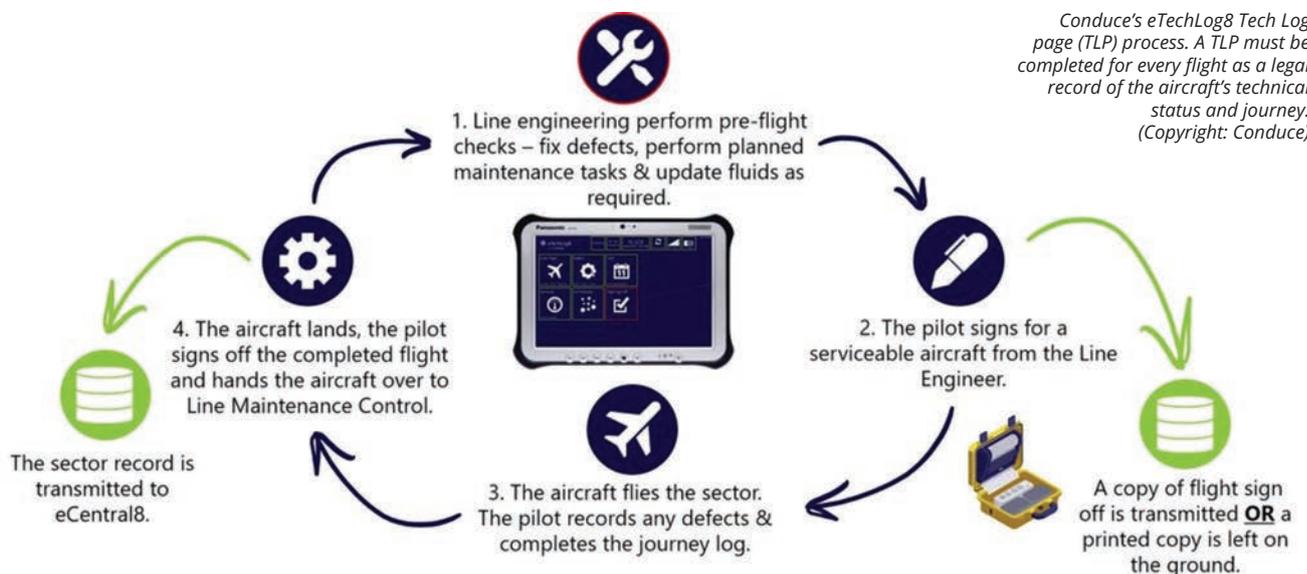Compelling maybe, but the adoption of ETLs by airlines has been slow in the past.

A cautious approach
Historically, there has been a reticence to commence an ETL project due to the levels of documentation and the regulatory approval complexities that are required to

deploy a fully approved ETL.

As Hood explains, the implementation of an ETL has to be agreed with the local aviation authority, and this will involve following an agreed plan, documenting the process, dual running and final acceptance. Additionally, introducing the ETL will require procedural change as part of the consultation with the aviation authority and will involve training for the airline pilots and engineers as well as potential training for third parties.

"ETLs are seen as difficult systems

Conduce's eTechLog8 Tech Log page (TLP) process. A TLP must be completed for every flight as a legal record of the aircraft's technical status and journey. (Copyright: Conduce)

1. Line engineering perform pre-flight checks – fix defects, perform planned maintenance tasks & update fluids as required.

2. The pilot signs for a serviceable aircraft from the Line Engineer.

A copy of flight sign off is transmitted **OR** a printed copy is left on the ground.

3. The aircraft flies the sector. The pilot records any defects & completes the journey log.

4. The aircraft lands, the pilot signs off the completed flight and hands the aircraft over to Line Maintenance Control.

The sector record is transmitted to eCentral8.

At the end of 2022, Jazeera Airways became the first airline in Kuwait to fully implement an ELB solution, eTechLog8, as the primary Tech Log system and remove the paper-based processes. (Copyright: Conduce)

to implement, as it involves both flight ops and tech ops team," notes Mann.

"I would not say that it is reticence but rather that it can be a large commitment for the airline," says Hood.

This includes defining requirements. "The technical log procedure is not something that receives a lot of focus generally," observes Hood. "Yes, it is important, but it is surprising how much misunderstanding can exist in airlines once details are discussed."

He believes this is exacerbated by the involvement of multiple departments. "Whilst the benefit of the ETL is primarily in the Maintenance, Maintenance Operation Control and Technical Records, it is the pilots and line engineers that actually complete the ETL. This adds complications in selection, implementation planning and acceptance."

Over the years, NVable has spoken with multiple airlines that have embarked on an ETL procurement process multiple times with a gap of two or three years in between. As Hood reveals, the company has also had customers where it takes a long time to finally implement a live solution because of engaging the local authority or any number of other factors.

Other factors include the perception by the airline that they do not have the bandwidth for such a project due to other operational challenges.

In these circumstances selecting the right supplier can play an important role.

Conduce for example provide a turnkey solution delivery model that provides full support along with everything that is required for a successful project, including hardware, software, cloud infrastructure, 4G/5G worldwide

data, 24/7/365 technical and helpdesk support – direct to flight crew and engineers as required. "This turnkey approach enables the project to be a focused engineering-led success within 6-to-12 months, instead of another never-ending airline IT project," says Boyd.

Those airlines who have been early adopters of ETLs been reaping **>**

TrustFlight's Tech Log can be used to better communicate aircraft status and get airworthiness issues resolved faster. (Copyright: TrustFlight)
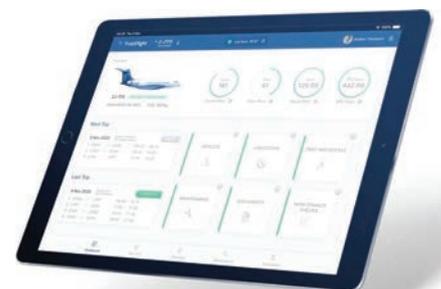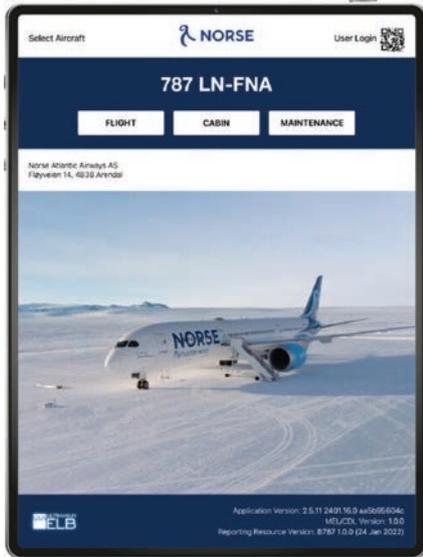
Top Ripht: Ultramain's ELB allows flight crews to record and transmit accurate write-ups in real-time as defects occur.
(Copyright: Ultramain)

Above: Norse Atlantic's flight crews will operate Ultramin's ELB iOS version on iPads on their fleet of 15 Boeing 787 Dreamliners.
(Copyright: Ultramain)
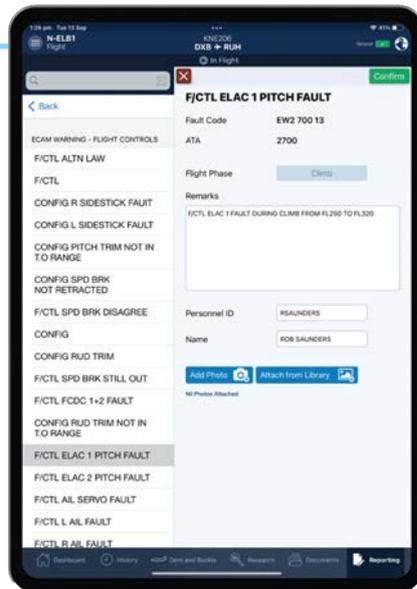
the benefits of improved safety and efficiency for much longer and have been slowly building up a competitive advantage by ensuring more streamlined data flows, a reduction in errors, and a reduction in labour resources required to complete the same tasks.

As Ultramain's Saunders expounds, as airlines who have successfully implemented such solutions talk about the benefits, that provides a better understanding for those who have been reluctant to move forward with an ELB project. "As they learn about the benefits our customers experience operating with Ultramain ELB, they are more open to pursuing a project they may have otherwise deemed as too risky," he says.

Boyd says that Conduce has seen significant growth in ETL deployment both during COVID and since, successfully implementing across some 30 AOC operators globally from a start point of less than 10 pre-COVID. "The take-up rate is increasing as more airlines see the benefits being achieved across the industry. Additionally, the approval process from the regulatory authorities is becoming increasingly understood allowing for speedier

projects," he states.

Frech agrees that ETLs are gaining momentum. "The potential is high, and the market is growing rapidly," she says. "There are more products on the market today than there were five years ago, and the situation is likely to continue to evolve over the next five years. The variety makes it difficult to choose, but on the other hand, with more solutions on the market, there's a better chance of finding the best fit. To increase the adoption rate, the industry must not only respond to operational needs in a genuine way, but also guarantee ease of use, adapted ergonomics and cutting-edge functionalities."

Protective measures
System security and data protection are the most significant issues when deploying an ETL.

eTechLog8 devices, for example, are 100% locked down to only run the required application.

This is accomplished by using a securely locked image installed on the dedicated device issued by Conduce with the relevant certification.

Boyd explains that no external connection to the internet is allowed from these devices outside of the locked down application. The back-office eCental8, is hosted on an internationally accredited cloud platform focussed on providing all required cybersecurity protections with the benefits of data georedundancy for disaster recovery insurance.

All data is encrypted both at

rest and in transit. In addition, Conduce are ISO 27001 certified, which ensures full compliance with internationally required data protection standards and practices.

Swiss-AS maintains ISO/IEC 27001 certification and undergoes annual independent audits, including SOC 1 and SOC 2 since 2024.

Frech says the company adheres to Secure Software Development Lifecycle (SDLC) policies and has implemented and maintains security measures throughout the software development lifecycle, which are validated by regular independent penetration testing.

For added security and access control, multi-factor authentication can be enabled within AMOSeTL.

The company has also implemented and maintains a threat and vulnerability management programme. Any new vulnerability is assessed, an action plan is defined and implemented, and finally the vulnerability is tracked until it is corrected.

Swiss-AS has implemented and maintains an incident management policy and procedures designed for the identification, response, remediation, recovery and reporting of information security incidents, including those involving personal data. "It is important to note that in the event of a cyber security incident, Swiss-AS has 24/7 access to a CERT team should specific technical assistance be required," Frech says, adding that the company also prioritises employee training and awareness of cyber security, with regular mandatory sessions, role-based training, and frequent security communications distributed to all employees to raise awareness and keep them up to date with security information, threats and news."

For its part Ultramain has been security hardened thereby blocking paths and methods for malware. Data is encrypted at rest and in transit. Says Saunders, "Our cloud offering provides Ultramain running on a well performing hardware stack that includes current cyber security protections that client devices

connect to via the internet. Our offering includes a redundant failover environment in a separate facility to reduce the risk associated with server failures or localised internet outages."

Ultramain also provides comprehensive access controls and management tools based on User Roles, that are easy to manage and powerful.

But what of the cutting-edge functionalities Frech speaks of?

Customer input

Saunders says that ETL enhancements and new features are driven by market demand and customer requirements. "There is an active user community providing direction to the development team. Current user group proposals include Advanced Dashboard, Repetitive Defect Monitoring, Repair Manager Integration, and eLine Checks," he reveals.

"Our annual R&D spend covers a broad spectrum of areas including improving the user experience, improved analytics and visualisation, advanced functional capabilities within existing products, development of new products, expansion of use of optimisation and AI, incorporation of new technologies, security improvements, and expanding the use profile on mobile devices. All have a focus on customer productivity improvement including ease of use," Saunders adds.

Hood believes there are interesting applications for machine learning and AI tools for the exploration and predictive fault analysis of the data collected in the ground servers.

"Whilst advancements such as natural speech processing and wearable technology (including glasses) are interesting, we feel the practical use in the aircraft environment is limited. These software technologies are emerging constantly, which will enable better data synchronisation and allow for different capabilities to be added to the solution"

NVAble has been working with a customer to enhance its iPad version of the Converge ETLB and this is expected to be in live operation

shortly. "We will continue to enhance this version to simplify the adoption process for our customers," says Hood who adds the company will continue to expand the ability for customers to control the ETLB configuration. "Our ultimate aim to allow airlines to define their ETLB themselves."

Also in the pipeline are improvements to the Crew Training Application and the introduction of Cabin Log Application - a separate application specifically for cabin crew and integrating with the ETLB.

"We are also improving the capability for concurrent devices participating in completing the ETL. More customers have been requesting the ability for pilots and engineers to be able to complete the ETL from different devices.

"However, our main driver will continue to be listening and responding to customer requirements," Hood declares.

Conduce also works with customers to continually evolve the product. "New features and functionalities are being added regularly and customers are encouraged to keep up a two-way dialogue regarding leveraging system usage," says Boyd.

Conduce has a significant number of projects on the roadmap particularly in companion application that sit alongside and enhance eTechLog8. These areas include enhancement to the eCabinLog8, primarily developed to track airworthiness defects. Further enhancement will focus on overall cabin quality, providing cabin services with accurate and timely data to ensure the highest levels of customer satisfaction.

The initial release of the new Structural Defect Reporting module has been released in early 2024 and will be further developed over the coming period, Boyd confirms. Planned Maintenance, currently
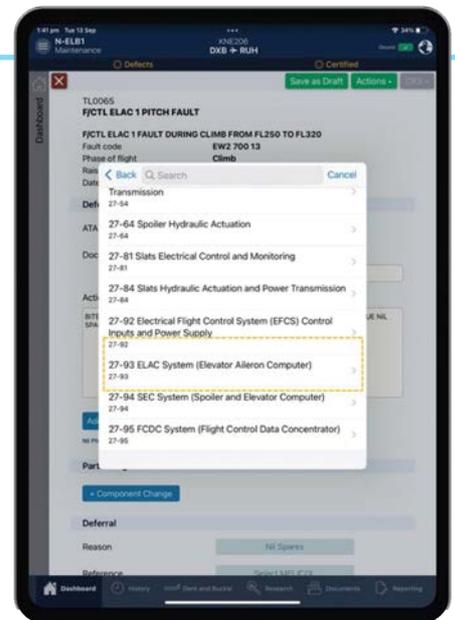
under test development, will be available soon. This module allows for the creation of Maintenance Tasks (work packs) by Maintenance Planning which will be deployed to the eTechLog8 tablet device for completion by the line engineers.

The other significant advance over the coming period will be greater, and tighter, integration with other airlines systems. "The aviation software solution market is seeing a significant increase in "best of breed" applications coming to the market that make use of secure API's allowing for easier integration. This will be of significant benefit to the airlines as they generally have many disparate systems with data siloed across its organisation. Conduce takes a very open approach to integration, with an inbuilt proprietary integration later, seeing this as a significant benefit when looking at the business case for projects such as ETL," express Boyd.

"Functional developments are always ongoing, and to an extent iterative, however Conduce is also always looking toward the future technologies as they become available. So much of what happens may not always be visible to the end-user," Boyd says.

Like AMOS, AMOSeTL is a community product whose development includes funding, expertise and active feedback from AMOS customers. Swiss-AS believes that a common definition of scope and validation review is a very effective

SWISS-AS' Electronic technical logbook for the cockpit, keeps pilots always up to date on all aircraft related items, enabling them to perform a handshake at the start of operations by 'Accepting the aircraft' after the routine health checks and precautions. (Copyright: SWISS-AS)

approach to delivering a mature and functionally advanced product.

"We have worked closely with customers to define the scope of the product, as we have done previously in the development of various AMOS functions," explains Frech. "This tradition has been extended and enhanced for the AMOSeTL project, which involves gathering requirements from cockpit crew, cabin crew and maintenance personnel. Together, we determined the scope and features of the future product, and customers were actively involved in the functional validation process."

The road ahead
Frech says the Swiss-AS team has many ideas to implement into its AMOSeTL, such as the extension of the helicopter's mission-critical configuration, the pre-flight briefing mode, the possibility for crew members to bring their own device and connect to the aircraft in service, integration of EFB and other third-party providers, predictive actions for pilot and maintenance mode, single sign-on, mobile dashboard application for MCC and many other features. "Stay tuned!" she advises.

Looking ahead, Mann says the most important aspect of ETLs will be their ability to integrate with other software platforms. "With competitor applications that are developed by M&E software providers, there is a tendency to develop closed-architecture systems to force users to adopt another module, or system

within their ecosystem. TrustFlight's philosophy is open architecture. We remain agnostic to all M&E systems, thereby ensuring complete integration with any set of solutions an airline has adopted. So, if an airline decides to switch an M&E system, they can continue to use our system without having to retain their pilots. This is a key focus for airlines because re-training employees on the use of a system is an added complexity and cost that can disrupt operations."

Another trend Mann identifies is connectivity. If there is inflight connectivity, then pilots and maintenance teams can have real-time access to information, even when the aircraft is in the air. This level of transparency is extremely important to operators that seek to turnover aircraft quickly for the next leg of their flight, Mann states.

At Conduce, considerations are currently being given to ML and AI technologies that could be utilised across the airline datasets that could then more proactively assist the crew and line engineers in areas such as defect raising and rectification activities. "Next generation ETL's are likely to include the adoption of AR Glasses for the line engineers," believes Boyd. "This would enable them to be diagnosing an aircraft fault and having direct access to AMM's / IPC's etc in a "hands-free" manner. The nature of being on the ramp under an aircraft, in often harsh environments, will of course be consideration as to how efficiently

these technologies can be adopted."

"We believe there are a lot of benefits in increased integration between the ETL, the aircraft maintenance database and maintenance systems to have a holistic offering for airlines," Hood states. "Preventative Maintenance" is one example where data from the aircraft Central Maintenance Computer Fault History Database can be collated and analysed to better understand the performance status of the aircraft to then better plan unscheduled maintenance, mitigating the risk of operational disruption to the airline's services.

The current NVable device is a "portable" (previously Class 1) unit which does not require an STC (Supplemental Type Certificate) for its use. "However, a portable device that has wireless connectivity to the aircraft would, in our view, provide the best benefits to the operator and manufacturer. This may or may not require an STC.

"The ETL feeds into the MRO's M&E system directly for Tech Records and Inventory Control; however, it is not universally accepted for the M&E system to feed into the ETL, and this is something Converge is already capable of, and greater use of this technology would only further enhance the operator's control and compliance," he adds.

By Alex Preston

SunExpress is the launch customer for AMOSeTL. (Copyright: SWISS-AS)

Pushing the Envelope Again: Britain's Sixth Generation Tempest Fighter Jet

British aviation has a history of pushing the envelope, as proven by legendary aircraft such as the Spitfire, the Concorde jetliner, and the Harrier VTOL jump jet.

Now Britain's BAE Systems and its partners are hoping to make history again with the Tempest, the country's proposed sixth generation jet fighter. If all goes to plan, the Tempest will enter service in 2035. It is being designed to match and/or exceed the capabilities of the US F-22 in terms of speed, range, ceiling, and stealth.

According to BAE Systems, the flying demonstrator now under development is the first UK crewed combat aircraft to be designed and built in 40 years. This piloted demonstrator will be a supersonic testbed for the Tempest's many innovative technologies, put together by BAE Systems (lead integrator), Rolls-Royce (engines), and MBDA UK (missiles), with the UK Ministry of Defence.

As well, Tempest is the UK name for the aircraft being developed under the Global Combat Air Programme (GCAP), where this aircraft will serve as the core platform in a new, sixth generation system-of-systems. "We're working with Italy (Leonardo S.p.A.) and Japan (Mitsubishi Heavy Industries) under the GCAP to design and develop this next generation aircraft," said John Stocker, BAE Systems' Business Development Director for Future Combat Air System. According to the Financial Times newspaper, "GCAP is one of the most ambitious military programmes ever attempted."

The UK industrial contribution to develop Tempest is being managed under the 'Team Tempest' banner, bringing together the UK's sovereign combat air partners. This involves Leonardo UK handling the sensors/communications systems and integration. "What we are working on, with our partners in Italy and Japan, is a set of products under the umbrella of an integrated sensing and non-kinetic effecting system (ISANKE) and an integrated communication system (ICS) designed to deliver sixth generation capability and operational advantage

A concept shot of the Tempest in a hangar. (Copyright: Leonardo UK)

to the user," said Jonathan Smith, Leonardo UK's VP Capability and CTO, Future Combat Air (GCAP). "We will then link all those things together."

Collectively, Team Tempest is working with the UK Ministry of Defence with the goal of delivering the Tempest in half the time and at significantly lower cost than previous combat air programs like the one that created the Typhoon jet fighter.

Why the Tempest?

The roots of the Tempest project can be traced back to 2018, when the UK government unveiled its 'Combat Air Strategy'. According to the Strategy's Executive Summary, "The Combat Air

sector delivers UK jobs, UK design, UK innovation and UK sovereign capability by taking an innovative and international approach. This Strategy lays out a vision for how the UK will remain at the forefront in this critical sector as we leave the EU; ensuring we can continue to make a pivotal contribution to European and global security."

BAE Systems, Leonardo UK, Rolls Royce and MBDA collectively formed 'Team Tempest' to meet the challenges identified in the Combat Air Strategy's "longer term capability requirement, that is driven primarily by what we describe as the '2040-plus threat environments," said Stocker.

"It fundamentally comes down to a principle of needing to retain 'control of the air', as we refer to it, because of the importance of control of the air to multi-domain operations and the UK's ability to deliver military effects in a whole range of different scenarios."

In designing the Tempest to meet these needs, BAE Systems is aiming to provide Britain with freedom of action, freedom of modification, and freedom of export for its domestically-built sixth generation fighter. These freedoms are not guaranteed when the country uses aircraft built elsewhere like the F-35. And although Lockheed Martin has been careful to spread contracts and jobs for this aircraft across its non-U.S. partners, there is no doubt that building its own fighter gives Britain an edge in earning profits and creating jobs at home.

Details to Date

For security reasons, BAE Systems is not releasing many details about the Tempest's design and capabilities. Nevertheless, some details have been released, while others can be deduced. As well, the RAF's website at raf.mod.uk has a section dedicated to Team Tempest (www.raf.mod.uk/what-we-do/team-tempest/the-tech/), which we will cite in this article and credit to the RAF.

Like the F-35 and F-22, the supersonic Tempest is designed to be a stealthy aircraft. Based on what information has been released, it is intended to fulfill missions such as air superiority, ground attack, and intelligence/surveillance/reconnaissance (ISR). This is why the Tempest will be built using a modular airframe, one that supports fast upgrades and new technologies as they emerge in the future.

"A key attribute of this future combat air capability is designing it so that it can evolve through its lifespan," said Duncan McCrory, Leonardo UK's Chief Engineer of Future Combat Air. "Having an architecture which is designed so that there are software-defined capabilities that enable us to that it

Tempest concept, showing flying over white cliffs of Dover, UK.
(Copyright: BAE Systems)

will remain relevant, and it can be updated rapidly in response to new and unforeseen threats."

To make this possible, "Tempest will bring a 'plug and play' approach, where software and hardware can be easily changed in and out depending on the capability and functions needed for a mission," said the RAF website (RAF). "That could be different kinds of weapons, sensors, or fuel tanks. This innovation removes the usual rigid structures of assembly and will make manufacturing more cost effective and flexible than before."

To maintain a stealthy profile, the Tempest will have an internal weapons bay. Its weapons suite could include directed energy (laser) and AI-guided weapons, plus hypersonic missiles. As well, "Operators will be able to carry different payloads, such as fuel tanks and camera pods, to adapt Tempest to a wide range of combat and surveillance roles," the RAF said.

Speaking of weapons, "Tempest needs to support existing weapons, planned weapons, and the weapons of the future," said the RAF. "For instance, the next generation Beyond Visual Range Air-to-Air Missile Meteor and the network enabled precision surface attack missiles of the SPEAR family of weapons, will be optimised

for Tempest. Effectors will be used to protect Tempest by helping to assess and evaluate incoming threats, and then in managing the deployment of the appropriate method to defeat it. We're also working to make effectors part of Tempest's sensor network, to further enhance the information available to pilots and operators."

The Tempest will also be designed to support electronic warfare (EW) and to resist EW attacks against itself, as well as being cyber-secure. "I think there's recognition that in both the current and the future operational environment, EW and Cyber are definitely threats that we need to be cognizant of, and they cannot be addressed in isolation," McCrory said. "This is why, within Leonardo UK, there is a significant EW and Cyber resilience effort. We have experts in the EW and Cyber domain who are working to ensure that the architectures that we're developing, the standards we're employing and the principles that we are bringing into the system design, will deliver a robust system that can be quickly adapted as the EW and Cyber threats evolve through the life of the program. And we're not doing that in isolation, we're working closely with our Team Tempest partners because the entire aircraft needs to be resilient to these threats."

Engine performance is central to any aircraft's success in combat (or failure). Although Team Tempest has not released details of this aircraft's jet engines, the RAF website said that "Tempest needs a range of high-density power and propulsion systems to be world beating. To achieve this, we are developing advanced composite materials and additive manufacturing to produce lightweight, power dense configurations capable of operating at higher temperatures."

"We're also developing world-leading electrical generation technology and intelligent integrated power management to power Tempest's advanced sensors and effects, particularly those which are laser-based," the RAF continued. "This integrated power approach reduces the number of energy exchanges, maximising the potential of the gas-turbine as the primary power source."

The Tempest's control systems will use AI to reduce the workload on the pilot, managing the Tempest's operations based on real-time sensor data so that its human operator can focus on decision-making and situational awareness. "The human brain is a hugely impressive thing, but it can only deal so much, especially in potentially stressful situations,"

Stocker observed. "AI will be part of a suite of technologies that will support the operator in effectively discharging their core responsibility as battlespace manager, to make the right decisions at the right time." This includes harnessing data from the fused situational awareness picture provided by the ISANKE system.

In a major shift, the functions normally shown on cockpit displays will instead be projected onto the pilot's helmet-mounted display, using augmented reality (AR) to show them without interfering with their view of the outside world. This AR-enabled control system will result in a physically blank cockpit, except for a joystick controller on the right side.

"We're working towards our concept of cockpits without a single physical dial or screen," said the RAF. "Other pilot support concepts such as virtual assistants are also being developed and tested."

The AR system will be pilot-configurable, allowing them to 'see through the floor' if they so choose to improve situational awareness.

The use of AI to analyse and assess the situational awareness picture from ISANKE, as well as to fly the aircraft and make real-time tactical decisions, will give Tempest pilots a profound advantage in the aerial battlespace. Thanks to these aids, "The Tempest operator will be able to think and act two to three steps ahead of their adversary because of the advanced and highly integrated sensors, non-kinetic effects, and communications systems," the RAF said. "All of these systems will be highly integrated, and designed to work seamlessly together, unlike current fighter jets that tend to be separate pieces of equipment, such as separate radar and electro-optics. Operators will be able to make decisions with more confidence because they are not relying on single sensors. Instead, multiple types of sensors will work in concert to gather information, which is automatically cross-checked and cross-referenced by the Tempest system. [As well] The Tempest will constantly mine and coordinate data from multiple sources, such as other aircraft, to provide extremely reliable and usable information that can in turn be shared with other aircraft in a 'combat cloud'."

"Essentially we're trying to provide an operational advantage to the user to enable them to make decisions faster, to make more effective decisions and to give them the confidence in the decisions that they're making based upon the depth

Tempest concept, shown flying over London skyline. (Copyright: BAE Systems)

> ## "We see this aircraft as having a service life of many, many decades,"
>
> **John Stocker, BAE Systems' Business Development Director for Future Combat Air System**

and the breadth of information that is being received and is being processed," said Smith. "Looking at that operational advantage, we're trying to make a pilot's job easier, to make sure that we can load more mission tasking onto that pilot. We're looking at enabling a pilot to perform multiple roles simultaneously that would normally have to be taken care of by multiple platforms."

As for integration of the Tempest into the RAF's mission management system? "We're contributing to the PYRAMID Open Mission System and exploiting technologies developed in the Ground Based Air Defence command and control domain," the RAF website said. "This will enhance the operational effectiveness of Tempest in Air-to-Air engagements." (According to the British government's GOV.UK website, "The UK MOD [Ministry of Defence] has developed a reusable and open avionics system reference architecture, applicable for both legacy and future air platforms. Known as PYRAMID, this approach will make upgrades more rapid and reduce software maintenance costs.")

The Big Picture

Taken as a whole, the sixth generation Tempest represents a quantum leap in the design and deployment of fighter aircraft. At the same time, the label 'sixth generation' does attach a great deal of expectations and assumptions to the aircraft as a physical entity. This is why BAE Systems prefers the name 'next generation' rather than

"A key attribute of this future combat air capability is designing it so that it can evolve through its lifespan"

Duncan McCrory, Leonardo UK's Chief Engineer of Future Combat Air

'sixth generation'.

"We tend to talk about 'next generation' rather than assign numbers to things because the Tempest's capabilities will be constantly evolving," said Stocker. "We see this aircraft as having a service life of many, many decades and one that will be continually changing in terms of additive capability that will be through software rather than physical hardware changes."

This notion of additive capability explains why the Tempest is being designed to be flexible and modular. With so much of modern warfare moving into the EW and cyber domain, the fighter aircraft of tomorrow must be able to adapt to seismic shifts in digitally-enabled strategies and technologies - many of which have likely not been imagined yet.

A case in point: The growing versatility and usefulness of drones - as shown in the Ukrainian war -is a trend that the Tempest's designers are taking into consideration. "While the core crewed core platform of the

Boeing 757 Excalibur Flight Test Aircraft (FTA). This will be used to de-risk the Tempest - The Global Combat Air Programme (GCAP).
(Copyright: Leonardo UK)

Tempest is very important, how the aircraft works with uncrewed types of aircraft or potentially other types of assets in the air, land, or space domains also matter," Stocker said.

In being able to work well with other systems, the Tempest will be well-suited for 'multi-domain integrated operations', which is a NATO strategy for coordinating military activities across all operating domains and environments. "For the US, the UK and advanced allied military capable nations, that journey towards multi-domain integrated operations is a key objective to be able to deliver more effective capability across the whole force," said Stocker. "This next generation combat air capability, as provided by the Tempest, will be a critical node in all of that."

Make no mistake: Keeping pilots alive is vital to modern military success. It takes years to train new pilots, and many missions for these pilots to become battle-hardened and operationally wise. So anything that enhances their survivability is a positive step forward, particularly at a time when the world's militaries are having a tough time recruiting and retaining talent.

In the meantime, Team Tempest has more immediate concerns to manage, with delivering a demonstrator aircraft being just one of many.

"We are working to a 2035 in-service date for Tempest," Stocker said. [To achieve this] "We tend to bracket the opportunity and the challenge areas into three main groupings. One is around what we call Enterprise Agility, which really means how do we put the right kind of organisations in place and give them the right authorities, the right funding, and the right capability to be able to deliver the program in a really efficient way."

In parallel to this, Leonardo UK is working closely with 2Excel Aviation Ltd and the UK Defence Science and Technology Laboratory (DSTL) to deliver the 'Excalibur' Flight Test Aircraft (FTA). The Excalibur FTA is a derivative of a Boeing 757 aircraft, and it will be used as a 'flying laboratory' to de-risk and demonstrate the critical sensing and communications technologies for ISANKE and ICS.

The second grouping is "Manufacturing Technology"; what it will take to build the next generation Tempest in an efficient and affordable manner. To figure this out, "we're investing heavily in a whole range of different technologies such as model-based systems engineering, next generation manufacturing, and massive 3D printing, for want of a better term," Stocker noted. "And then the third area is Product Complexity: How do we understand which technologies are going to be most suitable to develop different types of capabilities and also how can we pull it in from other sectors?"

The bottom line: Designing, developing and building the sixth generation Tempest is likely the greatest challenge ever tackled by the British aerospace industry (in concert with its partners in Italy and Japan). This being said, UK aircraft designers do have a strong history of surmounting similar challenges in the past, as proven by the Spitfire, Concorde, and Harrier.

By James Careless

Reaching For Green

The new D328eco from Deutsche Aircraft will be powered by conventional Pratt & Whitney PW127 turboprops. Surely a greener alternative could have been found? Not for want of trying. Ian Harbison investigates.

The D328eco, says Riaan Myburgh, Chief Engineer (Strategic Technology) at Deutsche Aircraft, is a modernised version of the original Dornier 328, rolled out in October 1991. The Pratt & Whitney Canada PW119A engines have been replaced by more powerful PW127XT-S turboprops. This reflects a 2.2m fuselage extension taking capacity from 32 to 40 seats, with a larger tail assembly, while retaining good field performance, cruise speed and range.

It is aimed at the replacement market and new growing markets for aircraft under 50 seats. The Japan Aircraft Development Corporation's 2023–2042 Worldwide Market Forecast shows there is demand for 434 new turboprops in the 20-40 seat category and 441 in the 41-60 seat category, with interest worldwide but especially in Asia.

Of course, there was also the 328 JET but this was never an option for the D328eco, he adds, as smaller turbofans are typically less efficient for regional aircraft. Hence selection of the PW127XT-S.

But it does bring environmental benefits. It has an increased capacity low-pressure compressor and high efficiency, high-pressure compressor, combined with a new high-pressure turbine module for improved performance and durability and a more efficient power turbine module. This produces 3% lower specific fuel consumption compared to earlier PW127 models.

More importantly, it is planned to use Sustainable Aviation Fuel (SAF) produced by Power-to-Liquid (PtL) technology, which uses renewably generated electricity, water and CO_2 from the atmosphere to create a syngas from which SAF can be produced.

The company is also taking care of the environment by constructing the first 100% climate friendly aircraft Final Assembly Line at Leipzig/Halle Airport. This includes carbon-neutral energy source (solar panels), responsible material selection, an advanced building management system, a green roof, a water recapture system, battery-powered

The 328eco will good field performance, enabling it to operate from small airfields in remote regions or from downtown airports.

ground equipment, REACH compliant processes, limited use of hazardous substances and a comprehensive recycling campaign.

As for the other technologies, he explains that the ranking of value in the market changes with time. While reduced fuel consumption – and lower operating costs – has always been a key target for generation aircraft improvements, climate science changes this view to overall

D328ALPHA features electric engines and propellers mounted outboard of the existing engines.

energy consumption – including where and how that energy was created, transported and used.

For any OEM, it is a difficult balance between exploiting the current products and exploring these new technologies and markets – in many cases, these new technologies do not fit into well-polished organisational centres of excellence and often do not match the needs of existing clients and markets. The choice is

often framed as 'ignore the change', 'protect the current products', 'create something new' or 'let someone else lead and follow fast'. Deutsche Aircraft's approach, as integrator of propulsion systems, is that of the fast follower. The first generation of these new systems are important to test the market viability, build out the infrastructure and, in general, give customers first-hand experience on the new set of trade-offs they will need to accept.

Deutsche Aircraft, and Sierra Nevada Corporation have been working on the integration of hybrid engines for a number of years, both in the USA and in Germany. Four years ago, with financial support from the German Government, the programme centre shifted to Germany, leveraging local partners and engineering expertise. The original intent was to modify an existing Dornier 328 aircraft and replace both PW119 engines with hybridised General Electric CT7 engines. The turboshaft engine integration, even prior to hybridisation, proved not to be a

Deutsche Aircraft is working with DLR on the UpLift and 328ALPHA programmes, giving it valuable insights into next generation powerplant technology.

value adding exercise and the overall architecture was changed to purely focus on the electric propulsion elements: Megawatt class electric engines, inverters, high voltage power distribution and energy storage. Additionally, it became clear that significant challenges remained with the weight of existing batteries. While technically feasible, the payload reduction would be too large to offer a viable commercial product.

Deutsche Aircraft is also working with the Deutsches Zentrum für Luft- und Raumfahrt (DLR, German Aerospace Center) on the UpLift program. The DLR acquired a Dornier 328 and is converting it into an open innovation platform for decarbonizing aviation. DLR exhibited this aircraft with the support of Deutsche Aircraft at the recent ILA 2024 Berlin air show following a successful flight campaign near Oberpfaffenhofen (outside Munich,

the original Dornier 328 production site) testing 100% synthetic fuel with zero aromatics. As this is an open innovation platform, with DLR collecting the best ideas from industry and testing, its involvement means the company can keep a watching brief on new technology that might make sense.

For hydrogen, the D328ALPHA programme is funded by the Bundesministerium für Wirtschaft und Klimaschutz (BMWK, German Federal Ministry for Economic Affairs and Climate Protection) through its LuFo Klima Civil Aviation Research Programme. Building on the lessons learned from the hybrid engine programme, D328ALPHA includes extensive ground verification and testing of systems with the ultimate aim of flight demonstration. The technologies being matured are MW-class electric engines, power distribution systems, high-power fuel

cells, thermal management systems and liquid hydrogen tanks. Rather than replacing the PW119 engines, the new electric engines and propellers will be mounted outboard of the existing engines – a configuration that Deutsche Aircraft says is well suited for technology development and maturation. The programme targets Technology Readiness Levels of 4-6 (with 6 being a flight demonstration at relevant flight conditions and environment, the last step prior to commercialization).

So, the new D328eco will be powered by conventional turboprops but Deutsche Aerospace has close involvement with all the other powerplant technologies under development. When the breakthrough arrives, the company will be ready.

by Ian Harbison

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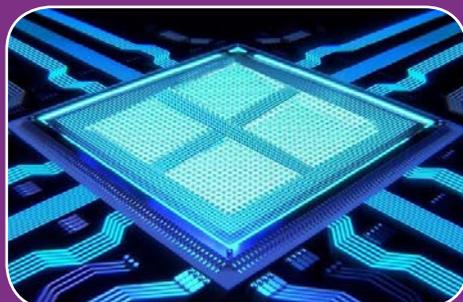
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