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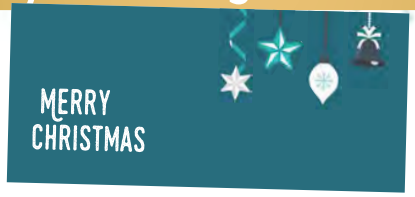

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From the Editor

ONE OF this month's big themes is Lockheed Martin's F-35 Lightning II fighter with an overview of the programme and the latest news from many of the countries now operating the stealth fighter.

Another big feature is devoted to Red Flag, America's premier air exercise with the latest insight into its evolution since the first edition was staged in November 1975, and the more recent big shifts to train in a multi-domain environment. Red Flag continues to lead the charge training combat air forces from around the world.

From the warmth of Cyprus, insight into how the Cyprus Air Force protects the Mediterranean island nation, a full overview of the Boeing KC-46 Pegasus tanker aircraft now in service with the US Air Force, but still snagged by problems.

Elsewhere in the world, we cover Japan and the Republic of Korea's plans to replace F-4 Phantom fighters, an overview of future airliners, the latest military flight training school in Italy, new Russian aerospace programmes, including the successor of the Antonov An-2, the theory and practice of aviation safety, and a look at Malaysia's fleet of F/A-18D Hornet fighters.

AIR International's January 2020 issue will include coverage of Boeing's 777X and will be on sale in the UK and around the globe from December 24.

Mark Ayton, Editor

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Headlines from the Dubai Airshow

The opening of the Dubai Airshow, the year's last major aerospace industry event, was relatively subdued. The major commercial announcements on the first day included Air Arabia ordering 120 A320neos and Emirates purchasing 50 Airbus A350-900s.

The Emirates deal amended a tentative agreement announced in February 2019 for 70 Airbus widebodies that was part of a restructuring of Emirates' backlog that involved the cancellation of 39 of its remaining A380 orders, a decision that prompted Airbus to axe the A380 as a current-production aircraft. The initial deal was for 40 A330neos and 30 A350-900s, but in the amended deal the A330neos are no longer part of the order.

Boeing announced an order from Biman Bangladesh for two more 787-9s. There were some regional aircraft purchases, with Palma Aviation Holdings ordering two De Havilland Aircraft of Canada Dash 8-400s and Air Peace ordering three Embraer E190-E2s.

On the technology side, Airbus announced what it describes as a, "demonstrator project inspired by biomimicry". The fello'fly initiative will test a concept of a jet flying in the wake vortex of a preceding aircraft, enabling the 'follower' aircraft to decrease engine thrust and reduce fuel consumption.

Boeing announced that a 787-9 it will deliver to Etihad Airways early in 2020 will serve as a flying laboratory to test procedures that could reduce fuel consumption and carbon emissions. The 'Greenliner', as the jet will be known, will operate in Etihad's network, but periodically serve as a testbed for assessing environmental sustainability initiatives, Boeing said.

Among other announcements, Embraer revealed the C-390 Millennium as the new designation and name of its KC-390 multimission aircraft. Russian Helicopters presented its VRT500 light single-engine helicopter and the VRT300, an unmanned variant of the design, overseas for the first time. This helicopter is a joint venture between Russian Helicopters subsidiary VR-Technologies and the Emirati company Tawazun. Mark Broadbent

Latest Norwegian NH90 delivery

NH90 NFH 358, the latest NH90 delivered to Norway, seen taking off from Maritime Air Station De Kooy in the Netherlands on September 30, where it made a weekend stop while on delivery from Leonardo Helicopters' facility in Tessera, Italy, to Bardufoss Air Station.

Although this is the 11th NH90 delivered, NH90 NFH 358 (c/n 1358, customer number NNWN13) is actually the 13th NH90 built for Norway, as the first two remain with NHIndustries for trials for the time being. Norway has ordered 14 NH90 NFHs eight for SAR and fisheries inspection used by the Kystvakt (Coast Guard) and operated by 337 Skvadron at Bardufoss Air Station. The remaining six were acquired for anti-submarine warfare by the navy, flown by 334 Skvadron from Bardufoss Air Station and Haakonsvern naval base. *Kees van der Mark*

Return of the MAX

The US Federal Aviation Administration (FAA) and other regulators continue work to certify software updates for the Boeing 737 MAX. The manufacturer said in November it is "possible" deliveries of the grounded jet could resume in December, but updated training requirements must be validated by the regulator before the aircraft resumes operation, and this process is not expected to be completed until January.

A multiday 'eCab' simulator evaluation to check the overall software system performs its intended function both normally and in the presence of system failures was completed in November, Boeing said.

The next steps are a multiday simulator session with airline pilots to assess human factors, including crew workload, before certification flights, delivery of materials to the FAA and finally a Joint Operational Evaluation Board (JOEB) Simulator Training Evaluation. The JOEB is described as, "a multi-regulatory body that will conduct a multiday simulator session with test pilots to validate training requirements".

The FAA issuing an Airworthiness Directive 'ungrounding' the aircraft and clearing a return to service is not expected until January 2020, Boeing said. Already, customers Southwest Airlines, American Airlines and United Airlines have all removed the 737 MAX from their schedules until March 2020.

Meanwhile, the Dubai Airshow saw a number of new commitments for the 737 MAX, from Air Astana (30 aircraft) and SunExpress (ten). Mark Broadbent

VSR700 prototype flies

The prototype Airbus Helicopters VSR700 performed its first flight at a test centre near Aix-en-Provence on November 8, 2019, performing several take-offs and landings in a secure flight test zone tethered to 98ft-long (30m) cables.

The VSR700 is in the 500–1,000kg (1,102–2,204lb) maximum take-off weight class of unmanned vertical take-off and landing systems. It is designed to carry multiple full-size naval sensors for extended periods and for operations from existing ships alongside a helicopter.

The VSR700 prototype, described by Airbus as a "fully fledged" unmanned aerial system, is a follow-on to an optionally piloted demonstrator first flown in 2017 based on a modified Guimbal Cabri G2 helicopter. The VSR700 has specialised avionics and an advanced flight control system, a payload bay and a sleeker, more aerodynamic shape.

The next steps in testing are free flight and opening the flight envelope. Airbus' target is to undertake trials with an operational demonstrator from a Marine Nationale (French Navy) vessel in 2021. Mark Broadbent

The Airbus VSR700 undertakes its tethered first flight in November 2019. *Airbus*

Lithuania to acquire Black Hawks

The Lithuanian Ministry of Defence announced on October 18, 2019, that it will begin negotiations with the US Government for the procurement of Sikorsky UH-60M Black Hawk battlefield airlift helicopters.

Six Black Hawks will replace Lithuania's ageing fleet of Mil Mi-8 helicopters and will be used by the Lithuanian Armed Forces, as well as supporting the NATO enhanced Forward Presence Battalion Group in the country. The helicopters will also provide a search and rescue (SAR) capability for the Lithuanian Government. Nigel Pittaway

Airbus' stealth research

Airbus' recently disclosed Low Observable UAV Testbed concept. *Airbus*

Airbus revealed recently it has been working in secret on a concept stealth unmanned combat aerial vehicle demonstrator for the German government. The Low Observable UAV Testbed (LOUT) was shown during a trade media briefing in November. The project remains highly secretive and limited details were provided.

A graphic in an Airbus presentation said LOUT development work began in 2007 in Manching and Bremen in what the company called a "Skunk Works approach". The German defence ministry awarded the company a contract in 2010 for a very low observable (VLO) ground testbed.

LOUT was developed to demonstrate, "wideband signature reduction technologies and [be] a testbed for further VLO integration". The presentation and accompanying images show the LOUT concept as having a distinctive diamond-shaped planform with a configuration intended to support "radar, infrared, visual and acoustic stealth".

Specific design aspects include an engine inlet with a low radar cross-section, an engine duct made of radar-absorbing materials, a diverterless inlet, a low-observable leading edge and an integrated flat nozzle design. The project has investigated various options for low-observable compatible thrust vector control and cooling structural parts.

The fuselage body and wing feature an "ultra-wideband leading-edge" and unspecified low-observable coatings including, "surface wave attenuation to decouple mutually spaced scattering effects" and optically transparent and electrically conducting transparencies.

Airbus said the project resulted in reduced radio frequency, acoustic and infrared signatures and "awareness of the own signature linked to the mission management system". The presentation said: "LOUT covers all aspects from simulation and development to production and measurement."

Mark Broadbent

Marineflieger's first NH90 Sea Lion

Airbus Helicopters announced on October 24, 2019, that it has delivered the first NHI NH90 Sea Lion naval multi-role helicopter to the German Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr (Equipment, information Technology and Information Support). A further two helicopters will be delivered before the end of 2019.

The German Marineflieger selected the NH90 Sea Lion to replace its Westland Sea King Mk41 helicopters in March 2013 and the acquisition contract was signed in June 2015.

The Navy has 18 Sea Lions on order, with deliveries expected to be completed by 2022. The helicopters will be used for land-based SAR operations, maritime reconnaissance and special forces support operations. They will also be embarked in the Bundesmarine's Berlin-class (Type 702) combat support ships.

The NH90 has also been selected by the Marineflieger to replace its fleet of 22 Westland Sea Lynx Mk88A embarked helicopters. The entire Marineflieger fleet of fixed and rotary-wing aircraft is based at Naval Air Station Nordholz. Nigel Pittaway

100 years of Flottille 11F

On September 27, Flottille 11F – the oldest fighter squadron within the French Aéronautique Navale (French Naval Aviation) – celebrated its 100th anniversary at Base d'Aéronautique Navale Landivisiau in Brittany, its home base since May 1967. The squadron applied centennial markings to the tails of five of its Rafale Ms (aircraft 10, 11, 32, 35 and 37) earlier this year. All five specially decorated 11F Rafale Ms sport the markings shown on the right side of the tail. *Kees van der Mark*

First Dutch KDC-10 retired from service

The Koninklijke Luchtmacht (KLu, Royal Netherlands Air Force) retired the first of its two KDC-10 tanker/transport aircraft on November 1, in anticipation of the arrival of the first two of eight Airbus A330 Multi-Role Tanker Transports for the Multinational MRTT Unit in the spring of 2020. KDC-10 T-264 'Prins Bernhard' of Eindhoven-based 334 Squadron flew its final aerial refuelling sortie in KLu service on October 28 over Poland. It departed to San Antonio Airport, Texas, on November 4, to undergo major overhaul before joining its new owner, US company Omega Aerial Refueling Services. Both KLu KDC-10 were recently sold to Omega. Since T-264 was up for a D check this year, the KLu decided to retire the aircraft early. Sister ship T-235 'Jan Scheffer' will soldier on until late 2021, when the first A330 MRTTs should be operational. *Kees van der Mark*

Freighter conversion for 777-300ER

The IAI 777-300ERSF is the first passenger-to-freighter conversion for the Boeing 777. *Israel Aerospace Industries*

Israel Aerospace Industries (IAI) has launched a Boeing 777-300ER freighter conversion option called the 777-300ERSF. Launch customer GE Capital Aviation Services (GECAS) has ordered 15 examples and 15 options, with the first conversion to be delivered to the lessor in 2022.

Although Boeing produces a new-build 777 Freighter based on the 777-200LR, IAI says the 777-300ER's greater length means the 777-300ERSF will have 47 standard-sized 96 x 125in (2.4 x 3.2m) pallet positions, ten more than the 777-200LRF.

The conversion involves the addition of a freighter lining and window plugs to the fuselage and a 9g rigid cargo barrier, and the deactivation of all passenger doors except the first pair.

The aircraft has modified environmental control system ducting, provision for powered and non-powered cargo loading, and a main deck temperature control system for the carriage of perishable goods and live animals.

There is a crew compartment with up to 11 supernumerary seats, a double bunk crew rest area, a wet galley with a chiller, a lavatory and an optional configuration for nine economy class seats.

IAI says the 777-300ERSF offers full commonality with the underfloor cargo configurations and the General Electric GE-115B turbofan engines on the 777-300ER, 777-200LRF and 777-200LR. There will be 90% spares and 95% ground support equipment commonality with the other aircraft, and no extra simulator training is required for flight crew.

The 777-300ERSF is the first Triple Seven aftermarket cargo conversion. It is being marketed as the Big Twin Freighter, a reference to the 'big twin' moniker often used in relation to the 777-300ER. IAI says the 777-300ERSF has 25% more volume than the 777-200LRF and will burn 21% less fuel per tonne than converted 747-400 freighters, the aircraft that historically dominated the larger-capacity segment of the freighter market.

The 777-300ER is one of the most successful widebody airliners ever, with 850 sold since launch. With older examples set to leave their initial operators over the next few years, there is a ready supply of aircraft for conversion.

The 777-300ERSF continues IAI's history of passenger to freighter conversion work on Boeings. It offers conversions for the 737, 747 and 767 and has converted more than 70 jets for GECAS over the last 20 years. Mark Broadbent

Flybe to become Virgin Connect

Flybe will be rebranded as Virgin Connect in 2020, it has been confirmed. A change of identity for Europe's largest regional airline was widely rumoured since the carrier's acquisition earlier in 2019 by Connect Airways, a consortium of Virgin Atlantic, Stobart Aviation and Cygnus Aviation.

A statement from Connect Airways saying, "We'll be saying goodbye to purple and hello to red", indicates an upcoming replacement for Flybe's current predominantly purple livery, which was only introduced in 2016.

Virgin Atlantic wants to boost connectivity from the regions to its services from Heathrow. The carrier initially tried to boost passenger feed at its hub through an Airbus A320-equipped subsidiary called Little Red.

This carrier operated UK domestic services using slots divested by British Airways' parent company International Airlines Group following the 2012 purchase of BMI. However, Little Red shut down in 2015 after two years of operations.

Virgin later signed a codeshare with Flybe to tap into the regional carrier's extensive network; it operates more than a third of UK domestic flights. Flybe recently announced its summer 2020 schedule starting next March will see it operate 104 routes with 2,500 weekly flights across its network, confirming its position as Europe's biggest regional player. Virgin's investment in Flybe via Connect Airways is part of this bigger picture of boosting passenger feed into Heathrow and the Virgin Connect rebrand is the next obvious step. Mark Broadbent

The purple on Flybe's aircraft will disappear when the carrier rebrands as Virgin Connect next year. *Flybe*

Superjet 100 with Sabrelets

Sabrelets are now offered as both line-fit and retrofit options on the Sukhoi Superjet 100. *Sukhoi Civil Aircraft Company*

The Sukhoi Civil Aircraft Company (SCAC) has completed flight testing of new composite Sabrelet wingtip devices developed for its Superjet 100-95B regional airliner. The winglets are manufactured by the United Aircraft Corporation company VASO and are offered as a line-fit option for new-build Superjets, as well as a retrofit for in-service examples.

Two SSJ-100s, 97006 (c/n 95032) and 97012 (c/n 95157), assessed the aircraft's stability and controllability with the Sabrelets at different speeds and angles of attack in more than 140 test flights. One aircraft, 97012, was fitted with attachments to its wing, stabiliser and vertical fin leading edges to simulate ice. The testing, carried out by SCAC with the assistance of the Central Aerohydrodynamic Institute at Zhukovsky, focused on fuel-burn calculations and achievable savings.

Russian Federation Minister for Industry and Trade Denis Manturov said the tests showed Sabrelets improve the SSJ100's take-off and landing performance and will reduce fuel burn by 4%. The manufacturer claims the devices will save up to RUB 10 million annually for each equipped aircraft. Sukhoi has received 295 firm orders for the type. Mark Broadbent

Rolls-Royce's latest flying testbed

Rolls-Royce is to introduce a second Boeing 747 to test the next generation of technologies for the company's commercial aircraft engines after acquiring ex-Qantas 747-434 VH-OJU (c/n 25566).

The aircraft was retired by Qantas in mid-October after flying more than 43 million miles (70 million km) during 20 years' service with the Australian airline. It was flown from Sydney to Los Angeles and then on to the AeroTEC facility at Moses Lake in Washington, where the aircraft will over the next two years undergo conversion from a 364-seat passenger airliner into a specialist testbed.

When the conversion is complete the aircraft will work alongside, although not replace, Rolls-Royce's existing flying testbed, 747-267B N787RR (c/n 21966), which the company says has now completed 285 test flights since starting its testbed role in 2007. Rolls-Royce employees will choose a name for the converted 747-400, which served its life with Qantas as Lord Howe Island.

Rolls-Royce says the 747-400 will be a "flying digital hub, analysing more flight test data than ever before". The company said the new instrumentation and systems will also obtain better data more quickly and take sophisticated measurements of engine performance in flight. Engines will be tested at higher altitudes and faster speeds. In an industry first, the 747 will be configured to test engines that power both commercial and business aircraft.

A CGI of the ex-Qantas Boeing 747-400 that will become Rolls-Royce's second flying testbed. *Rolls-Royce*

The 747-400 will support Rolls-Royce's IntelligentEngine vision that engines are 'smart' and, specifically, that connectivity means engines are aware of the environment, learn from their own experiences and adjust behaviour to achieve best performance.

Rolls-Royce is investing £56 million in acquiring and converting the 747-400. This is in addition to a £90 million investment in Testbed 80, described by the company as "the largest and most intelligent testbed in the world", which is under construction in Derby and set to be commissioned in 2020. Mark Broadbent

Manchester City Dreamliner

Etihad Airways Boeing 787-10 A6-BND (c/n 42373), delivered in October, wears a Manchester City livery marking the club's partnership with the airline and its ownership by Abu Dhabi. *Etihad Airways*

Air Canada A220

The first of 45 Airbus A220s for Air Canada recently rolled out of the paint shop in Mirabel. This A220-300, C-GROV (msn 55067), will enter service in December. *Airbus*

Star Wars 747

Virgin Atlantic recently repainted Boeing 747-443 G-VLIP (c/n 32338) into a special livery to promote a new Star Wars attraction at Disneyland. The aircraft has also been renamed 'The Falcon'. *Richard Vandervord*

IN NUMBERS

Airbus

AIRBUS

Customer	Aircraft	Number	Date
Air Austral	A220-300	3, purchase agreement	October 14
Aviation Capital Group	A320neo	8	October 31, announced November 7
Cebu Pacific	A330-900	16 (firms June 18, 2019 MOU)	November 4
China Airlines	A321neo	11	October 15, announced November 7
Czech Airlines	A220-300	4	October 23
	A321XLR	3 (converts March 30, 2016 order)	October 23
IndiGo	A320neo	300	October 29
JetSMART	A321neo	12	October 30, announced November 7
Spirit Airlines	A320neo	100 MOU	October 24
Tigerair Taiwan	A320neo	7	October 22, announced November 7
Undisclosed	A321neo	13	October 22, announced November 7
Vietjet	A321XLR	20 (five converted from existing A321neo order)	October 31

BOEING

Customer	Aircraft	Number	Date
Air Premia	787-9	5, purchase commitment	October 29
VIP customer	787-9		October 22

DE HAVILLAND

Customer	Aircraft	Number	Date
Tanzanian Government Flight Agency	DHC-8-400	1	October 19

Data covers orders announced October 8-November 12, 2019. Key: MOU – Memorandum of Understanding. Compiled by Mark Broadbent

100
JETS FOR SPIRIT

The Florida-based low-cost carrier Spirit Airlines has agreed a memorandum of understanding with Airbus for up to 100 A320neo Family aircraft comprising a mix of A319neo, A320neo and A321neo aircraft. Spirit Airlines said the additional aircraft will be used to support network expansion across the United States, Latin America and the Caribbean. Mark Broadbent

5
FIFTH C919

A fifth COMAC C919 flight test aircraft completed its first flight in late October. This latest jet, B-001F (c/n AC105), will mainly be used for extreme weather testing in both hot-and-high and cold conditions. It will also undertake environment control, electrical power and whole-aircraft drainage tests. COMAC said trials with four other flight test aircraft and static tests, "are in steady progress". A sixth C919 will fly by the end of 2019. Mark Broadbent

1
CLEARVISION-EQUIPPED ATR

Drukair is the latest carrier to introduce the ATR 42-600 aircraft equipped with the ClearVision to provide pilots with improved situational awareness. The aircraft's avionics include required navigation performance with authorisation required (RNP-AR) 0.3, which enables pilots to follow approach trajectories to within an accuracy of 0.3 mile (0.5km). This permits reduced minimums compared to conventional approaches. The Bhutan airline serves small airports in the Himalayas. Mark Broadbent

6
A321s FOR PLAY

Plans are advancing to launch a new Icelandic low-cost carrier called PLAY. The airline plans to launch with an initial fleet of six Airbus A321s and serve destinations across Europe and North America, with the fleet expanding to ten within three years. The start-up carrier has been set up by former WOW Air and Air Atlanta personnel. Mark Broadbent

IN BRIEF

United introduces CRJ550

The first Bombardier CRJ550 entered service with United Airlines on 15 regional routes out of its Chicago hub. Bombardier describes the CRJ550 as the first 50-seat airliner with three classes. It is a new CRJ Series model, with its type certificate based on the CRJ700. United has ordered 50 examples for routes to small cities with high numbers of business passengers. Each has ten business-class seats, 20 premium economy and 20 economy. Mark Broadbent

Czech Airbuses

Czech Airlines has amended its Airbus aircraft order. The carrier ordered seven A320neos in 2016, but in October cancelled four of those and upsized the three remaining orders to the A321XLR, the longest-range A321neo subvariant launched earlier this year. The carrier has also ordered four A220-300s. Mark Broadbent

Transpacific on the 787

American Airlines is to place Boeing 787s on more ultra-long-haul services across the Pacific next year. A three-times-weekly Los Angeles-Christchurch flight will start in October 2020 using 787-8s and a Dallas/Fort Worth–Auckland service will begin from an unspecified date with larger 787-9s. American already operates a seasonal LA–Auckland service. The carrier said the routes, "are a direct result of the recently approved joint business with Qantas". Mark Broadbent

Thomas Cook slots sold

All the take-off and landing slots owned by Thomas Cook at UK airports were purchased by other airlines in November. Slots at Gatwick and Bristol went to easyJet and those at Manchester, Birmingham and Stansted to Jet2. Thomas Cook's UK business and airline collapsed in September, prompting a huge repatriation effort.
Mark Broadbent

IAG buys Air Europa

The International Airlines Group (IAG) has agreed to acquire Air Europa through its Iberia unit. If approved, the deal will complete in the second half of 2020. IAG said it would strengthen its presence on routes to Latin America, the United States, the Caribbean and North Africa. The Air Europa brand will initially be retained.
Mark Broadbent

Low-cost from Abu Dhabi

Etihad Aviation Group and Air Arabia are to launch a low-cost carrier (LCC). Air Arabia Abu Dhabi will be an independent joint venture complementing Etihad's services. The new carrier will be based at Abu Dhabi. Sharjah-based Air Arabia is the largest LCC in the Middle East and North Africa. Low-cost operations are relatively under-developed in this market, with Air Arabia and Flydubai the main players in the segment. The JV is the first expansion by the Etihad Group since abandoning a previous strategy of acquiring stakes in smaller airlines. Mark Broadbent

X-37B lands after two years in orbit

The US Air Force's X-37B Orbital Test Vehicle Mission 5 pictured at NASA's Kennedy Space Center Shuttle Landing Facility on October 27, 2019. *Jeremy Webster/US Air Force*

The US Air Force's unmanned X-37B Orbital Test Vehicle (OTV) landed at NASA's Kennedy Space Center Shuttle Landing Facility on October 27 after a record-breaking stay in orbit of more than two years.

The X-37B OTV is an experimental test programme to demonstrate technologies for a reusable US Air Force unmanned space test platform. The X-37B OTV Mission 5 launched on September 7, 2017, from Cape Canaveral Air Force Station, Florida aboard a Space X Falcon 9 booster, so the mission broke the aircraft's own endurance record set on the previous mission from May 2015 to May 2017.

A US Air Force statement said X-37B OTV Mission 5, "conducted on-orbit experiments for 780 days". The aircraft has spent 2,865 days in orbit since its first mission in 2011. Details of its missions and payloads are classified, but the US Air Force says the system provides, "the performance and flexibility to improve technologies in a way that allows scientists and engineers to recover experiments tested in a long-duration space environment".

Managed by the US Air Force Rapid Capabilities Office, the X-37B OTV programme, "performs risk reduction, experimentation and concept of operations development for reusable space vehicle technologies". The US Air Force said the latest mission, "successfully hosted AFRL experiments, among others, as well as providing a ride for small satellites".

A statement said: "The distinctive ability to test new systems in space and return them to Earth is unique to the X-37B and enables the United States to more efficiently and effectively develop space capabilities necessary to maintain superiority in the space domain." A sixth X-37B mission will launch in 2020. Mark Broadbent

Improved ApusDuo

The second UAVOS ApusDuo variant has a 92ft (28m) wingspan. *UAVOS Inc*

Developer UAVOS Inc has test-flown an updated version of its ApusDuo solar-powered UAV. The second prototype has a wider wingspan of 92ft (28m), up from the first aircraft's 49ft (15m) wingspan. It will be able to carry a 17lb (8kg) payload.

The new version also has, the developer said, "improved control algorithms to reduce power consumption in horizontal flight". It features new energy converters for the solar panels mounted on the aircraft's wings for more efficient energy use in low and uneven lighting conditions.

The ApusDuo is designed to serve as a stratospheric telecommunications platform, providing video surveillance and monitoring, communications relay, jamming, radio link range extension and retransmission. UAVOS is currently working to secure permissions to perform stratospheric test flights.

A characteristic of the ApusDuo is an "extended aspect-ratio flexible wing" designed to adjust lift across the wing and distribute aerodynamic loads evenly to reduce weight and optimise control for long-duration flights. Mark Broadbent

VoloDrone for utility roles

German developer Volocopter has unveiled an unmanned multicopter called the VoloDrone for the logistics, agriculture, infrastructure and public service sectors. The fully electric system will be able to carry a 200kg (440lb) payload up to 25 miles (40km). It can be remotely piloted or flown in automated mode on pre-set routes, the manufacturer said.

The VoloDrone features a standardised payload rail attachment, with loads housed in the space between the landing gear. It can transport standard-sized palettes containing boxes and bottles, or heavier loads such as a sprayer or other customised equipment with a sling. In November the company announced a partnership with John Deere to demonstrate the VoloDrone's applicability as a crop sprayer. Demonstration flights will take place in the next growing season.

Volocopter said: "Use cases include transporting heavy packages to remote locations, protecting crops in agriculture, lifting voluminous parts on buildings on construction sites, and many more. Anywhere ground transportation means are challenged by difficult accessibility, the VoloDrone may help."

Volocopter, based at Oberpfaffenhofen near Munich, has developed the VoloDrone from its X2, a manned multirotor concept it is developing as an air taxi. Like the X2, the VoloDrone has a very distinctive configuration with 18 rotors; the rotor area is 9.2m (30ft) in diameter. Mark Broadbent

The VoloDrone is designed to offer a heavy-lift cargo capability. *Volocopter*

Upgraded Atlantique 2s

The Standard 6 upgrade now being rolled out through the Aéronautique Navale's ATL2 fleet is intended to maintain its relevance to at least 2030. *Dassault*

The first two Atlantique 2 (ATL2) aircraft modernised to Standard 6 configuration were delivered to the Aéronautique Navale at Lann-Bihoué Naval Air Station on October 29, 2019.

The ATL2 aircraft were upgraded to the new configuration by Dassault Aviation, which will modify a further five aircraft by the end of 2023. The remaining 11 aircraft will be upgraded in parallel by Service Industriel de l'Aéronautique (SIAé), the French Ministry of Defence Aeronautical Industrial Service.

The Standard 6 configuration features upgrades to the ATL2's combat systems, including a new Thales Search Master active electronically scanned array surveillance radar, Thales acoustic system, a navigation console from Dassault and new tactical display subsystems developed by SIAé.

Dassault is also responsible for integration of the core mission system, including Lot 11 software, developed by Naval Group.

The initial contract was awarded to Dassault by the Direction générale de l'armement (Directorate-General for Armaments) on October 4, 2013, covering 18 ATL2s in service with the Aéronautique Navale.

A Dassault spokesperson said: "The Standard 6 upgrade will improve the ATL2's capability to support the Force océanique stratégique (strategic ocean force), to deal with modern threats such as future nuclear or conventional submarines and naval forces at sea and to support air-land missions out to 2030."

In Aéronautique Navale service, the Atlantiques are based at Lann-Bihoué and fly with 21 and 23 Flotilles. Nigel Pittaway

Guardia di Finanza orders more ATR 72MPs

Italy's Guardia di Finanza law enforcement agency has ordered three additional Leonardo ATR 72MP aircraft, under a EUR 150 million deal announced on October 29, 2019.

The contract brings the service's order to four aircraft, following a contract for an initial example that was signed in July 2018. The first aircraft will be delivered by the end of 2019 and the additional three are expected to arrive before the end of 2022.

Leonardo's CEO Allessandro Profumo said: "We are proud that the Guardia di Finanza has chosen to rely once again on our ATR 72MP, an aircraft which fully represents Leonardo's technological capabilities in terms of design and integration of platforms and systems at the highest levels."

The four aircraft will be utilised by the agency for border protection, maritime surveillance and SAR missions.

Managing Director of Leonardo's Aircraft Division, Lucio Velerio Cioffi added: "The ATR 72MP combines reliability, low operating costs, all the advantages of the ATR 72-600 regional passenger transport aircraft, together with a state-of-the-art mission system."

The Italian Air Force already operates a maritime surveillance version of the popular ATR 72 airliner equipped with Leonardo's modular Airborne Tactical Observation and Surveillance mission system and known as the P-72A.

The GdF currently operates a fleet of four ATR 42-400MP and ATR 42-500MP aircraft, designated P-42A and P-42B respectively, with the Gruppo Esplorazione Aeromarittima, based at Pratica di Mare. Nigel Pittaway

Korean ISTAR platform

The Raytheon Company announced on October 15, 2019, that it will partner with Korean Air to develop a platform for the Republic of Korea Air Force's intelligence surveillance target acquisition and reconnaissance (ISTAR) aircraft.

The exclusive collaboration agreement was signed between the two parties during the recent Seoul Aerospace and Defense Exhibition (ADEX 2019).

Under the agreement, Raytheon will provide multi-intelligence (Multi-INT) technologies for the air vehicle as prime contractor, while Korean Air will deliver design, logistics and life cycle support services for the programme.

The platform will be based on Bombardier's Global 6500 business aircraft and modified for the Multi-INT ISTAR role by Raytheon and Korean Air, in partnership with the original equipment manufacturer.

Roy Azevedo, President of Raytheon Airborne Systems, said: "Technology is changing the way we fight and the speed at which we do it. For today's commanders, a few seconds can make the difference between success and failure. By combining multiple sensors with advanced communications systems, we give Korean commanders the information they need, when they need it."

A formal competition is yet to be launched by South Korea's Defense Acquisition Programme Administration, but the Republic of Korea Air Force's requirement is understood to be for four aircraft.

Raytheon said: "Multi-INT synthesises data from a variety of sensors – including radar, multifunction electro-optical/infra-red and signals intelligence suites – to create a comprehensive picture of the battlespace." Nigel Pittaway

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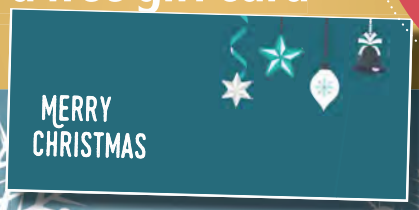

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Your Aviation Destination

Su-57, LMS and AHL

By Piotr Butowski

ON NOVEMBER 8, 2019 the Russia's Deputy Minister of Defence responsible for arms acquisitions, Alexei Krivoruchko visited Sukhoi's aircraft plant at Komsomolsk-on-Amur (KnAAZ). He toured the production facilities of the first series-production Su-57 and subsequent Su-35 fighters

Ministry of Defence TV channel Zvezda presented the almost complete Su-57 in the production hall. The aircraft was painted in the standard dark-grey pixel colour scheme (as per the T-50 prototypes) and a blue 01 tactical number; system installation was in progress. A board fixed to the work platform around the jet had the fighter's serial number, 51001.

Speaking at Komsomolsk, Krivoruchko said: "By the end of the year, it will be delivered to the Aerospace Forces. Next year, we expect one more." The second production Su-57 was also shown in the TV report; it was in a much less advanced stage of production; the first order for two series production Su-57s was placed by the Russian Ministry of Defence at the Army exhibition in August 2018. Last July the Ministry of Defence ordered 76 Su-57s to be delivered by the end 2027. After much conjecture, the Su-57 has been given a NATO reporting name; Felon

Alexey Krivoruchko confirmed that the Komsomolsk-on-Amur factory had undertaken the plan to deliver all of the Su-35S fighters ordered in 2019. He said: "KnAAZ completed the State defence order for 2019, delivering ten Su-35S fighters ahead of schedule. We expect to receive the last batch of ten aircraft included in the current contract during 2020 [that contract signed in December 2015 covered 50 fighters].

According to Krivoruchko, the factory will receive additional Su-35 contracts in the future.

Vityazi Su-35s

On November 12, 2019 four of the ten Su-35s built by the Komsomolsk factory were delivered to Kubinka Air Base near Moscow, home of the Russkiye Vityazi (Russian Knights), the Russian Air Force aerobatic team. Aircraft numbered 50 through 53 belong to the sixth Su-35S production batch; each batch has 20 aircraft.

The 237th Aviation Technology Demonstration Centre based at Kubinka hosts two aerobatics teams; the Russkiye Vityazi (Russian Knights) and the Strizhi (Swifts). Both were created in 1991. It is a combat unit, however, and the aircraft are fully capable fighters; no equipment was removed to reduce weight.

Since its activation on April 5, 1991, the Russkiye Vityazi team flew Su-27 fighters; re-equipping with eight Su-30SMs in November 2016, complemented more recently with four Su-35S aircraft. Russia's aerobatic teams are used primarily to demonstrate new aircraft intended for export, both the Su-30SM and Su-35S are offered for export by the Russian government so we can expect that both types will remain in the Russian Knight's inventory. Two-seat Su-30SMs are required for training while the Su-35 is not produced as a two-seat version. The Strizhi team, currently flying old MiG-29s, is to be equipped with new MiG-35s.

CR929 will be designed in Russia

An important decision in the future China-Russian CR929 long-range wide-body commercial aircraft has been made; the China-Russia Commercial Aircraft International Corporation's board of directors, a joint venture of Russian UAC and Chinese COMAC, has approved the creation of an engineering centre for developing the CR929 in Russia. That's according to head of Russia's Ministry of Industry and Trade, Denis Manturov who disclosed the move in November. He said: "In Shanghai, where final assembly of the aircraft will take place, a branch of the engineering centre will be disposed."

UAC and COMAC agreed to work as equal risk-sharing partners: to halve expenses and to conduct joint sales. It's a bitter pill for the Chinese team to swallow, since demand from the

Russkiye Vityazi Su-35S 50 blue at Komsomolsk-on-Amur in November before its delivery to Kubinka Air Base.
Sukhoi

The first production-series Su-57 Felon, 51001 (01 blue) on the production line at Komsomolsk-on-Amur. *Russian internet*

An-2 successor ordered

After decades of deliberation over what aircraft should replace the An-2, it seems the Russian government has decided.

On October 5, 2019 the Ministry of Industry and Trade settled on the design for the Lyogkiy Mnogotselevoy Samolyot (LMS or lightweight multipurpose aircraft) and ordered the design.

In basic configuration, and in accordance with a strict specification, the LMS must carry between nine and 14 passengers, attain a cruise speed of no less than 162kts (300km/h), a range of 810 nautical miles (1,500km) with a payload of 2,000kg (4,409lb) and a 45-minute fuel reserve. LMS take-off and landing characteristics must not be inferior to those of the An-2.

Finally, the cost of a production standard aircraft must not exceed RUB 120 million and the cost per flight hour no more than RUB 30,000. The aircraft will be powered with a single 800shp (596kW) Klimov VK-800S or a GE Aviation H80-200 turboprop.

Chinese market is estimated at approximately 1,200 wide-body airliners in the next 20 years, while Russia may require as few as 120.

Disagreement arose over the selection of the country in which the CR929 type certificate will be received. Manturov reckons certification options are being studied by the parties.

On another Russian-Chinese project: Russian Helicopters and AVIC have completed negotiations and agreed on all of the contract documentation for development of the Advanced Heavy Lift (AHL) helicopter according to Russian Helicopters' press service in October. The contract is expected to be signed at the end of this year.

Unlike the CR929, Russia is not a partner in the AHL programme, just a sub-contractor; the project is fully owned by Chinese AVIC, which is responsible for implementation of the programme in general, including design, construction of prototypes, carrying out tests, certification, and then the series production and sales of the helicopter.

The Russian side will complete the preliminary design and then develop some subsystems, including transmission and tail rotor; their technologies will be later handed over to China.

The AHL helicopter is expected to have a maximum take-off weight of 38,700kg with an internal load of 10,000kg and 15,000kg external. Service ceiling is set at 20,000ft (6,000m), range 430 nautical miles (800km), and a cruise speed of 145kts (270km/h). First delivery is set for 2032.

A mock-up of the CRAIC CR929 airliner. *Piotr Butowski*

Artist impressions of the future Russian LMS lightweight multipurpose aircraft. *Baikal Engineering*

For the time being, the LMS contract is modest at RUB 1.25 billion (approximately $20 million) paid by the Russian government providing for only the design and production of one static prototype for testing, to be completed by December 15, 2020.

Follow-on phases include production of prototypes and flight testing.

The LMS contract was granted to a company, only established on February 22, 2019, called Baikal Engineering located at Ulan-Ude, with authorised capital of just RUB 10,000. Yekaterinburg-based Ural Works of Civil Aviation (UWCA) is the founder which has participated in the assembly of Czech L-410 aircraft, Austrian Diamond DA42T trainers, Bell 407 helicopters, and Forpost unmanned aerial vehicles.

The LMS tender process had one standout ambiguity that the other competitor was UWCA, the holding company of Baikal Engineering.

Staff designing the new aircraft come from UZGA and the Moscow Aviation Institute design bureau. The aircraft will be produced in the facility at Ulan-Ude currently manufacturing Mi-8AMT and Mi-171 helicopters.

Russia's merged helicopter organisation

At the beginning of October, the Russian Helicopters board of directors decided to integrate Russia's two largest helicopter developers.

Under a unified structure, the design bureaus of Mil and Kamov will be merged in the Mil and Kamov National Centre of Helicopter Engineering. Legally, the new centre will be created in January-February 2020 by transformation of the Mil company; Kamov will be disbanded and its departments will join the new centre.

Integration of the design bureaus started back in 2007 when Mil and Kamov became part of Russian Helicopters. In 2015, Kamov was moved from Ukhtomskaya, where it had been based since 1940, to the site of the Mil design bureau at Tomilino. Kamov's buildings in Ukhtomskaya were sold; as a consequence, Russian Helicopters claim the total space occupied by Mil and Kamov decreased by 42%.

A mock-up of the AHL helicopter. *Piotr Butowski*

Perhaps the greatest advantage of the merger will be cost reduction, but there is a fear that the weaker partner, Kamov, will be consumed by the new structure and eventually vanish: a major disadvantage.

Russian Helicopter's management promises to save both of the original design bureaus and to keep Mil and Kamov in designations of new helicopters. Kamov may survive thanks to its niche products, which Mil never dealt with. Currently at the advanced stage of its design process is the Minoga (lamprey) multi-role maritime helicopter, successor to the Ka-27.

To Africa with love, and bombers.

The Black Sea resort of Sochi hosted the Russia-Africa Summit on October 23 and 24, where Russian President Vladimir Putin hosted leaders of 43 African countries.

Several aircraft were presented to the African leaders during the event including the VIP-configured Ansat light helicopter, MiG-35NG fighter, Mi-35P attack helicopter and Superjet regional airliner.

Speaking at the event, the head of Russia's Federal Service for military technical cooperation, Dmitry Shugayev said the African order book for Russian weapon systems stands at $14 billion; one quarter of all orders for the Russian arms. However, the majority of the figures come from just two countries, Algeria and Egypt. Orders from the sub-Sahara countries amount to just $2 billion where Russia is mainly in competition with China.

Much stir was caused by the visit of two Tu-160 Blackjack strategic bombers to South Africa during the Sochi summit; the bombers were supported by an An-124 transport and an Il-62M passenger aircraft.

Tu-160 RF-94102 (02 red) Vasily Reshetnikov and RF-94112 (04 red) Ivan Yarygin departed Engels Air Base, their permanent base, refuelled over the Caspian Sea, then bound for the Indian Ocean to South Africa. After a 5,950 nautical mile (11,000km), 13-hour flight, the bombers landed at Air Force Base Waterkloof. The Tupolevs

were escorted into South African airspace by three South African Air Force Hawk Mk120 trainers and two JAS 39 Gripen fighters.

Speaking at Waterkloof Commanding officer of Russia's Long-Range Aviation, Lieutenant General Sergey Kobylash said the primary reason for the flight was to train crews on long-range missions and improve co-operation with the South African Air Force.

Russia periodically deploys its heavy bombers to conduct out-of-area operations as a power-projection capability, but this was the first such visit to Africa. Notable international visits by Russian strategic bombers in recent years were two Tu-95MS bombers to Indonesia in December 2017, and two Tu-160 bombers to Venezuela in December 2018; other Tu-160s visited Venezuela in 2008 and 2013.

This Su-35S, RF-81719 (52 red) is the type recently presented to Turkish officials at Ataturk Airport, Istanbul. *Piotr Butowski*

Turkish Su-35s?

Ankara-based newspaper the Daily Sabath, referring to local sources reported on October 25 that Turkey is close to reaching a deal with Moscow over the purchase of Su-35 fighter jets as well as co-manufacturing some components of the Russian-made jets. As many as 48 Su-35 fighters are reported to be involved.

Russia is very interested in selling its combat aircraft to Turkey after the Euro-Asian nation purchased S-400 air-defence systems.

During MAKS 2019 at Zhukovsky in August, Turkish President Recep Tayyip Erdoğan watched the Su-35 and the next-generation Su-57, while in mid-September a Su-35 took part in Teknofest 2019 at Ataturk Airport, Istanbul. During the event, the Su-35 made a separate presentation to Turkish officials including the Minister of Industry and Technology Mustafa Varank and the President of Defence Industries İsmail Demir.

However, on October 29, the Turkish Minister of Defence Hulusi Akar called the reports about the purchase of the Su-35 a lie, re-affirming that Turkey is a partner in the F-35 programme. Time will tell on the latter.

Norwegian Superjets?

On October 25, Russian newspaper RBC reported that low-cost carrier Norwegian Air Shuttle had concluded a memorandum of understanding with the Sukhoi Civil Aircraft Company for 40 Sukhoi Superjet 100 (SSJ100) airliners.

In exchange, the Norwegian company has requested clearance to fly from Europe to Asia along the Trans-Siberian route and to allow a discount for payment of such flights. On the same day Norwegian Air Shuttle denied the existence of such a memorandum. The company's press officer said: "We can confirm we held meetings with Russian authorities and the SSJ manufacturer, but we did not sign any agreements."

Away from the Norwegian rumour, linking Superjet sales with general concessions is not a new practice. Russia's head of Russia's Ministry of Industry and Trade, Denis Manturov said in late October that Russia wanted Egypt to buy 15 Superjets. In return Russia would agree to resume charter flights from Russia to the resorts at Hurghada and Sharm-el-Sheikh. Flights to the two resorts were suspended in 2015 after the explosion of a bomb aboard a Russian aircraft departing Egypt.

Similarly, Kazakhstan wants Russian clearance for extending the exemption from duty on imported Airbus A320 and Boeing 737 airliners and larger types to 2032; Kazakhstan remains bound by the customs union with Russia. The Russians are intent on restoration of the duty to protect their own aircraft of similar class, the Irkut MC-21. Negotiations continue.

The most recent SSJ100 Superjet delivered was to Azimuth airline in October 2019 involving aircraft RA-89120 (msn 95174). *Azimuth airlines*

Artist impressions of the Bell Invictus 360.
Bell

FARA, FLRAA and multi-domain operations

By David C Isby

NEW US military rotorcraft will – starting in 2028 – increase capabilities to fight, manoeuvre and resupply forces as part of multi-domain operations (MDO), Army leaders said in Washington DC at the annual Army of the United States Association (AUSA) meeting on October 14-16. The Future Vertical Lift (FVL) programme – a family of rotorcraft designs (defined by five different categories as capability sets) – is intended to replace legacy helicopters as one of the Army's top six modernization priorities while also meeting other services' requirements. Brigadier General Walter Rugen said that 2019 had been "a breakout year in FVL" marked by, "a wonderful amount of accomplishment ... across four lines of effort: FARA [Future Air Reconnaissance Aircraft], FLRAA [Future Long Range Assault Aircraft], Future UAS [unmanned air system], all wrapped up in open system architecture." Rugen heads the cross-functional team (CFT) of the US Army's Futures Command that is working on FVL.

FARA

The FARA – the first FVL effort – is a replacement for the now-retired OH-58D Kiowa Warrior (AH-64E Apaches are currently filling the Kiowa Warrior's role). FARA represents FVL's Capability Set 1, an attack-scout helicopter. It will be limited to a 40ft (12.1m) rotor span to allow it to operate in urban canyons.

The five competing FARA designs will be submitted for evaluation – in electronic form – to the Army in December. In March, two designs will be selected, and prototypes will be built for a one-year fly-off starting in 2023, the last three months of which will be conducted by military pilots. Once a winner is decided in 2024, FARA may become a programme of record. If so, the first unit will be equipped in 2028 with initial operational capability planned for 2030. Affordability, both in procurement and sustainment, is a key parameter.

Amongst the competitors, the Sikorsky Raider-X2 is a scaled-up design based on its S-97 coaxial rotor and pusher propeller technology demonstrator. Sikorsky's programme manager, Tim Malia stressed the many changes made to produce an operational design while increasing the S-97's performance. He said: "I still get goose bumps every time I see this helicopter fly. The propeller at the back can be used for rapid acceleration or deceleration."

The Bell 360 Invictus combines a wing (for lift at high speeds) with coaxial rotors. A clean-sheet design, it incorporates technologies developed for civil helicopters to increase

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affordability and according to Bell's FVL director, Frank Lazarra "provide a high technical readiness level."

Karem Aircraft, after considering at a tiltrotor design, instead is offering a helicopter with co-axial rotors, a pusher propeller, and tilting wings. The design by the AUX team features a wing, coaxial rotors and twin ducted fans, with the digital capability required by the US Army provided by teammate L3 Harris Technologies' advanced electronics. Boeing's design has not been revealed.

FLRAA

The Army issued a request for information (RFI) to industry in April 2019 for the FLRAA, to meet the performance parameters set out in FVL Capability Set 3. A replacement for the Sikorsky UH-60 Black Hawk, FLRAA is planned to closely follow the FARA into development, with first unit equipped in 2030. But Congress' failure to pass legislation, even though FY2020 started on October 1, has the potential to impose delays. Rugen was among the many Army leaders emphasizing how continuing resolutions will prevent FVL progress; these will hold spending at FY2019 levels and block new starts.

Two FLRAA competitors will likely include operational versions of the Bell V-280 tiltrotor and the Boeing-Sikorsky SB>1 Defiant compound rotor helicopter, which are both currently flying under the Joint Multirole Rotorcraft – Technology Demonstration (JMR-TD) programme. The Army's Program Executive Officer for Aviation, Major General Thomas Todd said: "We would like to target technologies in each where we could do further development."

The V-280 test programme has logged 135 flight test hours and 200 rotor hours. Bell's programme manager Ryan Ehinger reckons the V-280 has proven as agile as a UH-60 Black Hawk. He said: "The program will expand to include autonomy testing later this year." The potential for both manned and autonomous flight is an objective for all FVL designs.

Identifying and correcting gearbox problems with the SB>1 has delayed the flight test programme: three hours logged so far. Boeing's programme manager, Ken Eland, cautioned: "It's not the number of hours but things that we can accomplish that counts at this point in the test programme, expanding the flight envelope with the objective of demonstrating 250-280 knots cruise speed."

The US Marine Corps, looking for a replacement for its Bell UH-1Y utility and AH-1Z attack helicopters, opened the Attack Utility Replacement Aircraft (dubbed AURA) programme on September 16 by issuing a RFI. AURA must be capable of 295 knots cruise speed with a 450 nautical mile unrefuelled radius of action; higher performance specifications than those associated with Capability Set 3, to enable the AURA design to

Artist impressions of the FAARA competitor by AUX/L3 Harris.
AUX

operate with Bell-Boeing MV-22 Osprey tiltrotors. Some teams planning to compete for FLRAA may also offer the Marines a modified version for AURA.

Army aviation programmes

The Army has started deploying operational DVE (degraded visual environment) equipment to enable helicopters to land in brownout and whiteout conditions. Sierra Nevada supplied DVE equipment, ordered in 2016, is being retrofitted to 15 UH-60M medical evacuation helicopters and will be completed by the end of the year.

The Army has started rebuilding the 101st Air Assault Division's capability to move a full brigade of troops in a single night. Funding reductions had led to the division's fleet of CH-47F Chinook medium helicopters being cut back, but the numbers have been increased back to 12, and eventually increased to 48.

Army test firings of the Israeli Rafael Spike-NLOS (non line of sight) missile from AH-64 Apaches at the Yuma Proving Ground, Arizona and in Israel, have proven successful, showing the value of designing FVL rotorcraft to carry long-range missiles.

All of the Spike-NLOS missiles fired hit their targets, including moving targets at night at up to 14 nautical mile (25km) range. Discussing the missile shots, Chief Warrant Officer 4 Scott Durrer of the 82nd Combat Aviation Brigade said: "The trajectory is different. A longer range stand-off missile, cued to the target area, allows you to start the fight from further handoff, such as from a UAV as part of manned-unmanned training."

Postponing the CH-47F Chinook Block 2 upgrade is intended to free up money to fund the FVL. It is uncertain Congress will agree.

However, MH-47G models assigned to Special Operations Command will all be upgraded to Block 2 configuration. This will help make the Block 2 configuration available for the current UK and UAE procurements and – if the CH-47 Chinook wins their current competitions – Israel and Germany. In addition, Boeing's programme manager for the Chinook, Chuck Dabundo said: "France has held lots of discussions over the past couple of years, but its current budget does not have room in it for Chinooks."

MDO and Defender 2020

Head of the Army Aviation Center of Excellence, Major General David Francis spent 2019 determining how to take an Aviation force currently optimized for counter-insurgency, while retaining a commitment to undertake multi-domain operations by 2028.

He said: "MDO is a concept, not doctrine yet because we cannot execute it. We will turn it into doctrine as quickly as we can."

The Army's MDO will have to mesh with the US Air Force's multi-domain command and control (MDC2), which is being developed separately. Both the Army's MDO and the Air Force's MDC2 define capabilities – and threats – in terms of networks of systems.

Land and sea-launch long-range missiles and those from submarines will help defeat threats posed to US airpower. This is nothing new. To cite just one example, US Navy offensive air operations have for decades counted on Tomahawk Land Attack Missiles to clear a path for manned aircraft.

The US Army's top modernization priority is precision long-range fires, including surface-to-surface missiles with longer ranges than any deployed since the height of the Cold War. Development of hypersonic missiles is underway by all three US armed services; the Army wants a battery of such weapons by FY2023.

Together, MDO and MDC2 will have to be part of a joint and multinational – US airpower does not fight without its friends and allies – effort lasting years to produce an effective operational capability. A starting point will be NATO Exercise Defender 2020 scheduled for the spring of 2020. The exercise will include command post drills simulating the MDO capabilities required by 2028. These drills will include a simulated unit equipped with FARAs.

Exercise Defender 2020 will involve the largest movement of troops from the US to Europe since the Cold War. Over 20,000 personnel will be airlifted, most by the US Air Force's Air Mobility Command. Five forcible entry scenarios will be staged in Poland, the Baltic States and Georgia. These events will include AMC transport aircraft carrying out air assaults by units from the 82nd Airborne Division and 173rd Airborne Brigade. The US Army will not deploy any US-based aviation units for the exercise although the current rotational unit in Europe, the 3rd CAB, will participate.

New capabilities for Japan, Korea and Philippines

By Nigel Pittaway

JAPAN, SOUTH Korea and the Philippines are all looking to upgrade existing capabilities or introduce new ones in coming months and years and a range of announcements made during October have provided more details.

The Japan Air Self Defense Force (JASDF) has announced it will upgrade almost 100 McDonnell Douglas/Mitsubishi Heavy Industries F-15J Eagle fighters to significantly enhance the aircraft's air defence capability. However, on the debit side of the ledger, Japan's Ministry of Defense is retiring the remaining McDonnell F-4 Phantoms from service and is due to hold a 'farewell' airshow for the type in early December.

South Korea unveiled a full-scale mock-up of its KF-X fighter at the recent ADEX exhibition in October and is also set to launch the second phase of the programme to develop the capability as a replacement for its F-4 and Northrop F-5 Tiger II fleets.

Finally, the Philippines government is continuing to overhaul its run-down defence capabilities with the imminent arrival of six Embraer A-29 Super Tucano light attack aircraft. In other news, the government has also announced it will acquire single examples of the Gulfstream G280 business jet and Airbus Defence and Space C295 transport for command and control missions.

Upgraded Eagle and Phantom farewell

On October 29, 2019, the US Defense Security Co-operation Agency (DSCA) advised that Washington has approved a potential Foreign Military Sales (FMS) contract to upgrade 98 of the JADF's F-15J fleet to Japanese Super Interceptor (JSI) configuration.

The upgrade will include the replacement of the F-15Js existing Raytheon APG-63(v)1 active electronically scanned array (AESA), with the APG-82(v)1 multi-mode AESA radar now being fitted to the US Air Force's F-15E Strike Eagles under the radar modernisation programme.

Other equipment specified in the $4.5 billion deal includes Honeywell Advanced Display Core Processor II (ADCP II) mission computers, BAE Systems ALQ-239 Digital Electronic Warfare System units and Rockwell Collins ARC-210 radios. While Boeing will be the prime contractor for the FMS portion of the work, MHI will assume the lead contractor role for the direct commercial sale elements.

The DSCA notification said: "This proposed sale will provide Japan a critical air defence capability to assist in defending the Japanese homeland and US personnel stationed there. Modernised F-15J assets will better enable Japan to respond to airborne threats and defend airspace."

The JASDF currently operates around 200 Eagles, comprising single-seat F-15Js and twin-seat F-15DJs, with the majority assembled in Japan by MHI.

In October, Japan's Ministry of Defense announced a 'Farewell to the F-4 Phantom' airshow will be staged at Hyakuri Air Base in the Ibaraki Prefecture northeast of Tokyo, on December 1, 2019. Two JASDF squadrons currently fly the venerable Phantom from Hyakuri, 301 Hikotai (Tactical Fighter Squadron) equipped with the F-4EJ and 501 Hikotai with the RF-4E. A third Phantom unit, 302 Hikotai, was disbanded at Hyakuri in March 2019, prior to standing up as a Lockheed Martin F-35A Lightning II unit at Misawa Air Base. The F-4 Phantom entered service in Japan in 1971 and the final two squadrons are expected to relinquish their last aircraft by the end of March 2020.

Two F-4EJ Phantoms take off from Hyakuri Air Base. *Nigel Pittaway*

Phantoms forever! *Nigel Pittaway*

KF-X progress

Korea Aerospace Industries unveiled a full-size mock-up of its proposed KF-X fighter at the recent Seoul International Aerospace and Defence Exhibition, dubbed ADEX 2019, in the presence of South Korean Prime Minister Lee Nak-yeon on October 15, 2019.

The unveiling follows completion of a critical design review of the home-grown fighter in September 2019.

The Republic of Korea Air Force (RoKAF) plans to acquire up to 120 examples of the production version of the KF-X towards the end of the next decade as a replacement for its ageing F-4 Phantom and F-5 Tiger fleets. The prototype is expected to make its maiden flight in first quarter of 2022 with an operationally representative aircraft planned to follow in 2026.

On October 7, 2019, Korea's Yonhap news agency reported that Seoul plans to initiate the second phase of the KF-X acquisition programme in 2021, marking a RoKAF order for an initial batch of 40 aircraft.

Quoting a Defense Acquisition Program Administration spokesman, Yonhap reported that the Republic of Korea National Assembly had voted to allocate KRW 3.99 trillion (around $3.35 billion) of funding for the programme over five years.

New kit for the Philippine Air Force

Local media reported on October 10, 2019, that the six Embraer A-29 Super Tucano aircraft on order for the Philippine Air Force (PAF) will be delivered during the first quarter of next year, possibly by the end of February 2020.

The aircraft will be used by the PAF on counter insurgency and close air support operations in support of Philippine Army units and will supplement, or possibly replace, the current fleet of North American OV-10 Bronco aircraft.

Embraer Defense and Security signed the contract for the six aircraft in late 2017, and the estimated PHP 4.968 billion funding is sourced via the Armed forces of the Philippines AFP Modernisation Trust Fund.

Gulfstream Aerospace Corporation announced on October 2, 2019 it has won a contract with the Philippine Air Force, via the US government's foreign military sales programme, for the purchase of one G280 mid-size cabin business jet.

President of Gulfstream, Mark Burns said: "The G280's unmatched performance, backed-up by our world-renowned customer support makes it an agile and reliable platform for the Philippine Air Force."

The aircraft, to be delivered in August 2020, will be configured with a VIP cabin, but a defence spokesperson told local reporters on October 8, that the aircraft will be used for command and control missions.

Speaking to local media, Philippines Department of National Defense spokesman Arsenio Andolong said: "The G280 will primarily serve as a platform to carry our senior leaders and commanders in a crisis situation, for example it can be used by the Chief of Staff, the Secretary of National Defence, our major service commanders and the president."

Local media reports on October 7, 2019, suggested the PAF is also to receive a single Airbus C295 aircraft, also configured for command and control operations, with delivery expected in the first half of 2020. The aircraft will also be used for maritime patrol and transport missions.

Airbus Defence and Space has previously delivered three C295Ms in transport configuration to the Philippine Air Force. The company has yet to publicly acknowledge the latest order, however a fourth aircraft was noted at the manufacturer's facility in Seville in May 2019.

F-35

Same old song and dance

***Mark Ayton** reviews the latest news from the world's largest defence programme, the F-35 Lightning II fighter*


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Fast pass! *Senior Airman Alexander Cook/US Air Force*

During a joint hearing of the House Armed Service Committee titled 'F-35 Program Update: Sustainment, Production, and Affordability Challenges' on November 13, Dr Robert Behler, Director, Operational Test and Evaluation at the United States Department of Defense said the F-35's Initial Operational Test and Evaluation could not resume until mid-2020 at the earliest. F-35 IOT&E was placed on pause in < TBC > because development delays of the Joint Simulation Environment used to evaluate the F-35 in robust threat scenarios. Based at Edwards Air Force Base, California, the Joint Operational Test Team started F-35 IOT&E in December 2018 and expected to complete its test programme during the summer of 2019. A fully functioning Joint Simulation Environment is a critical system requirement for completion of the F-35's IOT&E. While the JSE remains incomplete, IOT&E remains on pause. So what's incomplete after so many years of development devoted to the F-35? Lockheed Martin and the US Department of Defense's agencies are behind schedule in integrating a simulated model of the F-35 air vehicle, its systems and weapons into the JSE.

As a result of the pause at least two big issues arise. One, with the very expensive IOT&E programme on pause running costs mount up placing additional budget pressure on the programme. Two, US Federal law prevents a major defence acquisition programme from proceeding to full-rate production until the director of operational test and evaluation submits a final report to the secretary of defense and Congress following the conclusion of the testing process. On < TBC > Under Secretary of Defense for Acquisition and Sustainment, Ellen Lord signed off of a F-35 programme deviation report documenting the expected schedule threshold breach in the Milestone C full-rate production decision of up to 13 months. Until then, low-rate initial production will continue through Lot 12, Lot 13 and Lot 14.

Testifying, Dr Robert Behler said: "So far the Joint Operational Test Team has conducted 91% of the open air test missions, actual weapons employment, cybersecurity testing, deployments and comparison testing with fourth-generation fighters, including the congressionally directed comparison test of the F-35A and the A-10C. IOT&E events have assessed the F-35 across a variety of offensive and defensive roles. Operational suitability of the F-35 fleet remains below service expectations. Test results show that neither the F-35B nor the F-35C are currently on track to meet ORD reliability or maintainability requirements when they attain flight-hour maturity. In short, for all variants, aircraft are breaking more often than planned and taking longer to fix. However, there are several suitability metrics that are showing signs of improvement this year.

"There are two phases of IOT&E remaining. The first is electronic warfare testing against robust surface-to-air threats at the Point Mugu Sea Range. The other is testing against dense surface and air threats in the Joint Simulation Environment at Naval Air Station Patuxent River. I would approve the start of these tests when the necessary test infrastructure is ready. The Joint Simulation Environment is essential, a man-in-the-loop synthetic environment that uses actual [F-35] aircraft software. It is designed to provide scalable, high-fidelity, operationally realistic simulation. I would like to emphasize that the JSE will be the only venue available other than actual combat against peer adversaries. To adequately evaluate the F-35, due to the inherent limitations of open-air testing, these limitations do not permit a full and adequate test of the aircraft against the required types and density of modern threat systems, including weapons, aircraft, and electronic warfare that are currently fielded by our near-peer adversaries. Integrating the F-35 into the JSE is a very complex challenge, but is required to complete IOT&E, which will lead to my final IOTE report.

Based on the current schedule, Behler does not expect the JSE to be ready to start final phase of operational testing until July 2020.

Also testifying, F-35 Program Executive Officer, Lieutenant General Eric Fick said: "We're not only integrating the F-35 in a box into this environment, we're also integrating all of the blue and red threat vehicles — ground systems, airborne systems, weapons, electronic warfare — and all of the things needed to bring a full 8-on-8 [aircraft] or greater scenario to life in a synthetic environment. We're trying to come as close to a combat environment without putting iron in the sky."

According to Ellen Lord: "The F-35 Autonomic Logistics Information System [ALIS] is a key enabler for tactical and operational availability and sadly, as presently constituted, ALIS is not delivering the capabilities the warfighter needs. The department is progressing towards a future ALIS developed and sustained utilizing agile software development techniques designed to rapidly deliver flexible applications on a modern secure architecture." Major shortfalls include non-timely delivery of spare parts and difficulty in its use, especially at remote locations and on board amphibious warships.

In addition, Robert Behler said integration of ALIS on board an aircraft carrier has challenges due to weight and power, while General Fick said problems remain with data transfer between the aircraft and an amphibious ship. According to the Director of defence capabilities at the Government Accountability Office, Diana Maurer, during FY2019 F-35s were only able to perform one of many potential missions less than two-thirds of the time and all missions only one-third of the time, and that for about 30% of time, F-35s can't fly because parts are breaking more often than expected and maintenance write-ups are taking twice as long as expected to fix.

An F-35A breaks away from the tanker during Exercise Agile Lightning. *SSgt Chris Thornbury/US Air Force*

Chair of the House Armed Services readiness subcommittee, Rep. John Garamendi (D-California) said the F-35 is plagued by high operating costs, inadequate repair capacity, spare part shortages and poor replacement part reliabilities, ongoing challenges running the Autonomic Logistics Information System which compounds spare part problems. Garamendi also highlighted that the F-35 programme's acquisition costs are currently expected to exceed $406 billion, and sustainment costs are estimated to exceed $1 trillion.

Garamendi all but squashed any hope of a multi-year contract being awarded until the fundamental questions that have been asked thus far, and several that have not yet been put on the table have been resolved. He said: "Heretofore, the contractors have had the long end of the leather, and the government has been on the short end of the leather, that's going to change."

Ellen Lord affirmed that the Pentagon is at least a year away from giving consideration to asking for approval for awarding F-35 multi-year contracts.

Fifteen days before testifying to the House Armed Service Committee, Ellen Lord announced an agreement between the Department of Defense and Lockheed Martin for three low-rate initial production lots for a total of 478 aircraft and $34 billion; Lot 12 (149), Lot 13 (160), and Lot 14 (169). By variant the agreement covers 351 F-35A CTOLs, 86 F-35B STOVLs and 41 F-35C CVs. With so many ongoing problems still rattling around the rafters of the F-35 house, let's hope the warranties of these jets are enforceable.

33rd Fighter Wing F-35As at Volk Field, Wisconsing during Northern Lightning 2019. *Airman Heather Leveille/US Air Force*

Strike Fighter Squadron 147 (VFA-147) 'Argonauts' is the US Navy's first operational F-35C unit. *Chief Petty Officer Shannon Renfroe/US Navy*

What about the unit costs of the air vehicle and its F135 engine? The combined air vehicle and engine cost is referred to as the unit recurring flyaway cost or URF. The F-35 Joint Program Office expects the URF to continue to fall over the next three years. Price tag for an F-35A is expected to drop from $89.2 to $77.9 million in 2022; F-35B from $115.5 to $101.3 million; and F-35C from $107.7 million to $94.4 million. According to General Fick the price tag of a Pratt & Whitney F135 engine is not declining at the same rate as the rest of the aircraft. Pratt & Whitney's chief flack, John Thomas reckons the company cut the price of the F135 engine by more than half between 2009 and 2018, with ongoing single-digit percentage cost cuts from order to order. He said: "Deeper cost reductions would only be possible through major technology and design upgrades."

In early October, Pratt & Whitney announced a US Department of Defense contract award valued at $5.7 billion for 332 F135 engines; the power plants for aircraft in low-rate initial production Lot 12 and Lot 13.

Based at Edwards Air Force Base, California, the F-35 Joint Operational Test Team has a fleet of 23 aircraft assigned, comprising 8 F-35As (including two Dutch jets), 9 F-35Bs (including three UK jets) and 6 F-35Cs. All 23 were manufactured in the early low-rate initial production lots and had received a series of upgrades to operationally representative configuration prior to the start of IOT&E. That said, some of the aircraft remain configured with specific flight test systems and instrumentation. Given the fleet's operational test programme, so crucial to the entire F-35 programme it's surprising to discover that in June, the 23 aircraft test fleet achieved an 8.7% full mission capable rate, according to an official F-35 ITF chart acquired by the Project on Government Oversight. The chart provided aircraft availability rates from December 2018 through to mid-July. Since IOT&E started on December 5, 2018, the 23 aircraft test fleet bottomed-out with a 4.7% full mission capable rate in May, against a monthly average of 11%.

Marine Corps Air Station Cherry Point, North Carolina is home to Fleet Readiness Center East (FRCE), a depot-level maintenance facility for Navy and Marine Corps types including the F-35. It now has an F-35 laser shock peening facility which will use laser technology to strengthen F-35 structural components; the facility will become fully operational in 2020. In June 2020, the first F-35 aircraft will be inducted to undergo the validation and verification process prior to laser shock peening.

The 16,000-square-foot facility comprises two bays, where the actual laser shock peening process will take place, and a connected area that will house the laser generator. The state-of-the-art process will allow FRCE to conduct heavy structure modifications that will strengthen areas of the F-35's airframe without disassembling the entire aircraft.

The process strengthens designs without adding additional metal or weight, which increases the aircraft's life and reduces maintenance costs. It has been used on the F-22 Raptor and in manufacturing aircraft components including engine blades, but has never been employed for the F-35. FRCE will use the technology to help Marine Corps aircraft reach their full life limit.

Department of the Navy's F-35C transition plan

Squadron	Name	Status	Air Wing	Base
VFA-147	Argonauts	in work up	CVW-2	USS Carl Vinson cruise in 2021
VMFA-314	Black Knights	operational in FY2020	CVW-17	MCAS Miramar in FY2020
VFA-97	Warhawks	operational in FY2022	CVW-5	MCAS Iwakuni, Japan in FY2024
VMFA-311	Tomcats	operational in FY2025		MCAS Miramar
VFA-115	Eagles	operational in FY2025		NAS Lemoore
VMFA-115	Silver Eagles	operational in FY2026		MCAS Beaufort
VFA-151	Vigilantes	operational in FY2027		NAS Lemoore
VMFA-251	Thunderbolts	operational in FY2028		MCAS Beaufort

Aircraft maintenance personnel at FRCE will conduct preparation work and some structural modification on the F-35s inducted into the depot, then turn them over to the contractor running the laser shock peening operations. The contractor will complete the process to strengthen the bulkheads and airframes without adding weight, and FRCE will re-assemble the jets, perform functional check flights and return them to the fleet.

In laser shock peening, the surface of the media is first coated with an ablative layer and covered with a water tamping layer. A high-energy laser beam is fired at the metal, which creates an area of plasma on the metal's surface. The impact creates a shock wave, which travels through the metal, and compressive residual stresses remain. This compression helps improve the metal's damage tolerance, fatigue life and strength.

The process creates a square laser beam, and the intensity is consistent across the entire laser beam. Using a grid pattern, square lasers are stacked up right beside each other so the entire surface of the part is completely uniform without weak spots in between that would then induce cracking later.

Laser shock peening will be a main focus of the F-35 line for the next four to five years completing modifications to the remaining jets in the F-35B fleet that require this treatment. The F-35C fleet will be processed by Ogden Air Force Base in Utah. Heather Wilburn, Fleet Readiness Center

The first US Air Force F-35A combat sortie was flown from Al Dhafra Air Base in the UAE on April 26, 2019. *TSgt Jocelyn Ford/US Air Force*

Australia

By the end of 2019, the Royal Australian Air Force's Air Combat Group expects to have eight F-35As at RAAF Base Williamtown in New South Wales and over 30 jets by the end of 2020. In January, the first two aircraft delivered on December 10, 2018 commenced flight operations. Many of the flights flown to date are part of the F-35A Lightning II Verify and Validation programme (V&V) designed to verify and validate the entire F-35A system in the Australian operating environment. Specifically, the V&V programme will assess the F-35A air system against F-35A initial operating capability (IOC) requirements, including: functionality with Australian logistics, base support and local training systems, assessment of processes and procedures, producing required sortie generation rates, i.e. number of flights per day and weapons events and live-firing exercises. The V&V programme will continue through 2020 in the build-up to declaration of initial operational capability (IOC) at the end of next year. Additional F-35A aircraft will be added to the V&V programme as they are delivered to Australia.

Commander of Air Combat Group (ACG), Air Commodore Michael Kitcher said: "In December 2020, Australia will have up to 33 aircraft, established a sovereign training capability and completed verification and validation of the Australian F-35A capability. By the end of 2020, one operational squadron [3 Squadron] will be proficient in air combat, strike and offensive air support, and ready to deploy in support of Australia's national interests."

In May, up to four F-35As started the first phase of weapons training at the Salt Ash Air Weapons Range. Commander Air Combat Group, Group Captain Harvey Reynolds said: "The initial training runs would involve a series of dry passes over the range, and be followed by gunnery activities. The weapons training programme will include practising F-35A weapons loading and unloading procedures, and gunnery practice which remains an essential skill for fighter aircrew. The Air Force has a responsibility to ensure personnel are ready and able to deploy at short notice and this involves necessary air-to-ground training that is employed at the Salt Ash Air Weapons Range."

On July 15, two Royal Australian Air Force pilots conducted their first training mission on the F-35A after completing a two-month academic and simulator transition training program at Williamtown.

Speaking about the mission, Officer Commanding 3 Squadron, Wing Commander Darren Clare said: "Although we currently still send pilots to the United States [Luke Air Force Base, Arizona] for training, this shows Australia is quickly becoming self-sufficient and it all contributes to our F-35A squadrons reaching combat readiness as planned. The introduction of a fifth-generation aircraft and all of its new systems has been highly complex. It has only been since January that we started testing out how the F-35A integrated with the Australian logistics, base support and local training systems."

On August 2, Australian Defence Minister Linda Reynolds announced a five-year, AUD $91 million contract between the Ministry of Defence and Lockheed Martin Australia dubbed the Autonomic Logistics Information System Integration (ALIS), Maintenance and Administration Services (IMAS) contract. Under the contract, Lockheed Martin Australia will provide mission combat system support and cyber accreditation for Australia's F-35 program.

Linda Reynolds said: "This is a significant milestone towards achieving initial operating capability for the F-35A. It delivers a more responsive and cost-effective solution for key aspects of Australian F-35A maintenance management, and will create up to 60 jobs in the Canberra, Adelaide, Hunter and Katherine regions.

Lockheed Martin Australia, CEO Scott Thompson told Australia's Defence Connect: "Our new contracts with the Department of Defence are a world first and are an important step in developing fifth-generation sovereign capability, providing an opportunity for potentially billions of dollars' worth of new sustainment contracts for local industry."

Air Commodore Damien Keddie, Director-General Joint Strike Fighter Division told

F-35Bs assigned to VMFA-122 on board USS America (LHA 6) in October. *LCpl Juan Anaya/US Marine Corps*

Italian F-35As over Iceland during the type's first NATO deployment in September. *Aeronautica Militaire*

Defence Connect: "These agreements are the next stage in maturing the sovereign maintenance and sustainment programme for Australia's F-35 capability and the sovereign sustainment and capability for Australia. This is important for supporting the ALIS agreement is particularly important because working with Lockheed Martin Australia enables us to keep the mission data and fidelity of the information generated by Australia's JSFs in our hands while supporting the development of Australia's sovereign industry."

Belgium

October 25, 2018 was the day that the Belgian government announced it had selected the F-35A Lightning II as its next-generation fighter; the 13th country to do so. The US State Department had approved the deal with an estimated value of $6.5 billion for 34 aircraft. During the official announcement, Belgian Defence Minister, Steven Vandeput said the F-35 beat the other contenders in all seven selection criteria.

Secretary of the Air Force, Barbara Barrett selected Luke Air Force Base, Arizona, as a candidate to host a Belgium F-35A Formal Training Unit, for up to seven years, starting in 2023. She said: "Because of Luke's infrastructure and its experience in hosting international F-35 customers, Luke is uniquely suited to provide an optimal training environment for our Belgian allies."

The Belgian Air Component's transition from the F-16 to the F-35 will take place between 2023 and 2030. Luke will receive the first Belgian Air Component F-35As in 2023 and a further four in 2024. The eight aircraft are expected to be delivered from Luke to Florennes Air Base in 2025. The Belgian Air Component has not confirmed how many squadrons will operate the F-35A at both Florennes, currently home of 1 and 350 Squadrons under 2 Wing, and Kleine Brogel Air Base, currently home of 31 and 349 Squadrons under 10 Wing. All 34 aircraft will be delivered by 2030.

New infrastructure will be constructed at Florennes to support F-35 operations including squadron buildings, training facilities with four flight simulators and maintenance hangars for six aircraft; similar facilities will also be constructed at Kleine Brogel.

Denmark

Denmark's acquisition of the F-35A, announced on June 9, 2016, currently comprises 27 aircraft, a number that might be increased in order to permanently base at least four of the fleet at Thule Air Base, Greenland to counter potential Russian threats to the island.

According to the Danish Ministry of Defence, parts of Greenland will soon be within reach of Russian aircraft, capable of breaching Greenland's airspace without hindrance. The Danish Ministry of Defence reckons that Russia's military build-up in the Arctic involves tanker aircraft and fighter jets based at Nagurskoye Air Base on the Arctic island of Alexandra Land located about 1,000 kilometres from the coast of Greenland.

In Denmark, acquisition of 27 F-35As will ensure Denmark has freedom of action and the ability to assert Danish sovereignty, to be deployed on international operations and contribute to NATO's collective defence of Danish and allied territory. The Danish government said the F-35A ranked higher than all other competing types in all four major requirements; strategic, military, economic and industrial.

The Kongelige Danske Flyvevåben (Royal Danish Air Force) plans to introduce its F-35s to service between 2021 and 2026 such that all national tasks can be undertaken by the new fighter from 2024 before the last F-16 aircraft will be phased out by the end of the year, ensuring Denmark's quick reaction alert can be continuously maintained. A deployed limited combat capability is expected in 2025

An F-35B assigned to VMFA-211 conducts a vertical landing on board USS Essex (LHD 2) in the Arabian Gulf. *Mass Communication Specialist Adam Brock/US Navy*

Vapour and vortices swirl around the top of an F-35A during a high-performance demonstration. *Senior Airman Alexander Cook/US Air Force*

followed by the full combat capability from 2027. Consequently, the Kongelige Danske Flyvevåben will be unable to conduct any international commitments with a full combat capability between 2022 and 2024 and with only limited combat capability through 2026.

Flyvestation Skrydstrup, is the base selected by the Danish government to base its fleet of F-35s; the base is currently being upgraded to the standard require to operate the Lightning II.

The Danish government has estimated the acquisition cost of its F-35 fleet over the phase in period between 2021 and 2026 to be DKK 20 billion.

Italy

Italy is the first NATO nation to deploy the F-35 to Keflavik Air Base, Iceland for NATO's interim air policing operation Northern Lightning which started on October 2, 2019. This commitment is also the first in which the F-35A falls under the command and control of NATO.

Six Aeronautica Militaire F-35As assigned to 13° Gruppo, part of 32° Stormo based at Amendola Air Base in southeastern Italy, deployed to maintain quick reaction alert at Keflavik to safeguard the integrity of NATO air space, and strengthen surveillance activity in Icelandic air space. Four aircraft flew to Keflavik on September 24 supported by a KC-767 tanker, followed by another two on September 25.

Organised as Task Force Air 32nd Wing, led by Italy's Comando Operativo di Vertice Interforze (Joint Operation Command), the Italian contingent also included Task Group Lightning, an Air Defence Controller team from Comando Operazioni Aeree (Air Operations Command) based at Poggio-Renatico; the latter conducted in cooperation with the Icelandic Coast Guard.

An Icelandic-specific initial operational capability was declared on October 1 followed by a final operational capability the following day; a declaration of the contingent's readiness to conduct the Icelandic air policing mission.

Armed with two AIM-120 AMRAAM missiles, this weapon load configuration is the standard load out used back home at Amendola where 13° Gruppo maintains a quick reaction alert on a rotational basis with other fighter units under the Servizio Sorveglianza Spazio Aereo (Air Space Surveillance Service) mission.

Using its brand new fighter for a NATO-led mission enables the Aeronautica Militaire to evaluate the F-35 while operating from a different base with significantly different weather conditions to those at Amendola following different procedures under a different chain of command, a significant milestone ahead of the type's final operating capability declaration.

Japan

On April 9, Japan lost F-35A 79-8705 (c/n AX-05) in the Pacific Ocean during a training mission flown from Misawa Air Base with the tragic loss of pilot, Major Akinori Hosomi.

Bound for a combat training mission with three other jets, Major Hosomi took off from Misawa around 7pm and proceeded to the training area. At around 7.26pm ground control told Major Hosomi to descend to maintain separation from a US military aircraft some 36km away, but the F-35 kept descending and disappeared from the radar.

Air Self-Defense Force investigators concluded the crash was caused by spatial

Chief Petty Officer Shannon Renfroe/US Navy


VFA-147
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Chief of the Royal Norwegian Air Force, Major General Tonje Skinnarland declared the Kongelige Norske Luftforsvaret's F-35A fleet operational on November 6.
Kongelige Norske Luftforsvaret

disorientation on the part of Major Hosomi and not by any mechanical problem. Investigators found that Major Hosomi did not have enough time to stabilize the aircraft after a warning alarm sounded, and concluded Major Hosomi crashed without realizing his plane was barrelling toward the sea.

Misawa is home to 302 Hikotai, Japan's first F-35A squadron, which began operations in March 2019.

This was the second F-35 crash, the first involved Marine Fighter Attack Training Squadron 501 (VMFAT-501) F-35B BuNo 168057/VM01 on September 28, 2018 near Marine Corps Air Station Beaufort, South Carolina.

Japan joined the F-35 club in December 2011 with an order for 42 F-35A jets. Last December, Japan's Prime Minister Shinzo Abe increased the F-35 order to 147 by requesting an additional 63 F-35As and 42 F-35Bs from the US government. Japan became the fourth nation to opt for the short take-off, vertical landing variant of the F-35 Lightning II.

Japan's government plans to deploy F-35Bs to its southern islands where runways of the length required by the F-35A are in short supply. In addition, the Japanese Ministry of Defence now plans to modify its two Izumo-class multi-purpose operation destroyers, Izumo (DDH-183) and Kaga (DDH-184), currently in service with the Japanese Maritime Self Defense Force with reinforced decks and systems required to support F-35Bs. Both programmes are being implemented to bolster Japan's air defence capability around its southern islands.

Netherlands

The Royal Netherlands Air Force (Koninklijke Luchtmacht or KLu) reached a major milestone with the delivery of the first F-35A Lightning II to the Netherlands on October 31. This was not the first KLu F-35A Lightning II to touch down at a Dutch Air Case – Dutch F-35As based at Edwards Air Force Base, California previously visited the Netherlands on two occasions; once in 2016 and earlier this year (see *Bombing the Netherlands,* August, p10-11). What made this occasion special is that it marked the first F-35 delivery to a Netherlands-based squadron.

Although the Dutch requirement is for more aircraft, due to budget limitations the government decided in September 2013 to limit the number of F-35As ordered to 37 – including two test aircraft acquired in 2009 and 2011. The first eight (serials F-001 to F-008) had been delivered by May 2019 and are permanently based in the United States for operational testing and pilot training. These were all built at Lockheed Martin's facility at Fort Worth, Texas. The remaining 29 will be built at the Final Assembly and Check-Out facility at Cameri, Italy. The jet delivered to Leeuwarden on October 31, serial number F-009, is the first Italian-built Dutch F-35A. The aircraft made its maiden flight from Cameri on September 9 and was officially rolled out three days later. The next jet off the assembly line, serial number F-010, took to the air for the first time on November 4.

In recent years, the Netherlands has increased its defence spending in an effort to meet its NATO obligations. In 2018, NATO called for three operational Dutch F-35 squadrons. With 15 F-35s projected for each squadron, 37 jets are inadequate to equip three squadrons plus a training unit. On October 8, the Ministry of Defence confirmed plans to order nine additional F-35As for the KLu before the end of 2019, bringing the total to 46. Another follow-on order will be necessary to fully meet the NATO commitment. A Lockheed Martin representative recently suggested that a solution for the Netherlands might be the acquisition of F-35As that have been built for Turkey, but will not be delivered because the US government excluded Turkey from the F-35 programme in July after Turkey took delivery of the Russian S-400 air defence system.

At Leeuwarden, the first aircraft arrival event on October 31 was attended by more

than 2,000 invited guests, including Minister of Defence Ank Bijleveld, State Secretary of Defence Barbara Visser and KLu commander Lieutenant General Dennis Luyt. Also present were politicians and many people from the military and industry involved in the F-35 project, plus inhabitants of the city of Leeuwarden and villages surrounding the base.

The F-35 was flown to its home base by Lieutenant Colonel Ian Knight, the recently appointed commanding officer of the F-35 Squadron at Leeuwarden. Throughout its delivery flight, F-009 was accompanied by two KLu F-16BMs acting as chase plane and photo ship. Upon arrival Knight made a couple of low passes and a formation fly past with three of its predecessors – an F-16, Hawker Hunter and Spitfire – before landing on runway 23 at 1524hrs. After taxiing onto Leeuwarden's northern platform, F-009 received the usual hose-down treatment by the air base fire brigade. Unfortunately, one of the crash tenders' crew had accidently selected foam instead of water, so the F-35 came to a standstill between the grandstands covered in foam. Since fire extinguishing foam may have a corrosive effect on the aircraft and its engine, Lockheed Martin was consulted and the jet got washed with water during an engine run immediately after the welcoming ceremony. With inspections already planned before the KLu formally accepts the jet, additional inspections should reveal whether any damage has occurred.

According to Leeuwarden's base commander Colonel Arnoud Stallmann it would take up to three weeks for F-009 to be accepted and F-35 flying operations to commence. Lieutenant Colonel Laurens Jan Vijge, head of operations at Leeuwarden, became the first KLu pilot to fly an F-35A on December 18, 2013. He said: "In the coming months the squadron will gradually build up and get used to working with our new weapon system. This allows technicians to get acquainted with the aircraft and us to see how the logistic aspects develop. Of course we benefit from the experience gained with our F-35s in the US, particularly at Edwards where we operate relatively independent as a Dutch team."

Until the first F-35 squadron reaches initial operational capability status towards the end of 2021, two squadrons will operate side-by-side at Leeuwarden: 322 (F-16) Squadron continues to fly the old jets from the southern part of the air base, while 322 (F-35) Squadron operates the new ones from the northern part.

Delivery of F-010 is scheduled before the end of the year and F-011 should follow in April or May 2020. The Cameri FACO will deliver eight F-35As to the KLu annually. Full operational capability (FOC) of 322 Squadron is scheduled in the first quarter of 2024. The first Volkel-based squadron will start converting to the F-35 in 2021 and initially operate from Leeuwarden to benefit from the experience and infrastructure there, before relocating to Volkel in mid-2022. The final F-16s are slated for retirement in 2024.

Over in America, KLu F-35As are involved in pilot training and operational testing. The Nederlands Opleidingsdetachement F-35 (NODF-35, Netherlands F-35 Training Detachment) at Luke Air Force Base, Arizona, achieved several milestones in the past months. On July 19, F-005 flew the 500th hour for the Dutch fleet within the 308th Fighter Squadron 'Emerald Knights' since the Dutch jets started flying at Luke on February 21. The Emerald Knights received the sixth – and, for the time being, final – Dutch F-35A on July 23, when F-008 relocated to Luke from Edwards Air Force Base, California. Delivered to Edwards on May 10, 2019, this jet had been used temporarily by the KLu's 323 Test and Evaluation Squadron for test flights within the multi-national F-35 Initial Operational Test and Evaluation (IOT&E) programme. On September 16, it was again F-005 that completed the 500th sortie flown by the Dutch jets at Luke. And on October 8, the first operational Leeuwarden-based pilot graduated from the conversion course at Luke.

At Edwards, 323 Test and Evaluation Squadron continues to participate in the much delayed IOT&E, a test programme that's now likely to not be concluded until 2021. Consequently, F-35As F-001 and F-002 will not relocate to Luke at the end of this year as originally foreseen, but remain committed to operational testing until the conclusion of IOT&E. A decision has yet to be taken on whether the Netherlands will remain involved in F-35 operational testing beyond the end of IOT&E. Aircraft F-002 is fully instrumented as a dedicated test aircraft, so it seems likely that the KLu will to some extent – if not permanently, then at least occasionally remain at Edwards for follow-on operational test and evaluation. Kees van der Mark

Norway

On November 6, Chief of the Royal Norwegian Air Force, Major General Tonje Skinnarland declared the Kongelige Norske Luftforsvaret's F-35A fleet operational after completing a deployment to Rygge Air Station in November to validate they are able to operate the jets away from Ørland Main Air Station.

Over the last two years, the Kongelige Norske Luftforsvaret has conducted an intensive operational testing and evaluation of the F-35A in Norwegian conditions including winter operations, operations in the northern areas and cooperation with the Army, Navy and Special Forces. To conclude the test period, aircraft, personnel and equipment were transferred from Ørland to Rygge to train and practice operations from the base. This was the first time Kongelige Norske Luftforsvaret F-35s conducted flight operations from a base other than Ørland.

Japan has more F-35s on order than any other nation. The Japan Air Self Defense Force currently operates one squadron at Misawa Air Base in northern Honshu.
Japanese Ministry of Defence

Japan's first F-35A squadron is 302 Hikotai based at Misawa. *Japanese Ministry of Defence*

Next year Norwegian F-35s will deploy to Keflavik, Iceland to conduct the NATO air-policing mission, and by 2022, the Kongelige Norske Luftforsvaret expects to have built up enough F-35s, pilots and maintainers in Norway to enable the F-35 to take over the 24/7 quick reaction alert from Evenes Air Station in northern Norway, a mission that requires pilots to scramble and intercept aircraft flying near Norwegian airspace.

Poland

On September 11, the Polish government announced it has requested 32 F-35A Lightning IIs, a full mission trainer, training, logistics and support, which the US State Department and the Congress duly approved by late September. The deal is estimated by the Defense Security Cooperation Agency to be valued at $6.5 billion. In service with the Siły Powietrzne Rzeczpospolita Polska (Polish Air Force), the F-35As will replace the remaining MiG-29 Fulcrums and Su-22M-4 and Su-22UM-3K Fitters (officially 18 aircraft, 12 combat-coded and six dedicated to training).

According to the Warsaw-based Casimir Pulaski Foundation, the Siły Powietrzne Rzeczpospolita Polska operates four squadrons of combat-coded MiG-29s and Su-22s, amounting to 64 machines.

Poland's MiG-29s are assigned to two tactical squadrons; 41. Eskadra Lotnictwa Taktycznego based at 22. Baza Lotnictwa Taktycznego, Malbork and 1. Eskadra Lotnictwa Taktycznego based at 23. Baza Lotnictwa Taktycznego, Mińsk Mazowiecki. Two tactical squadrons; 8. and 40. Eskadra Lotnictwa Taktycznegos are based at 21. Baza Lotnictwa Taktycznego, Swidwin.

Given the number of F-35 involved in this $6.5 billon deal, it appears the Polish government is replacing half of its current 64-aircraft fleet. Which Tactical Aviation Base or bases will receive the F-35As has not been announced, though it's more likely to be Malbork and Swidwin; Mińsk Mazowiecki is perhaps the base that would require the most expenditure to configure for F-35 operations.

Minister of National Defence of Poland, Mariusz Błaszczak tweeted that the purchase of the F-35 jets would be "the most important contract in the history of the Polish armed forces. But this is not the end of our work. We will be negotiating hard to secure the best possible price."

South Korea

Cheongju Air Base in the south-central North Chungcheong province of the Republic of Korea is now home of the Asian nation's first F-35A unit, 151 Fighter Squadron, a component of 17 Fighter Wing.

The first two jets arrived at Cheongju on March 29, seven days after departing Luke Air Force Base, Arizona. Luke is home to the 56th Fighter Wing, host unit of the F-35 international pilot training schoolhouse, where the first six Republic of Korea Air Force F-35As were delivered and operated by Air Force Reserve Command's 944th Fighter

An F-35B assigned to VMFA-211 fitted with a 25mm GAU-22 cannon during deployment on board USS Wasp. *US Marine Corps*

Wing. Republic of Korea Air Force pilots commenced F-35 flight training with the 944th in 2017 with the first solo flight flown in July 2018. By the end of 2019, 151 Fighter Squadron is scheduled to have 13 F-35As on strength, with a further 14 to follow through 2020. The Republic of Korea government placed a 40-aircraft order in September 2014 under the US government's foreign military sales programme. All 40 Republic of Korea Air Force F-35As will be assembled at Air Force Plant 4 in Fort Worth, run by Lockheed Martin.

A Defense Acquisition Program Administration report presented to the Republic of Korea National Assembly on October 7 stated that the government is preparing to launch the second phase of the F-X III in 2021 lasting five years; official language for the acquisition of 20 more F-35s at a cost of around $3.3 billion. The specific variant was not disclosed, but in general, Republic of Korea defence sources predict the aircraft will be F-35As; the alternative F-35B has a higher unit recurring flyaway cost and the nation's first 30,000-ton large-deck landing ship will not arrive until the 2030s.

Turkey

In July 2019, the US Congress suspended Turkey's participation in the F-35 programme thereby halting its involvement in the manufacture of production of aircraft components and parts used on the final assembly lines at Cameri, Italy and Fort Worth Texas, and delivery of jets to the nation. The suspension decision was made because of the Turkish government's procurement and acceptance of the first shipment of Russian S-400 air defence systems, a lethal system that the US government says is in compatible with NATO equipment. In reality, the US does not want Russian operators supporting the Turkish armed forces gaining 'eyes on' to any of the F-35's systems.

Turkey was a significant player in the F-35 programme; the Türk Hava Kuvvetleri had a requirement for 100 F-35As to replace aging F-4 Phantoms and its oldest F-16 Fighting Falcons.

Aeronautica Militaire F-35A MM7358/32-08 trails vortices during a mission over Iceland. *Aeronautica Militaire*

Four Türk Hava Kuvvetleri F-35As have been resident at Luke Air Force Base, Arizona since mid-2018 where they were assigned to the 56th Fighter Wing's 63rd Fighter Squadron, and used to train Turkish pilots and technicians to fly and operate the fighters; 42 Türk Hava Kuvvetleri pilots and maintainers returned home following Turkey's suspension from the F-35 programme.

F-35 Program Executive Officer, Lieutenant General Eric Fick is expecting Turkey's entire phase out from the programme to be complete by March 2020. Testifying to a joint hearing of the House Armed Service Committee on November 13, he said: "We began just over a year ago, very quietly but deliberately, taking actions to find alternate sources for all of the parts produced in Turkey. We have, on the airframe side, 11 components we have to mitigate to be at full-rate production ... and on the engines, there's one: integrated bladed rotors."

Some parts ordered from Turkey however, will be delivered after the March 2020 deadline.

United States

In a press release issued on May 9, the office of the Secretary of the Air Force announced F-35A Lightning IIs will be moved from Eglin Air Force Base, Florida to Nellis Air Force Base, Nevada from early 2022 to equip the re-activated 65th Aggressor Squadron.

The aggressor squadron's re-activation is part of an initiative to improve training for fifth generation fighter aircraft by using the F-35A to replicate emerging threats entering service with the Voyenno-Vozdushnye Sily Rossii (Su-35 and Su-57) and the People's Liberation Army Air Force (Su-35 and J-20)

Commander Air Combat Command, General Mike Holmes recommended improving training for fifth generation fighter tactics development and close-air support by adding F-35s to complement the fourth generation aircraft currently being used. To support this requirement, the Air Force has decided to create a fifth-generation aggressor squadron at Nellis and move nine non-combat capable F-35A aircraft from the 33rd Fighter Wing based at Eglin.

The first F-35A delivered to Leeuwarden Air Base in the Netherlands arrived on October 31. *Kees van der Mark*

Four generations of Dutch fighters; two British and two American. The Spitfire looks magnifcent leading the formation. *Kees van der Mark*

The Air Force has already re-assigned two F-35A aircraft from the 31st Test and Evaluation Squadron based at Edwards Air Force Base, California, to join the F-16C-equipped 24th Tactical Air Support Squadron, a close air support unit also based at Nellis. The 24th TASS assignment will provide the Air Force with F-35As dedicated to close air support training.

At Eglin, the 33rd Fighter Wing will only begin to reassign its early lot F-35A aircraft to Nellis once new replacement jets have filled the billets currently expected in early 2022.

The first brand new F-35As for Vermont Air National Guard's 158th Fighter Wing were delivered to its Burlington base on September 19. Vermont is the Air National Guard unit to receive the F-35A.

One month later to the day, the 158th Fighter Wing officially welcomed the F-35A Lightning II into the wing. Eighteen more jets will arrive over the coming months as the wing continues to develop its skills in flying and maintaining the stealth fighter.

Back in 1986, the 158th Fighter Wing transitioned from F-4D Phantoms to Block 1, 10 and 15 F-16A Fighting Falcons; only the second Air National Guard unit to re-equip with the Fighting Falcon.

The 158th Fighter Wing's operational squadron is the 134th Fighter Squadron, the fifth Air National Guard unit to be formed. Squadron Airmen are carrying on the long lineage with their famed 'Yellow Scorpions' emblem painted on the side of the F-35's vertical stabilisers.

Converting to the F-35 has affected the entire wing with changes required at all levels. While pilots needed to learn to fly a new aircraft and maintainers needed to learn new procedures, everyone from the fire department to security forces also needed to adapt as the base facilities and taxiways were overhauled to accept the new aircraft.

Vermont's 158th Fighter Wing is the first of 15 Air National Guard units currently planned for transition to the F-35A Lightning II involving 300 aircraft. TSgt Ryan Campbell, 158th Fighter Wing

Lieutenant Colonel Ian Knight makes a flypast in F-009 at Leeuwarden on October 31. *Kees van der Mark*

On the other side of the nation, at the sprawling Marine Corps Air Station Miramar on the northern outskirts of San Diego, Marine Fighter Attack Squadron 314 (VMFA-314) 'Black Knights' retired its last F/A-18A Hornet on June 21. Prior to that date, the initial cadres of the squadron's pilots were already at Naval Air Station Lemoore in California's central valley learning to fly and operate the F-35C with Strike Fighter Squadron 125 (VFA-125) 'Rough Raiders', the Navy and Marine Corps' F-35C Fleet Replacement Squadron.

VMFA-314 is transitioning to the F-35C, the first Marine Corps squadron to convert to the type, a process that is scheduled to complete in the spring of 2020; the first aircraft with squadron markings is F-35C BuNo 169601/VW434. Squadron maintainers are undertaking their initial training at Eglin Air Force Base, Florida before moving to Lemoore. Pilot training started with VFA-125 at Lemoore in early September. Once the squadron is certified as safe-for-flight by a Marine Corps officer, actually the Commanding Officer of Marine Aircraft Group 11 after which it will move to Miramar its future home base.

As the US Air Force continues with its goal to become a more lethal and ready force, the 388th Fighter Wing based at Hill Air Force Base, Utah, the first combat-coded F-35A Lightning II wing has been a key contributor to the force's overall readiness.

Over the summer, all three squadrons assigned to the 388th FW, the 4th, 34th and 421st Fighter Squadrons — nearly 70 F-35A aircraft — were operating away from home station. They conducted operations in nine different countries on three separate continents, supporting multiple combatant commanders. The 421st FS supported a European Theater Support Package, the 34th FS conducted off-station operations at Mountain Home Air Force Base, Idaho, while Hill's runway was under construction, and the 4th FS conducted the first F-35A combat deployment.

Commander 388th Fighter Wing, Colonel Steven Behmer said: "We're focused on maintaining and improving every aspect of

readiness – training, manning, and developing our people and tactics to meet current threats. Our maintainers are doing a great job providing the sorties we need to do just that."

Successes can be attributed to several factors, from higher experience levels of the maintainers, to rebounds in the supply process. And not everything has been a recent fix. The numbers are catching up to past process improvements.

Explaining, 388th Maintenance Group chief enlisted manager, Chief Master Sergeant Trey Munn said: "A lot of the time people's perceptions and expectations of the programme are influenced by stale data, old, inaccurate information. A really good example is the Autonomic Logistics Information System [dubbed ALIS]. There are definitely applications within ALIS that still need to be addressed, but the prognostic health management system and joint technical data are great examples of where ALIS, on the whole, has improved and we've improved."

Commander 388th Maintenance Group, Colonel Michael Miles said: "The jet's prognostics health management system can detect problems before they fail and allow maintainers to prioritize workload. Making prudent maintenance decisions in coordination with the operations group's flying schedule is a key process enabled by these systems."

The newest jets assigned to the 388th FW are also reflected in the improvements as Col Miles explained: "We're not seeing the same problem parts and issues that we did in the past. Problems sent in from the field are being addressed and solutions are woven into the production line. I like the trajectory we're currently on. There have been some valleys, but our overall experience shows we're on a readiness incline."

Last autumn, former Defense Secretary James Mattis directed Air Force and Navy fighter squadrons to improve material readiness by achieving a mission capable rate of 80% – something many believed to be a lofty goal given the operations tempo, manning and resource constraints faced by all of the services.

Twelve months later, materiel readiness at the 388th FW, to include one squadron deployed, has seen remarkable improvements. This was highlighted when 388th FW units hit a single day in September with two units above 90% mission capable and the third unit above 80%. This is testament to the level of effort the Airmen maintaining and sustaining the F-35 have put in over this year.

Col Miles believes his is a reflection of processes that are on the right track. He said: "It took hard work and there will be a lot of naysayers, and many people don't understand the trajectory the programme is on."

Mission capable rates are just one component assessed at the unit level to determine readiness. In a recent interview, Air Force Chief of Staff General David Goldfein described five aspects of overall readiness, which include training Airmen, sustainable budgets and funding, mission preparation, a reliable logistics supply chain of available parts, and flying hours so pilots have more time in the air.

Parts and systems are not the only thing required to maintain aircraft. So are people, as Col Miles explained: "Experience levels are often overlooked in the maintenance equation. We had a really robust talent pool [of personnel] when we stood up our first operational aircraft maintenance unit [AMU] in 2015. Over time, that experience level became diluted as we stood up two other AMUs, lost people to PCS and retirement, and we had a lot of brand new F-35A maintainers. It takes time to build that experience level back up."

General Goldfein said mission capability rates are important, but don't represent a complete measure of overall readiness. He said: "What really matters is that I've got trained and ready crews...and we've been able to meet those timelines and actually exceed them. That's what counts."

In late October, Airmen from the active-duty 388th and Reserve 419th Fighter Wings returned home following a six-month deployment to Al-Dhafra Air Base, United Arab Emirates.

The 4th Fighter Squadron's deployment, which started in April, was the first F-35A Lightning II combat deployment supporting Central Command's regional task providing various missions, including close air support and regional deterrence. The 4th FS also conducted Agile Lightning, a demonstration of adaptive basing methodology in which personnel and aircraft operate in austere environments to complete essential missions.

Discussing the deployment, the 4th Fighter Squadron commander, Lieutenant Colonel Joshua Arki said: "We demonstrated that the F-35A is ready for any of the missions we may be called upon. We can hold any conflict in any theatre at bay."

With more than 455 aircraft operating from 20 bases around the globe, the F-35 is playing a critical role in today's global security environment. More than 955 pilots and 8,485 maintainers have been trained, and the F-35 fleet has surpassed more than 230,000 cumulative flight hours. Nine nations have F-35s operating from a base on their home soil and eight services have declared initial operating capability. **AI**

Vermont Air National Guard's 158th Fighter Wing is the latest Air Force unit to transition to the F-35A Lightning II.
TSgt Ryan Campbell/Air National Guard

Expansion t

London Southend Airport (LSA), situated 45 miles (72km) from the centre of London, is the fastest growing airport in the UK for the second year running.

In 2018–2019, it handled a total of 1,502,000 passengers, an increase of 33% in the group of UK airports with under five million passengers. It is on track for the same achievement in 2019–2020.

Glynn Jones, the Chief Executive Officer of Stobart Aviation, the owners of LSA, said he is, "absolutely delighted with the passenger figure". Jones added LSA is on course for 2.5 million passengers this year after Ryanair started its services in April 2019, with expectations the number will reach five million by 2023.

In January 2019, the airport celebrated the tenth anniversary of the Stobart Group buying the airport from Southend Council for £21 million. Since then, Stobart has completely redeveloped LSA with a major £160 million programme, turning it into an international airport by constructing a new terminal building, control tower, railway station and hotel, and extending the runway by 984ft (300m).

New routes, more passengers

Southend Airport has a rich 100-year history. It was at one point in the 1960s the third-busiest airport in the UK, with Channel Airways passenger flights to Europe and British United Air Ferries cross-channel car ferry services using ATL-98 Carvairs. As other airports developed, Southend declined and became more of a general aviation airfield, rather than an airport. Jones said: "When [Stobart Group] took over the airport in 2008 it was only handling 47,500 passengers a year and now it is handling more than 1.5 million."

The first major airline to set up a base at LSA when the new terminal building opened in 2012 was easyJet, which had signed an initial ten-year agreement the previous year. The carrier based three Airbus aircraft at the airport to operate scheduled services to European destinations in 2012. Due to the success of these routes, a fourth aircraft and new routes were added.

EasyJet went on to break the passenger numbers record for a flight from Southend in March 2014 with a flight to Faro with 177 passengers aboard an A320, beating the

akes off

Simon Murdoch reports from the fast-growing London Southend Airport as it outlines ambitious future plans

Wizz Air began A320 and A321 flights to Lithuania and Romania in October 2019.

previous record of 170 passengers set by a British Air Ferries CL44 on a flight to Ostend in 1972.

EasyJet is not the only low-cost carrier to move into Southend. In June 2018, Ryanair announced a £228 million deal with Stobart Aviation to set up a base at LSA and operate 55 flights a week to 11 new destinations. The carrier has based three Boeing 737-800 jets at the airport since April 1, 2019. The first three to arrive were EI-GDT (c/n 44815, now with Air Malta as 9H-QAG), EI-GDZ (c/n 44820) and EI-GJG (c/n 44829).

Jones said: "The airport has the theoretical capacity for up to five million passengers a year, and with Heathrow and Gatwick continuing to struggle with a capacity crisis Southend is the answer."

Southend's new terminal opened in 2012.
All photos Simon Murdoch

Loganair now uses Saab 340 turbprops and Embraer ERJ135s to serve Aberdeen, Carlisle, Glasgow and Stornoway.

Even more new routes

In summer 2018, the airport operated passenger flights to 35 European destinations, with Amsterdam, Dublin and Manchester the most popular routes. During the summer of 2018, nearly 100 scheduled passenger flights were operating from the airport every day. In 2019 flights operated to 40 destinations during the summer.

The low-cost giants easyJet and Ryanair are far from the only new commercial operators at Southend. Air Malta started flights to Malta, Cagliari and Catania in 2018 and Flyone operates to Chisinau in Moldova.

Franchise, ACMI (aircraft, crew, maintenance, insurance) and leasing specialist Stobart Air bought three E190 aircraft from Flybe to continue operating their franchise services from Southend alongside ATR 72 turboprops. Stobart Air now leases these three E190s aircraft to KLM, Great Dane Airlines and British Airways CityFlyer via their new leasing company Proteus and continues to operate two ATR 72s on services from Southend.

Loganair started three new daily services from Southend to Scotland on May 12, 2019, to Aberdeen, Glasgow, Stornoway (the first ever London to Stornoway flight) and Carlisle. The carrier operates 17 weekly flights to Aberdeen, 15 to Glasgow, six to Stornoway (via Glasgow) and four to Carlisle. The latter route, launched on July 4, 2019, using Saab 340s, was due to begin last year but was delayed due to operational reasons at Carlisle.

In October 2019, Loganair switched its flights from London to the City of Derry (a route the carrier took over after the demise of Flybmi earlier this year) from Stansted to LSA. Loganair will operate 26 flights a week (13 return flights) using 49-seat Embraer 145 aircraft. The route has been made possible through government Public Service Obligation funding to maintain the route.

Another new operator is Blue Islands, which started a daily service from Guernsey to Southend from May 20, 2019 using ATR 72s. An advanced pre-launch publicity charter flight was operated on March 15 with newly delivered ATR 72-500 G-ISLN (msn 884). The services are part of the franchise arrangement with Flybe.

Infrastructure investment

The Stobart Group is planning to invest a further £40 million in LSA through to 2021. This year £10 million was spent on resurfacing and grooving the runway to improve the braking efficiency for larger aircraft with full passenger loads, such as the Ryanair 737-800s, to enable them to operate from the airport.

Lagan Airport Maintenance was appointed to carry out the essential maintenance project to upgrade the durability and performance of the runway by removing 50mm (1.9in) of the existing surface and replacing it with 200mm (7.8in) overlay of grooved Marshall asphalt by using an onsite batching plant.

Other works included friction testing, airfield lighting and white lining. The work was carried out at night between January and April 2019 to minimise disruption to services.

The runway improvements followed work during 2017 on the apron, taxiways and parking stands. The apron and taxiways were all completely dug up and relaid, and six new stands were added to bring the total for passenger airliners near the new terminal building to 16.

The airport now has ten stands in front of the new terminal, five in front of the Jet Centre on the south apron and six on the north apron that could be used for overflow of commercial airliners at busy times with passengers being dropped off at the terminal first and the aircraft then being towed to the other stands.

LSA now has a solar power panel energy farm, reputedly the largest at any airport in the world, and has become entirely self-sufficient in generating electricity to power all

Passenger operations restarted at London Southend Airport in 2012.

EasyJet started flights from Southend in 2012 and has steadily grown its network from the Essex airport.

Services from Southend

Airline	Destination
Loganair	Aberdeen, Carlisle, City of Derry, Glasgow, Stornoway
Blue Islands	Guernsey
EasyJet	Alicante, Amsterdam, Barcelona, Bordeaux, Budapest, Dubrovnik, Faro, Geneva, Ibiza, Jersey, Lanzarote, Malaga, Malta, Menorca, Murcia, Paderborn, Palma, Paris, Prague, Pula, Sofia, Tenerife
Flybe	Antwerp, Caen, Groningen, Guernsey, Lyon, Newquay, Rennes, Reus
Flyone	Chisinau
Ryanair	Bilbao, Brest, Cluj-Napoca, Corfu, Cologne, Copenhagen, Dublin, Faro, Kosice, Malaga, Milan, Venice
Volotea	Palma
Wizz Air	Bucharest, Vilnius, Isai (from summer 2020)

Note: Data refers to summer 2019 schedule.

its needs. The airport recycles all its rainwater from the terminal buildings and uses it to flush the toilets, with the water collected in an underground tank.

The infrastructure investment also includes new passenger facilities. Four new retail units were opened in the airside departure lounge in 2018 including a Bourgee seafood and steak bar and a new World Duty Free shop.

A £5 million ten-year franchise deal with The Restaurant Group also saw a Giraffe Stop and Costa Coffee open to complement the existing coffee outlets, along with the Navigator Bar and Restaurant, which replaces the original Lakers Bar and Restaurant.

Jones commented: "We have been voted best airport in the London area for six years now in the Which? magazine consumer survey and a key part of our mission is to deliver a great experience for our guests and food and beverage offer the main way we can make their experience even better."

Other operations

There are currently no aircraft maintenance facilities for large airliners at Southend, following the collapse of ATC Lasham in 2016 and Inflite Engineering closing its maintenance base at Southend as part of company restructuring moving operations to Stansted.

Air Livery continues to thrive and has been repainting most of the easyJet Airbus fleet into the airline's new colour scheme. Its existing hangar was destroyed by a fire in 2017 and a new, much larger 'super hangar' is currently under construction. This should open by the end of the year and will enable larger aircraft to be painted. In the meantime, Air Livery has been using a spare hangar at the airport for painting work.

JOTA Aviation, an ACMI charter operator based at the airport, continues to expand, with two BAe 146 and one RJ.100 passenger aircraft for leasing contracts to other airlines when required. The company has also launched JOTA Cargo to operate cargo flights using four BAe 146QT freighters bought from ASL Airlines of Spain. The first BAe 146QT with JOTA Cargo titles, G-JOTE (c/n 3182), entered service at the end of July 2018.

A new Stobart Jet Centre for business jets was set up by the Stobart Group and opened in summer 2018. It is already proving a success and attracting flights and customers from all over the world, because Southend is open 24/7 while quotas have been imposed on business jet movements at Luton and Stansted. The facility was particularly busy during the 2018 World Cup football tournament with lots of bizjets flying to and from Russia. Stobart hopes to handle around 2,500 business jets a year.

Wizz Air routes

Further expansion at Southend is coming from another low-cost operator, Wizz Air, which started flights from Southend to Bucharest, Vilnius and Sibiu in October 2019 using A320s and A321s.

Warwick Brady, Chief Executive Officer of Stobart Group, said: "The agreement with Wizz Air is another significant milestone in the development of the UK's fastest-growing airport. The partnership increases the domestic and European destinations we can offer customers to more than 40 by adding exciting and increasingly popular destinations in central and Eastern Europe."

To celebrate the tenth anniversary of Stobart Group ownership of LSA, a special exhibition has been put up in the terminal along with a Second World War memorial plaque, proudly displayed landside in the new terminal in memory of those pilots who lost their lives operating from RAF Rochford.

With the Ryanair agreement and now Wizz Air joining the other airlines, things are looking good for the foreseeable future at LSA. The airport is on track to become London's new fifth, if not fourth, busiest airport, potentially overtaking London City. It is all very different to the relatively quiet operations of just a few years ago.

Jones said: "The Stobart Group has ambitious plans to ensure the growth and success of the airport, including plans to extend the baggage areas in the new terminal building, making it 75% bigger, resurfacing the runway and grooving it to enable slightly larger aircraft such as the 737-800. A new hotel is also part of the plans for the next decade." **AI**

JOTA Aviation is an ACMI specialist based at Southend, with ex-PSA, US Air and CityJet BAe 146-200 G-SMLA (c/n E2047) used for charter flights.

Blue Islands ATR 72 G-ISLN departs LSA on a pre-launch flight for the new daily Guernsey service.

Mythical, wing

In ancient Greek mythology a Pegasus is a mythical winged divine horse. In modern America, a Pegasus is a Boeing 767 with a few clunky subset designators, dubbed the KC-46A. It's the brand new all-American aerial refueller that's set to replace the god father of tankers, the majestic, 1950s era KC-135 Stratotanker. But its development and service introduction with the US Air Force has been an ugly tale of 'big deal' problems and a multi-billion-dollar cost tag for Boeing, which marketed the aircraft as a low-risk solution for the US Air Force's new tanker requirement. There can be little doubt that if the Air Force had been permitted to stick with its original selection for the KC-X programme, the A330-based KC-45, new tankers would be operational in combat zones right now.

Initial deliveries

On January 25, 2019, the US Air Force KC-46A tanker programme delivered the first two KC-46As to the 22nd Air Refueling Wing at McConnell Air Force Base, Kansas. Aircraft, serial numbers serial numbers 15-46009 and 17-46031, departed Everett Paine Field on their delivery flight to McConnell; a notable milestone for the programme.

The US Air Force posture statement for FY2020 released by the Secretary of the Air Force said: "Our aerial refuelling capability underwrites the global nature of Air Force power and enables the rapid deployment of aircraft. We recently welcomed our first KC-46 tankers and are proposing to buy 12 more KC-46 tankers in Fiscal Year 2020."

Colonel Rich Tanner, 22nd Air Refueling Wing commander told AIR International: "As of October 2019 we are up to 15 airplanes. Our Airmen have worked diligently since [first] delivery to generate the sorties and fly the missions required for IOT&E and beyond. Along the way we've learned a lot and our hands-on work helps the Air Force and the manufacturer address the concerns from operator and maintainer perspectives."

ed and divine?

***AIR International** outlines the KC-46A Pegasus aerial refuelling tanker, America's new air mobility workhorse, and the challenges remaining for the programme*

A KC-46A Pegasus connects with an F-15E Strike Eagle during an aerial refuelling mission flown from Edwards Air Force Base, California. *John Parker/Boeing*

A KC-46A Pegasus takes off for the first crew familiarization flight from McConnell Air Force Base, Kansas on February 26, 2019. *Airman 1st Class Alexi Myrick/US Air Force*

The second unit to receive the KC-46 was the 97th Air Mobility Wing based at Altus Air Force Base, Oklahoma; the KC-46 school house. AIR International received an update concerning operations at Altus from Colonel Matthew Leard, the 97th Air Mobility Wing commander: "The 97th received its first KC-46A Pegasus on February 8, 2019, and is now [October 2019] home to five KC-46s. Here at mobility's hometown, we have a long history of training our nation's airlift and air refuelling crews and we will remain the first stop in training KC-46 pilots and boom operators. Like every new advanced weapon system, we are working through the challenges of building up its combat capacity, but we are 100% confident it will bring the right suite of capabilities to any future fight."

On hold, off hold

However, after delivery of six new KC-46As the Defense Contract Management Agency (DCMA) halted any further deliveries on February 20, 2019 because foreign object debris was found at various locations inside the brand new aircraft; a critical issue for any aircraft. According to a March 1 report in the Seattle Times, the debris included loose tools and pieces of debris. At the time Air Force spokeswoman Major Malinda Singleton said the Air Force would not accept deliveries of the tanker until the production aircraft were cleared, and the service and DCMA had approved a corrective action plan by Boeing designed to prevent FOD in the future. A memo issued by Boeing's factory managers, obtained by the Seattle Times, stated that eight tools were found in aircraft delivered to the Military Delivery Center at Everett Paine Field, which declared a Level 3 alert on the assembly line, one level from mandatory factory shutdown.

Following an out brief of the Defense Contract Management Agency-approved corrective action plan to the Air Force service acquisition executive and Commander, Air Mobility Command, Boeing delivered the seventh KC-46 to Altus on March 11 following a new closely scrutinized acceptance process.

With lives and billions of dollars on the line, Boeing declared a FOD amnesty day on March 15. Defense One got to see a copy of an email issued by Gena Lovett, vice president for manufacturing, safety and quality which cited multiple foreign object debris escapes involving some of the companies most critical programs. Lovett wrote: "This includes the identification and removal of unnecessary tools, equipment, electronic files, documents and refuse. We all have a responsibility to maintain safe, clean, efficient and FOD-free working areas and it's so vitally important to who we are we're making it a company-wide priority."

This initial plan didn't do the intended job because on March 23 the Defense Contract Management Agency halted KC-46A deliveries for a second time. Once again because foreign object debris was found in closed compartments on a KC-

A C-17A Globemaster III aircrew assigned to the 3rd Airlift Squadron, Dover Air Force Base, Delaware, conducts aerial refuelling training with a KC-46A Pegasus on March 22, 2019. *TSgt Laura Beckley/US Air Force*

A KC-46A Pegasus from McConnell Air Force Base approaches a KC-135 Stratotanker. *Airman 1st Class Skyler Combs/US Air Force*

46A at the Everett production facility. This led to a more stringent pre-delivery inspection process approved by Dr Will Roper, Assistant Secretary of the Air Force for Acquisition, Technology and Logistics on April 5. This process includes very close inspection scrutiny of all the aircraft's sealed compartments for foreign object debris. Such was the concern about the closed compartment issue that KC-46A tankers already delivered to McConnell and Altus also had to be checked. Air Force personnel at both bases were tasked to drain and inspect the fuel tanks for foreign object debris.

Boeing said it is committed to delivering FOD-free aircraft to the Air Force and is conducting additional company and customer-specified inspections of the jets, and has implemented preventative action plans.

During April 2019 Congressional hearings, then Secretary of the Air Force, Heather Wilson commented: "We expect excellence in the manufacture of our aircraft, and we are working with Boeing on corrective action plans."

In its June 12, 2019 National Defense Authorization Report for FY2020, the House Armed Services Committee expressed concerns about the progress of the KC-46A: "The committee notes that the Department of Defense Mobility Capability Requirement Study identified a tanker force structure inventory requirement of 479 aircraft. Integral to this capability is the delivery of mission capable KC-46A aircraft and the continued development of additional tanker aircraft after the expiration of the current KC-46A contract with Lot 13 in 2027.

The committee notes that the Secretary of the Air Force has completed a capability-based assessment and signed off the initial capability document for the requirements associated with the next-generation tanker, but has not started an analysis of alternatives. The committee believes the Secretary of the Air Force has several viable options to ensure future tanker capability, to include acquiring a non-developmental commercial derivative tanker while bridging from the end of the KC-46A production to the new developmental tanker. Therefore, the committee directs the Secretary of the Air Force to submit a report to the congressional defence committees...on a 30-year vision for the tanker force structure. The report shall include the following. One, the current KC-46A tanker acquisition timeline through Lot 13. Two, future tanker production options to include an acquisition timeline comparison of a bridging non-developmental commercial derivative tanker and new tanker development. Three, modernization options for the entire tanker force structure through the 30-year vision timeline.

Deliveries resumed

Deliveries were once again resumed. On August 8 and 9, two KC-46s (serial numbers 17-46029 and 17-46034) flew to Pease Air National Guard Base, home of the New Hampshire Air National Guard's 157th Air Refueling Wing. AIR International received an update from Colonel John Pogorek, 157th Air Refueling Wing commander: "We received the Air National Guard's first two KC-46s in August 2019 and expect to have our full complement of 12 aircraft on-station by June 2020. Pease Air National Guard Base has undergone $100 million in construction projects to accommodate the KC-46 Pegasus. Currently, we have pilots and boom operators training with the KC-46 at Altus Air Force Base, Oklahoma and McConnell Air Force Base, Kansas. Ultimately, these activities will result in our ability to generate the sorties and fly the missions required by Air Mobility Command."

KC-46A Pegasus characteristics	
Wingspan	156ft 1in (47.5m)
Length	159ft 2in (48.5m)
Height	51ft 9in (15.5m)
Max take-off weight	415,000lb (188,240kg)
Max fuel capacity	212,299lb (96,297kg)
Max cargo capacity	65,000lb (29,484kg), 58 passengers
Pallet positions	18 pallet positions
Engines	Two Pratt & Whitney PW4062 turbofans each rated at 62,000lb

Cat ones

The US Air Force uses a deficiency categorization protocol for all issues with a weapon system. A category 1 deficiency is classed as one which may cause death or severe injury; may cause loss or major damage to the weapon system; or critically restricts the combat readiness capabilities of the using organization.

Boeing is working to correct four Category 1 deficiencies impacting the KC-46A tanker. Two with the remote vision system used for aerial refuelling, one affecting the refuelling boom's performance, and since September, one involving cargo restraint devices.

A cargo pallet is positioned with open doors as aeromedical evacuation crews prepare to load the container with litter equipment at McConnell Air Force Base, Kansas. The medical cargo pallet contains the necessary stands and support equipment to build litters. *2nd Lt Daniel de La Fé/US Air Force*

Remote Vision System

The Rockwell Collins remote vision system (RVS) generates and displays video feeds on the aerial refuelling operator station using a set of cameras located around the underbelly of the KC-46.

In January, US Air Force Acquisition spokesperson, Captain Hope Cronin said the Air Force was allowing deliveries to proceed but programme issues were still to be resolved.

AIR International spoke with Michael Hafer, Boeing's Global Sales and Marketing Director for the KC-46 Program concerning the remote vision system on the KC-46. He said: "This system is a major upgrade to similar systems developed and used on Dutch KDC-10 and Japanese KC-767 tankers. The US Air Force has done extensive flight testing with the RVS, and has identified visual acuity challenges in a small percentage of the tanker flight envelope.

Airmen assigned to the 60th Aerial Port Squadron from Travis Air Force Base, California, load cargo onto a KC-46A Pegasus. *Senior Airman Christian Conrad/US Air Force*

"More specifically, the Air Force has an issue where the KC-46 boom operator, using the RVS, may not have the visual acuity to confirm the boom made contact with the receiver aircraft during refuelling, contacts outside of the air refuelling receptacle. Boeing and the US Air Force are working on changes to hardware and software, and a test programme to achieve Air Force certification."

Fly-by-wire boom

There are issues associated with development and operation of the new digital flying boom used for refuelling US Air Force aircraft. A June 2019 US Government Accountability Office report said the new KC-46A boom is stiff and could affect operations and cause damage to aircraft with low observability coatings.

Explaining the fault, Mike Hafer said: "The KC-46 boom is a fly-by-wire, digital aerial refuelling boom built in house by Boeing to US Air Force specifications. The Air Force has tested the new boom with 14 different types of aircraft and has so far achieved certification with seven types of aircraft. However, light weight, thrust-limited receivers, like the A-10, have challenges for remaining in contact with the boom in corners of the aerial refuelling envelope. Testing is still underway, and hardware and software changes are being evaluated to improve and finalize the boom's air refuelling performance".

Boeing is also working to deliver the Wing Aerial Refueling Pod System (WARPS) to the Air Force for testing; WARPS is the system used to aerial refuel probe equipped aircraft; those operated by the US Marine Corps, US Navy and many allied nations.

A complete litter configuration built inside a KC-46A Pegasus Fuselage Trainer at McConnell Air Force Base, Kansas. Configured for the aeromedical evacuation role, a KC-46A can carry 54 patients, 24 litter and 30 ambulatory. *2nd Lt. Daniel de La Fé/US Air Force*

A Boeing spokesperson for the KC-46 program commented: "The Wing Aerial Refueling Pod System flight testing, including WARPS receiver certification for the F/A-18 Hornet is complete. The Boeing-Air Force team will perform one more flight for electromagnetic effects testing for WARPS FAA Supplemental Type Certification issuance using a production standard aircraft in January 2020. This form of flight testing is the precursor to system delivery. Boeing is working with the Air Force on the delivery plan and schedule".

Cargo restraint devices

According to the US Air Force, during several long-range KC-46A test flights with the aircraft loaded with cargo, multiple cargo floor restraint locks malfunctioned and came unlocked. Prior to departing on each mission, aircrew fully installed, locked and thoroughly inspected each restraint, and performed routine inspections of the restraints in flight. Despite the safety measures, the unlocking occurred during flight, though no cargo or equipment moved and there was no specific risk to the aircraft or crew.

A KC-46 is cleared to carry two types of rolling pallets; one for passenger seating (up to 58) and 463L cargo pallets (up to 18) or a combination of both. Each type of pallet is fixed to the floor of the aircraft's cargo hold with cargo restraint devices.

Explaining the problem, Mike Hafer said: "The Air Force requirement calls for the aircraft to be able to reconfigure within two hours after landing. These locking systems secure to the floor with a switch lock, but are removable. During flight testing, dynamic vibrations caused several of the mechanisms to move out of confirmed locking position. We have developed a mechanical fix to this problem. It has passed initial flight testing and we are on path to provide a permanent fix to this problem."

During the Air Force Association's Air, Space and Cyber conference held at National Harbor, Maryland, Commander Air Mobility Command, General Maryanne Miller told reporters: "We are eight months into accepting our airplanes, and Boeing has not presented a solution that meets all the parameters. Boeing's solutions for the RVS just aren't good enough. The cameras used to monitor the fuelling systems feed three images to the screen and Boeing has struggled to provide effective depth perception, which makes it pretty challenging to mate the boom and manage refuelling. In a couple months, that is what I'll be looking for...

Temporary litters can be added and removed expeditiously to meet the immediate needs of patients.
2nd Lt. Daniel de La Fé/US Air Force

A KC-46A Pegasus and a KC-135 Stratotanker on the flight line at Dover Air Force Base, Delaware.
Mauricio Campino/US Air Force

we have got to get this airplane into the fight." Air Force and Air Mobility Command leaders met with Boeing representatives at Scott Air Force Base, Illinois, Headquarters Air Mobility Command on September 30 to discuss ongoing efforts to identify viable solutions for KC-46 deficiencies.

Creating a hot mess

The US Air Force tanker fleet comprises 396 KC-135 Stratotanker aerial refuelling aircraft (with an average age of 63 years), an aircraft which have been updated several times after deliveries between 1955 and 1965. In addition, the tanker fleet includes 59 KC-10 Extenders delivered in the 1980s (with an average age of 32 years). During a much shorter service life compared to the KC-135s, KC-10s have sustained a heavy utilisation rate to the point where today, they are a challenge to maintain.

While the KC-135 fleet is old, the airframes still have service life remaining, and the Air Force operates an established programmed depot maintenance system which keeps the aircraft overhauled and updated.

A 2018 Transportation Command study supported the Air Force's stated requirement for 479 aerial refuelling tanker aircraft.

America's jet-powered tanker fleet is assigned to Air Mobility Command with each air refuelling squadron supporting aerial refuelling, aeromedical evacuation and personnel/cargo transportation as their primary mission assignments.

Aerial refuelling is a core element of global reach, increasing US and coalition range and capability. Air Mobility Command's posture priorities include readiness, sustaining nuclear response, mobility operations in a contested environment, force development, modernization and innovation.

The road to KC-46 has been long, difficult and a touch perverse. In the 1990s, the Air Force considered buying and/or leasing an upgraded version of the 767 tanker from Boeing. In 2003 the project was put on hold when allegations of corruption were discovered; ultimately the contract was cancelled in 2006.

A request for proposal was released in 2007 for the KC-X programme including 179 new tankers.

Boeing proposed its KC-767 and faced off against the larger Northrop Grumman-EADS A330 Multi Role Tanker Transport. On February 29, 2008, the A330 dubbed the KC-45 was selected. Boeing was hopping mad at the decision and protested the contract award. This was sustained by the Government Accountability Office with its June 2008

Total acquisition costs for the KC-46 Pegasus

Total acquisition cost estimate category	February 2011	October 2017	Percent change
Development	7,149.6	5,835.1	-18.4%
Procurement	40,236.0	35,523.8	-11.7%
Military construction	4,314.6	2,999.8	-30.5%
Total	51,700.2	44,358.7	-14.2%

A KC-46A Pegasus assigned to the 344th Air Refueling Squadron on the flight line at Dover Air Force Base, Delaware.
Mauricio Campino/US Air Force

A KC-46A Pegasus from the 22nd Air Refueling Wing.
SSgt Mary McKnight/US Air Force

decision in favour of Boeing. Bidding was reopened in July, KC-X solicitation was cancelled in September. One year later the Air Force started its process for accepting new bids. In March 2010 Northrop Grumman withdrew but EADS soldiered on. That was in vein. On February 24, 2011, Boeing won the hotly contested contract for a new generation tanker based on a revised version of the proven 767-200LRF (flown by many cargo companies) but with a 767-300 series wing, landing gear, cargo door and floor, flight deck and glass cockpit plus other updates.

The KC-46 design includes a permanent aerial refuelling boom and wing aerial refuelling pod systems, a capacity to carry 18 463L pallets (the KC-135 holds six) and medical systems for the transportation of patients in the aeromedical mission.

The aerial refuelling boom can transfer more than 1,200 gallons of fuel per minute (7,200lb), and more than 400 gallons per minute (2,400lb) from the drogue. The mould line of the new fly-by-wire boom is similar to the KC-10 but all hardware is new.

The KC-135 and KC-10 both have an air refuelling operator, a boom operator, located in the rear of the aircraft to operate the boom from a control station, watching the receiver aircraft approaching the tanker through purpose-fitted windows.

Boeing's KC-46 proposal elected to place the air refuelling operator near the flight deck and manage boom operations from an aerial refuelling operator station (AROS). Cameras located around the KC-46 fuselage, operating in visual and infrared modes, feed their imagery to the air refuelling operator at the AROS.

Fitted with the latest communications and networking systems, including Link 16, the KC-46 also has armour around the cockpit, explosion and fire suppression, electromagnetic protection shielding and self-protection systems. The latter include Raytheon's ALR-69A radar warning receiver, and Northrop Grumman's AAQ-24(V) Large Aircraft Infrared Countermeasures system dubbed LAIRCM, which provides automatic

KC-46A Pegasus timeline

January 2013 - DOT&E approved the post-Milestone B Test and Evaluation Master Plan, with concerns about adequate calendar time for correction of discrepancies or deficiencies between the end of developmental testing and the beginning of IOT&E.
December 28, 2014 - First flight of the first EMD aircraft, six months late, primarily due to electrical wiring design problems. The aircraft began flight testing at the end of July 2015.
January 2015 - The Air Force accepted Boeing's Stage 4 (final build) test plans.
May 2015 - DOT&E approved the Air Force Operational Test and Evaluation Center's second KC-46A operational assessment (OA-2) plan to support the Milestone C decision.
September 2015 - The first fully configured aircraft, EMD-2 started flying; originally planned for January 2015.
January and February 2016 - Initial AR testing uncovered unanticipated axial loads in the boom that approached the boom's structural limits, resulting in temporary suspension of further AR testing.
July 2016 - Demonstration flights of Boeing's redesigned the boom control system were completed.
August 2016 - The KC-46A program successfully accomplished a Defense Acquisition Board Milestone C decision.
November 2016 - DOT&E approved the Milestone C TEMP, with concerns about adequate calendar time for correction of discrepancies or deficiencies between the end of developmental testing and the beginning of IOT&E.
Through 2016 - LAIRCM testing provided hit point distribution data to inform the vulnerability assessment and to verify both LAIRCM system configurations (Block 20 with ultraviolet missile warning system and Block 30 with two-colour infrared missile warning system) LAIRCM performance on the KC-46A.
July 2017 - Naval Air Systems Command conducted EMP testing at Naval Air Station Patuxent River, Maryland on behalf of Boeing. Testing was not accomplished in accordance with the DOT&E-approved TEMP and the LFT&E Strategy. The NAVAIR testing demonstrated flight critical capabilities were still available after exposure to a 6dB pulse. However, testing did not fully demonstrate AR capabilities as required. The program uninstalled or deactivated multiple mission critical systems prior to testing and, therefore, their EMP tolerance was not tested on the aircraft in mission-representative configuration, nor was the functionality of the AR boom and WARP pods tested.
July 2017 - The KC-46 program completed all planned flight test events necessary for the FAA Aircraft Amended Type Certificate of the Boeing 767-2C aircraft. FAA Supplemental Type Certificate test events continue to complete FAA certification of the KC-46A aircraft.
August 2017 - A KC-46A deployed to Yuma, Arizona, for hot weather testing.
October 2017 - Flight testing began to certify the AR system and the first eight types of aircraft for receiver operations.
October 2017 - Flight testing began to certify the KC-46A AR system and the first eight aircraft for receiver operations, and will continue into FY2019.
December 2017 - A KC-46A deployed to Guam for extreme humid weather testing.
Through 2017 - Boeing completed Block 20 LAIRCM flight testing at Moses Lake, Washington to confirm installed system performance.
Through 2017 - Testing ongoing of the production-representative version of the redesigned prototype boom.
January 2018 - A KC-46A deployed to Fairbanks, Alaska, for cold weather testing.
April 2018 - The Air Force completed KC-46A Joint Interoperability Testing with Link 16 with other aircraft.
June 2018 - The KC-46A program completed follow-on developmental testing of an RVS software-only fix.
June 2018 - The KC-46 program completed flight test requirements for the first KC-46A aircraft delivery by finishing test events for the RVS and the F-16, C-17, and A-10 receivers, and KC-135 refuelling the KC-46A as a receiver.
June 2018 - Boeing completed Block 30 LAIRCM flight testing at Moses Lake, Washington to confirm installed system performance.
July 2018 - A KC-46A deployed to Yuma, Arizona, for hot weather testing.
September 2018 - Flight tests completed for FAA Supplemental Type Certification.
Through 2018 - Initial centreline drogue system testing revealed deficiencies in software and hardware that resulted in unexpected disconnects during AR operations. Boeing identified the root cause and implemented new coupler tolerances and updated control software logic.

Director, Operational Test and Evaluation Assessments

DOT&E 2015 Assessment

• The expected IOT&E start date was delayed 10 months from the post-milestone B TEMP schedule. DOT&E analysis during 2015 indicated that operational testing would likely be delayed by 12 months.

DOT&E 2016 Assessment

• At Milestone B, in February 2011, the Air Force had planned to be 66% complete by Milestone C. However, upon accomplishing Milestone C in August 2016, Boeing had completed only 30% of the total EMD testing.

• AR demonstrations to date have been at a single point of the KC-46's operational envelope for only three boom receivers (A-10, C-17 and F-16) and two probe and drogue receivers (AV-8B and F/A-18C), during daylight only, and no aircraft have completed certification as a receiving platform.

• The boom variant used during 2016 was a prototype designed to solve boom axial load problems encountered in early testing and was not production-representative.

• During the second operational assessment testing (OA-2), the aerial refuelling operators (AROs) identified a problem that can occur when the ARO station is set to dual operation such that the controls at both the primary and instructor stations are active. When both positions apply a flight control stick command, the boom will move to a summed position due to the system's summation logic. There are situations where this could result in a rapid boom movement to the instructor-commanded position; if the receiver aircraft is in the path, the potential exists for the boom to inadvertently strike the receiver aircraft.

• The AROs also noted the long-wave infrared cameras, part of the RVS system, produced an undesirable effect when interacting with the sun and clouds. For example, a solar trail occurs when the sun moves across the screen (such as during a turn) and leaves a persistent afterimage forming a line. Additionally, the ARO station screen overlays – which provide boom envelope position and other information – interfere with the ARO's ability to view and monitor AR operations.

• Given the recent problem with KC-46A cargo floor restraint devices unlocking, with hindsight its revealing that the Director of Operational Test and Evaluation 2016 Annual Report said in its assessment of the KC-46A, that OA-2 testing had not identified any critical deficiencies with the cargo handling mission, though testing did identify deficiencies the Air Force should address. Surely the restraint device was not one such deficiency?

DOT&E 2017 Assessment

• Analysis of boom AR testing through 2017 showed a significant number of instances where the boom nozzle contacted the receiver aircraft outside the refuelling receptacle and in many of those instances, the AROs were unaware those contacts had occurred. Boom nozzle contact outside the receptacle can damage antennae or other nearby structures, but is especially problematic for low-observable receiver aircraft by damaging radar-absorbing coatings.

A potential contributing factor for both the number of contacts outside the receptacle and undetected contacts was determined to be reduced visual acuity of the ARO using the remote vision system. Boeing and the Air Force teams conducted root cause analysis, reviewed the historical data, and collected additional data during subsequent tests. Without an appropriate solution, the problem has adverse operational mission effects on low-observable aircraft at a minimum.

• LAIRCM testing provided hit point distribution data for the vulnerability assessment and to verify LAIRCM performance on the KC-46A. Evaluation included both LAIRCM system configurations; Block 20 with ultraviolet missile warning system and Block 30 with two-colour infrared missile warning system.

DOT&E 2018 Assessment

• The DOT&E forecast the earliest likely start of IOT&E as March 2019. Schedule analysis identified two key milestones affecting IOT&E start and completion. One, completion of AR certification of the initial group of receiver aircraft before the beginning of IOT&E. Two, certification of activity.

• In 2017, the program started flight testing with a production-representative version of the redesigned boom.

• During FY2018, the Air Force planned to complete two nuclear threat-focused assessments for the KC-46A. One, to assess the ability to launch and fly a safe distance from a simulated nuclear attack to a KC-46A staging base. Two, assess the KC-46A's inherent nuclear hardness to blast, radiation, flash, thermal, and EMP effects.

protection for large aircraft against shoulder-fired, vehicle-launched, and other infrared-guided missiles.

Programme challenges

The KC-46 contract included $4.4 billion for the development and manufacture of four test aircraft. Additionally, Boeing received a $3.5 billion engineering and manufacturing development (EMD) contract.

The first KC-46A N461FT (c/n EMD-1) flew on September 25, 2015. Four test aircraft flew many missions and the EMD programme showed progress. However, Boeing ran into problems with the schedule. This was the first major programme seeking to secure both military and FAA certification at the same time for a single platform.

Lessons were learned in flight testing and many issues and required changes were identified. Boeing decided to continue building the aircraft and incorporate changes at later dates as they were confirmed. Development and production fell behind schedule and the programme went over budget. However, the US taxpayer was protected from footing the bill thanks to the firm fixed-price contract.

Keeping a check on the KC-46 programme, like all US government programmes, is the Government Accountability Office (GAO) which performs an annual audit. In its April 2018 report titled GAO-18-353 KC-46 Tanker Modernization, the GAO assessed programme progress and challenges toward achieving its cost goals and delivery schedule. The total acquisition cost estimate for the KC-46 tanker aircraft remained stable over the last year at $44.4 billion. As shown in the table below, the estimate has decreased about $7.3 billion (14%) since the initial estimate. This decrease is due in part to stable requirements.

In September 2017, US Air Force KC-46 Program Manager Colonel John Newberry commented: ""One of the risks we probably underestimated collectively was the concurrency of doing an amended type certificate on a brand-new aircraft — the 767-2C is a brand new 767 [that] obviously takes advantage of the heritage of the 767 family. Doing that all at the same time was underestimated [as to] the complexity and scope of effort. I think Boeing is now paying for those underestimates."

In a 2017 article, former Boeing employee, Raymond Cosner said: "It's not so simple to convert an existing commercial passenger jet into a militarized flying gas station. I should know: I helped prepare Boeing's proposal for the KC-46A tanker. In addition to installing a first-of-its-kind refuelling system that will use both a refuelling boom and the hose and drogue system, new defensive systems, sensors and other electronic systems, will enable the KC-46 to operate in an increased threat environment. Wiring and hydraulic lines have been extensively modified, and numerous other changes are being made to enable the aircraft to perform its missions. Many of these advanced technologies are being used for the first time."

Given the fixed price contract form, Boeing has had to write off more than $3 billion of expenses due to changes in the development of the aircraft and its systems. In late 2018, after many serious debates,

The first local aerial refuelling sortie between a KC-46A Pegasus and KC-135 Stratotanker from McConnell Air Force Base. *Airman Skyler Combs/US Air Force*

Above and bottom right: A KC-135R assigned to the Utah Air National Guard's 151st Air Refueling Wing, conducts aerial refuelling operations with a KC-46 Pegasus assigned to the 22nd Air Refueling Wing, McConnell Air Force Base, Kansas. The KC-46 is the Air Forces newest aircraft in its fleet and can carry a combination of more than 210,000 pounds of fuel, 65,000 pounds of cargo and 58 passengers.
TSgt John Winn/Utah Air National Guard

reportedly the Air Force and Boeing agreed on a revised delivery schedule. On January 24, 2019, Air Force Secretary Heather Wilson reported that 36 KC-46As would be delivered in 2019.

KC-46A Phase II certification was completed in 2018 after the four test aircraft had flown more than 3,800 hours, and refuelled nine different types of aircraft; eventually 64 types of US and NATO aircraft will be certified for refuelling operations.

On January 22, 2019 a KC-46A refuelled a US Air Force F-35A Lightning II fighter over the desert skies near Edwards Air Force Base, California meeting a Phase III milestone in the test programme; this was the first aerial refuelling of a stealth aircraft by a KC-46A. Phase III certification testing and the type's initial operational test and evaluation, all led by the 418th Flight Test Squadron, continue at Edwards Air Force Base, California.

A divine future?

The FY2019-2023 KC-46 production plan includes $20 billion to support production of 75 aircraft plus billions of dollars for base infrastructure construction and modification programmes. Production of the KC-46A is expected to continue until FY2027 when all 179 aircraft are planned for delivery.

In 2016, the US State Department filed paperwork concerning the potential sale of four KC-46 tanker aircraft to Japan. The first Japanese aircraft is now in production and the second will start soon. Boeing projects a market for up to 60 export KC-46 tankers.

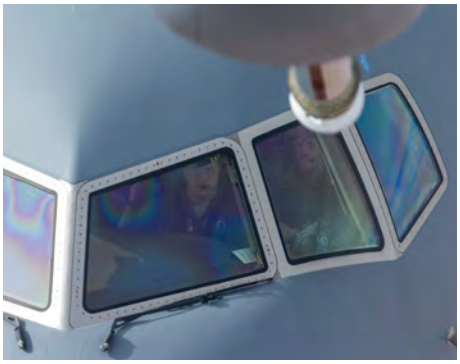
The KC-X programme called for a 179 aircraft buy of KC-46As with options for KC-Y and KC-Z tanker programmes to fully replace the KC-135s, KC-10s and upgrade of US Air Force tanker capabilities. However, as a result of changing threat conditions and defence plans the Air Force, defence companies, think tanks and other groups have advocated different concepts for future tankers. US Air Force planning for a future tanker is now being re-evaluated and some KC-135s may have to stay in service longer. However, in early 2019 the US Air Force Chief of Staff, General David Goldfein commented: "I don't know if it's manned or unmanned, and I actually don't care that much as long as it brings the attributes we need to win."

Given that in August 2018 the US Navy committed to develop the MQ-25 Stingray unmanned air vehicle with aerial refuelling as one of its primary missions, it's likely that the Air Force's future tanker mix will include similar unmanned tankers. The MQ-25 was born of Naval Air Systems Command's Carrier Based Aerial Refueling System programme.

Given the KC-46's ugly tale to date, was there any positive developments for the program this year? Yes, if you consider the appearance of a KC-46A in the static display at the 2019 Paris International Airshow in June to demonstrate positivity. From an editorial perspective, flying a Boeing 767 from the United States to France is neither a new event nor particularly impressive!

Elsewhere, and by October Boeing had delivered 25 KC-46A aircraft to McConnell, Altus and Pease where additional deliveries were expected imminently. That's a good thing for the Air Force, but let's not get carried away with the number. At the same point in time there were as many KC-46 jets parked up at Everett and Boeing Field in Seattle as there were in service.

Perhaps a more significant fact is that production standard KC-46 aircraft are now involved in flight testing such that operational testing has been moving forward. On October 22, the Program Executive Officer for tankers formally certified the KC-46's transition into initial operational test and evaluation dubbed IOT&E. This phase will test the KC-46's effectiveness, suitability, and mission capability toward accomplishing its three primary mission sets: aerial refuelling, cargo and passenger airlift, and aeromedical evacuation. The Air Force continues to flight test its new tanker, while Boeing continues to try and correct the category 1 deficiencies in parallel, a process deemed as the most expeditious means of achieving full operational capability. Despite the problems and delays, in October the US Air Force awarded Boeing a $2.6 billion contact for 15 KC-46 aircraft, spares, engines, refuelling kits and other systems. This was the fifth production lot awarded to the Chicago Illinois-based company for a total of 67 KC-46A aircraft. ***AI***



Aviation safety – t

Although one of the safest forms of transport, aviation has suffered some tragic losses. In 1974, an explosive decompression downed a Turkish Airlines DC-10 with the loss of 346 lives. In 1977, a Pan American 747 collided with a KLM 747 killing 583. In 1979, following the failure of an engine mounting, an American Airlines DC-10 spiralled into the ground killing 272. In 1980, a flash-fire on a Saudia L-1011 TriStar killed 301. In 1983, an off-course Korean Airlines 747 was blown out of the sky by a Soviet fighter, killing 269. In 1985, an explosive decompression downed a Japan Airlines 747 with the loss of 520 lives. In 1988, a US Navy surface-to-air missile downed an Iran Air A300 with the loss of 290 lives. In 1996, a mid-air collision between a Saudia 747 and a Kazakhstan Airlines Il-76 killed 349. In 2014, a Russian-made missile downed a Malaysia Airlines 777 killing 298. In October 2018, a Lion Air Boeing 737 Max 8 crashed shortly after take-off from Jakarta. In March 2019, an Ethiopian Airlines 737 Max 8 crashed shortly after take-off from Addis Ababa. A total of 346 passengers and crew died in the two disasters.

Aviation has, by its nature, the capacity to kill large numbers of people in an instant. Given the human, financial and reputational costs of disaster, the industry is tireless in its pursuit of new thinking on safety. Occasionally, academia helps. For example:

Coupling, complexity and the human touch

In the 1980s, American safety advocate Professor Charles Perrow suggested that coupling and complexity are inversely related to reliability and resilience. That is, the more tightly coupled (linear) and complex a system, the less reliable it is. Perrow's safety formula links reliability with simplicity, redundancy and 'slack' (buffers).

More recently, Professor Erik Hollnagel has argued that when things go awry, operators (for example, pilots), must be able to make timely and effective interventions. In Hollnagel's socio-technical conception of safety (known as Safety-II), the operator is considered an asset rather than a liability. Frequently, it is the employee who saves the day. In 1983, a Soviet military satellite mistook reflected sunlight for missile launches during NATO's annual Able Archer exercise. Soviet defence computers informed the duty officer, Stanislav Petrov, that the United States had launched five ballistic missiles against the USSR. Protocol required Petrov to recommend a retaliatory strike. However, Petrov judged that the satellite trace was a false alarm (a 'false positive'). He reasoned that the United States would have launched all its missiles in a first strike. Using his judgment and intuition, Petrov decoupled the USSR's tightly-coupled missile-defence system and, arguably, saved the world from accidental nuclear war. In a paper titled Close Calls with Nuclear Weapons, the Union of Concerned Scientists notes: "The strongest, and one of the few, safety links in the chain was the judgment of the officer in command of the early warning centre". Despite the bellicose context – heightened East-West tension fomented by US and Soviet leaders, a large military exercise and the recent downing by Soviet fighters of a Korean Airlines Boeing 747 – Petrov maintained his capacity for reason. The 1983 near-miss demonstrated the importance of affording those in charge of automated

Pexels

systems opportunities to exercise judgment. Petrov's management of the incident to a satisfactory conclusion supports Hollnagel's argument that operators make a net positive contribution to safety and reliability: "Things do not go right because people behave as they are supposed to, but because people can, and do, adjust what they do to match the conditions .... As systems ... introduce more complexity, these adjustments become increasingly important".

The saving of US Airways Flight 1549 in 2009 by Captain Chesley Sullenberger, First Officer Jeff Skiles and flight attendants Donna Dent, Doreen Welsh and Sheila Dail, is the best recent example of operators' contribution to safety. On January 15, 2009, US Airways Flight 1549, an Airbus A320 carrying 155 passengers and crew, encountered a flight of Canada geese. Canada geese have a wingspan of around six feet and can weigh up to eighteen pounds. The bird-strike, which happened at 2,900ft with the aircraft making 200 knots, disabled both engines. Drawing on their experience, skill and judgment, Sullenberger and Skiles 'worked the problem'. In his autobiography, Sullenberger recalled the moment the birds struck: "The symmetrical loss of thrust ... was shocking and startling .... I could feel the momentum stopping, and the airplane slowing .... Within eight seconds of the bird strike ... I knew that this was the worst aviation challenge I'd ever faced. It was the most sickening, pit-of-your-stomach, falling-through-the-floor feeling I had ever experienced". Having taken control, Captain Sullenberger elected to ditch his stricken aircraft in the Hudson River. For Sullenberger, this was the least-worst option. "We're gonna be in the Hudson" he announced to air traffic control, then proceeded to execute a text-book ditching.

Flight 1549's passengers were saved not by automation, but by the flight-deck's capacity for seat-of-the-pants flying. They were saved by a Captain who had soloed on just seven hours and twenty-five minutes flying, had flown fast jets in the United States Air Force and had been a commercial pilot for nearly 30 years. They were saved by a Captain who, drawing on his experience, picked the least-worst option. As happened during the 1983 missile crisis, lives were saved because operators were able and willing to exercise judgment. In Perrow's argot, lives were saved by introducing slack into a tightly-coupled system.

In July, 2018, Reuters reported that: "Airplane manufacturers are working ... to build new cockpits designed for a single aviator in order to ease a global pilot shortage and cut airline costs". Asked to comment, Cranfield University's Professor Graham Braithwaite said: "The technology to fly an aircraft on automatic is brilliant .... We are really short of pilots. They are a very expensive resource". Those who advocate single-pilot flight-decks should ask themselves whether Sullenberger could have saved Flight 1549 on his own. In his autobiography, Sullenberger praised his First Officer: "Jeff and I had met just three days before .... Yet during this dire emergency – with no time to verbalise every action and discuss our situation – we communicated extraordinarily well. Thanks to our training and our immediate observations in the moment of crisis, each of us understood the situation, knew what needed to be done, and had already begun doing our parts in an urgent, yet co-operative fashion".

heory and practice

***Simon Bennett** provides an overview of aviation safety*

Arguably, if Sullenberger had been alone on the flight-deck he would have been overwhelmed. As to Braithwaite's claim that today's automatics are 'brilliant', during my two decades on the flight-deck I have witnessed numerous malfunctions, including of the autopilot.

Despite the proven safety benefits of a two-person flight-deck, the one-person flight-deck is still mooted. In a September, 2010, interview with the *Financial Times*, Ryanair Chief Executive Michael O'Leary claimed that short-haul flights could be operated safely by a single pilot. Following O'Leary's claims, Ryanair said: "We are starting the debate so that we can look to reduce costs without compromising safety .... Given the sophistication of our aircraft [the Boeing 737 was designed in the 1960s] we believe that one pilot flying can operate safely on short routes and reduce fares for all passengers". In August, 2018, Boeing's vice president Steve Nordlund talked about the airframer's plans for the flight-deck: "I don't think you'll see a pilotless aircraft ... in the near future .... But what you may see is more automation and aiding in the cockpit, maybe a change in the crew number up in the cockpit".

The single-pilot flight-deck, while economically attractive, is an accident waiting to happen. What if the pilot is taken ill? What if, as happened to Germanwings Flight 9525, the pilot decides to commit suicide-by-aircraft? What if, as happened to US Airways Flight 1549, the flight-deck finds itself processing inputs and deciding options under extreme time pressure? Airframers and CEOs should re-familiarise themselves with the phenomenon of 'task saturation' – something I have witnessed on the flight-deck. One of the pillars of safety is the monitoring and cross-checking by one pilot of the decisions and actions of the other. Removing one of the pilots removes this safeguard. Having a back-up pilot on the ground – so-called 'distributed crewing' – is no substitute for having a pilot on the flight-deck. The industry would be well advised not to jeopardise its improving safety record to save a few dollars. Professor Erik Hollnagel has spent his career encouraging designers to think of operators (for example, pilots) not as liabilities, but as assets. "Humans are ... a resource necessary for system flexibility and resilience [providing] flexible solutions to many potential problems" notes the Professor. For his part, Chesley Sullenberger is convinced that he would have lost his aircraft had Jeff Skiles not been at his side: "If Jeff Skiles had been on the ground ... there's absolutely no way. It could not have been".

Common-cause failures

A common-cause or common-mode failure sees multiple systems disabled by a single failure. The International Organisation for Standardisation (ISO) defines common-cause failures as "failures of different items, resulting from a single event, where these failures are not consequences of each other". The complexity, coupling and density of aircraft create opportunities for common-cause failure. In 1989, a United Airlines DC-10 suffered a catastrophic engine failure at 37,000ft that severed all three of the aircraft's hydraulic lines, leaving the crew having to use differential thrust (from the number one and number three engines) to control the aircraft. Author Andrew Brookes explains that the destruction wrought by the disintegration of engine number two was absolute: "When the [engine number two] fan-disk disintegrated ... it flung out shrapnel in all directions. Fifty hits were found in the tail structure, including one measuring 10 x 12 inches, and among other effects, the debris burst severed the three separate hydraulic lines .... Experts were unsure whether any hydraulic system could have survived the disintegration that befell United Flight 232". The loss of control experienced by Captain Al Haynes and his crew was the product of a common-cause or common-mode failure – a single event (the fan-disk disintegration) taking down multiple systems (the DC-10's three independent hydraulic systems). There is a positive relationship between density and vulnerability. The denser an aircraft (that is, the more tightly-packed its systems), the more vulnerable it is to common-cause or common-mode failure. The addition of new elements such as in-flight entertainment (IFE) systems is making aircraft denser – and more vulnerable.

Opacity and intractability

Complex, high-speed systems with limited feedback are difficult to control. Operators struggle to understand them. Opacity and intractability make it difficult, or impossible, for operators to take back control in an emergency. The problems of opacity and intractability were first discussed by political scientists Eugene Burdick and Harvey Wheeler in their best-selling 1962 novel *Fail-Safe*. The novel's premise – that machines are fallible – is pertinent today. The novel describes how an unanticipated and difficult-to-analyse malfunction in a defence computer sees a squadron of B-58 Hustlers tasked to eliminate Moscow. The film of the book contains noteworthy observations. During a seminar, General Black (played by Dan O'Herlihy),

Steve Riot

observes: "We're going too fast. Things are getting out of hand .... We are setting up a war machine that acts faster than the ability of men to control it. We are putting men into situations that are getting too tough for men to handle .... We have got to slow down".

Automation is framed as the answer to society's many ills, from creaking health services (computer-based triage) to road deaths (driverless cars). In *Fail-Safe*, Burdick and Wheeler drew attention to automation's *inherent* dangers. In 1983, social scientist Lisanne Bainbridge revisited the evils of opacity and intractability in her seminal paper 'Ironies of Automation'. She wrote: "If the human operator is not involved in on-line control, she or he will not have detailed knowledge of the current state of the system. One can ask what limitations this places on the possibility for effective manual takeover, whether for stabilisation ... or for fault diagnosis". More recently, Pamela Munro, a Boeing human-factors specialist, has argued that pilots must be kept in the loop: "Engineers don't always realise that automation can lull people into complacency .... People are expected to be able to jump in when something goes wrong, but if they haven't been getting feedback, they lose the ability to analyse the situation". In his June 2019, testimony to the Aviation Subcommittee of the United States House Committee on Transportation and Infrastructure on the Boeing 737 MAX 8 crashes, Captain Chesley Sullenberger said: "We must ... provide detailed system information to pilots that is more complete .... We should all want pilots to experience ... challenging situations for the first time in a simulator, not in flight with passengers and crew on board".

"Examination of their last training records and check-rides made it clear that the co-pilots had not been trained for manual aeroplane handling of approach to stall and stall recovery at high altitude" noted the BEA.

In 2009, an Air France Airbus A330, en-route from Rio to Paris, plunged into the sea from altitude, killing everyone on board. According to the Bureau d'Enquêtes et d'Analyses (BEA), immediate causes included "obstruction of the pitot probes by ice crystals that ... caused ... autopilot disconnection", "the crew not identifying the approach to stall" and "the crew's ... lack of inputs that would have made it possible to recover from [the high-altitude, high-speed stall]".

Proximate causes included the flight-crew's inability to quickly access angle-of-attack data, and the airline's failure to train stall-identification and recovery skills.

Regarding the former issue, the BEA noted in its July 2012 Final Report: "The aeroplane's angle-of-attack is not directly displayed to the pilots .... It is essential in order to ensure flight safety to reduce the angle-of-attack when a stall is imminent. Only a direct readout of the angle-of-attack could enable crews to rapidly identify the aerodynamic situation of the aeroplane and take the actions that may be required. Consequently, the BEA recommends ... that the European Union Aviation Safety Agency and the Federal Aviation Authority evaluate the relevance of requiring the presence of an angle-of-attack indicator directly accessible to pilots on board aeroplanes".

Regarding the latter issue, the BEA's report stated: "Examination of their last training records and check-rides made it clear that the co-pilots had not been trained for manual aeroplane handling of approach to stall and stall recovery at high altitude". The angle-of-attack data display issue, together with the crew's inadequate stick-and-rudder skills, created a perfect storm of latent errors (see the work of Professor James Reason) that increased the chance of mishap. A latent error is an accident waiting to happen.

When automation inhibits situation awareness to the point where it is no longer possible for an operator to remedy a malfunction, consideration should be given to removing or re-engineering the system in question. Lives may depend on it. Despite the claims of Steve Nordlund, Michael O'Leary and others, automation is not a panacea. Sometimes it is lethal. The compensation claims and premium hikes resulting from an aircraft careening into a terminal because its single pilot suffered a heart-attack on short-finals will eclipse the dollars saved by eliminating a crewmember. United Airlines Flight 232 was saved neither by a computer nor by distributed crewing. It was saved collegially *in situ*, by Captain Al Haynes, First Officer William Records, Flight Engineer Dudley Dvorak and Check Pilot Dennis Fitch. Haynes is convinced that he could not have saved the aircraft on his own: "We had 103 years of flying experience there in the [DC-10's] cockpit, trying to get that airplane on the ground, not one minute of which we had actually practiced, any one of us. So why would I know more about getting that airplane on the ground ... than the other three? So if ... we had not let everybody put their input in, it's a cinch we wouldn't have made it". In 1991, The Honourable Company of Air Pilots bestowed on Captain Al Haynes the Hugh Gordon-Burge Memorial Award. An industry that ignores men of integrity like Al Haynes and Chesley Sullenberger is heading for a fall. **AI**

Protecting Cyprus

***Ian Harding** and **Neil Dunridge** report from Andreas Papandreou Air Base on the Kypriaki Stratiotiki Aeroporia*

At 08:00 hours engineers from 450 Mira Elikopteron Aeroskafon (Helicopter Squadron) are conducting pre-flight checks on three Mil Mi-35Ps and two Aérospatiale SA-342L1 Gazelles. Conducting a combination of offensive, defensive and special operations within the Cyprus Flight Information Region, the squadron maintains a constant state of readiness in a politically sensitive region.

The Kypriaki Diikissi Aeroporias (Cyprus Air Force Command) was established in 1987 shortly before the arrival of six, sandy coloured SA-342L1 Gazelle anti-tank helicopters subsequently delivered in January 1988. Two Pilatus PC-9s followed one year later followed by a single BN-2B Islander, but these types are now withdrawn from service. Established in 1995, 55 Combat Group, a subordinate unit to the Cyprus Air Force Command, currently comprises two helicopter squadrons operating from Andreas Papandreou Air Base, a military facility located on the north side of Paphos International Airport. Each squadron comprises two platoons, each platoon operates a single type.

450 Helicopter Squadron

Established on October 15, 2001 to operate Mil Mi-35Ps (delivered in July 2001), the significance of the arrival of the Russian gunships is reflected in the squadron's emblem, which alongside a black panther, contains 12 stars, one for each Mi-35P acquired. One aircraft was lost in July 2006.

Training of the initial aircrew cadre was conducted in Russia by the Russian Army, but the squadron now uses its four remaining SA-342L1 Gazelles to do so. The strong association Cyprus shares with Greece is reflected in the training as Lieutenant Colonel Savva Kypros; Commanding Officer of 450 Helicopter Squadron and a Mi-35P instructor pilot explained: "Our pilots commence initial flight training at Tatoi Air Base [Dekhelia, near Athens] on the Cessna T-41D and now the Tecnam P-2002JF, before commencing fast jet training at Kalamata Air Base [Kalamata, Peloponessus] on the Textron T-6 Texan and finally the Rockwell T-2E Buckeye. We are like no other helicopter squadron in Europe, because we provide our pilots with fast jet experience, which I believe prepares them

Photographed during a SAR crew training mission, the hoist aircrewman operates the winch as a rescue swimmer recovers a training dummy.
All images Ian Harding and Neil Dunridge

better. When you see the Mi-35P for the first time, you ask yourself, how will this heavy flying-tank get airborne? Once it leaves the ground, you realise how powerful and responsive the helicopter is.

"Initial helicopter pilot training is completed on the Gazelle which takes approximately 50 flight hours. Those pilots selected for the Mi-35P complete basic and operational flight training. They start as the co-pilot [pilot operator] in the front seat before moving to the back seat as the commander [pilot in command] after approximately 300 flight hours if successful; a standard crew also includes a flight engineer."

Pilots confirmed the Mi-35P is a reliable but demanding helicopter to fly, and reinforced the importance of crew resource management due to the cockpit ergonomics. Daily training flights reinforce this ethos. The squadron forward deploys, regularly participates in exercises and undertakes live firing at nearby ranges several times a year to stay current as Lieutenant Colonel Kypros explained: "During missions, the pilot operator works as a navigator and communicates with both Army and Air Force Joint Terminal Attack Controllers using secure communications, whilst the pilot in command flies the helicopter. As commander, the pilot plans and takes the operational decisions including the position of the helicopter formation which often includes other helicopter types like the Gazelle if we conduct dissimilar formations. The big advantage of the Gazelle is its size; it is very difficult to spot and when we fly with them on low-level missions, we can lose sight of them if we don't keep them in our view."

Pilots consider the Gazelle a reliable and agile aircraft, perfectly suited to Cyprus' rugged terrain, given its ability to fly low and disappear from sight thanks to its camouflage. With its standard two-man crew, Cypriot Gazelles are capable of carrying four HOT-2 or HOT-3 missiles (High subsonic, Optical, remote-guided, Tube-launched second-generation anti-tank missile) which have a range of approximately 2 nautical miles (4km). Targeting is completed by the pilot in the left-hand seat using a targeting sight.

One day per week is dedicated to night flying using night vision goggles. Given the local terrain, intense seasonal heat and

450 Helicopter Squadron
1st Platoon **SA-342L1**
2nd Platoon **Mi-35P**

460 Search and Rescue Squadron
1st Platoon **AW139**
2nd Platoon **Bell 206L3**

Seen here along Cyprus' southern coastline, AW139 serial number 702 has recently returned from Belgium following depot-level maintenance with a new colour scheme.

humidity, this requires specialist training. Safety is paramount and flight operations stop if a specific combination of humidity and temperature is achieved.

460 Search and Rescue Squadron

Established on May 25, 2010 when the Cypriot government took exclusive responsibility for national search and rescue missions, 460 Search and Rescue Squadron is one of the nation's newest squadrons. It currently operates three AgustaWestland AW139s delivered between December 2010 and July 2011, and two Bell 206L3 Long Ranger helicopters which were transferred from 449 Helicopter Squadron in 2010. The two Bell 206L3s are fitted with a VIP cabin configuration and fulfil a range of duties which include liaison and most importantly crew training in a similar fashion to the Gazelle. Those aircrew that transition to the AW139 require approximately 150 flight training hours in the Bell 206.

The AW139s primary role is maritime search and rescue, which along with the AW139s operated by the Cyprus Police based at Larnaca International Airport, is coordinated by the Cyprus Joint Rescue Coordination Centre (JRCC); an independent agency of the Ministry of Defence based in Larnaca. JRCC determines which agency is best placed to undertake specific SAR tasks.

The squadron has a diverse range of secondary tasks which include parachute dropping, medical evacuation, aerial photography, firefighting, personnel transport and tactical operations. After becoming Commanding Officer on August 30, 2019, Major Panoyiotis Athinodorou made his first command decision which was to redesign the colour scheme of AW139 serial number 702, which now carries distinctive dayglo markings, SQN 460 and Cyprus Air Force titles.

Major Panoyiotis Athinodorou said: "We completed our day-night SAR crew training within one year. A flight crew comprises two pilots, one hoist aircrewman and one rescue swimmer. Each year our pilots return to Sesto Calende in Italy for continuation training which comprises a two-day course and three days of simulator work.

"On 24-hour duty, we aim to be airborne within 30 minutes for SAR, and 45 minutes for

Initial pilot training for 460 Helicopter Squadron is carried out on the Bell 206L3 Long Ranger, which is also used for VIP and liaison flights. Pilots then progress onto the AW139.

AW139 serial number 702 waits to approach a cliff face during a crew conversion training mission.

firefighting. For the latter we have to connect the bambi-basket and complete other weight checks, but we are normally airborne within 15 minutes. Our medevac target is 45 minutes as we have to determine which hospital [Nicosia or Paphos] will receive us based on the injury. If necessary, we can attach a triple stretcher weighing approximately 150kg (330lb) to transport patients. When off-base, aircrew are on a three-hour call notice. Aside from normal SAR tasking, regular calls involve rescuing refugees. During one incident approximately 27 nautical miles (50km) off-shore, we rescued 25 people in two hours in very rough sea conditions. I flew as the pilot with another aircraft from the Police. Winching was very difficult on this occasion as the boat's height varied in the swell making it difficult to gain a reference point, plus some people reacted very badly with one refugee jumping into the water. We flew them to Larnaca Airport where the Justice Department had organised ambulances for hospital transfer."

The squadron's firefighting duties commenced in 2014 following specific Police training. Major Athinodorou confirmed the intense Cyprus firefighting season extends from May 1 to November 15, with a national firefighting plan called Ikaros that coordinates the various assets involved. These include Police and Forestry Department helicopters. Russian Kamov Ka-32s from PANH Helicopters leased by the Republic of Cyprus government and stationed at Paphos International Airport, plus Royal Air Force Griffin HT1s from 84 Squadron based at Royal Air Force Akrotiri.

In the near future, Major Athinodorou hopes to have operating procedures in place to enable his aircrews to exercise with the 84 Squadron. He said: "For a firefighting mission we fly with a three-man crew comprising a pilot, co-pilot and hoist operator. The bambi-basket carried weighs 2,650lb [1,200kg] but we generally don't fill it with water because of the distance we have to travel to the fire, the reservoir height we collect from, and the hot and high conditions we face fighting the fire. Our crews are also restricted to two firefighting missions per day, so I have to switch crews."

The squadron has completed a number of exercises in Cyprus with other nations keen to share knowledge and has also participated in two overseas exercises; Aetos 2016, a SAR exercise held within the Greek FIR east of Rhodes and Inihios 2019 at Andravida Air Base, home of the Hellenic Air Force Air Tactics Centre. This was the first time the squadron had participated in such a large-scale international exercise during which it completed both SAR and combat search and rescue missions. During the week long flying phase the squadron participated in the complex briefing process and completed six missions; the first time it had flown as part of a large Composite Air Operation comprising over 20 fighter aircraft and other helicopters. In one mission 460 Helicopter Squadron worked with JTACs calling in strikes, and another as a CSAR asset collecting a pilot who had completed a simulated ejection.

Maintenance

Each squadron has its own engineers who are responsible for completing flight line (level one) and base (level two) maintenance for their respective aircraft in accordance with manufacturer's technical documentation. All depot level maintenance takes place overseas; St Petersburg and Rostov in Russia for Mi-35Ps and Belgium where one AW139 is currently undergoing heavy maintenance and specific structural inspection.

During AIR International's visit to Andreas Papandreou Air Base, 450 Helicopter Squadron had seven Mi-35Ps and three Gazelles operational, with its remaining aircraft in scheduled maintenance. The squadron's objective is to retain a 100% operational capability across the fleet.

Second Lieutenant Giorgos Karavias said: "Mi-35P base maintenance is completed after approximately 200 flight hours and takes approximately 20-man days. Unlike the Gazelle, the Mi-35P requires a lot of maintenance hours because of the number of lubrication points. Its Klimov TV3170 engine is very reliable, but salt corrosion is an issue due to our location. We therefore complete an engine and compressor wash every three hours. Most issues, are picked up during the pre-flight checks which is an engineering responsibility. In the case of the Mi-35P, these are completed approximately 90 minutes before the aircraft is required for a mission; less for the Gazelle."

The Gazelle helicopter is used by the Kypriaki Diikissi Aeroporias for airborne forward air control.

Major Marios Constantinou, Chief Engineer with 460 Helicopter Squadron, confirmed the unit hopes to have all three AW139s available by the end of the year. However, the AW139s are also experiencing corrosion issues. He said: "The main issue with the AW139 is corrosion control effecting both the airframe and some dynamic components. We protect the helicopter daily, which is very difficult to accomplish because we fly so low over salt water. We wash the engines every day as per the maintenance manual using either chemicals or just water, and are trained to rectify minor structural issues. However, we sent one aircraft to Belgium after 1,200 flight hours because we needed structural support, plus an independent check is helpful. Despite this specific issue, our AW139 serviceability record has been good over nine years of operation. The Bell 206 is a very nice helicopter, old but very reliable, easy to maintain and excellent for training."

The Cyprus Air Force plans to further upgrade its future capability, though no plan has been finalised. Local media reports have suggested the Air Force may upgrade its attack helicopter capability. On October 8, local media also confirmed that the Cyprus government has acquired four Israel Aeronautics Aerostar Tactical unmanned aerial systems at a cost of €12 million. The unmanned air vehicles will be used to monitor the Cyprus Exclusive Economic Zone. **AI**

An Mi-35P over the Asprokremmos reservoir.

Tomorrow's airliners

What might airliners look like years from now? Mark Broadbent rounds up some of the research projects into future concepts

The CityBird is a low-wing configuration concept airliner with aft-mounted engines, a small and faired landing gear and a high-lift system designed for short take-off and landing operations from inner-city airports.
Bauhaus Luftfahrt

Airliners have mostly always had the same basic fuselage tube and wing configuration, whether it is a large twin jet or a small turboprop, but innovations in design, materials and production mean numerous research projects are underway exploring new airframe configurations and power sources.

Blended wing body

One especially striking concept is a blended wing body (BWB) concept. A BWB looks like a cross between a conventional aircraft and a flying wing, with no line between the wings and the fuselage. The cabin, cargo hold and fuel tanks are integrated into a single structure and the engines mounted high on the rear fuselage.

The BWB concept is not new. Indeed, research into it can be traced as far back as the 1920s, but recent times have seen greater interest in it. Building on its research into the concept in the 1990s, NASA worked with Boeing's Phantom Works division in the 2000s to explore BWB designs, resulting in the two Boeing X-48 subscale UAVs (built, incidentally, in the UK by Cranfield Aerospace Solutions) that flew between 2007 and 2011.

The X-48 flight testing, carried out at the then NASA Dryden (now Armstrong) Flight Research Center, focused on the low-speed, low-altitude flight characteristics of the BWB configuration, including engine-out control, stall characteristics and handling qualities.

More recently, in 2016, Boeing and NASA conducted further BWB concept wind tunnel testing using a 6%-scale 13ft (4m) wingspan BWB model in the 22ft (6.7m) Subsonic Tunnel at the NASA Langley Research Center in Virginia. The aim was to validate BWB testing methodology by mapping airflow over the fuselage using lasers and smoke.

Boeing said it sees a use for BWB, "possibly beginning with military transport variants for airlift and aerial refuelling", but with the technology offering aerodynamic efficiency and quiet operations (the high-mounted engines shield noise) there is clearly potential for BWB in the commercial arena. Boeing said some of the wind tunnel work was part of NASA's Environmentally Responsible Aviation programme to develop technologies to improve fuel efficiency, lower noise and reduce emissions.

The Flying-V concept is supported by KLM. *TU Delft*

A BWB concept does have downsides. Boeing Vice-President Product Development and Future Airplane Development Mike Sinnett told an American Institute of Aeronautics and Astronautics meeting in 2018, reported Leeham News and Comment, that although a BWB is efficient it carries more empty weight than a tube-and-wing configuration, because it requires more fuel. The large wingspan might also present obstacles for airport compatibility, Sinnett said.

Flying-V

Another BWB research concept intends to tackle this potential compatibility issue. The Flying-V concept from TU Delft in the Netherlands, which has received support from KLM, is designed to be compatible with existing infrastructure. At 55m (180ft) in length and 17m (55ft) in height, with a 65m (213ft) wingspan and capacity for 314 passengers, it would have the same wingspan, passenger capacity and cargo volume as the Airbus A350-900.

TU Delft says the Flying-V is designed with current-generation turbofan engines in mind while also being adaptable for electric or hybrid-electric engines, and that the aerodynamic shape and reduced weight will mean it uses 20% less fuel than an A350-900.

TU Delft has conducted wind tunnel testing campaigns into the Flying-V's aerodynamics, structure, airframe-engine integration, cabin design and expected flight characteristics. Data has been acquired through balance measurements and flow visualisation techniques to study specific aerodynamic characteristics such as stability, angle of attack and lift-to-drag ratio. TU Delft has said it intends to fly a scale model of the design by the end of this year.

CityBird and Ce-Liner

As the CGI renderings released by manufacturers or developers show, BWB concepts catch the eye because of their look, but they are not the only rakish future airliner concepts out there.

The German research institution Bauhaus Luftfahrt (the name is a reference to the famous Bauhaus art and design school) has worked on several ideas. It has a concept called CityBird for an aircraft with a low-wing configuration, aft-mounted engines, a small and faired landing gear and a high-lift system along the entire span of the wing. It is designed for short take-off and landing operations from inner-city airports, yet also to offer high levels of efficiency and speed.

Another Bauhaus Luftfahrt concept is the Ce-Liner for a zero-emission aircraft with

Blended wing body configurations continue to interest NASA, with joint tests using a 13ft-wingspan model in the 22ft Subsonic Tunnel at the NASA Langley Research Center. *NASA*

189 seats (or up to 233 in an extended-fuselage variant) using 100% electric engines mounted on the rear fuselage in a distinctive 'C-wing' design.

Novelties of the Ce-Liner are two ducted fans driven by high-temperature superconducting electric motors, advanced lithium ion batteries carried in specially adapted LD-3 cargo containers positioned side by side, and a 'self-trimming' wing using morphing techniques to adapt its shape constantly to varying flight conditions.

Distributed power

A separate Bauhaus Luftfahrt concept called the Propulsive Fuselage relates to a distributed propulsion system, where conventional wing-mounted turbofan engines power electrical generators that drive smaller motors and fans to improve wing and engine performance and reduce energy use.

This is an example of the move to research electric and hybrid-electric technologies, which itself is part of the wider momentum across industry for cleaner and more sustainable technology (see also Back Pages, this issue). Research into turboelectric systems that use electrical power to drive engines and hybrid-electric systems (that use both conventional fuel and energy storage systems) is another big research area.

The Institute of Propulsion Technology at the DLR (German Aerospace Centre) is investigating and developing new architectures with electrically powered or distributed engines under the EU's Clean Sky 2 aeronautics research programme. It is coordinating work packages for the development of design and evaluation methods, the entire operating cycle of the engine, the fan design (the fan generates the thrust), aeroacoustics, aeroelasticity and structural mechanics.

NASA's Aeronautics division is working on concepts in this area in the Subsonic Ultra Green Aircraft Research (SUGAR) programme. One part of this project, SUGAR Freeze, aims to achieve a 70% reduction in carbon dioxide emissions with a partially turbo-electric architecture that generates power in flight by integrating a solid oxide fuel cell with the turbine engine, with the resulting electrical energy used to drive an aft propulsor at the tail of the aircraft.

Another part of the SUGAR project is SUGAR Volt, a concept for a hybrid-electric aircraft using onboard batteries to drive a motor attached to the turbofan engine augmenting the shaft speed during the cruise phase. The idea is to reduce the amount of jet fuel required to produce thrust from the engine and cut emissions.

Separate to SUGAR, another NASA distributed power concept is STARC-ABL for a single-aisle turboelectric aircraft. In this concept, high-power generators are integrated with two wing-mounted turbofan engines. In addition to producing thrust, these generate megawatts of electricity to power cabin cooling and instrumentation.

A further NASA distributed power concept is N3-X, for a large fully turbo-electric twin-aisle passenger aircraft that uses wing-mounted turbo-generators powered by liquid hydrogen fuel. Each generator will distribute 30 megawatts of power to 14 motor-driven fans at the aft of the vehicle.

Boundary layer ingestion

Many future airliner research initiatives involve a concept called boundary layer ingestion (BLI), which involves using the boundary layer (an area of slower-flowing air that develops along an aircraft's surfaces as it flies) as a power source. In a BLI concept,

An artist's rendering of NASA's STARC-ABL concept hybrid-electric propulsion aircraft. *NASA*

The EU CleanSky Hyper-F research project, which involves the DLR, is one of several projects researching boundary layer-ingesting propulsion for new airliners. *DLR*

the engine inlet and fan are embedded at the back of the fuselage.

As its name implies, the fan ingests the slower boundary layer airflow to propel the aircraft. According to NASA's Glenn Research Center, engines using air in the boundary layer are more efficient because they do not work as hard, with the engines literally ingesting high-speed airflow.

NASA Glenn has tested a new Boundary Layer Ingesting Inlet/Distortion Tolerant Fan propulsor designed by United Technologies Research Center in its high-speed 8 x 6ft (2.4 x 1.8m) wind tunnel. Industry, NASA and academic experts contributed to the design and analysis.

NASA Glenn engineers modified the wind tunnel at the facility to accept the fan, installing an active boundary layer control system and complex instrumentation to measure the characteristics of the air coming into the model and the aerodynamic performance of the fan and inlet.

When it spoke about the research in 2018, NASA said the testing would involve researchers changing the wind tunnel speed and varying the boundary layer thickness and fan operation, "to see how these changes affect the propulsor's performance, operability and structure".

The agency said results of the tests will be applicable to "multiple cutting-edge aircraft designs" being pursued by NASA as well as by academic and private industry partners. The agency has not revealed any detail about the results, but said it plans to continue BLI propulsion technology research and development, testing fan designs in NASA Glenn facilities and applying them to aircraft design concepts being investigated by NASA and its academic and industry partners.

The BLI work has also fed into the STARC-ABL concept, which has a BLI thruster mounted in the tail, and the N3-X concept which has aft-mounted engines to 're-energise' the aft boundary layer.

The Bird of Prey is intended to inspire a new generation of designers with biomimicry features. *Airbus*

ONERA Nova

Research into BLI is not unique to NASA. Working under a European Commission-funded project called DisBURSAL, Bauhaus Luftfahrt is studying BLI in its Centreline project, leading the design of a turbo-electric version of the Ce-Liner involving a third tail-mounted turbine engine powering a BLI thruster.

At the DLR, researchers are investigating the potential of boundary layer-ingesting propulsion systems as part of the EU CleanSky Hyper-F research project. Focus areas are the interaction between unsteady airflow and fan design, acoustics, structural mechanics and the performance and operating characteristics of the entire propulsion system.

Separately, the French aerospace research centre ONERA is studying a BLI thruster in its Nova concept for a medium-haul transport aircraft able to carry 180 passengers on 3,000-nautical-mile (5,556km) routes at Mach 0.82. Nova is also exploring new possibilities for wing and engine options integration options, such as modifying the wing dihedral angle in its inner portion to a gull-wing shape, semi-buried engines in the fuselage fed by a BLI air intake, and a high-aspect ratio wing with downward-oriented winglets to improve aerodynamics.

ONERA also has a cooperative agreement with Airbus and the DLR to research computational fluid dynamics capabilities for flow prediction. This has created what Airbus calls a "common development and integration team with the capability to deliver tested and industry-ready code containing the latest state-of-the-art features relevant to aeronautics".

Biomimicry

Among other research projects for new airliner technologies, Airbus' Bird of Prey concept announced in July 2019 stands out. Although this project's primary purpose is simply to act as an inspiration for future aerospace engineers, it has nevertheless provided a striking representation of what a future turboprop-powered regional aircraft with around 80 seats could look like.

The Bird of Prey's most notable feature is a bird-like blended wing and tail structure, designed to mimic a bird of prey's aerodynamic profile. It has movable wingtip surfaces, mimicking an eagle's wings, to provide active flight control and minimise drag and noise. There is a split tail to provide control and no vertical tail to reduce drag.

Hypersonic airliner

The UK-based Reaction Engines has been working on technologies for its SABRE (Synergetic Air Breathing Rocket Engine) for propelling both high-speed aircraft and spacecraft for 30 years.

By combining the fuel efficiency of a jet engine with the power and high-speed ability of a rocket, the SABRE engine will be capable of Mach 25 in rocket mode for spaceflight, although the company says it, "can be scaled in size to provide different levels of thrust for different applications", with the engine also able to operate at Mach 5.4 in air-breathing mode.

The company says SABRE-powered high-speed airliners will be capable of cutting the flight time from London to Australia to four-and-a-half hours, with SABRE also being developed for a new generation of rockets to provide access to space.

In October 2019, Reaction Engines announced it had successfully tested an innovative precooler at airflow temperature conditions representing Mach 5. A ground-based test at a specially constructed facility at the Colorado Air and Space Port achieved the highest temperature objective of its HTX testing programme. The precooler successfully quenched airflow temperatures in excess of 1,000°C (1,832°F) in less than 1/20 of a second.

Reaction Engines said: "The tests demonstrated the precooler's ability to cool airflow at speeds significantly in excess of the operational limit of any jet-engine powered aircraft in history. This most recent test builds upon the success of previous HTX hot tests undertaken in April, which saw the precooler successfully operate at temperatures of 420°C (788°F) – matching the thermal conditions corresponding to Mach 3.3 flight."

The precooler heat exchanger is an enabling technology for other precooled propulsion systems and a range of commercial applications, the company said.

Opportunities?

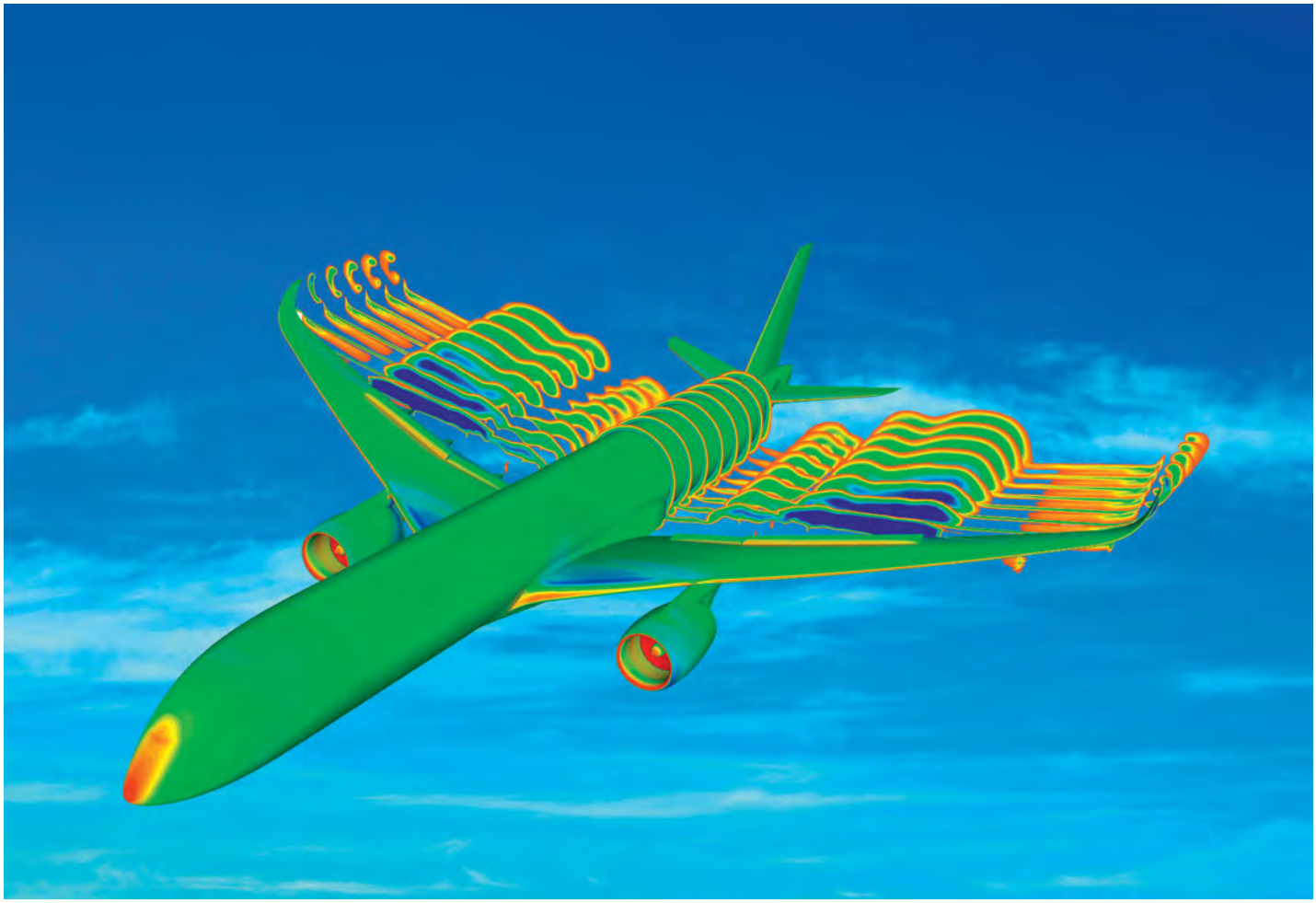
Despite all the various research activities underway into new power sources like these and new airframe configurations in which they could be installed, there is obviously a bigger question: will any of these futuristic concepts become reality?

All the different, potentially game-changing, disruptive technologies are being studied because they have very clear promise. As ONERA has observed, "the remaining gains to be obtained by [current aircraft] are now very low", which opens the door for more focus and investment in new configurations.

On the other hand, airliners with the type of exotic new technologies profiled in this article are trying to break the mould of an industry with mature aircraft, engines and systems and a very established infrastructure of suppliers, operators and airports supporting them.

The hundreds of thousands of flights carried out safely every day worldwide testify to this maturity. Moreover, aircraft with disruptive new technologies will, as ONERA has noted, "have to convince regulatory authorities and cost-sensitive decision-makers in the airline business".

Ultimately, the conventional tube-and-wing configuration has endured for decades because it works. Regardless of how novel technologies are, if ambitious futuristic visions are to move from concept to reality, they will need to be cost-effective, s calable and above all practical. ***AI***



Airbus, ONERA and the DLR are researching computational fluid dynamics. *Airbus*

Two F/A-18Ds break over Langkawi airfield during an airshow.
All images Nigel Pittaway

Malaysia's mi

The eight McDonnell Douglas F/A-18D Hornets in service with the Tentera Udara Diraja Malaysia (TUDM – Royal Malaysian Air Force) represent, together with the Sukhoi Su-30MKM, the cutting edge of Malaysian air power today.

In recent years, the small but capable fleet of Hornets have been called upon to drop weapons in anger in East Malaysia, flying strikes against armed insurgents, and have undergone a significant upgrade to keep them relevant into the next decade.

In 2018, the TUDM deployed Hornets to Australia for only the second time since they entered service in 1997, when five aircraft participated in Exercise Pitch Black 2018. During Pitch Black, the largest air combat exercise in the southern hemisphere, AIR International was privileged to visit the TUDM Hornet detachment in Darwin to find out more.

Hornets for Malaysia

By the early 1990s the TUDM was, from a technology standpoint, in danger of falling behind its rival, the Republic of Singapore Air Force, which was then introducing the General Dynamics F-16A/B Fighting Falcon, under a major modernisation plan.

In response, the Malaysian government under the leadership of Dr Mahatir Mohamad, then (as now) the country's Prime Minister, embarked upon its own modernisation plans for the TUDM in the early 1990s. Malaysia's most potent fighter at that time was the Northrop F-5E and F-5F Tiger II but the TUDM also had a requirement for an all-weather, multi-role aircraft. Reportedly unable to afford sufficient quantities of a western fighter design, the Government subsequently elected to purchase just eight Hornets and also acquire the (much cheaper) MiG-29N from Russia.

The F/A-18D Hornet was ordered in the middle of 1993 and the acquisition contract was subsequently signed on December 9, 1993. TUDM crews travelled to the United States to undertake training with the United States Marine Corps, who also operate the twin-seat F/A-18D version of the popular Hornet family. The TUDM aircraft subsequently arrived in Malaysia in two batches of four aircraft during 1997.

To operate the new aircraft, the TUDM established No.18 Skuadron (Squadron) at TUDM Base Butterworth, situated on the east coast of the Malaysian Peninsular opposite the resort island of Penang. Although their official name is Lipan (a local species of centipede) the squadron refers to itself as the 'Mighty Hornets' and their unit crest also aptly depicts a Hornet. The squadron is tasked with interdiction and maritime strike missions. In TUDM service, the Hornets carry the serials M45-01 to M45-08 and to date, none have been lost in accidents.

In-country support for the Hornet was provided by the original equipment manufacturer, initially by McDonnell Douglas before the company was merged with Boeing in August 1997. Boeing has continued to support Malaysia's Hornet fleet at Butterworth, including the completion of the fleet upgrade in 2017.

TUDM Hornets described

Malaysia's Hornets are similar to their twin-seat US Marine Corps equivalents, including a mechanically-scanned Raytheon APG-73 fire control radar, General Electric F404-402 engines and BAE Systems ALE-47 Airborne Countermeasures Dispenser System. The initial four aircraft (M45-01 to M45-04) are fitted with flight controls in the rear cockpit to assist local conversion and training, and the remainder have a rear cockpit in a similar configuration to the US Marine Corps F/A-18Ds operated by the all-weather attack squadrons.

Initial weapons included Raytheon's AIM-9L and AIM-9P Sidewinder, AIM-7M Sparrow, Boeing AGM-84A Harpoon anti-shipping missile, Bristol Aerospace CVR-7 rockets and a range of laser-guided precision weapons. As delivered, the targeting pod was the Lockheed Martin AAS-38 Nitehawk, but the recent upgrade has seen this replaced by a modern pod.

The aircraft wore an overall 'Gunship Grey' colour scheme on delivery but this is now giving way to a lighter shade, referred to by local sources as Air Mobility Command grey but, unlike the MiG-29N and F-5E and F-5F, Malaysia's Hornets have never worn permanent unit markings.

In December 2005 the US government approved the sale of Raytheon AIM-120 AMRAAM missiles to Malaysia for use on its Hornet fleet and these weapons had all been delivered by the middle of 2008. In April 2007, Raytheon was also awarded a contract by the US government for the upgrade of 57 TUDM AIM-9M missiles, with the work completed in 2009.

More sting for TUDM Hornets

The durability of the Hornet designed has served the TUDM well and it is worth noting that by the end of the last decade the service was struggling to keep its MiG-29N fleet in the air, whereas the F/A-18D was looking forward to a capability upgrade. Fast forward to the present day and the MiGs have long been withdrawn from use and even the much-vaunted and more recent Su-30MKM fleet is displaying very low serviceability rates.

Nigel Pittaway provides an overview of the Tentera Udara Diraja Malaysia's F/A-18D Hornet fleet

ity Hornets

At the Langkawi International Maritime and Aerospace exhibition in December 2011, Boeing announced it had won a major FMS contract for the design, development and installation of retrofit kits for the TUDM Hornet fleet, intended to enhance navigation, targeting and situational awareness. Included in the upgrade were a colour moving map cockpit display, enhanced Identification Friend or Foe capabilities and the addition of a Joint Helmet Mounted Cueing System. Software was also to be upgraded to the then-current 25X configuration.

At the time of contract award, Julie Praiss, director of Tactical Aircraft and Weapons Support at Boeing Global Services and Support, said: "These upgrades will deliver enhanced capability for the TUDM (Hornet) fleet to remain effective, interoperable with allies and operationally relevant for years to come. Boeing looks forward to our continued partnership with the Royal Malaysian Air Force and the US Navy to ensure that these F/A-18Ds continue to serve Malaysia's strike and interdiction mission needs."

Concurrent with this upgrade was the replacement of the Nitehawk targeting pod with the next generation Raytheon ASQ-228 Advanced Targeting Forward-Looking Infra-Red pod and the sale of the latest version of the Sidewinder missile, the AIM-9X-2 Block II weapon to Malaysia. Other weapons capabilities added during this process included global positioning system guidance kits for the Joint Direct Attack Munition (JDAM) series of precision weapons.

In 2012, L3 Link Simulation and Training was awarded a contract by the US Naval Air Warfare Training Systems Division for the supply of an F/A-18D Tactical Operational Flight Trainer to Butterworth in support of the upgraded aircraft. The trainer is capable of realistically simulating close formation flying, suppression of enemy air defences, and reconnaissance, forward air control, close air support and aerial refuelling missions, including the use of night vision goggles.

TUDM F/A-18D M45-01 painted with a full colour tail to mark the 20th anniversary of Hornet ops.

The TOFT includes two separate but linked cockpits, one each for the pilot and weapons systems operator and was subsequently delivered to Butterworth in December 2014. L3 Link vice president of strategic development, Frank Casano, said: "The F/A-18D Tactical Operational Flight Trainer delivered to the Royal Malaysian Air Force will provide a significant increase in training capability. This enhanced level of training will enable aircrews to prepare for the full range of force multiplier capabilities that the F/A-18D can support during rapidly changing battle scenarios."

Initial upgrade work was carried out by Boeing in St Louis, but all subsequent aircraft were upgraded at Butterworth, with the final aircraft completed in April 2015. In 2017 the Hornet celebrated 20 years of operational service with the TUDM and one aircraft (M45-01) was painted in special markings to commemorate the event.

Strike missions - Operation Daulat

Malaysia's Hornets went to war in 2013 in response to an incursion of armed militants from the Philippines in the Lahad Datu District of Sabah, East Malaysia, on the island of Borneo. The Malaysian Government declared an emergency in response to the conversion and the following stand-off was eventually resolved by a major military operation, which included the use of airpower.

Airstrikes were carried out by the Hornets of 18 Skuadron and BAE Systems Hawk Mk208s of 6 Skuadron against the intruders under Operasi (Ops) Daulat (Operation Daulat), the Malaysian Defence Force's combined response to the emergency. The first airstrike was carried out in

TUDM maintainers conduct post-mission checks at RAAF Base Tindal during Exercise Pitch Black.

The TUDM always provides a rigorous F/A-18D flight demonstration at the Langkawi airshow.

Lahad Datu on March 15, 2013, a month after the insurgents had arrived in Sabah by boat.

One F/A-18D aircraft (M45-07) released two 1,000lb (454kg) GBU-16 Paveway IIs in an airstrike on targets at Kampung Tando for the first time on the above date, reportedly marking the first use of the weapon under operational circumstances in the region. M45-07 was suitably marked with mission markings after the event to denote the type of weapons released and other TUDM Hornets noted with Ops Daulat mission markings include M45-01 and M45-02. When M45-01 was repainted to commemorate the 20th anniversary of TUDM Hornet operations during 2017, the Ops Daulat tally was amended to include the numbers of each weapon released, rather than just the type.

Mighty Hornets down under

TUDM Hornets first participated in a Pitch Black exercise in Australia in 2008 when six aircraft deployed from Butterworth to Darwin, marking their longest deployment since arriving in Malaysia in 1997. The six aircraft were supported on the flight by a Lockheed KC-130H Hercules from 20 Skuadron TUDM, which also participated in the exercise, regularly refuelling the F/A-18Ds on air combat missions. During Pitch Black 2008, the TUDM Hornets also regularly tanked from Royal Australian Air Force Boeing 707 tankers, which were then in the twilight of their operational careers.

Malaysia's Hornets regularly participate in Five Power Defence Arrangements exercises, such as Bersama Lima and Bersama Shield series, with RAAF Hornets and fighters from other partner nations on home soil, but their second major international deployment was again to Australia in 2018. Pitch Black 2018 (PB18) was also the first time the jets had participated in a large multilateral exercise since they were upgraded with the 25X software, JHMCS, ATFLIR and AIM-9X-2 capability.

Five F/A-18Ds were involved in Pitch Black 2018 (M45-01, 02, 06, 07, 08), together with a supporting Airbus A400M from 22 Skuadron (M54-04). The combined force departed Butterworth on July 24, 2018, flying via Kuching and Denpasar and arrived in Darwin on the following day.

The TUDM Hornets were based at Darwin for the duration of PB18, operating from a series of shelters, alongside RAAF F/A-18A/B Hornets from 77 Squadron. Using the squadron's Ghostrider callsign, the first TUDM Hornet PB18 sortie was flown by M45-01 and M45-06 on July 30, 2018 and during the exercise, 18 Skuadron participated in daily day and night sorties, operating as either Red air or Blue air as required by mission planners, during the large force employment (LFE) phase. The LFE Phase involved up to 80 combat jets, from nine nations and during this time, the TUDM Hornets were also cleared to receive fuel from the RAAF's Airbus KC-30A Multi-Role Tanker Transport.

During the first week of the two-week LFE Phase, AIR International spoke with Mejar (Major) Faiz Fauzi, callsign Havoc, a Hornet pilot with 18 Skuadron about his experiences.

Mej Fauzi said: "We are participating in the day and night missions during Pitch Black, mainly in the LFE phase. We have brought five jets down to Darwin, together with a maintenance force."

He added: "Operating as part of the LFE is different to back home, where we don't operate with so many assets, but here it's large scale – operating with different nations (and) different procedures and there are differences on the operations side. We have learned a lot, regarding procedures and how other nations operate, so we can bring some of the good things back home to learn and digest."

Although 18 Skuadron did not employ live air-to-ground weapons on the Delamere Air Weapons Range within the Pitch Black training area, it did simulate the use of 500lb (227kg) GBU-38 JDAMs during close air support missions.

Mej Fauzi, who has been flying the Hornet for four years, said: "We brought five jets and we fly four at any one time, we switch between Blue and Red air, but we're doing more flying for Blue. We are flying both air-to-air and air-to-ground missions during Pitch Black and the learning outcomes are not just from the air operations themselves, but also the exercise planning and so forth, there are lots to bring back home."

He added: "We brought the A400M, but we have also been tanking with the KC-30A. The A400M is dedicated to us but we also wanted to try tanking with other platforms. It depends on the mission, how long we want to stay in the fight, so we plan the tanking through the mission planning cell. We don't often deploy outside Malaysia for exercises and Pitch Black is our longest deployment."

Finally, describing the upgraded capabilities of the TUDM Hornet, Mej Fauzi said: "We use ATFLIR for the close air support part of the exercise, which gives us greater definition than the previous Nitehawk targeting pod. We've had AIM-9X in the inventory for the last two years, when we were upgraded to 25X software and that gave us JHMCS capability as well. Pitch Black was really challenging, but in a good way. We learned a lot during the exercise, and we will take a lot of the lessons learned back home." ***AI***

A TUDM F/A-18D uploads fuel from a Royal Australian Air Force KC-30A tanker during Pitch Black.

The crew of a RC-135 assigned to the 38th Reconnaissance Squadron based Offutt Air Force Base, Nebraska, prepare for night operations during Red Flag 16-3 at Nellis Air Force Base, Nevada.
Airman 1st Class Kevin Tanenbaum/US Air Force

Red Flag's big shift

*On the 44th anniversary of the first Red Flag at Nellis Air Force Base, **Mark Ayton** charts the origin, objectives and evolution of America's premier air warfare exercise*

A B-1B Lancer assigned to the 34th Bomb Squadron based at Ellsworth Air Force Base, South Dakota undergoes pre-flight checks during night operations at Red Flag 17-1.
Airman 1st Class Kevin Tanenbaum/US Air Force

For those readers fortunate enough to have visited the State of Nevada, the City of Las Vegas or indeed Nellis Air Force Base, you'll know what notable places they are. Find yourself at Nellis during a Red Flag exercise and you're likely to see witness and significant amount of flight operations. When the author first visited Nellis, during a Red Flag at least, in the summer of 1991, the exercise was a six-week long event, organised in three two-week phases. Each phase involved around 150 aircraft from all US armed services. Fast forward to this summer's Red Flag, and the event looks very different. Long gone are the six-week, three phase editions. Instead, a three-week one phase edition. No longer during Red Flag is the vast Nellis flight line rammed with 150 aircraft, mostly fighter/strike fighter types, but sprinkled with 80 or so aircraft. Not just fighters and strike fighters, but electronic attack, command and control, rescue and ISR aircraft, and of course tankers and strategic bombers.

Back in 1991, a Red Flag mission involved 100+ aircraft taking off from Nellis in a well-orchestrated flow, all bound for the Nevada Test and Training Range to the north. Modern day Red Flags involve quite considerably different take-off flows; more fragmented with fewer aircraft. The mix of aircraft seen in a modern day Red Flag does of course involve types that are much more capable than their predecessors of the late 1980s and early 1990s. Gone are the A-6 Intruders, A-7 Corsairs, F-4 Phantoms and F-14 Tomcats. In are EA-18G Growlers, F-15E Strike Eagles, F-16C Fighting Falcons, F-22 Raptors and F-35 Lightning IIs. Occasionally, B-2 Spirit bombers also participate.

A crew chief, assigned to the 4th Aircraft Maintenance Unit, launches an F-35A Lightning II at Nellis.
Ronald Bradshaw/US Air Force

Red Flag 1

The first edition of Red Flag started at Nellis on November 29, 1975 with five units, 37 aircraft and 561 personnel participating. Just 552 sorties were flown over a four-week period ending December 20, very few by comparison to modern day editions.

The Nellis-based 4440th Tactical Fighter Training Group, a component of the Tactical Fighter Weapons Center, held responsibility for implementation of the Red Flag programme designed to provide combat training for squadron size units, complementary support forces, and other major commands and services.

Lead unit was the F-4D Phantom-equipped 49th Tactical Fighter Wing based at Holloman Air Force Base, New Mexico tasked with strike missions against targets defended by Soviet surface-to-air missiles and anti-aircraft artillery batteries. Back then, the T-38 Talon and F-5 Tiger II-equipped 64th Fighter Weapons Squadron, the forerunner of today's F-16C-equipped 64th Aggressor Squadron, provided a Soviet-style Red air opposing force. Of the five Blue air units participating in Red Flag 1 was an unknown Wild Weasel F-105G Thunderchief squadron. The other three participating units remain unknown to AIR International.

Such was the success of Red Flag I that Tactical Air Command started a monthly exercise programme; ten were staged each year between 1976 and 1979. Unsurprisingly the number of sorties flown each year rocketed; 7,510 (1976), 14,987 (1977), 18,081 (1978), and 21,009 (1979). From 1980, Red Flag switched to a lower tempo programme, more similar to the modern day schedule.

Following the US Army's establishment of its National Training Center at Fort Irwin, California in 1981, the Air Force removed close air support from Red Flag transferring the CAS-specific training to a new exercise named Air Warrior.

Royal Australian Air Force F/A-18A Hornet A21-35 at Nellis during Red Flag 19-1. This aircraft is painted with a full colour tail marking the 75th anniversary of 77 Squadron. *Airman 1st Class Bailee Darbasie/US Air Force*

Electronic warfare units attended Red Flag for the first time in 1982, the same year that one edition was devoted to close air support.

The first edition of the FY1983 programme had a dedicated close air support unit as the lead unit, the same year that one edition involved aircraft from five of the Air Force's major commands (Air Force Reserve, Air National Guard, Military Airlift Command, Strategic Air Command and Tactical Air Command), the US Marine Corps and the US Navy.

Dedicated suppression of enemy air defence units attended for the first time in 1984 which helped open up the battlespace to allow deep strike and offensive counter-air operations to take place.

Red Flag planners introduced night operations on 92-1 by moving the day time afternoon mission to night time.

At a Red Flag staged in FY1995, the B-2 Spirit bomber made its exercise debut followed by regular appearances in subsequent editions.

In 2000, two Red Flag periods were classed as US-only editions, the so-called 'Black Flags' that included B-2 Spirit bombers, EC-130H Compass Call electronic warfare aircraft, RC-135 Rivet Joint reconnaissance aircraft, E-8 Joint STARS battle management, command and control aircraft, F-117 Nighthawk strike aircraft, U-2 surveillance aircraft and MQ-1 Predator unmanned aerial vehicles. Black Flags also involved various systems used to kinetically and non-kinetically target air defence networks.

In February 2004 a Combined Air Operations Center opened at Nellis. Dubbed CAOC-N, the facility remains at the heart of all training events conducted at the Nevada super base and enabled considerable change to the structure of Red Flag since its commissioning. The facility enables all units, systems and capabilities to plan and execute each mission in the live fly training environment with real time command and control.

Red Flag's 25th anniversary

In the November 2000 issue of Air Force Times, Walter Boyne wrote about Red Flag to mark its 25th anniversary. Boyne provided considerable background information behind the objectives for establishing Red Flag at Nellis. He wrote: 'During the Vietnam War, it became apparent that the overwhelming concern about flying safety in peacetime compromised air-to-air combat training to an unacceptable degree. The most tangible symptom of this failure was the decline in the exchange ratio (enemy losses vs US losses) between US Air Force and enemy forces. The exchange ratio obtained in the Korean War had been a highly satisfactory 10-to-1. In the Southeast Asian conflict, however, that exchange ratio fell to less than 1-to-1 during a period in the spring of 1972.

'There were reasons for this. Air warfare was focused on the air-to-ground dimension; American aircraft were employed in integrated strike packages designed to get bombs on important targets. They were opposed by a sophisticated defence system that incorporated anti-aircraft artillery, surface-to-air missiles, and interceptors operating under ground control.

Boyne highlighted the lack of dissimilarity in US Air Force air combat manoeuvre training at the time. He wrote: 'Up to that time, the Air Force had conducted almost all air combat manoeuvre training by matching identical aircraft - F-4 against F-4. Not only that, but US Air Force's training exercises usually featured duels between fighter aircraft from the same squadron.

US Air Force pilots were inhibited by rules of engagement requiring visual identification of the enemy and thus ensuring that air combat

MH-60 Seahawk pilots assigned to Helicopter Sea Combat Squadron 23 (HSC-23) prepare to lift off from Nellis on a combat search and rescue mission during Red Flag. *Airman 1st Class Bryan Guthrie/US Air Force*

An Air Force pilot is picked up by an MH-60 Seahawk assigned to Helicopter Sea Combat Squadron 23 (HSC-23) during a combat search and rescue mission at Red Flag 19-1. *Airman 1st Class Bryan Guthrie/US Air Force*

would occur at close ranges, where gun armament had an edge over missiles.

Boyne explained how, during the Vietnam War, the US Air Force conducted a thorough analysis of air superiority operations called Red Baron. The study demonstrated three sobering facts about USAF aircrews:

- The enemy often caught them by surprise.
- They had inadequate training for the mission.
- They were not fully informed about the enemy.

He wrote: "After Vietnam, one change was the renewed emphasis on training the human beings who had been shown in the Red Baron study to be poorly prepared for battle. Red Flag did not come into being fully formed. It derived from a series of ideas from different people over many years. In the March 1968 issue of the Fighter Gunnery Newsletter, an article noted a change in Tactical Air Command procedures calling for training in dissimilar aircraft. The Air Force in the fall of 1972 established the 64th Fighter Weapons Squadron at Nellis AFB, Nevada. It was equipped initially with T-38s and then with Northrop F-5E Tiger II aircraft. These small supersonic aircraft were used to simulate the MiG-21 in air combat manoeuvres. The resulting exercises [in which F-5Es participated] were deemed to be so useful that the Air Force fashioned a second squadron, the 65th Fighter Weapons Squadron, at Nellis and two more for overseas training.

An Airman assigned to the 388th Operations Support Squadron aircrew flight equipment shop, checks a mask for an F-35 pilot. *Ronald Bradshaw/US Air Force*

Boyne detailed how Major Moody Suter, a US Air Force officer who became known as the father of Red Flag, and a strong proponent of the aggressor squadron concept had worked out the training programme at Nellis. He wrote: "Suter was visualizing a large-scale combat training operation going beyond mere air-to-air combat manoeuvring. He saw it from the start as a means of improving and extending the ability of Air Force integrated strike packages to get to their targets with maximum accuracy and minimum losses. Suter knew of studies demonstrating that the majority of combat losses occur during a pilot's first ten combat missions. After that point, losses dropped nearly to zero. Suter argued for the creation of a training environment so realistic that a new pilot would log his first ten combat missions in a controlled environment. The idea was that when he went into actual combat, the pilot would have 'survived' his most vulnerable period. Red Flag was to teach pilots how to adapt quickly to combat and show them what would happen to them if they did not; an environment that offered an intense learning opportunity-and was not a career-threatening

F-35A Lightning II fighter jets assigned to the 388th Fighter Wing's 4th Fighter Squadron on the Nellis flight-line during Red Flag 19-1 where the 388th served as lead wing for the exercise. *Ronald Bradshaw/US Air Force*

test. Suter wanted to employ the whole force; tankers, electronic countermeasures, bombers, fighters, reconnaissance aircraft against a realistic enemy that operated advanced radar systems, integrated missile and anti-aircraft systems, and first-rate, dissimilar interceptors.'

Walter Boyne wrote: 'The Gulf War of 1991 was the first war to showcase the results of Red Flag, and it produced a curious tribute. It came from an Air Force pilot who, returning from a combat mission over Iraq, was heard to remark, "It was almost as intense as Red Flag."

Red Flag 19-1: Wild Weasels

Airmen assigned to the F-16C-equipped 79th Fighter Squadron based at Shaw Air Force Base, South Carolina participated in this year's first edition of Red Flag dubbed 19-1. During the three-week event the 79th FS conducted its core suppression of enemy air defences role as part of the air superiority mission. Red Flag 19-1 included Royal Air Force and Royal Australian Air Force aircraft.

Discussing the exercise, 414th Combat Training Squadron commander, Colonel Michael Mathes spoke of five ways to quantify flag-unique warfighter culture at Nellis. He said: "We give the fighters professional adversaries, integration with forces they can't integrate with anywhere else, personnel recovery integration they can't get anywhere else, a debrief that can't be replicated anywhere else and a resilient air fighter culture."

Commander of the 57th Adversary Tactics Group, Colonel Travolis Simmons said: "Debriefs are never unprofessional, but the conversations can get heated. Frankly, you have a lot of pilot egos in that room, and nobody wants to stand on that stage embarrassed at becoming the DFP [the debrief focal point]. The DFP is the main thing that went wrong on the mission, and you might spend two hours analysing and talking about that one mistake to make sure it never happens again in actual combat. That can require speaking truth to power. So the debrief is our secret sauce, and part of the beauty of Red Flag."

Captain Tyler D'Agostino, a pilot with the 79th FS said the Nellis range provides valuable and realistic simulation of enemy missile systems. He said: "These allow us to test and validate our techniques and procedures against today's modern air and ground threats, operating with units from Australia, the UK and the US Navy against a multitude of potential threats." Senior Airman Christopher Maldonado/US Air Force

Crew chiefs assigned to the 4th Aircraft Maintenance Unit prepare to launch F-35A Lightning II fighter jets during Red Flag 19-1. *Ronald Bradshaw/US Air Force*

Members of the 62nd Fighter Squadron from Luke Air Force Base Arizona pose for a group photo at Nellis on March 9, 2019 during Red Flag 19-2. The team included Italian, Norwegian and US personnel. *Airman 1st Class Bryan Guthrie/US Air Force*

Red Flag 19-1: Adjustments

Red Flag is a realistic multi-domain training exercise that maximizes the combat readiness and survivability of participating units by providing a robust, accurate training environment.

The exercise has been run by the 414th Combat Training Squadron for years and changes are afoot to improve efficiency at base.

Col Mathes said units arrive at Nellis at varying levels of being prepared. By the end of three weeks, units are not just capable of executing their wartime mission with confidence. They are ready for combat. The value of integration exercises like Red Flag is in the building block approach. It starts with unit-level preparation, making sure the unit can function as a team. It moves to package integration, which makes sure that functional teams, like strike fighters and bombers – can work together. Then we get to Red Flag where multi-package integration comes into play, learning how to integrate different packages –superiority, strike and mobility aircraft – into one mission to achieve the same goal."

According to Mathes, Red Flag enables the Air Force to quickly harness readiness through exposure to professional adversaries, also known as the Red force and reckons Red Flag will continue to evolve further to meet today's challenges. He said: "We're continuing to improve threat replication, how we focus on the supported commands and implementing improvements to our debrief process to make the training more effective and efficient."

Explaining the importance of debriefs Mathes said: "We are leveraging new technology to validate mission effects and compile data so we can quickly give facts to the mission commander, tactical mentors and air expeditionary wing leadership. This facilitates a more efficient and effective process of providing information for the person-to-person debrief, where the learning really happens. Airman 1st Class Bryan Guthrie/US Air Force

Red Flag 19-1: F-35A pilots

One unit participating in Red Flag 19-1 was the 4th Fighter Squadron based at Hill Air Force Base, Utah which was on its first visit to the exercise newly equipped with the F-35A Lightning II.

Ronald Bradshaw/US Air Force

Fuerza Aérea Colombiana Boeing 767 tanker, serial number 1202, during engine start prior to a Red Flag 19-2 aerial refuelling mission with US Navy EA-18G Growlers. *TSgt Angela Ruiz/US Air Force*

Unit commander, Lieutenant Colonel Yosef Morris said the biggest difference between Red Flag 19-1 and the one involving the first Hill-based F-35A squadron two years ago was the number of pilots on their first assignment; thirteen had never flown the F-35 in Red Flag, and four had just graduated pilot training. He said: "Putting them alongside more experienced wingmen is what Red Flag was designed for. When I was a young pilot in the F-16, I had a couple of responsibilities in the cockpit. One, don't lose sight of my flight lead. Two, keep track of a bunch of green blips on a small screen in front of me, and correlate the blips to what someone is telling me on the radio. Now, we're flying miles apart and interpreting and sharing information the jets gather, building a threat and target picture. We're asking way more of young wingmen, but we're able to do that because of their training and the capabilities of the jet."

Captain James Rosenau flew the A-10 in four previous Red Flags, but he was brand new to the F-35 at Red Flag 19-1 having completed the transition course in December 2018. He said: "In the A-10, I was called upon to directly support troops on the ground. To bring a fight to the enemy. Now I like being the pilot who can support legacy fighters when they may be struggling to get into a target area because of the threat level. The F-35 has more freedom to operate and a big radar that can sniff out threats. The jet can gather all of that and pass it along or potentially take out those threats ourselves."

The Red force threat level is high comprising advanced integrated air-defence systems, an adversary air force, cyber-warfare and information operations, a force that fights in all domains to take out or limit the technologies that modern aircraft and weapons depend upon; the F-35A has the ability to cut through such clutter as Lieutenant Landon Moores a new pilot with the 4th FS explained: "One of the jet's greatest capabilities is to detect things that others can't, take all the information it's gathering from the sensors and present them to the pilot. One of our biggest jobs is learning how to process and prioritize that. Seeing the aircraft's capabilities being put to use as part of a larger force exercise has been invaluable. When we mission plan with other units, it's not always about kicking down the door. It may be about looking at what the enemy is presenting and 'thinking skinny.' With the F-35, we can think through a mission and choose how we want to attack it to make everyone more survivable."

Breaking Defense also reported that Red Flag 19-1 also incorporated some political ambiguity, IFF (identify friend or foe) challenges, and proxy war protocols that Air Force pilots have encountered in Syria.

General Robert Novotny the 57th Wing Commander said: "On top of those rules of engagement challenges, Blue Forces at Red Flag are contested in the air, subject to aggressor missile strikes on their operating and logistics bases, and hit with cyberattacks on their command-and-control and space systems designed to disrupt satellite communications and GPS targeting."

The US Navy regularly deploys EA-18G Growler aircraft to Red Flag to provide its highly specialised electronic attack capability in the exercise scenarios. *TSgt Angela Ruiz/US Air Force*

The Royal Netherlands Air Force participated in Red Flag 19-2 by deploying F-16 fighters to Nellis from its permanent training detachment at Tucson Air National Guard Base. *Airman 1st Class Bailee A. Darbasie/US Air Force*

Novotny added: "The F-22 and F-35 have complicated our job here at Red Flag, because their speed, stealth and sensor fusion capabilities make it difficult for our aggressors to really challenge and push them. Nellis officials are working hard to modernize the air defence systems and aggressor squadron capabilities so they can keep pace, but it's not a fair fight." Micah Garbarino/US Air Force

Red Flag 19-1: Proof in the pudding

Airmen from the 4th FS and its parent 388th and 419th Fighter Wings reckon that Red Flag 19-1 was an exponentially more challenging exercise. The squadron's F-35As were integrated into a large Blue force and tasked with a diverse set of missions against an equally capable Red force made up of hybrid threats, combinations of the most advanced weapons systems in existence to replicate potential near-peer enemies.

The 388th Operations Group commander, Colonel Joshua Wood said that the threat level and complexity are at a different level compared to when he first took part in 2004. He said: "It's no longer assumed that we will gain and maintain air superiority. That's a big shift."

Because of the diverse capabilities of the Red force, many Red Flag missions are flown in contested or denied environments with active electronic attack, jamming of communications, satellite communications and GPS receivers for denial, the latter performed by the 527th Space Aggressor Squadron.

According to Lt Col Morris such situations highlight the fifth-generation capabilities of the F-35. He said: "We're still able to operate and be successful. Our ability to continue to fuse and pass information to the entire package makes every aircraft more survivable."

During the first week of Red Flag 19-1, the F-35 pilots flew in a counter-air mission as part of a large Blue air force blinding many of the 60-plus fourth-generation aggressor aircraft with robust electronic attack.

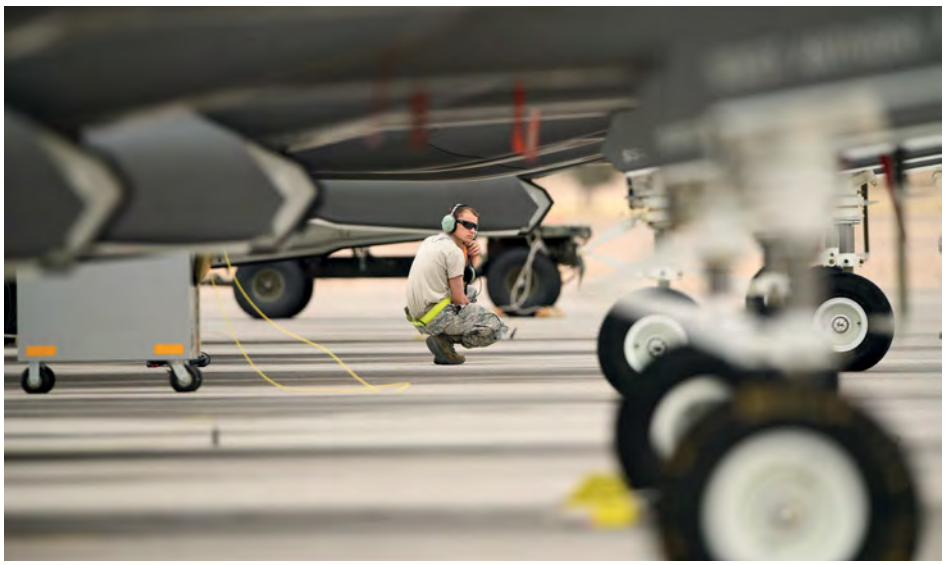
Colonel Wood had never seen anything like it before. He said: "It was a mission you would not want a young pilot flying in. My wingman was a brand new F-35A pilot, seven or eight flights out of training. He told an experienced, 3,000-hour pilot in a very capable fourth-generation aircraft. 'Hey bud, you need to turn around. You're about to die. There's a threat off your nose. The young pilot then killed the enemy aircraft and had three more kills in the hour-long mission. Even in this extremely challenging environment, the F-35 didn't have many difficulties doing its job. That's a testament to the pilot's training and the capabilities of the jet."

Each mission involved the squadron's aircraft being airborne for 90 minutes but more significantly 12 hours of intense planning the day prior, a two hour pre-brief, and then several hours of debriefing after the mission to analyse the outcome and look for ways to improve.

The 4th FS deployed 12 aircraft and more than 200 Airmen to Red Flag 19-1 – pilots, maintainers, intelligence officers, weapons crews, and support personnel, including reservists from the 419th Fighter Wing. Maintainers didn't lose a single sortie to a maintenance ground-abort and had spare aircraft available for every mission. Lt Col Morris reckons that as the F-35A matures the Air Force will continue to perceive the jet as a significant force-multiplier in a threat-dense environment. Micah Garbarino/US Air Force

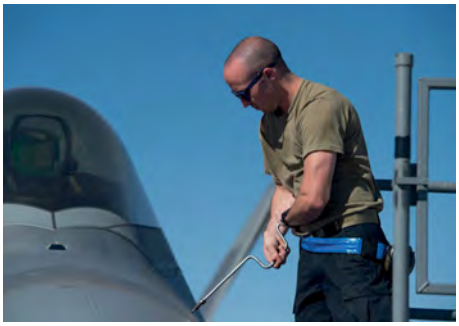
Red Flag 19-2: Colombian tanker

In March the Colombian Air Force returned to Nellis for Red Flag 19-2. A single Boeing 767 Jupiter tanker spent three weeks at the Nevada super base flying daily missions too aerial refuel US Navy EA-18G Growlers by day and night.



A crew chief, assigned to the 4th Aircraft Maintenance Unit, prepares to launch an F-35A Lightning II at Nellis. The 4th Fighter Squadron and 4th Aircraft Maintenance Unit participated in Red Flag 19-1, the units first attendance to the exercise since transition to the F-35A. *Ronald Bradshaw/US Air Force*

Marine Fighter Attack Squadron 122 (VMFA-122) deployed to Nellis in July for its F-35B debut at Red Flag 19-3. One of the squadron's pilots steps up the crew access ladder to crew-up. *Senior Airman Julian Kemper/US Air Force*



An Airman assigned to the 94th Aircraft Maintenance Unit reattaches a panel after performing maintenance on an F-22's avionics systems at Nellis. *Senior Airman Tristan Biese/US Air Force*

Colombian Air Force Colonel Kerly Sanchez, Colombian Air Force Red Flag delegation commander said: "It's important for the Colombian Air Force to maintain consistent training with NATO partners to increase interoperability and continue to be a good partner to its allies. Colombia is the first and only Latin American country that is a NATO Global Partner."

Red Flag 19-2 was the third time the Colombian Air Force had participated in the exercise. Kfir fighters took part in 2012 and 2018, the latter also included a Boeing 767 Jupiter tanker. TSgt Angela Ruiz/US Air Force

Red Flag 19-2: Historical participant

Something historical happened at Red Flag 19-2, the attendance of a multinational squadron. Equipped with F-35A Lightning II fighters and based at Luke Air Force Base, Arizona, the 62nd Fighter Squadron 'Spikes' arrived at Nellis with five aircraft and a cadre of instructor pilots from the US Air Force, Aeronautica Militare and the Kongelige Norske Luftforsvaret (Italian and Norwegian Air Forces). Italian and Norwegian pilots train to fly the F-35A with the 62nd FS.

Aggressor units

57th Adversary Tactics Group
Boasts the world's most capable and professional aggressor force to train US and coalition personnel during exercises and deployments, while overseeing US Air Force-wide air, air defence, space and information aggressor initiatives and threat academic programmes. To accomplish this mission, it directs operations of seven squadrons, including three geographically separated units.

57th Information Aggressor Squadron
The mission is to know, teach, and replicate advanced, realistic, and credible adversary cyber and information operations to train US and coalition personnel.

64th Aggressor Squadron
One of two US Air Force professional adversary squadrons flying F-16C aircraft, the 64th AGRS prepares US and coalition aircrews for aerial combat with accurate and realistic threat replication training.

177th Information Aggressor Squadron
A Kansas Air National Guard unit based at McConnell Air Force Base that provides adversarial replication of current and emerging threats by gaining persistent access and exploiting all forms of cyber systems using network tactics, close access and intelligence analysis.

507th Air Defense Aggressor Squadron
The 507th is the only squadron of its kind in the US Air Force. Its mission is to provide part-task and fully integrated realistic surface-to-air threat replication (by utilizing surface-to-air missile simulators on the Nevada Test and Training Range), training and instruction to US and coalition aircrew for full spectrum combat operations. In short, ensuring pilots are more aware of what a potential enemy can do with a surface-to-air missile, and how to defeat it.

527th Space Aggressor Squadron
Based at Schreiver Air Force Base, Colorado, the 527th was activated in 2000 as the first US Air Force space aggressor squadron. Its mission is to prepare US and coalition forces to fight in and through contested space environments by analysing, teaching and replicating realistic, relevant and integrated space threats. The 527th has three mission sets which involve GPS electronic attack (putting noise over the GPS signal to prevent reception), satellite communications electronic attack (send noise to the satellite so communication on the satellite is no longer possible) and orbital engagement systems (playing the role of an adversary against satellites).

Red Flag 19-2 was the first edition that Italian instructor pilots had flown F-35As at Nellis. The Italian and Norwegian pilots were tasked with air superiority missions in the suppression of enemy air defences role escorting Blue air aircraft and protecting them from surface-to-air missile threats. Operating with F-15Cs, the F-35As defended Blue air aircraft from Red air fighters providing air superiority for the Blue air strike packages. Furthermore, flew some defensive counter air missions which involved conducting the battle manager role, sharing tactical information to other aircraft.

F-35s acted as force enablers neutralizing several threats: on average about seven surface-to-air missile systems and five Red air assets were killed during each mission, according to the Italian Air Force. Moreover, the five aircraft deployed to Nellis were able to launch 100% of the planned missions: two four-ship missions, each day.

Aeronautica Militaire Major Alessandro P said: "The results achieved in the two weeks are almost unbelievable: the statistics do not need comment. The F-35 was the most effective asset in neutralizing surface-to-air missile systems and absolutely essential in the timely sharing of all the specific information needed for the success of the mission."

Major Emanuele A, one of the Italian IPs flying with 62nd FS at Red Flag 19-2 said: "We knew we had an operational advantage, due to the fifth-generation technology, but we

RAF Lakenheath's 492nd Fighter Squadron participated in Red Flag 19-3 operating from the revetments located on the southern side of the runways which enabled the F-15E crews to use live weapons. *Airman 1st Class Olivia Grooms/US Air Force*

At Red Flag 19-3, the F-22-equipped 94th Fighter Squadron was given the core function of air superiority to provide air-to-air support to Blue air.
Airman 1st Class Bryan Guthrie/US Air Force

didn't expect such a high kill ratio: in the 16 offensive counter air missions we flew, we neutralized more than 100 surface-to-air missile systems and never lost a plane."

Major Alessandro P added: "During our missions we were among the first to enter the area of operations, far beyond the enemy lines, and the last to leave it, thanks to the persistence and the low-observable characteristics of the aircraft. We were able to identify, transmit and neutralize ground and air threats very quickly, protecting Blue air's assets in high threat environments: the capabilities of the F-35 were often decisive."

Lieutenant Colonel Pete Lee, 62nd Fighter Squadron commander said: "Red Flag 19-2 was the first time the F-35 was the dedicated SEAD [suppression of enemy air defences] asset. We were tasked to protect other people and the F-35 is very good at that. We have the legs to protect the entire strike train and we covered the whole time."

While the stats read well, Lt Col Lee said the real story is that of the team's integration and cohesion, teaching the participating units about the integration of the F-35 in a strike package which means much more to the 62nd FS and the F-35 program as a whole."

According to a Luke Air Force Base the 62nd FS destroyed a total of 110 surface-to-air missiles during the 87 missions flown as part of 18 large force missions. SSgt Jenna Bigham/US Air Force and Colonel Igor Bruni/ Aeronautica Militaire

Red Flag 19-3: Marines take charge

Air Force Lieutenant Colonel Julie Sposito-Salceies, commander of the 505th Test Squadron said: "This is the first time where we've had Marines as the lead Air Operations Center. We've had Marine Corps participation before, but not in such a leadership role where they were the ones that integrated Air Force, Navy, Army, Marines, coalition."

Marines from Marine Tactical Air Command Squadron 38 (MTACS-38), 3rd Marine Aircraft Wing led the Combined Air Operations Center Nellis (CAOC-N) augmented by other units from both the 2nd and 3rd Marine Aircraft Wings, none of whom had ever worked in an Air Operations Center before.

Red Flag has evolved into two parts; the tactical portion, in which pilots perform the simulated combat flights, and the operational side, where military members in the CAOC-N train to control agencies that fight the war. The CAOC is made up of military members across the Department of Defense and coalition members, who work side by side

Airman 1st Class Bryan Guthrie/US Air Force

F-16C Fighting Falcon 97-0110/SW, assigned to the 55th Fighter Squadron based at Shaw Air Force Base, South Carolina, takes off from Nellis on an air superiority mission. *Airman 1st Class Bryan Guthrie/US Air Force*

to coordinate and ensure execution of air combat operations in an integrated manner.

Trainers and supervisors of the exercise, known as the White force, put CAOC members through both real and simulated complex scenarios guided by subject matter experts, to sharpen their decision making skills.

MSgt Peyton Tomblin, superintendent of the 505th Test Squadron said: "War is dynamic and we make a plan for everything, but nothing ever goes as planned. At Red Flag, you're just going through the motions as planned, like the CAOC receiving a command from the Coalition Forces Air Component Commander for a rescue mission. And then the White force, which builds up the simulations and acts as the enemy in this exercise, throws things in there that are not planned."

The Marines leading the CAOC at Red Flag had experience running a Marine Tactical Air Command Center (TACC), a smaller, similar version of the CAOC. They had led exercises such as Steel Knight 19, Pacific Blitz 19, Weapons and Tactics Instructor Courses, and Integrated Training Exercises.

Lieutenant Colonel Grant Clester, commanding officer of MTACS-38 said: "The Marine TACC is scalable and flexible enough to assume the responsibilities of a CAOC and enable a Joint Force Air Component Commander. Red Flag gives us the edge to conduct large scale air operations with joint and coalition forces in any clime and place."

The higher level of operational assets, dynamic pieces and joint-coalition based training made the opportunity to lead the CAOC so valuable.

Prior to 19-3, Marines assigned to MACG-38 participated in Red Flag 19-1 which proved to be such a good learning opportunity that planning and preparation commenced for the challenge of leading the CAOC during Red Flag 19-3.

One of the initial training challenges that every branch of the US military encounters when running the CAOC at Nellis is the diversity among the service branches and coalition partners. Red Flag gives individuals the unique opportunity to train alongside others to strengthen their interoperability.

An EA-18G Growler assigned to Electronic Attack Squadron 135 (VAQ-135) heads to the runway on a night time Red Flag mission. *Airman 1st Class Dwane R. Young/US Air Force*

Senior Airman Tristan Biese/US Air Force

An HC-130J Combat King II aircraft assigned to the 71st Rescue Squadron based at Moody Air Force Base, Georgia, takes off for a personnel recovery mission.
Airman 1st Class Dwane Young/US Air Force

Royal Australian Air Force Flight Lieutenant Steven Booth, an exchange officer with the US Marine Corps and assistant operations officer for MTACS-38 explained: "At the tactical level, I can share my knowledge and experience and at the same time fully understand and integrate with a multi-functioning service that does procedures in a different way. Both parties learn a lot from each other and revise their own tactics, techniques and procedures to effectively create a more absolute and resolute way of solving problems."

"The Marines are very outspoken, direct in a very positive light and they are truth tellers. They don't tell me what they think I want to hear," said Lieutenant Colonel Julie Sposito-Salceies. "They brought new ideas into the CAOC, such as the execution checklist that we will be implementing for future iterations."
LCpl Levi Guerra/US Marine Corps

Success of the Combat Air Forces

Once President Ronald Reagan authorised Operation El Dorado Canyon April 1986 units of the US Air Force and US Navy prepared to undertake an historic strike on Libya against its leader, Colonel Muammar Gaddafi.

From an Air Force perspective, El Dorado Canyon proved that its post-Vietnam realistic training revolution worked. Aircrew tested at Red Flag flew ten 'combat missions' in a training environment which prepared them for real combat. For the F-111F-equipped 48th Tactical Fighter Wing based at RAF Lakenheath in England two things were realised. One, Red Flag had prepared its aircrews for actual combat through realistic training. Two, the combat success of El Dorado Canyon demonstrated how a new air warfare paradigm, led by Red Flag, had matured since the exercise's inception in 1975. Once the mission was done, El Dorado Canyon showed how F-111F bombers, classed as tactical aircraft, provided effect classed as strategic-level. The latter was indicative of how aircraft assigned to the then Tactical Air Command were supplanting missions once flown by Strategic Air Command bombers; theatre air power had arrived. The eventual result of this mission supplanting was activation of Air Combat Command on June 1, 1992; the Air Force's brand new command that combined all combat-coded aircraft types previously assigned to both Tactical and Strategic Air Commands.

However, before the Air Force was able to activate Air Combat Command it was tasked with another fight. This time the US-led operation to liberate Kuwait from the occupying forces of the then Iraqi president Saddam Hussein dubbed Operation Desert Storm.

SSgt Natasha Stannard/US Air Force

The combat-coded Air Force of 1990 was better equipped, better trained and better prepared to engage Iraqi forces than their predecessors in Vietnam. Thanks to realistic training at events like Red Flag, pilots and weapon system officers flying Air Force combat-coded types were able to dominate the conflict in an unprecedented way.

The new air warfare paradigm introduced at Red Flag was applied to Operation Desert Storm in January 1991 changing decades old concepts of operation pretty much forever.

Choosing precise delivery rather than just precision-guided munitions for targets in Desert Storm showed the effect Red Flag had on the planning and execution of the operation.

Fancy kit or not, it was the pilot's responsibility to complete the complex mission tasked.

Red Flag's procedures are designed to destroy an enemy's ability to conduct combat operations by integrating all available assets and aspects of air power. In Desert Storm, air planners sought to destroy strategic and tactical targets, and force enemy units to react without input from their command. The Iraqi air defence system remained potent throughout the air campaign successfully engaging 23 coalition aircraft with anti-aircraft artillery fire and surface-to-air missiles to shoot down.

After the decisive nature of the US-led air war against Iraq in early 1991, exercise planners at Red Flag moved to night time operations and increased the number of aircraft participating in each edition.

Only three years passed before the US Air Force was called to task again, this time in Balkan skies to push back and ultimately engage with the armed forces of the then President of Serbia, Slobodan Milošević.

NATO launched Operation Allied Force in March 1999, an air campaign designed to halt the humanitarian catastrophe unfolding in Kosovo. The decision to intervene followed more than a year of fighting within the province and the failure of international efforts to resolve the conflict by diplomatic means.

SSgt Natasha Stannard/US Air Force

From a US Air Force perspective, Allied Force showed that the realistic training conducted by combat-coded aircrew at Red Flag worked, none more so than for two specific roles; close air support and combat search and rescue.

During a night time mission from Aviano Air Base, Italy, F-117 Nighthawk pilot Lieutenant Colonel Dale Zelko was shot down close to the Serbian capital Belgrade. Dozens of aircraft were involved in Zelko's rescue that night which once again showed how very realistic combat search and rescue training with emphasis on exact timings and close coordination saved Zelko from capture by Serbian forces. First and foremost, Zelko had the various aircrews to thank for his rescue, but also the training given to those aircrews at Red Flag.

Red Flag's success led to dozens of countries applying to participate. Many nations have attended from Asia, Europe, the Middle East and South America. Exercise planners continue to train aircrews to conduct air warfare in an operational theatre of war.

Despite its longevity and success to date, Red Flag attracts different perceptions; world's most prestigious combat training exercise or an innovative training event that continually adapts to America's perceived threats.

US Air Force combat successes in Operations El Dorado Canyon, Desert Storm, Allied Force, Iraqi Freedom, and Enduring Freedom have led to a comprehensive type of aerial warfare dubbed theatre air power. Major Moody Suter's 1975 roll-out of Exercise Red Flag has changed the way in which the US Air Force conducts combat operations. **AI**

Royal Australian Air Force E-7A Wedgetail A30-002 assigned to 2 Squadron taxies at Nellis for a Red Flag mission in which the aircraft was tasked to provide command and control capability.
Airman 1st Class Dwane Young/US Air Force

Italy's international flight training school

In an exclusive interview with Colonel Luigi Casali, Chief of Planning and Operations for 61° Stormo, Riccardo Niccoli reports from Lecce Air Base, Italy on the joint flight training school run by Leonardo and the Aeronautica Militare

THE AUTHOR began the interview by discussing the period of great change which 61° Stormo has gone through, asking Colonel Casali to briefly describe what the objectives were, and what the plan was to achieve them?

Colonel Casali: "For some time 61° Stormo has been involved in a substantial process of transformation into a modern and international key facility. Several years ago the Aeronautica Militare [Italian Air Force] decided to focus on the Salento region facility based on a series of factors, amongst which, in particular, were the decades of experience in the flying training sector, the geographical and topographical area in which the airfield is located, the climate, and, moreover, the integration of the base with the territory and its local institutions. So, in the course of the last decade, the flying school at Lecce-Galatina, thanks to upgrading of its infrastructure, introduction of new technologies, reorganisation of the unit structure which moved the focus of its activities toward the training of pilots destined for jet aircraft, and a fundamental review of the entire military pilot training syllabus, has resulted in the stand-up of a training facility of absolute excellence, attracting the attention of numerous foreign air forces. Today, 61° Stormo, which represents a shop window for the AM and Italian industry in the world, hosts students and instructors from Argentina, Austria, France, Greece, Kuwait, Singapore, Spain and the United States, and continues to host visits by foreign delegations. It continues to develop and expand. Fundamental roles will be undertaken by the T-345, which will gradually replace the MB.339 fleet, and realisation of the International Flight Training School [IFTS] project."

Author: "Which phases and in what ways has the innovative IFTS accord with Leonardo developed?"

Colonel Casali: "At the 2018 Farnborough Air Show, General Vecciarelli, the then Chief of the Air Staff and the CEO of Leonardo, Alessandro Profumo, signed an agreement finalising the launch of the Italian International Flight Training School. This collaboration was the result of a series of ideas that the Italian defence structure has developed together with Italian industry. In detail, this was perceived to be an initiative of high strategic value which could be based around the common factor of two national excellences, one public and one private: the training competences of the Aeronautica Militare and the resources of the largest company in the Italian defence sector. Substantially the common objective was to expand the training on offer in the military flight training sector in order to satisfy the growing needs, emerging above all from our international partners. This growth will be articulated through a number of steps, which will initially see an additional delivery of aircraft (T-346 trainer aircraft have already been assigned to 61° Stormo); the introduction of the new T-345-HET and the concentration of phases 2 and 3 at Lecce-Galatina, and the creation of a new structure at Decimomannu where Phase 4 on the T-346 will be conducted. You could equate the concept of the revision of the syllabus with the world of education: Phase 2 is the sixth form, Phase 3 is a three-year degree, and Phase 4 is the Masters. Lecce-Galatina will expand Phases 2 and 3, competencies instructed by the school for a long time. Future military pilots will continue to receive the Turreted Eagle for which they strive so hard, the symbol of the Brevetto di Pilota Militare (Italian pilot's military licence), during the solemn Eagle wings ceremony' at Galatina. The Aeronautica Militare has created a board which works to ensure this new method is achieved through the programme and within the planned timescale for the benefit of both the system and the nation."

Simulator based training is part of the M-346 integrated training system. Featuring touch screens, and with very low operating costs, the system can be used by the students to gain familiarisation with the HOTAS switches and systems which all function exactly like an M-346 aircraft. *Riccardo Niccoli*

Author: "What is the planned service entry date for the T-345, and in what measure does it stand in respect of the aircraft that it will replace, the T-339A?"

Colonel Casali: "The gradual introduction into service of the T-345 is planned to commence in 2020. The introduction of a new weapon system is in itself an extremely complex and articulated process, within which a variety of factors play a role, operations, infrastructure, logistics, and qualification of the personnel. The variables that have to be considered are infinite, and care must be taken to ensure nothing is overlooked or left to chance. Definitely our recent experience with the phase-in of the T-346 will be a great help, underpinned by the fact that the two aircraft are conceived with the same philosophy, based around an integrated system of training; therefore, in some ways the impact will be less revolutionary in respect to the recent past. It is not possible to compare the aircraft with the MB.339 [T-339A], an aircraft which has been flying for 40 years, as we are a generation, if not two, ahead. In the development of this new trainer the concept of efficiency was given priority, a concept which is reflected in the actual designation of the aircraft, High Efficiency Trainer. The T-345 has exceptional capability to generate sorties, and is a machine which can be utilised for up to five missions every day: this will allow pilot production, with a smaller number of aircraft, or a larger quantity of flying hours. Further savings in resources are derived from the utilisation of an integrated platform with the aircraft, thanks to which it will be possible to reduce the training timescale while obtaining an elevated quality of training and significantly lower cost

Another point in favour of the T-345 is down to the significant reduction in operating costs in comparison to those of the T-339. Summing up, the objective which we have been pursuing for some years has been that of transferring the most advanced phases of training towards more economical aircraft. Another factor which should not be overlooked is the compatibility with the T-346, a requirement which will enable a less stressful transition from Phase 3 'fighter' to Phase 4. Finally, it is opportune to underline that the T-345 will also replace the MB.339PAN, the mount of our aerobatic team the Frecce Tricolori, maintaining the link between

The M-345 prototype in formation with an M-346 over Lake Como; two complementary jet trainer aircraft which can be used for all phases of flight training, from initial all the way through lead in fighter training. *Leonardo*

An Aeronautica Militaire T-346A assigned to 212° Gruppo immediately prior to a training mission from Lecce Air Base in March 2015, when the type was undergoing its service introduction phase. At the time, this aircraft was brand new evidenced by a lack of a code usually applied to the forward fuselage.
Riccardo Niccoli

Lecce-Galatina and the team, which will see our students flying in the same aircraft as operated by the Pattuglia Acrobatica Nazionale (national aerobatic team)."

Author: "With the T-345, the Aeronautica Militaire is confirming its faith in the training philosophy adopted since the 1960s with the MB.326: a short screening phase on a propeller-driven light aircraft, and then the bulk of the subsequent instruction on a jet. What are the advantages in respect of the formula that uses a turboprop trainer, which since the 1990s has been introduced by many air forces?"

Colonel Casali: "Italy has a considerable tradition in basic flying training using jet aircraft, a tradition that dates from the early 1960s when the then Scuola Volo Basico Iniziale Aviogetti received the first MB.326 destined to be used by the student pilots for the Phase that was immediately and consequently called jet ab initio. The decision to acquire the T-345 for Phase 2 confirms this tradition, which was later consolidated in the early 1980s with the MB.339. For almost 60 years we have been conducting basic training on jets, and we will continue on this path. The T-345 is an aircraft capable of offering the performance and effectiveness typical of jet aircraft at a cost which is comparable with that of high performance turboprop-powered training aircraft. Furthermore, the student pilot can complete the training process by completing fewer flying hours, and can achieve a decidedly higher level of competence with respect to training in a turboprop. The T-345 represents an economically ideal solution in which, despite having operating costs comparable to those of a turboprop trainer, it offers all the advantages in performance typical of a jet, and consequently possesses a wider flight envelope, both in terms of speed and altitude."

Author: "What do you consider to be the principal advantage of Phase 2 and 3 training in a jet, when compared to a turboprop?"

Colonel Casali: "The jet vs turboprop evaluation goes hand-in-hand with the training system in use, with particular reference to the modalities in which the various phases of military pilot training are articulated. In Italy these modalities have changed many times over the years. In the current system [Integrated Pilot Training System 2020], after Phase 1 screening [on propeller aircraft] comes selection for the final operational fleet [Phase 2] and, to follow, there are diversified phases for the attainment of the Brevetto di Pilota Militare, where the diversification is based on whether the student has been selected for the fighter, transport, helicopter, or remotely piloted aircraft fleets. Since the early 1960s, as we have noted, the use of jet trainers from basic training has remained unchanged: we began with the MB.326, then the MB.339, and now we will continue with the T-345. Certainly the effectiveness of the final product [number and quality of the students who qualify] is down to a number of factors. For the student of Phase 2, trained on a jet, the initial impact proves to be undoubtedly more aggressive in comparison with what they have experienced in a turboprop: greater stresses, faster speeds, and more complex procedures. On the other hand, the student acquires such capacities and competencies,

Landing at Venegono in January 2019, M-345HET trainer CPX.624 is the pre-series aircraft, that flew for the first time on December 21, 2018.
Oscar Bernardi

A T-346A taxies from the 212° Gruppo flight line at Lecce-Galatina Air Base. *Riccardo Niccoli*

and, returning to the concept of the quality of the final product, is decidedly more advanced and complete which, besides constituting the bases on which the student can develop their professionalism as a pilot, will be fundamental to the progress of their career in the Air Force. It should also be underlined that Phase 2 also fulfils the function of track selection: at the conclusion of this phase, the student pilots are directed towards the fleet to which they will be posted, from fighters to helicopters, on the basis of the potential identified during the training. As for Phase 3 'fighter', it must not be forgotten that today the latest fighter aircraft are much easier to fly, and the real difference is made by their avionics systems. This is why, even for Phase 3, I believe that the use of a jet rather than a turboprop as a trainer is decidedly more effective and functional."

Author: "When do you predict that T-345 IOC will be achieved, and when is it planned to commence the first courses with Italian and foreign students?"

Colonel Casali: "Presumably we will spend a good part of 2021 performing all the actions aimed at achieving full operational status for the new trainer: in particular this will require the qualification of the instructing personnel and the preparation of the new syllabi for Phases 2 and 3 on the T-345. These will be complex activities, but the fact that we have already been through the conversion onto the T-346, and have already confronted the change of mentality from a more dated aircraft to one from the latest generation, means that launching this activity will be less problematic. This signifies that, in principal, we should achieve IOC and the consequent start of the courses during 2021. In respect of foreign personnel, obviously this will depend on international agreements, and on the interest that foreign nations express in the new trainer."

This particular M-345 prototype, CPX-619, has now been grounded, and all current test activity is carried out with CPX-624, which is a Leonardo-owned aircraft. *Leonardo*

Author: "For the advanced phase, 61° Stormo has already been using the T-346 for some years. Are you satisfied with the results achieved in this aircraft?"

Colonel Casali: "I think the success of the T-346 as a trainer has been observed by many, not just in Italy. After four years of operational use, we can safely affirm that it is the ideal platform, moreover being completely made in Italy, to train pilots for fourth and fifth-generation fighters. It is the most modern advanced/lead-in to fighter trainer actually being produced, and is the only new generation trainer equipped for this role. Its performance and flying qualities are identical to the most modern fighter. Perfectly engaged in an integrated system, in which, apart from the aircraft, there is the ground element [the most technologically advanced simulators] and the logistical support. Thanks to the capacity to simulate a wide range of sensors and armament, and to the live virtual and constructive philosophy [capable not only of generating extremely complex virtual operational environments, but even able to connect aircraft in the air to the network], the T-346A has enabled the offloading of part of the training roles from the most expensive operational aircraft, resulting in a notable saving in resources. It is for this reason that a constantly increasing number of nations and foreign air arms are interested in sending their pilots to train in Italy, attracted by the extraordinarily innovative range of integrated training systems connected to the aircraft." AI

Mil and Kamov join forces


Russian Helicopters

RUSSIAN HELICOPTERS Holding Company announced on October 11, 2019, that its board has made the decision to merge the Mil Moscow Helicopter plant and Kamov into a single entity, to be known as the JSC National Helicopter Centre (NHC).

Russian Helicopters says it will combine the two helicopter design companies to: "combine the potential of two helicopter design schools for more efficient and higher quality rotorcraft design and upgrade".

Although the consolidation of the two companies is aimed at growing their products, the Mil and Kamov brands will be preserved. Russian Helicopters says the creation of the NHC will break down "administrative, legal and economic barriers" that currently stand in the way of co-operation.

Mikhail Korotkevich, Deputy Director General for Science, Technology, Policy and Helicopter Development at Russian Helicopters, said: "According to our estimates, distribution of tasks between the two design bureaus and serial and aircraft repair plants of the NHC should cumulatively free up around 15–20% of annual working capacity of the two design bureaus, which can be allocated to the creation of technical groundwork and development of new helicopters. Earlier, there was certain competitiveness between the companies: the same types of rotorcraft were being developed in parallel."

Korotkevich added that the common objective of the two companies is to compete with western helicopter manufacturers, rather than one another.

He said: "Economic effect from design bureau consolidation is expected, due to optimisation of the use of common ground infrastructure and reduction of performing same-type tests. At the same time, a part of [the] freed resources shall be channelled towards enhancing scientific and technical potential and engaging new designers."

The initial stage of the merger will be completed by mid-2020, with finalisation of the activity set to occur in 2022. Nigel Pittaway

Japanese Bell 412EPIs

BELL TEXTRON announced on October 15, 2019, that it has sold two Bell 412EPI helicopters to Japan.

The Prefectures of Wakayama and Ishikawa have ordered one helicopter each, for use by their respective fire-fighting departments. The sales were facilitated through Rotorcraft Services Group and EuroTec Japan Corporation.

Jacinto Monge, Managing Director of Bell's North Asia Division, said: "We are honoured that the Wakayama and Ishikawa Prefectures have selected the Bell 412EPI for their fire-fighting and disaster relief and response missions. This agreement demonstrates the helicopter's strength in the Japanese para-public sector and the confidence the Japanese government has in the aircraft to save lives." Nigel Pittaway

Air Greenland selects H225

AIRBUS HELICOPTERS has concluded a deal with Air Greenland to deliver two H225 Super Puma helicopters to support the latter company's bid for Greenland's SAR helicopter contract.

The two H225s are second-hand machines, having previously been operated by the oil and gas industry and will replace Air Greenland's ageing Sikorsky S-61N helicopters.

Air Greenland CEO Jacob Nitter Sørensen said: "These two specific aircraft have low numbers of flight hours and their remarkable capability on SAR operations ensures that they will be able to provide a highly effective service in that role for many years to come."

The two helicopters will be delivered to Air Greenland in coming months. Nigel Pittaway


Airbus Helicopters

Austrian Ministry of Interior H125s

Airbus Helicopters

AIRBUS HELICOPTERS handed over the first of two H125 helicopter to the Austrian Ministry of the Interior (Bundesministerium für Inneres, BMI) in a ceremony in Innsbruck on October 17, 2019.

The two helicopters are configured for law enforcement and SAR missions and fitted with a customised suite of mission equipment designed by Airbus Helicopters in the UK and installed at the company's headquarters in Oxford.

Equipment includes a dual cargo hook, night-vision compatibility, searchlight, fire-fighting equipment (including an interface to permit the carriage of a Bambi bucket), and TETRA tactical communications.

The new H125s will join the BMI's existing fleet, which includes Airbus Helicopters' H135 and AS350 Ecureuil helicopters. They will be based in Innsbruck and Salzburg on behalf of the Tyrolean Government.

BMI Head of Air Police Werner Senn said: "It has been a complex design and implementation process to provide the H125 with the capabilities that we wanted and it is a tribute to the excellent cooperation between our respective teams that we achieved the desired result. This will give the BMI and the Tyrol region one of the most advanced police aviation capabilities in Europe on an aircraft of this size." Nigel Pittaway

Gulfstream launches G700

Gulfstream Aerospace

GULFSTREAM AEROSPACE Corporation used the recent National Business Aviation Association Business Aviation Conference and Exhibition (NBAA-BACE) in Las Vegas to launch its new G700 design.

Gulfstream unveiled its new flagship on the eve of the conference on October 21, 2019. A full-scale mock-up of the aircraft was also on display at NBAA-BACE.

Mark Burns, president of Gulfstream said: "The G700 takes the very best elements from our most innovative products and unites them with cutting-edge advances to create an all-new, advanced technology aircraft that redefines safety, comfort and range at speed. This announcement is the biggest news in business aviation history and is the result of the investments General Dynamics made to develop technology for our products."

Gulfstream says the G700 will be capable of flying 7,500 nautical miles (13,890 km) at Mach 0.85, or 6,400 nautical miles (11,853 km) at Mach 0.90.

The company also used the NBAA-BACE event to formally announce that Qatar Airways, via its Qatar Executive charter service, will be the launch customer for the new aircraft.

Qatar Executive will purchase 10 G700s, in addition to their recently announced order of more G500 and 650ER aircraft.

Qatar Airways Group CEO, Akbar Al Baker, said: "We are excited to be the launch customer of the G700, the largest business jet in the industry, and we are looking forward to the aircraft joining our fleet."

The announcement of Qatar Airways as the international launch customer was made on October 21, 2019 and on the same day Gulfstream also revealed that Flexjet will become the first North American fleet customer for the aircraft, with an order for an undisclosed number of aircraft.

In a prepared statement at the launch event, Flexjet Chairman Kenn Ricci, said: "The Gulfstream G700, with its speed, range and versatility, will make an exceptional fractional offering. We anticipate that it will be ideally suited for those companies that need occasional access to global markets and will be the pinnacle of our Red Label offering. It will be the fifth large-cabin aircraft type in the fleet as we continue our international expansion."

Nigel Pittaway

Global 5500 and 6500 gain EASA certification

BOMBARDIER ANNOUNCED on October 15, 2019, that its Global 5500 and 6500 business jets have received Type Certification from the European Aviation Safety Agency.

The milestone follows certification from Transport Canada and entry into service on September 30, 2019.

Bombardier's senior Vice President of Programme Management and Engineering, Michel Ouellette, said: "Obtaining Type Certification from EASA marks one of the final chapters in our very successful development programme."

In other news, Bombardier announced at the NBAA-BACE show on October 21, 2019, that the G5500 is able to fly 200 nautical miles (370.4 km) farther than planned, and now boasts a range of 5,900 nautical miles (10,900 km) at Mach 0.85. The company said the 5,900 nautical mile range will be a standard feature of its baseline Global 5500 aircraft and come at no additional cost to either existing or future customers.

Bombardier Aviation's President, David Coleal, said: "We are thrilled to offer this extended range to our customers. Not only are we standing by our commitment of certifying and bringing to the market an exceptional aircraft on time, we are exceeding expectations along the way."

Nigel Pittaway

Flexjet signs for Praetor

EMBRAER ANNOUNCED at NBAA-BACE on October 21, 2019, that it has also signed a purchase agreement with Flexjet, for a fleet of Praetor and Phenom 300 aircraft.

However, the Brazilian manufacturer did not say which variant of the Praetor family is covered by the deal, nor did it disclose either total numbers or the mix of the two business aircraft types.

The deal is valued at up to $1.4 billion at current list prices and was included in Embraer's second quarter backlog figures, Deliveries will commence in the fourth quarter of 2019 and Flexjet becomes Embraer's Praetor Fleet launch customer.

Flexjet CEO, Michael Silvestro, said: "We are proud to introduce the Praetor jets to the fractional marketplace and make technologically advanced mid-size and super mid-size aircraft available to Flexjet owners. This order also represents the longstanding trust we have in Embraer and in their enhanced commitment to support the growth of our programmes and of our partnership with industry-leading business jets."

Nigel Pittaway

Leading a charge

THE PROMISE of electric and hybrid-electric technology is encouraging ambitious start-ups and established manufacturers alike.

Los Angeles-based Wright Electric is researching a concept for a hybrid-electric regional passenger airliner able to undertake flights of under 300 miles (555km). The project, which involves easyJet, intends to develop a proof-of-concept system, then a ten-seater and eventually a 120-seat single-aisle design.

Swedish company Heart Aerospace is researching a 19-seat hybrid-electric regional aircraft called the ES-19 to serve routes in Scandinavia (the carriers SAS, Wideroe and BRA are all project partners) and Spanish developer Dante AeroNautical is similarly researching a 19-seat hybrid-electric design, the DAX-19, in conjunction with regional carrier Volotea.

Californian company Ampaire has a vision for an electric regional aircraft for services linking remote communities. It flew its Ampaire 337, a Cessna 337 retrofitted with a proprietary hybrid-electric propulsion system, from Amarillo in June 2019. The company is planning a pilot project on a commercial route on the Hawaiian island of Maui using another retrofitted Cessna 337.

The Israeli company Eviation is developing a nine-seat commuter aircraft called the Alice, powered by either MagniX Magni250s 375shp (280kW) or Siemens 349shp (260kW) electric motors. The company aims to achieve certification and service entry in 2022.

More established manufacturers are also involved in electric aviation, converting conventionally powered aircraft into electric or hybrid-electric technology demonstrators.

Airbus has partnered with Rolls-Royce and Siemens to convert a BAe 146 into the E-Fan X hybrid-electric demonstrator. This aircraft's right inboard 7,000lb-rated (31kN) Lycoming AF502 turbofan has been replaced by a new hybrid powerplant, which has an electric motor in place of a turbine core and inverter together with an AE2100 turboshaft and an AE3007 nacelle. The jet is due to fly from Cranfield in Bedfordshire in 2020.

Separately, Rolls-Royce recently announced an R&D initiative with the German aviation engineering company APUS and the Brandenburg University of Technology to develop a hybrid electric flight demonstrator using the company's hybrid M250 engine. Experimental flights are scheduled "after 2021", the company said in November 2019.

In 2020, Embraer is due to fly a modified EMB-203 Ipanema with a hybrid-electric engine. Turboprop manufacturer ATR is studying hybrid and electric technologies for turboprop airliners in conjunction with Air New Zealand, and UTC Aerospace plans to test a hybrid-electric propulsion system on a Dash 8-100 in 2022.

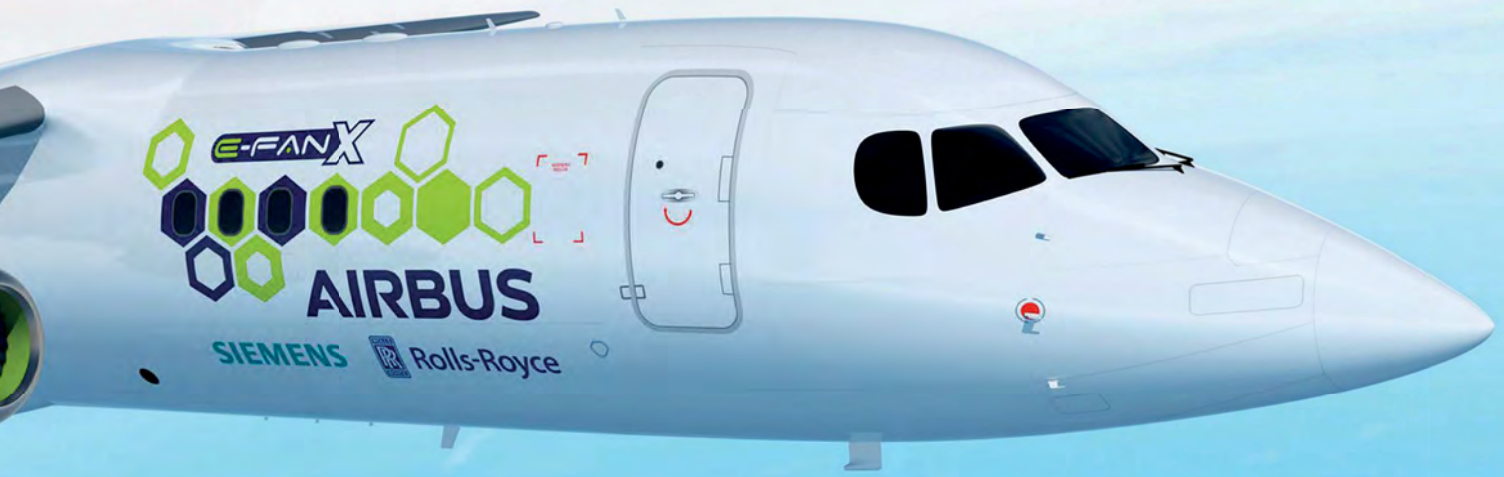
Regional and commuter aircraft are the focus for all these projects, as their smaller airframe and engine size and payload/performance demands provide a more practical way of researching and introducing electric technologies.

Electric aviation involves power systems, energy storage and battery technologies, as well as airframes. Research efforts in these areas are underway, too. September 2019 saw Boeing and Safran announce a joint investment to develop aviation-grade energy storage and battery systems.

Meanwhile, NASA has a reconfigurable testbed called NEAT (NASA Electric Aircraft Testbed) at its Glenn Research Center, a reconfigurable facility that industry, academia and government can use to further mature electric aircraft technologies. Mark Broadbent

The E-Fan X demonstrator, a modified BAe 146 with a hybrid-electric engine, is due to fly from Cranfield in 2020.
Airbus

The DAX-19 regional airliner is one of several new electric aircraft concepts.
Dante Aerospace



The changing game?

PERHAPS THE most significant development in the commercial air transport industry in recent years is low-cost long-haul.

Sustained lower fuel prices over the past half-decade and a relatively solid global economy have encouraged airlines and investors to move into this area, especially in Asian and transatlantic markets.

Norwegian, AirAsia and WestJet started long-haul flights, new carriers such as French Blue entered the market, and some of the large network airlines that have dominated long-haul air travel set up low-cost long-haul operations (for example, Singapore Airlines' Scoot, IAG's Level and Air Canada's Rouge).

This has fundamentally changed the game in some markets. As the CAPA Centre for Aviation put it, Norwegian starting long-haul flights in 2014, "has changed the landscape and taken some market share away from the leading operators".

Norwegian now offers nearly 50 non-stop transatlantic routes from Europe to the United States. According to CAPA's analysis of OAG schedule data, since the carrier started London Gatwick to New York JFK flights it has captured 10% of the total travel market between the two cities.

As in all areas of the airline industry, however, low-cost long-haul can be unforgiving. The Icelandic carrier WOW Air ceased operations in March 2019, Primera Air collapsed in 2018, and low-cost long-haul ventures by the Lufthansa Group and Air France-KLM Group, respectively a unit of Eurowings and a start-up called Joon, both proved to be short-lived.

Norwegian has also struggled. Although it recently announced frequency increases between Gatwick and some destinations such as San Francisco and Tampa for its summer 2020 schedule starting next March, it has pared back frequencies and axed routes in other parts of its schedule. Matthew Wood, Senior Vice-President Commercial at Norwegian said: "In line with our business strategy of moving from growth to profitability we are ensuring that we concentrate on key routes across our network where we see strong demand."

October 2019 saw Norwegian announce an interline partnership with JetBlue connecting more than 60 destinations in the United States and nearly 40 Caribbean and Latin American cities to Norwegian's network via JetBlue's JFK, Boston and Fort Lauderdale hubs.

This partnership, and a similar interline agreement between

Norwegian operates long-haul with Boeing 787s.
Norwegian

WestJet (which flies 787-9s on transatlantic routes) and easyJet as part of the UK carrier's Worldwide service, reflects the importance of offering lots of connectivity to boost passenger feed and fill aircraft.

During the recent CAPA Low Cost Long Haul Summit in Hamburg, Emirates' President Sir Tim Clark warned of a coming "gathering storm" and Qatar Airways' CEO Akbar al Baker questioned the feasibility of low-cost long haul if fuel prices increase.

In a recent review of the segment, CAPA analysts wrote: "The period of high profitability is unlikely to continue as oil prices, currently in the mid $60/barrel for Brent Crude, creep up and as business and consumer confidence – at least, outside the United States – slips rapidly."

They added: "The IMF recently issued a warning that the global economy is weakening 'faster than expected' and downgraded GDP growth forecasts for 2019, and the European Central Bank has 'substantially' revised downwards its economic growth projections for 2019, implying a slackening of demand in markets which have become increasingly price sensitive."

Sustainability will be the key watchword for low-cost long-haul airlines. Mark Broadbent

Lufthansa Technik works on A350

P Pigeyre/Airbus

LUFTHANSA TECHNIK Malta recently started technical services work on the Airbus A350 at its Luqa Airport facility.

Three international airlines have signed maintenance, repair and overhaul (MRO) contracts for the A350 family with the company. The first aircraft, from an undisclosed operator, arrived at Luqa for a C-check.

More than 100 aircraft from different customers already receive comprehensive MRO and technical support from Lufthansa Technik Malta for components, auxiliary power units, engines and other parts of the aircraft.

The company said the start of modification and overhaul work on the A350 strengthens the company's position as the leading MRO services provider for the A350.

The German Federal Aviation Office certified the company for A350-1000 MRO work in August 2019, complementing the approval for A350-900 overhaul work attained in 2018. Mark Broadbent

More A321XLR sales

Airbus

AIRBUS HAS recently picked up more business for its A321XLR, the latest longer-range subvariant of the A321neo it launched earlier in 2019.

Vietjet has signed a firm order for 20, which includes the conversion of five existing A321neo orders to the variant, and the shareholders of Hungarian low-cost carrier Wizz Air approved a provisional order for 20 examples.

Czech Airlines has amended an existing order so it will now receive three A321XLRs rather than baseline A321neos, and IndiGo's recent 300-aircraft order for A320neo Family aircraft includes an ability for the carrier to place orders for the A321XLR as part of the mix.

The orders further expand the backlog for the A321XLR, which has now attracted more than 250 orders (a mix of firm orders and provisional deals including commitments) since its launch at the Paris Air Show in June 2019. Mark Broadbent

Spirit acquires Belfast factory

BOMBARDIER AEROSPACE has agreed to sell its wing production factory in Belfast to Spirit AeroSystems as part of a $1.1 billion (£850 million) deal.

The Canadian aerospace company put the historic former Short Brothers factory up for sale in May 2019 as part of a wider realignment of its activities that has also seen it divest its Dash 8, CRJ and A220 airliner programmes.

The Belfast factory manufactures an innovative all-composite wing for the Airbus A220 as well as composite parts for A320neos and Bombardier business jets.

Wichita, Kansas-based Spirit AeroSystems will pay Bombardier $500 million in cash for the Belfast facility, as well as composite manufacturing facilities in the United States and Morocco.

About 4,000 employees will transfer to Spirit. The transaction, which is expected to close in the first half of 2020, is subject to regulatory approvals and customary closing conditions.

Reportedly Airbus had considered buying the factory to secure the supply of wings for the A220, after taking majority ownership of the former C Series from Bombardier in 2017 and rebranding the aircraft.

Unions welcomed the deal, with Unite assistant general secretary Steve Turner quoted as saying: "It is a sale that offers hope for a positive future for Bombardier workers in Northern Ireland and their colleagues in the supply chain."

There had been fears over the Belfast site's future. However, the capabilities of the plant and its workforce meant the odds were always good on a sale to a major supplier such as Spirit.

To produce the A220's wings the factory uses a highly advanced manufacturing process called resin transfer infusion, designed to achieve greater control over the laying up of composites to create better predictability and repeatability and the ability to produce large composite parts.

Spirit's Chief Executive Tom Gentile commented: "The Bombardier operations bring world-class engineering expertise to Spirit and add to a strong track record of innovation, especially in advanced composites. Belfast has developed an impressive position in business jet fuselage production, in addition to the world-acclaimed fully integrated A220 composite wing."

The statement released by Spirit announcing the deal attests to the factory's specialist capability. It said: "In aerostructures and fabrication, the acquired business is a global player, delivering composite and metallic wing components, nacelles, fuselages and tail assemblies, along with high-value mechanical assemblies made out of aluminium, titanium and steel.

"The acquired business also brings a world-class aftermarket business which more than doubles Spirit's geographic reach globally."

At the start of 2019 Spirit announced it had secured a role on Airbus' Wing of Tomorrow programme, and that it would contribute to four technology projects relating to the fabrication and assembly of leading edges, wing boxes and lower wing covers.

On one of these projects, Spirit will use "cutting-edge composite resin-flow simulation tools" to infuse a 23ft (7m) lower wing cover. The company said the demonstrator, "is a major step towards delivering a full-scale, resin-infused lower cover to Airbus".

Although the Belfast factory acquisition is not related to the Wing of Tomorrow programme, for Spirit taking on the facility clearly fits into a requirement for specialist suppliers to develop highly innovative, lower-cost and higher-performing structures for newer aircraft.

As the company said: "The addition of the entire work package for the A220 wing and its technology are critical for the future of next-generation aircraft."

Mark Broadbent

Spirit AeroSystems will be responsible for producing the A220's all-composite wing, in a deal due to be finalised in 2020. *Airbus*

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