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November 2020

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A CLEAN SLATE

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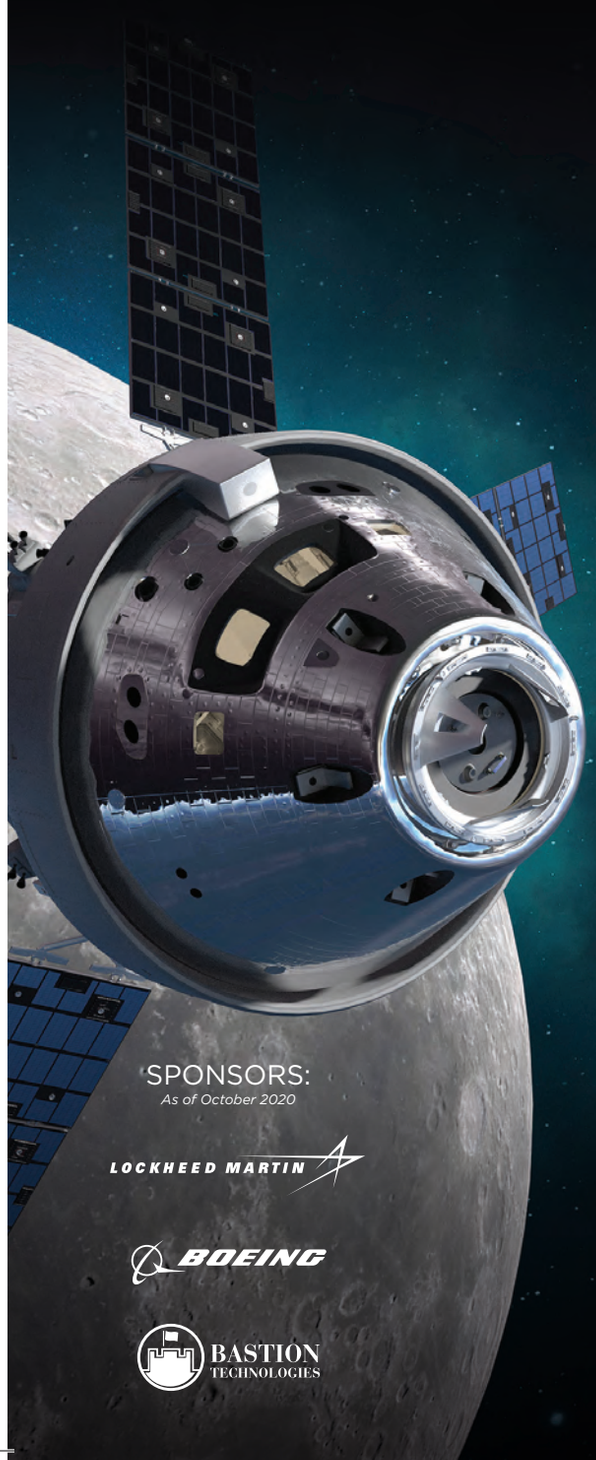

The 2021 AIAA SciTech Forum, the world's largest event for aerospace research and development, will be a comprehensive virtual experience spread over eight days. More than 2,500 papers will be presented across 50 technical areas including fluid dynamics; applied aerodynamics; guidance, navigation, and control; and structural dynamics.

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AERO SPACE

Volume 47 Number 11
November 2020

EDITORIAL

Drone wars are here

What happens when 'precision effects' from the air are available to everyone? Nagorno-Karabakh is now the latest conflict where a new way of remote war is evolving with cheap persistent UAVs, micro-munitions and loitering anti-radar drones, striking tanks, vehicles, artillery pieces and even SAM sites with lethal precision. The use of these Turkish-made armed UAVs by Azerbaijan against Armenian ground forces, follows similar results in Northern Syria and Libya this year, where even the presence of the latest Russian-built air defence systems like Pantsir S-1 SA-22s made little difference to countering these air strikes from armed UAVs. Even if destroyed, the low-cost and ultra-rapid development of such platforms means that a newer version, with lessons learned, will likely be heading for the battlefield in short order. Though technically not classed as an integrated 'swarm' of co-ordinating UAVs, the number of drones being used in this latest conflict, as judged by the sheer amount of target video footage released in a short time, is a measure of the damage that these drones can inflict on fielded forces when used in significant numbers at once to overwhelm and disrupt the enemy. For countries like Azerbaijan, which fields a squadron of MiG-29s and Su-25s each as its main offensive air power, using cheap, disposable drones and loitering munitions in this way gives them a precision strike and a SEAD capability that even some NATO countries may envy. For Western forces, that have enjoyed almost uninterrupted air superiority since Korea, this should be a critical wake-up call to invest in long-neglected organic air defences and to think anew about camouflage and concealment from these unblinking eyes in the sky – and how to counter these threats. It will not be the last time we see this – as the use of drones expands from hunting insurgents to state-on-state war.

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Additional content is available to view online at: www.aerosociety.com/aerospaceinsight
Including: Securing Earth's space environment, Simulating UAMs, Airbus reveals plans for hydrogen-powered aircraft, 21 Things I discovered while writing *Harrier 809*, In the October issue of *AEROSPACE*, New Member Spotlight, Invaders to Mars, Economics of electric aircraft – Part 2.

Front cover: Airbus' three hydrogen-powered aircraft concept designs. (Airbus)

Contents

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Features

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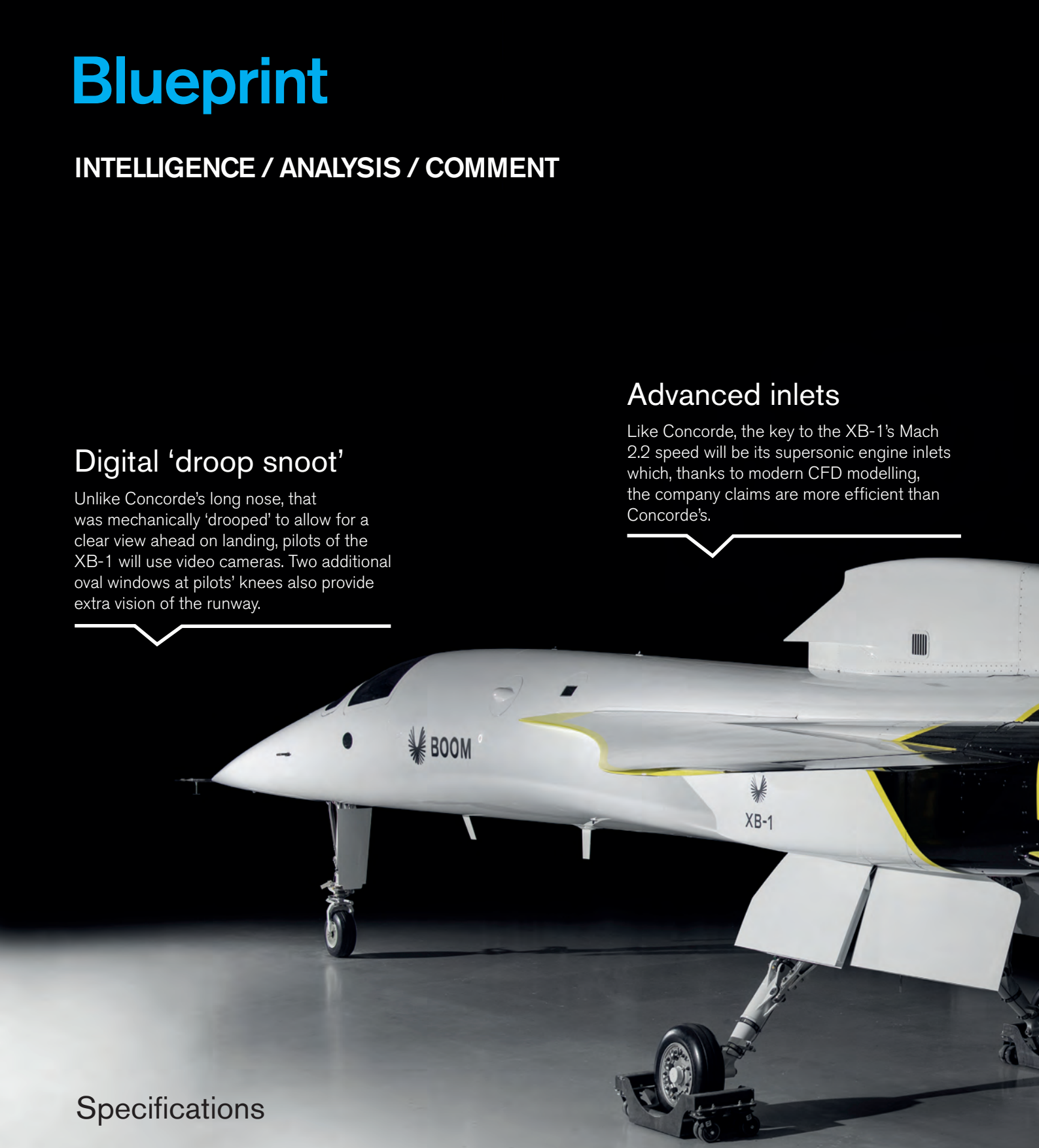
INTELLIGENCE / ANALYSIS / COMMENT

Digital ‘droop snoot’

Unlike Concorde’s long nose, that was mechanically ‘drooped’ to allow for a clear view ahead on landing, pilots of the XB-1 will use video cameras. Two additional oval windows at pilots’ knees also provide extra vision of the runway.

Advanced inlets

Like Concorde, the key to the XB-1’s Mach 2.2 speed will be its supersonic engine inlets which, thanks to modern CFD modelling, the company claims are more efficient than Concorde’s.



Specifications

Crew:	One
Length:	68ft
Wingspan:	17ft
Top speed:	Mach 2.2
Range:	1,000nm

Composite structure

XB-1 is constructed mostly of carbon-fibre components – with composite fuselage skins 50ft long.

Boom Supersonic

Carbon-neutral testing

To address environmental concerns, Boom says the XB-1 flight test programme will be 'fully carbon-neutral'. It plans to use sustainable fuel from Prometheus Fuels which turns CO_2 from the air into jet fuel using renewable energy sources.

Engine thrust

Boom XB-1 is powered by three 4,300lb thrust GE J85 turbojets, of the same type used by the F-5E Tiger II fighter. For the larger Overture airliner, Boom and Rolls-Royce have now entered a MoU to study options for civil supersonic engines.

AEROSPACE

Boom rolls out XB-1

On 7 October, US start-up Boom Supersonic rolled out its completed XB-1 demonstrator in Denver, Colorado. The GE J85-15-powered Mach 2.2 'Baby Boom' prototype, set to fly next year, will support development on the company's 55-seat Overture supersonic airliner – with the goal of flying the airliner in 2025 and entry into service in 2029.

Radome

COVID-19

AIR TRANSPORT

Air travel crisis could see 46 million jobs lost globally

Dubai Airport

New figures from the Air Transport Action Group (ATAG) estimate the eventual damage done by the coronavirus could see up to 46 million jobs lost worldwide in aviation, tourism and the wider sectors supported by air travel. The cross-sector body says that normally, air travel and tourism support some 87.7 million jobs worldwide but now over 50% of these could be at risk due to the Covid-19 pandemic. ATAG predicts that 4.8 million jobs in the aviation sector itself could be lost by the beginning of next year.

AIR TRANSPORT

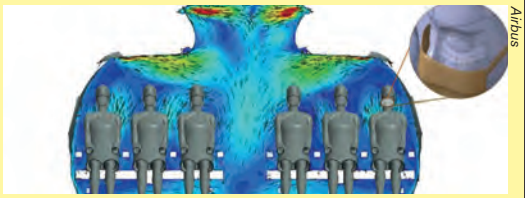
Boeing forecasts 11% drop in airliner deliveries over next decade

Boeing

Boeing has published its latest Commercial Market Outlook which foresees a fall of 11% in airliner deliveries in the next decade due to the effects of the coronavirus crisis. However, it predicts that air travel will return to growth, with a long-term forecast of 43,110 new commercial aircraft needed over the next 20 years and 2.1 million new personnel required. (see 'By the Numbers', p 10)

AEROSPACE

In-flight Covid-19 risk less than 'being hit by lightning'



Airbus

The International Air Transport Association (IATA) has revealed the results of research conducted by airliner OEMs which supported evidence that the chance of contracting Covid-19 onbord an airliner cabin is one in 27.3 million passengers, or less likely than being struck by lightning. Using published reports, IATA found that there had only been 44 secondary cases of transmisson on board aircraft out of 1.2 billion passengers carried in 2020. These findings were backed up by studies from three OEMs, (Airbus, Boeing and Embraer) which used high-fidelity CFD simulations and live trials to model the spread of particles in an airliner cabin. Airbus research found that out of 10,000 droplets caused by a cough, a combination of masks, gravity and airflow means that a maximum of five particles will reach the person sitting in the next seat – less than a cough 6ft away. Boeing produced similar results – finding that an airline cabin is equivalent to being 7ft away from a coughing person in other environments such as a conference room. Embraer's studies found that wearing a mask decreased the mass of a cough by 0.02%. Summing up: "The risk of a passenger contracting Covid-19 while on board appears very low," said Dr David Powell, IATA's Medical Advisor.

NEWS IN BRIEF

The World Trade Organization (WTO) has authorised the EU to impose $4bn worth of import tariffs on US goods, including aircraft, tractors, fish, alcohol and dried fruit, over illegal US state support to Boeing. It comes a year after the WTO authorised the US to impose $7bn tariffs on the EU for Airbus subsidies.

According to the *Irish Independent,* Irish budget carrier Ryanair is now in negotiations for a bumper 150-200 order of the currently grounded Boeing 737 MAXs. A deal for 150 737 MAXs, would be valued at $15.9bn at list prices, with the paper reporting that the sale could be sealed by the end of this year. The airline already has an order for 100 firm and 100 optional 737 MAX 200s.

The UK's Marshall Aerospace and Defence Group has been awarded a ten-year contract to provide depot-level maintenance for US Marine Corps KC-130J tanker-transports. The deal, one of the largest in the group's history, covers 66 USMC KC-130Js and will see the first aircraft arrive for overhaul in Cambridge before the end of this year.

Small satellite company OneWeb has announced that it hopes to exit bankruptcy before the end of the year and resume launches for its global broadband network in December. OneWeb has reached agreement with Arianespace for a modified 16-launch contract to complete the deployment of its global satellite constellation in low Earth orbit before the end of 2022.

Gulfstream has added a fourth G700 test aircraft to join its flight certification programme. The fourth G700 will be used to test avionics, the environmental control system, mechanical systems, electrical power and hydraulics. The four flight-test aircraft have now flown over 600 hours since the first flight of the G700 in February.

Boeing has confirmed that it will end production of its 787 Dreamliner airliner in Washington State, moving the entire production to its South Carolina 787

DEFENCE

Armed drone war erupts in Nagorno-Karabakh

Azerbaijian MoD

Simmering tensions between Armenia and Azerbaijan over the disputed region of Nagorno-Karabakh have seen the use of armed drones to target ground forces. Azerbaijan, supported by Turkey, has been reported to be operating the Turkish TB2 Bayraktar UCAV, as well as the Israeli Harop loitering 'kamikaze' drone, with footage of Armenian T-72 tanks, artillery pieces and SAM systems being struck by armed UAVs.

SPACEFLIGHT

Space agencies sign up to Artemis Accords

Australia, Canada, Italy, Japan, Luxembourg, UAE, UK and the US have signed up to the NASA-proposed Artemis Accords, which seeks to establish a practical set of principles to guide deep space exploration co-operation and broaden NASA's Artemis Moon mission into a wider international effort. The Accords cover lunar mining and resource exploitation, as well as the protection of historic space sites and hardware.

● Europe's space sector is set to benefit too, with ESA contracting Airbus to study a heavy lunar payload lander, while ThalesAleniaSpace will build two modules, (I-HAB and ESPRIT) on the Gateway station. Thales UK will contribute the chemical refuelling system for the ESPRIT module.

GENERAL AVIATION

1,000th TBM turboprop rolled out

French GA manufacturer Daher Aircraft has rolled out the 1,000th TBM single-engine turboprop since the aircraft was first produced in the late 1980s by SOCATA. The TBM 940 was rolled out from the manufacturer's Tarbes final assembly line in France for a US-based customer, with the official handover to be in Pompano Beach, Florida. Acquired by Daher ten years ago, the number of TBMs produced just in the past decade is now more than when the original TBM 700 was first launched 30 years ago. The latest model, the TBM 940, features autothrottle, Garmin G3000 touchscreen avionics with the new HomeSafe emergency autoland function, which will automatically land the aircraft if the pilot is incapacitated.

AEROSPACE

ZeroAvia flies largest-yet hydrogen-powered aircraft in UK

ZeroAvia

Alternative fuel specialist company ZeroAvia has announced that it has made the first flight of a Piper M350 powered with hydrogen fuel cells on 24 September. The six-seat aircraft, which was used as a testbed for a battery-electric flight in June, was flown from the company's research facility in Cranfield. (See 'Airbus spearheads zero-carbon moonshot', p 38).

facility starting in mid-2021. Opened in 2011 as a non-unionised factory, Boeing's Charleston, South Carolina factory is currently the sole assembly line for the 787-10 Dreamliner.

Malaysia-based AirAsia Group is reported to be winding up its AirAsia Japan regional subsidiary due to a slump in demand resulting from the Covid-19 crisis. AirAsia posted its largest ever quarterly loss in August of $238m – a 98% revenue fall.

On 25 September, a Ukrainian Air Force An-26 transport crashed in the Eastern Kharkiv region with at least 26 of the 27 on board being killed. The casualties included cadets from the Ivan Kozhedub National Air Force University. The aircraft had reportedly declared an emergency with one engine, when it came down 1.2miles away from a military airbase in Chuhuiv.

After two weeks of delays due to bad weather, on 6 October, a SpaceX Falcon 9 rocket launched from Cape Canaveral, Florida, and successfully put another 60 Starlink communication satellites into orbit, bringing the total fleet in orbit to 715.

On 30 September, the Norwegian Air Ambulance Foundation took delivery of the first five-bladed variant of the Airbus H145 helicopter. The extra blade allows for an additional 150kg of payload, while making for a smoother and quieter flight. The NAAF will use it for HEMS R&D projects, including a pre-hospital cabin CT scanner designed to check for head and brain trauma at the site of the incident.

UAV specialists UMS Skeldar has carried out trials of what it calls a world-first in automated remote flight – allowing customers to fly and test its V-150 rotary-wing UAV from anywhere in the world. The flight tests, took place in Switzerland this summer, with the V-150 controlled from the UK and from 'the other side of the globe' according to the company. The client requires a small ground control station and an internet connection.

Radome

AEROSPACE

Q-Starling breaks cover

Samad Aerospace

UK start-up Samad Aerospace has unveiled a new concept for a two-seat hybrid-electric eVTOL – the Q-Starling.The personal air vehicle would be powered by a hybrid-electric drivetrain and use biofuel or sustainable aviation fuel, with a centrally mounted lift fan providing downward thrust in the hover. Its range would be 500nm with a cruise speed of 250kt.

DEFENCE

India tests new missiles for armed forces

India has test flown a new supersonic anti-submarine missile, allowing submerged targets to be engaged from 400nm away. Tested on 5 October, DRDO's Supersonic Missile Assisted Release of Torpedo, (SMART), is a missile that carries a lightweight torpedo and is designed to give shore units or warships a long-range stand-off anti-submarine capability.

● Meanwhile, on 9 October, the DRDO conducted the first live firing trial of RUDRAM, the first indigenously-developed anti-radar missile (ARM) from India. The long-range missile was fired from an IAF Sukhoi Su-30MKI at a radar target on Wheeler Island off the coast of Odisha.

GENERAL AVIATION

Airbus launches A220-derived ACJ TwoTwenty

Airbus has unveiled a new product in its ACJ VIP/Corporate jet range – the ACJ TwoTwenty, a large-cabin business aircraft derived from the single-aisle A220 airliner. The TwoTwenty, developed in partnership with luxury cabin specialist Comlux, would have a range of 5,000nm and have 723m² of cabin space for 18 passengers. The company says that the ACJ TwoTwenty will have two-thirds more cabin space than competing bizjets yet have one-third of the operating costs. The company has announced it has already won the first six orders for the bizjet, with two orders from Comlux and a further four from undisclosed customers. Entry into service is scheduled for 2023.

AIR TRANSPORT

Last two British Airways 747s fly off into retirement

British Airways

On 8 October the final two Boeing 747-400s from the British Airways fleet of 28 Jumbo Jets, took off from a rainy London Heathrow for St Athan, Wales and Kemble airport for storage. The flights close an era of 47 years of the 747 in service with BA, after the airline deciding to phase them out in July. The retirement of BA's 747 fleet has been accelerated by the coronavirus crisis which has seen long-haul travel decimated.

NEWS IN BRIEF

German flag carrier Lufthansa is to put its entire Airbus A380 fleet and ten A340s into long-term storage with no date to return them to service. The aircraft will only return to flight in the case of an 'unexpectedly rapid market recovery', according to the airline.

Leonardo UK has announced that it has carried out trials for the RAF of 'swarming drone technology' designed to overwhelm and confuse enemy air defences. The tests in July involved a number of Callen Lenz UAVs fitted with the company's BriteCloud digital decoys.

The UK Government is to initiate a new programme to explore wider alternatives to the European Galileo satellite navigation system. The 'Space-Based Positioning Navigation and Timing Programme' will 'explore the use of different kinds of satellites at various levels of orbit by exploiting technologies offered by companies at the cutting-edge of innovation, such as OneWeb, Inmarsat and Airbus, according to a Whitehall press release. The programme is a reboot of the Global Navigation Satellite System (UK GNSS) which concluded at the end of September.

German urban air mobility specialists Volocopter has begun selling 'VoloFirst' tickets for piloted air taxi flights after commercial launch. The tickets are priced at €300 and can be reserved for a 10% deposit and are valid for a 15-minute flight in a VoloCity eVTOL. Volocopter says that it intends to launch the first eVTOL flying taxi flights within the next two to three years.

US FAA chief Steven Dickson conducted a personal test flight of the troubled Boeing 737 MAX, ahead of the type's approval and return to airline service. The unusual move by the head of the FAA, a former military and commercial pilot, saw Dickson evaluate the aircraft's changes and design tweaks himself over a two-hour flight on 30 September. However, the FAA refused to speculate on how much longer the aircraft would continue to be grounded for commercial flights.

SPACEFLIGHT

German rocket company to launch from Norway

Rocket Factory Augsburg

German space access start-up Rocket Factory Augsburg (RFA) has signed an agreement to launch its mini-launchers from Norway in 2022. The agreement will see RFA operate its RFA ONE small-satellite rocket from Andøya Space Center in northern Norway.

AIR TRANSPORT

Latest bail-outs for crisis-stricken airlines

Flag carrier Qatar Airways has received a cash injection of $1.95bn from the Qatar Government as the Covid-19 pandemic continues to wreak havoc on airlines. The carrier recorded net losses of $1.9bn up until March 2020. The airline is now serving 90 destinations in its network, down from the 160 it flew to before the pandemic.

● Meanwhile, China Eastern Airlines is to receive a cash injection of $4.60bn from four state-owned investors (China Life Investment Holding Ltd, Shanghai Jiushi Group, China Reform Holdings Corp and China Tourism Group), as part of a move to diversify ownership. The airline recorded a net loss of $1.2bn in for the first half of 2020.

AEROSPACE

Autonomous B-N Islander to be developed

The UK's Britten-Norman is to work with UAV and AI specialists Blue Bear Systems to develop a semi-autonomous version of its classic Islander STOL utility and small airliner. The first phase would see a semi-autonomous version of the twin-engine aircraft developed, replacing the need for a co-pilot and be available by the mid-2020s. A semi-autonomous one-pilot Islander, says Britten-Norman, will "present a significant efficiency increase and cost saving for regional air operators". Further in the future, it is envisaged that a fully unpiloted autonomous Islander could be ready in the 2030s. Around 750 Islanders are still in service around the globe.

DEFENCE

Tempest could generate £25bn for UK economy, finds study

BAE Systems

An independent study on the value of the Tempest combat aircraft programme by PwC has reported that it would generate £25bn to the UK economy in the first 30 years – with 20,000 jobs being supported annually between 2026-2050. This excludes export sales or spin-off R&D value. As an example of the latest technology involved, the 'Multi-Function Radio Frequency System' integrated radar/sensor being developed for Tempest by Leonado UK will see the data equivalent of the internet traffic of a large city being captured by the aircraft's mission systems every second.

US carrier American Airlines and United Airlines are expected to lay off over 32,000 workers after the US Government failure to reach agreement to extend its Payroll Support Program. American may reduce its staff levels by 19,000 and United by 12,000. Other US airlines are expected to make additional reductions.

Textron has won a contract from the Royal Thai Air Force for 12 Beechcraft T-6C Texan II military trainers as part of an integrated training system at the RTAF Flying Training School at Kamphaeng Saen airbase. The first T-6C Texan IIs, which will be called the T-6TH in Thailand, are due for delivery between the end of 2022 and early 2023.

China launched nine small Earth observation satellites into orbit on 15 September. The satellites were launched aboard a Long March 11 launcher from a ship in the Yellow Sea.

US drone manufacturer Sonin Hybrid has unveiled a 140mph+ drone designed for first responders. The new Recruit hybrid-electric drone is built of carbon fibre, has an endurance of 3+ hours and is fitted with a video camera with fixed and mobile target tracking, FLIR with night vision, PA speakers, spotlight and additional sensors for first responders' missions.

ON THE MOVE

Chief Executive of British Airways, Álex Cruz is stepping down. He is being replaced by Aer Lingus chief Sean Doyle.

The new Team Leader for the RAF Red Arrows display team for 2021 will be Sqn Ldr Tom Bould.

GKN Aerospace CEO Hans Buthker has resigned, reports *Flight Global*, with Peter Dilnot, Chief Operating Officer, Melrose taking over in the interim.

Glenn Bradley is the new Head of Flight Operations at the UK CAA.

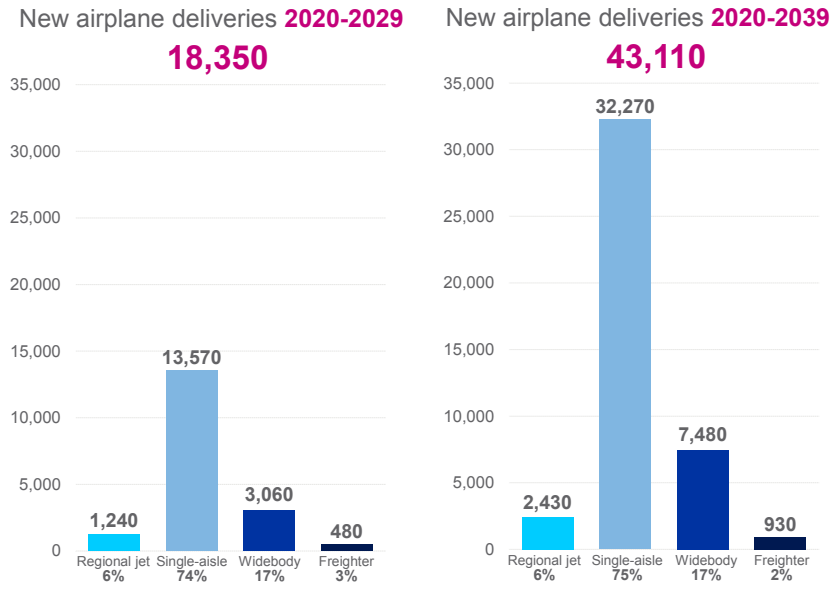
Boeing astronaut Chris Ferguson has pulled out from flying CST-100 Starliner on its first flight in 2021, citing personal reasons. In his place will be NASA astronaut Barry 'Butch' Wilmore.

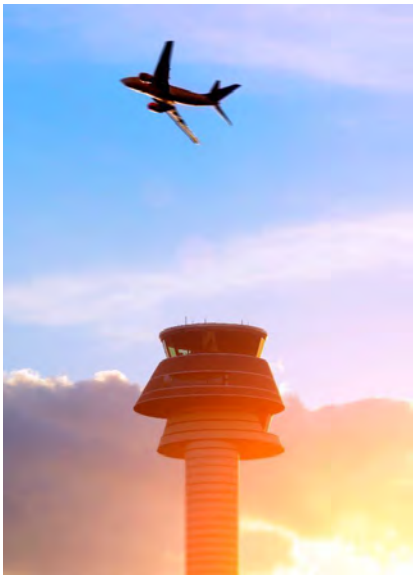
By the Numbers

Understanding the world of Aerospace through data

Boeing reveals latest airliner 20-year market forecast

First decade delivery impact, longer-term resilience driven by single-aisle

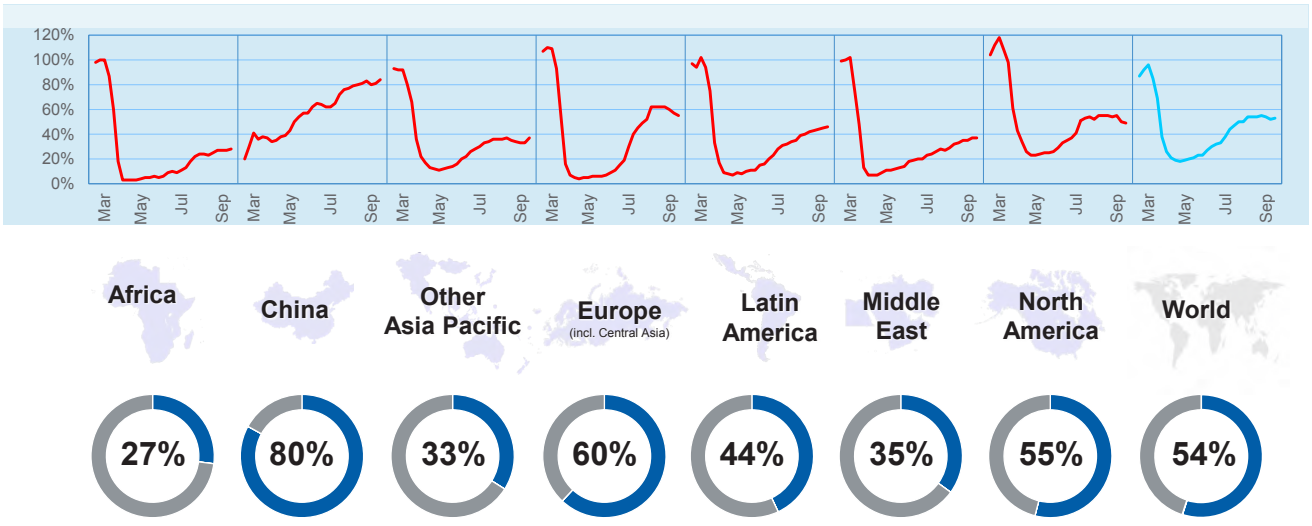




Boeing

Post Covid-19 crisis recovery by region

Varied recovery paths across regions so far



Boeing

SOURCES: Weekly level of passenger operations through Week 38 (9/13 - 9/19) FlightRadar24, BR&T Europe, Boeing
Normalized based on 1/12-18 operations

Pushing the Envelope

Exploring advances on the leading edge of aerospace

Robert Coppinger

DARPA and the Horizon Drive

An alternative hypothesis to cosmology's dark energy and matter which is believed to explain the accelerating expansion of the Universe could be the key to a propellant-less form of propulsion.

This form of propulsion has already been tested and produced thrust of 0·1 Newtons per kilowatt; better than ion drives which propel satellites. An ion drive accelerates a gas' atoms in a magnetic field for thrust. Far more efficient than a rocket engine but with a fraction of the power, it still requires a propellant – the gas.

Tapping into Dark Matter

The 0·1N/kW was achieved by Spanish researchers funded by the United States' Defense Advanced Projects Research Agency's (DARPA) nascent light-matter interactions programme. The Spanish propulsion design is based on the alternative hypothesis to dark energy and matter quantised inertia (QI) and its Unruh (pronounced Un-roo) radiation. Unruh radiation is named after Canadian physicist William Unruh who, along with researchers Paul Davies and Stephen Fulling, proposed its existence in 1976. In 2007, physicist Michael McCulloch, now a University of Plymouth geomatics lecturer, proposed QI, which is based on Unruh radiation.

McCulloch is the Principal Scientist leading that DARPA-funded research. His QI hypothesis says an interaction between objects and distant horizons, including the edge of the Universe, replaces dark energy and dark matter. Dark energy is believed to accelerate the Universe's expansion while dark matter restrains celestial bodies. Neither dark energy nor matter are proven scientific theories, they are still hypotheses. In McCulloch's view, instead of dark energy accelerating the Universe's expansion, all matter is simply attracted to the edge of the Universe, the cosmic horizon.

In QI, what restrains celestial bodies from their acceleration towards the cosmic horizon is the existence of a distant horizon behind them. It is Unruh radiation's interaction between an object and that rear horizon that causes inertia by restraining the acceleration. This interaction between Unruh radiation and distant horizons is why McCulloch, in a blog post a few years ago, coined the term Horizon Drive. DARPA contacted McCulloch about QI in July 2017. McCulloch then applied for DARPA funding after reading a paper by US Army Space and Missile Defense Command physicist, Travis Taylor.

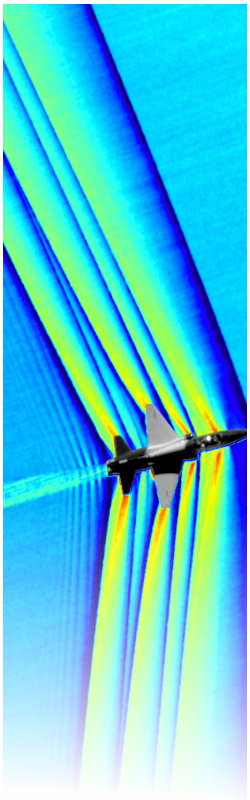
'Fringe science' or genuine breakthrough?

The Journal of the British Interplanetary Society published Taylor's paper in 2017. It referenced unexplained Cassini, Rosetta and Galileo spacecraft acceleration changes as possible QI effects. It also described a Horizon Drive experiment that looks like an electromagnetic (Em) drive but uses lasers. The EmDrive was invented by Roger Shawyer. For thrust, his design uses microwaves, not a laser, in an asymmetric metal truncated cone and Shawyer does not accept the Unruh radiation hypothesis. As *AEROSPACE* goes to press, Shawyer is set to make public his work on developing his microwave frequency EmDrive for Cubesat propulsion.

McCulloch's team are not using microwaves or lasers. Their Horizon Drives use visible light or the infra-red to create a local horizon, not distant, which dampens Unruh radiation's restraining effect because of its proximity. This allows the acceleration. DARPA awarded McCulloch's team £1.3m in 2018 for a four-year study called, *Propellant-less propulsion using quantised inertia*. McCulloch's team includes those Spanish researchers, based at the University of Alcalá in Madrid, and others at Dresden University. Dresden's researchers have previously studied Shawyer's EmDrive.

Since McCulloch's 2018 award, his team has had to pass three-month milestones and demonstrate progress after 18 months to continue to receive the funding, and they did, he says. McCulloch also has a research partner in the US. He, and the University of Southern California's astronautical engineering research professor David Barnhart, applied to Antelope Valley College's California Aerospace Technologies Institute of Excellence for funding. They were awarded $100,000 for Horizon Drive research last March. CATIE exists to link the US Air Force, and its industry partners, which include Lockheed Martin and Boeing, to academia.

Barnhart said in September that a Horizon Drive is now ready in their vacuum chamber, placed on a levitation platform. The experiment will completely isolate the drive to validate if the propulsion effect is real. Dark energy and matter are a, 'complete mystery', according to NASA's astrophysics website, while many scientists criticise the quantised inertia hypothesis. But, if Unruh radiation is the solution to one of cosmology's greatest mysteries, it could send humanity to the stars.



> INSTEAD OF DARK ENERGY ACCELERATING THE UNIVERSE'S EXPANSION, ALL MATTER IS SIMPLY ATTRACTED TO TO THE EDGE OF THE UNIVERSE, THE COSMIC HORIZON

Transmission

LETTERS AND ONLINE

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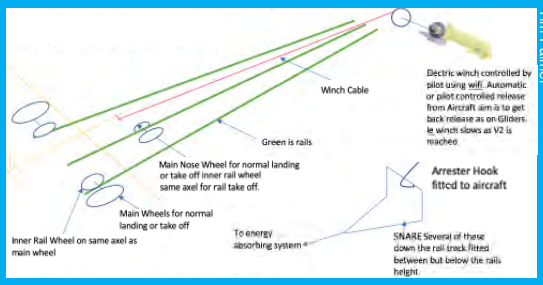
Electric aircraft assisted take-off?

I have just read the article in the September issue of *AEROSPACE*[1] on the English Aviation Group concept for the 70-seat hybrid electric regional airliner which features an electric power-assisted take-off with motors embedded into the undercarriage wheels, together with electric propeller motors. It struck me that the limited range of this aircraft of 800 miles could be boosted a good bit by using the take-off run itself to provide electric power from electrified rails embedded in the runway with pickup tabs on the aircraft to deliver the power to both wheel and propeller motors. Thus, giving a fully charged battery in the aircraft at the point of take-off, a greater range could be obtained by using this idea, as the energy is not taken from the aircraft's batteries for the take-off and can be used for assistance in gaining height and, therefore, range. Low friction rail take-offs will also enable higher weight take-offs or shorter take-offs. In addition, strong crosswind take-offs should be safer because the aircraft is on rails.



Tim Palmer

On landing, the electric wheel motors could spin up the wheels to the aircraft's touch-down speed in order to reduce landing shocks and tyre wear. Thereafter, reverse torque from the wheel motors will give electric braking, thus eliminating tyre skid and saving on friction brake wear and tear.

Alternatively, the electric aircraft could be launched using winch assistance controlled by the pilot using wi-fi. Automatic or pilot-controlled release from the aircraft could be operated as it is on gliders with the winch slowing as V2 is reached. If an on-rail take-off abort is needed, then an arrester hook system, as fitted on aircraft carriers, could be used which could give the ability to abort as late as V2. The arrester cable would run under the rails but not transverse as on a carrier deck but using a snare pickup instead.

Tim Palmer

Remembering 4 February 1971

I always enjoy and value the commentary from Professor Keith Hayward but an error crept into The Last Word in October 2020[3]. The date of 4 February 1971 is permanently engraved on my memory as the day Rolls-Royce collapsed, not in January. As one of the 4,000 employees who were redundant in March 1971, it is not something you forget. However, I cannot believe it's almost 50 years ago. Thank you Keith, for reminding me that I'm getting old.

David Lee MRAeS

New thinking needed on risk management training

The recent article by Lee Balthazor in *AEROSPACE*[2] raises rather interesting issues. Risk management is a vital tool for all managers and can be learned online or part-time within six months at a low cost but is often a skill lacked by managers at all levels.

As the cost of education increases, many education establishments have continued to build and extend programmes with what appears to be a primary aim of earning more fees rather than providing what a student requires which is to have rapid low-cost training to equip them to gain work where demand requires skills rather than labour. The cost of obtaining an undergraduate degree is between £35,000 and £40,000 in the UK and £101,000 in the USA if one includes the cost of living expenses and accommodation. These costs are escalating rapidly which is pricing out students from poorer backgrounds.

The global pandemic is promoting changes in many areas of work and may well do so in education. In China, companies such as the Tai Education Group, New Education Group and others are providing after-school learning. Google is about to promote certification in subjects such as data analyst, project management and user experience designers, with other proposals in the chain. My own company, the AICP.org, provides training programmes in risk management and procurement 100% online which will equip managers at all levels to carry out those functions. They set standards, are flexible and can provide mobile learning and provide shorter, more affordable options to quickly build skills. They are available worldwide and can be taught to groups or individuals and be completed while in work, possibly sponsored by employers.

It will be interesting to have members' comments on these new approaches.

Allan Robertson MRAeS

Capt 'Winkle' Brown

Dhaval Panchal [On archive video of lecture by Capt Eric 'Winkle' Brown[4]] I read his autobiography, *Wings on my sleeves*. What a fantastic book, and an incredible person!

Terry Bromwich He was amazing. I had the honour of listening to him at a Solent Branch lecture a few years ago. Every single story contained more excitement than most of us see in a lifetime. Any story that starts with: "So, I said to Churchill..." or "So, I climbed into that Nazi jet without an instruction manual..." is bound to be entertaining and he was a fantastic speaker too. A true gentleman and genuine hero.

Hydrogen power

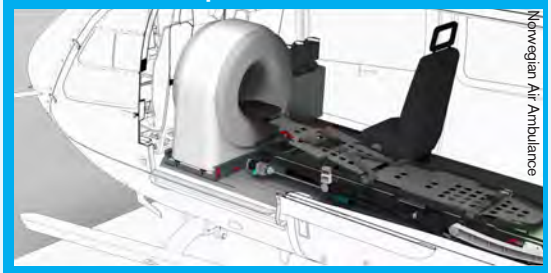
Jason Nicholson [On Airbus development of hydrogen-powered aircraft[5]] The hydrogen fuel cell is the way forward for light aviation and all motor vehicles. The biggest problem with lithium ion batteries are the environmental issues that they can't at present be recycled and the emissions in the manufacturing of the batteries and mining/processing the raw materials, like cobalt, used in them. Metal hydrides do offer a good method of safely storing hydrogen as an alternative. Until these hydrogen systems are developed to a point in which the energy output per kg matches kerosene, we're going to be stuck with hydrocarbon transportation.

Nicholas Hill Does it really make sense to burn coal to create hydrogen, and then to convert that to electricity? Overall calorific conversion must be appalling.

UK Spending Review

Yvonne Elsorougi [On RAeS' response to UK Government's Comprehensive Spending Review[6]] As a Fellow and Council Member of the Society, I wholeheartedly endorse these recommendations. I am particularly pleased to see the Brunel Challenge/Design Smarter in number one position, as this is fundamental to the future success of Aerospace and Advanced Engineering in the UK. The West of England is already leading the way with its investment in the Digital Engineering Technology & Innovation (DETI) programme which will hopefully become part of a wider national network within the Brunel Challenge/Design Smarter context.

Medivac helicopter mobile CT scanner


Norwegian Air Ambulance

@Kevin_Fong [On Norwegian Air Ambulance to equip Airbus H145 with a prehospital mobile CT scanner to check for head injuries/stroke treatment] Pretty amazed really. But I prefer the iron man jet pack thing.

@narkoselaegan The goal is to distinguish between hemorrhagic and thromboembolic stroke. If hemorrhagic you go to neurosurgery. If thromboembolic you initiate thrombolysis prehospitally to save time and brain.

@CraigCCRNCEN This did cause me to raise an eyebrow about the expense, risk, and decreased patient and staff load with all that weight. But it is cool that we're taking another step closer to Star Trek level medicine.

@drrobgrieg So if the scan is negative you take to hospital because they have neurology that triggered imaging. If scan is positive, you still take to hospital and you can't fly while scanning because of radiation.

From the RAeS photo archives


RAeS/NAL

Avro Manchester IA, L7515, of No207 Squadron flying from RAF Station Waddington in November 1941. This month marks the 80th anniversay of the entry into service of the Avro Manchester medium bomber. Regarded as an operational failure, primarily as a result of its Rolls-Royce Vulture engines which were underdeveloped and unreliable, production was terminated in 1941. However, the Manchester was redesigned into a four-engined heavy bomber, powered by the Rolls-Royce Merlin engine instead, the very successful Lancaster.

North Korean lights


North Korea media

@knowelesm [On North Korean MiG-29s with LED lights take part in night parade] Seen plenty of Essex boys' cars tricked out like that speeding past in Epping Forest. But this is a new one...!

@VirtualAvi8or When gamers design aircraft - integrated RGB lighting!

@Billy_Chisholm They do look good though.

Baby boomer

@realcni [Boom Supersonic rolls out XB-1] You've got to say at that angle, no prizes for guessing the source of the design inspiration ... and anything that looks as good as Concorde, gets my #avgeek vote!

@BenBrelje_says I too want a lot of things that physics renders virtually impossible lol. I guess if flight crew costs increased like 10,000%, then the block time savings could dominate...

Hydrogen challenges

@IanPsDarkCorner [On Airbus hydrogen moonshot[5]] How do they propose to capture hydrogen in sufficient quantities? Or store it, for that matter, considering it is vastly more volatile than Jet A1! Just being able to burn it for thrust is a tiny part of the requirement.

@PlaneCrashGuy Going from jet generation 1 of the CV-990 subsonic to Concorde did not muck about with incremental changes. Having optimised and tinkered with current designs, it is time to get bold. Blended wing around hydrogen tanks might be the way to go to beat flight shaming.

F-35 data sharing

@PhilipClare1 [On USMC F-35s deploy with RAF 617 Sqn on HMS *Queen Elizabeth*[7]] Yes, but the journey towards 'Multi Domain' means sharing data across a coalition. Likely to be an issue for a long standing alliance like NATO, let alone ad hoc coalitions.

Upgrading the U-2

@TheDewLine [On USAF updates U-2's software in flight in test] This may be a bit different than adding a new row to the threat library during flight. Cognitive EW is already looking at that, including jamming techniques. This is about optimising the software configuration as the system learns during flight.

Farewell to the Jumbo


British Airways

@msjhaffey [On BA retires its last 747s] I want to buy one for my garden.

@PhillipCovell I'm really going to miss the 747!

@MichaelJPryce It is sad they will no longer fly from LHR. Growing up, they took off over our house and always made you look up.

@Phil_rowles It says it all that a top architect would insert the 747 into a series about great buildings. My architect girlfriend at the time was appalled!

@RichardGlassock Why don't we preserve almost all of them? Plenty of locations available and great BnB structures for the world.

1. *AEROSPACE*, September 2020, p 4, Blueprint – English electric excites
2. *AEROSPACE*, September 2020, p 31, Managing risk – back to basics
3. *AEROSPACE*, October 2020, p 58, The Last Word
4. https://www.aerosociety.com/news/video-audio-classic-lecture-highlights-of-a-life-in-aviation-by-capt-eric-winkle-brown-honfraes-rn/
5. https://www.aerosociety.com/news/airbus-spearheads-european-moonshot-for-zero-carbon-aviation/
6. https://www.aerosociety.com/media/14558/2020_09_23_raes_response_comprehensive_spending_review.pdf
7. *AEROSPACE*, October 2020, p 25, Lightning pathfinders

Wake-up call for space threats

As space gets more contested, ALLEN ANTROBUS FRAeS, Key Account Military Space for Airbus DS in the UK, assesses the impact of the increased militarisation of space for the commercial space sector.

ESA

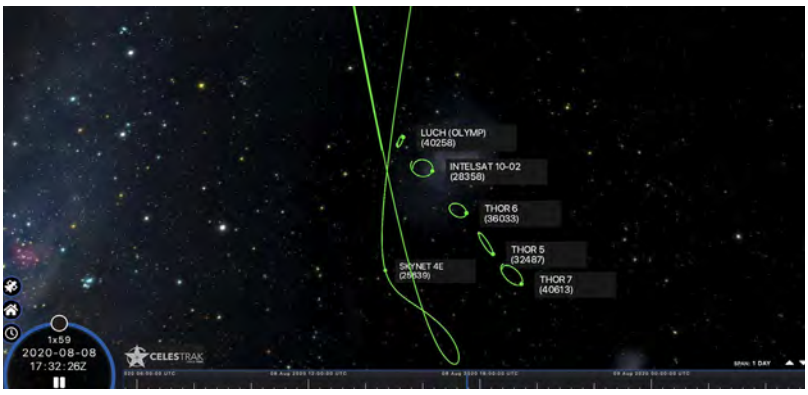
The anti-satellite (ASAT) weapons test this summer, reported by the UK and US Governments, and denied by the Russians, is another indicator that in-orbit tests and direct ascent tests (DA-ASAT) appear to be on the rise. According to the Secure World Foundation, the Russians have conducted ten possible ASAT tests since 2014; over the same period, the Chinese have conducted four tests and the Indians two. This trend is worrying to all actors in space, including the UK space commercial sector.

Orbital manoeuvres in the dark

On 15 July 2020, a Russian military satellite, Kosmos 2543, released a high speed projectile from the main body of the spacecraft and, although there was no indication the projectile collided with another satellite, this action, according to US Space Command, was 'consistent with a test of a new anti-satellite capability'. This event followed a Russian DA-ASAT test on the 15 April 2020 from a system termed Nudol and which was launched from Northern Russia but again did not collide with another satellite. The Nudol system is designed to engage targets in low Earth orbit between the 150-2,000km above the Earth's surface. Along with these ASAT tests, both the Russians and Chinese have engaged in orbit behaviour that could be interpreted as aggressive. In 2014, a Russian satellite called 'Luch' manoeuvred around the geostationary belt and came close to both French and Italian military communication satellites. More recently, from July 2017 to December 2019, a Chinese satellite SJ-17 made a series of manoeuvres in the geostationary belt and conducted a series of space rendezvous with a number of other Chinese satellites; these manoeuvres took SJ-17 past the UK MoD's Skynet 5A satellite.

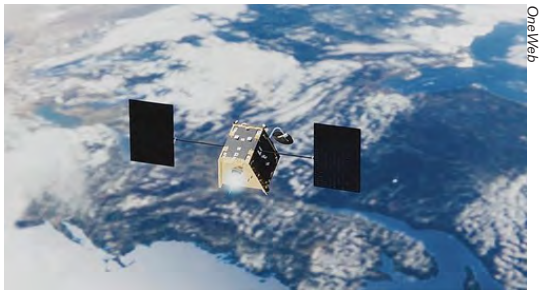
Space has always been the preserve of the military and intelligence services of the US and Russian (previously the USSR) governments but, since the mid-1980s, there has been little overt testing of anti-satellite weapons. The status quo changed when the Chinese government shot down a defunct weather satellite (Fengyun-1C) on 11 January 2007. This destructive event created over 3,000 pieces of debris and was widely condemned by the international community. Since then, the US, Russia and, more recently, the Indians have conducted tests, as well as rendezvous and proximity operations (RPO), which could be interpreted as a test run for possible military action. International law and treaties offer little advice or

Below: Russian satellite 'Luch' and the UK's Skynet 4E satellite.



CelesTrak

guidance on how to interpret these actions. Article IV of the Outer Space Treaty of 1967 declares that: 'Parties to the treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction'. Consequently, as the treaty only mentions nuclear weapons and WMD, then it could be interpreted that other types of weapons are allowable. Any misinterpretation on the use of RPO or anti-satellite tests could have grave consequences for the UK space sector but also the wider UK economy.



OneWeb

A critical dependency

Space assets have significantly changed the way we live our lives on Earth. Position, navigation and timing data from the US GPS constellation or the EU's Galileo constellation have transformed the transport and financial sectors that enable 'just-in time' supply chains, support millions of pounds of global financial transactions and synchronisation of everything from utility networks to mobile phone systems. Accurate data from meteorological satellites have transformed the way farmers cultivate the land reducing waste and improving food production. Large satellites, over 36,000km above Earth, broadcast news and sports direct to our home. In the not too distant future, mega-constellations such as OneWeb will provide broadband services direct to homes and this will enable those of us who live in remote locations to benefit from 'fibre-like' speeds from space. All of this is at risk if a conflict between nations extends into space.

Although space is vast, it is a finite resource; there is already congestion in certain orbits and the management of the spectrum is becoming more challenging for the International Telecommunications Union (ITU) – the UN agency tasked to allocate global radio spectrum and satellite orbits. Additionally, debris caused by launching satellites, in-orbit failures, explosions and collisions continues to grow and is an issue for all spacefaring nations and satellite operators. NASA estimates there are more than 23,000 pieces of orbital debris larger than 10cm hurtling through space at 8km/sec and any collision will involve considerable energy. The most significant events have been the collision of a Russian communications satellite (COSMOS 2251) with a US commercial satellite (Iridium 33) and the Chinese ASAT test. These events have caused over 5,000 pieces of debris that can be tracked and possibly as many as 200,000 objects that are too small to be tracked effectively; even these smaller objects could cause a mission-ending event for a satellite operator.

However, the precise risk to operators is still unknown and, although there is a growing understanding of the issue, no one can be sure how dangerous the current situation is and what the impact of future launches of mega-constellations will be. In the late 1970s, a NASA scientist called Donald Kessler predicted that if there was too much debris in orbit then it could create a chain reaction whereby more and more objects collide creating more debris; a concept termed the Kessler Syndrome. The UN, through the Inter-Agency Space Debris Coordination Committee (IADC), continues to lead the international effort on space debris research activities and has guidelines which describe practices that can limit the generation of space debris in the environment.

Above left: Satellite mega-constellations such as OneWeb are set to bring benefits but also increase congestion in orbit.

Right: Launch of Russian anti-satellite missile.

Russian MoD

Implications for commercial satellite operators

So what can the UK and, in particular, the commercial entities such as Airbus Defence and Space, Inmarsat, OneWeb and Surrey Satellite Limited do to alleviate this risk?

At state level, the UK requires a clear national space strategy that seeks to ensure the UK can access and use space now and in the future. It is five years since the publication of the National Space Policy and a national strategy should clearly articulate how the UK's civil, commercial and defence sectors will co-ordinate their activities; instrumental to this will be the National Space Council, led by the Chancellor. Previous space strategies have focused on growth and innovation

and, while any future strategy should seek to ensure the UK space sector can continue to grow, create jobs and drive prosperity, this can only happen if the environment is stable and secure. It is now over two years since the then Defence Secretary, Gavin Williamson, announced at the UK Defence Space Conference that this country would have its first Defence Space Strategy and one is sorely required. The planned strategy will require collaboration across Government, in particular between the UK Space Agency (UKSA) and the MoD but it should also include UK satellite operators and the wider space enterprise.

In parallel to the strategy, UK commercial companies will continue to support the efforts of the UK Government in defining and implementing norms of behaviour in space. The FCO, through its use of its establishment at Wilton Park, has run a number of successful international events that have included government policy makers, space agency personnel and commercial entities where norms of behaviours have been debated and discussed. A number of events have examined the changing space environment which has seen an increase in new actors and the potential outcomes from developing mega-constellations of hundreds or possibly thousands of satellites; space is no longer the preserve of the military.

However, the rules and regulations covering activity in space have not significantly moved since the earliest concepts and, consequently, there is now a significant gulf between the limited legal regime and the activity taking place in space. There is a requirement to establish a set of norms of behaviour for operating in-orbit. These norms should seek to sustain the space environment for future generations by avoiding collisions between spacecraft and debris while simultaneously reducing uncertainty around satellite manoeuvres that can be perceived as threatening.

UK Space

A Commercial Integration Cell has been set up in the RAF's SpOC at High Wycombe.

A more joined-up approach needed

In order for the UK to understand what is occurring in space and to monitor the risk associated with orbital debris and any future weapons tests, then the UK should create a national space operations centre. The centre should be the focus for integrating data from current systems, such as the RAF's Phased Array Radar at RAF Fylingdales, and from commercial providers, such as Space Insight which operate ground-based telescopes that monitor satellites in

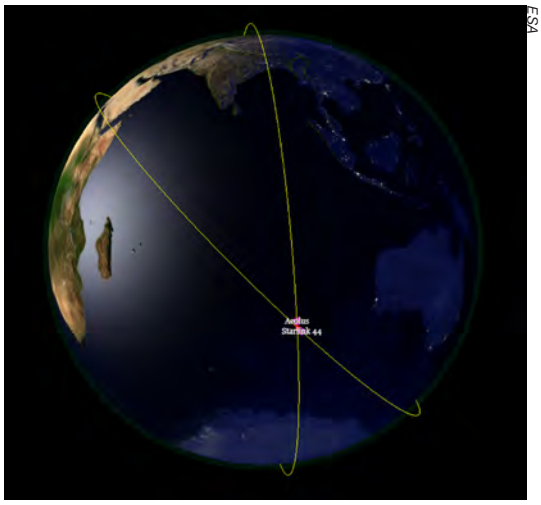
higher orbits. Currently both the UKSA and the MoD are pursuing different space situational awareness initiatives; UKSA is involved in the EU programme called the Space Surveillance and Tracking initiative and the MoD has been involved with the US-led Combined Space Operations programme. The UK was the first formal partner to sign up for an American-led coalition called Operation Olympic Defender in July 2019. Given the UK has now formally left the EU, it will need to re-evaluate its current efforts with both defence and civil partners.

Commercial satellite operators and space situational awareness partners should be included in any future activity, as they can contribute to the overall understanding of the space environment. In particular, given that commercial operators may have a more comprehensive knowledge base and are as concerned about nefarious activity as the Government, then they could offer more detailed analysis of any ongoing interference with a satellite, network or signal. Additionally, commercial space situational awareness companies are not normally hampered by national security issues and could start to highlight poor or misleading actions and this, in turn, could start to drive different behaviours.

One recent success has been the establishment of the Commercial Integration Cell inside the Royal Air Force's Space Operations Centre at RAF High Wycombe. The cell has been created by UKspace, the space sector trade association which represents over 90% of the space companies in the UK and was formally established in July 2020. The aim is to enable day-to-day military-commercial interface and establish mechanisms to enhance space situational awareness, electro-magnetic interference awareness and provide indicators and warnings of any potential threats.

Developing the 'rules of the road'

Independent of government, commercial operators can also play another role. Many companies are signatories to the Space Sustainability Coalition which outlines the 'Best Practices for the Sustainability of Space Operations'. These measures, which build upon guidelines designed by the IADC and the UN's Committee on the Peaceful Uses of Outer Space (COPOUS), seek to tackle the issue of orbital debris and have argued the need for mitigation measures to ensure that space is accessible for the future. With a predicted number of future space launches of between 70 to 90 a year and a number of those launches delivering 30 or more satellites per launch then the future is challenging. The European Space Agency is recommending the removal of five to ten large objects from regions in space that have high density. Surrey Satellites Limited designed and manufactured the Remove Debris mission that included four innovative experiments to test how to clean up space. Another commercial company, Astroscale, based at Harwell is establishing a national in-orbit servicing facility that will help with the removal of debris.



ESA

Last year ESA took the unusual step of going public with a close encounter of its Aeolus satellite with a SpaceX Starlink to highlight the dangers of potential collisions in orbit.

Rules of the road

However, there is much more work that needs to be done. The UK needs to better understand the role the US Department of Commerce will have in developing 'rules of the road' in its pursuit for space traffic management. As an example, these rules could specify how spacecraft might prioritise manoeuvres if the operators find themselves in a situation where the collision risk is high. In September 2019, ESA was required to perform a 'collision avoidance manoeuvre' of its Aeolus satellite due to a potential collision with a SpaceX satellite. There is also more work required to include national defence and intelligence entities within such forums as the Space Data Association (SDA). The SDA allows operators to share relevant space information operator-to-operator to coordinate space activities and the inclusion of defence and intelligence assets would be a significant step to reducing risk. Finally, there should be significant effort made across spacecraft manufacturers, governments and supranational bodies, such as ESA, to strive to de-orbit all spacecraft at the end of their operational life in order to sustain the environment for the future.

The risk to spacecraft in orbit has grown significantly over the last decade and the UK needs to prepare to deal with the double threat of orbital debris and suspicious behaviour. While individual departments are leading efforts to tackle these issues, the lack of a clear strategy bringing coherence across the Government is required. UK commercial space companies will be fundamental in supporting this effort.

Qatar Cargo

Air freight shifts its centre of gravity

Cargo, traditionally the less glamorous aspect of the air transport business, has become exponentially more important during the coronavirus pandemic and has supported many airlines. ALAN DRON asks, how have operators responded?

Most people never stop to wonder how the shelves of European supermarkets carry constant stocks of fresh strawberries and cut flowers in the middle of winter. Or how doctors' surgeries obtain constant supplies of drugs. Or even how racehorses reach overseas circuits for the big events in the international equine race calendar.

Cargo has traditionally been 'the far side of the airport' aspect of commercial aviation. Although carrying an importance greater than its visibility, to the travelling public it has been a classic case of 'out of sight, out of mind.'

Also unappreciated by many people is the fact that around 50% of the world's air cargo is moved, not by dedicated cargo aircraft, but in the underfloor holds of passenger airliners. So, when those airliners were grounded in March, as ever more countries closed their borders in response to the pandemic, a 'cargo crunch' quickly developed, with severe shortages of capacity to move urgently needed goods.

Will ill winds increase deliveries?

They say 'it's an ill wind that blows nobody any good'. For the past couple of years, the airfreight business has been in the doldrums, with 2019 seeing the first decline in cargo quantities since 2012. That changed suddenly this year, as demand for medical supplies and other essentials rocketed. For those able to take advantage of the circumstances, cargo suddenly became profitable again.

However, the picture has been decidedly mixed, said Glyn Hughes, IATA's Global Head of Cargo. "Has there been a revival in the cargo sector? There's no straightforward 'yes/no' answer. You need to look at the longer term. One thing about the air cargo industry is that no two months are the same. Those airlines that have prospered have been those that have been flexible and able to adapt to changing conditions," he said. Some airlines, faced with a combination of sky-high demand for personal protective equipment (PPE), the resulting very high prices paid by desperate governments and 'incredibly low' fuel prices, pulled older aircraft out of retirement to take advantage of the boom.

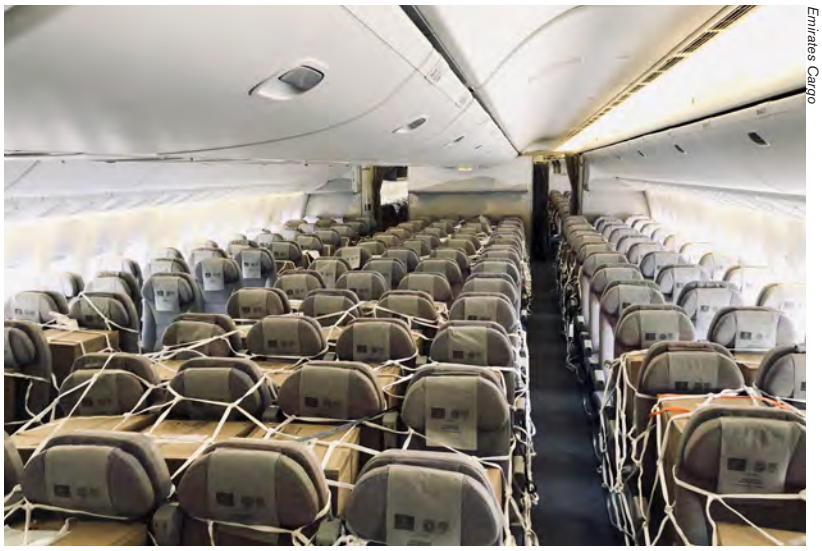
Others, such as Lufthansa, postponed plans to put their McDonnell Douglas MD-11 freighters out to pasture and brought them back into service with two Boeing 747-400s that were "sitting around parts of the world, not quite old enough to go to the scrap heap but not economical enough for day-to-day use".

Above: A Qatar Airways Boeing 777F unloading cargo.

Opposite page: Both Emirates and Lufthansa store cargo on the seats of their passenger airliners.

Below: Horses enjoy a Lufthansa transport flight.


Lufthansa Cargo



Emirates Cargo

Lufthansa Cargo

Freight for passengers

The pandemic has been notable for passenger airliners being pressed into service as temporary freighters, with seats removed to provide space in the cabin or the seats remaining and packages being piled on to them with net restraints.

"The numbers of these are staggering," said Hughes. By late June, more than 2,200 passenger aircraft had been deployed on cargo-only flights. The ease of redeploying certain passenger aircraft made it simple for airlines, he added. A Boeing 777, for example, needed only 'very mild additional certification' to carry cargo on seats.

Emirates Airline, for example, at one point had more than 90 of its 155-strong fleet of 777s hauling freight. "They can get 60 tonnes on a (passenger) 777: that's around 40% more than a 767 (dedicated) freighter."

IATA put together a large internal task force to provide guidance for airlines planning to operate these 'passenger-to-freighter' (P2F) aircraft, bringing together experts from fields such as risk management, cabin safety and flight operations. There were regular conference calls with the FAA, EASA, Transport Canada, CAAC and other regulators to co-ordinate a response and pull together guidance material. Other regulators, notably in southeast Asia and Africa, gratefully followed their lead in navigating this unknown landscape.

Regulations were quickly publicised: packages could not be piled above the height of seats, for example, and the lack of fire detection systems in airliner cabins (as opposed to cargo holds) meant that cabin crew and loadmasters had to be stationed in the cabin with fire extinguishers to act as 'cargo marshals' in the event of a blaze breaking out mid-flight.

One airline particularly heavily engaged in ramping up its cargo operations during the crisis was Qatar Airways. For a primarily passenger-based airline, it has an unusually large dedicated freighter fleet: 21 Boeing 777Fs, two 747-8Fs and five Airbus A330Fs.

The airline, nevertheless, had to be extremely agile to keep up with swiftly changing trading patterns as a result of the pandemic, said Guillaume Halleux, the airline's Chief Officer, Cargo.

For example: Australia is normally a major provider of halal meat to the Arab world. Shipping it to the Middle East is normally done in the underfloor holds of passenger aircraft – the country is not usually a market for dedicated freighters, as it is too distant. With passenger aircraft grounded, that meant that new, closer sources of meat had to be found, from countries as far apart as Ireland and South Africa.

Quick to change

Only fast-moving airlines were able to take advantage of these changes, said Halleux at the


Lufthansa

Above: A Lufthansa airliner unloading at Shenzhen

Opposite page: Emirates handle cargo in Colombo.

height of the outbreak: "The market literally changes by the hour. If your decision-making process is slow and you need a million signatures, you can't ride the wave. At the moment, a phone call in the morning can trigger a flight in the afternoon."

That agility sometimes required changes in direction. Early in the crisis, he described the practice of piling boxes on the seats of passenger aircraft as too complex and time-consuming. Perishable goods such as fruit could leak juice on to the seats, for instance, while medical products risked being crushed if boxes were piled on top of each other.

However, "In France, we have a saying: 'Only dumb people never change their opinion'. So, we did change. I'm still not a huge fan of it, because we believe it's a niche product, but we do have a couple of aircraft where cargo is placed on seats. There are limitations. You can't place drums or pipes on seats, only very small boxes." These seat cargoes are secured by nets, attached to the already-installed points in the cabin floor.

The new balance

Five months into the pandemic, Qatar Airways was operating 120 flights a day using passenger aircraft as temporary freighters with empty cabins and with the belly hold filled with freight, rather than passengers' baggage. This posed a problem that had not previously been encountered.

"What we've discovered is a whole new problem of weight and balance. We know very well how to (adjust the centre of gravity) with passengers but, when aircraft are entirely empty, it creates a problem."

One specific problem is Qatar Airways' specially designed Q-Suite business cabin with its individual compartments. "It's extremely heavy. Being at the front of the cabin, that makes the aircraft nose-heavy. So, you can't put cargo in the front of the belly, you have to load it at the back. Sometimes you don't have the right mix (of cargo) and you don't have weight to compensate.

"One thing Qatar has plenty of is sand. So, we went out to the dunes in lorries, loaded them with sand, then put that in bags and loaded 1.5 to 2 tonnes at the rear of the hold; that then allowed us to put cargo in the front."

Qatar Airways Cargo's rate of growth will change in the light of the continuing need for freight capacity: "We're expanding, and will expand in 2020-21, beyond our pre-Covid expansion plans. Those passenger freighters we're operating right now are staying for a while."

The aircraft that suffered most during the pandemic has undoubtedly been the Airbus A380. Almost every carrier has grounded its fleet and several, such as Air France, have said the double-deck aircraft will not return to service. As its presence on passenger flights shrinks, could it find a new role as a freighter?

A new role for the A380?

Portuguese wet-lease specialist Hifly converted its sole A380 into a temporary freighter by removing the economy-class seats on the main and upper decks. This created 320m³ of cargo space across all three decks, giving it a 60 tonne cargo capacity. Cargo is loaded on the main deck through the passenger doors, while the existing underfloor hold has space for 38 LD3 containers.

A more permanent cargo-carrying role for the A380 has meanwhile been devised by Lufthansa Technik (LHT), which has been undertaking the necessary calculations to convert the aircraft into a full-time freighter.

The German company stresses that it is not cutting metal on this project, which was requested by an undisclosed customer. Rather, it has been working out exactly what measures would be required and creating the paperwork necessary to gain a supplemental type certificate (STC) for the aircraft in its new role.

More generally, LHT has extended its technical and engineering services to handle the operational changes needed to alter an aircraft's use to carry 'real' cargo, as opposed to the 'self-loading' variety. By mid-May, the company's cabin modification specialists had implemented more than 15 projects in this field and enquiries for this type of work had been received from at least 40 airlines. "As the workscope comprises much more than just taking out seats, you need engineering experts who know exactly what the challenges are and how to document the technical solutions so that the aviation authorities agree," said Henning Jochmann, LHT's Senior Director, Aircraft Modification Base Maintenance.

"This means that anyone who opts for LHT's exceptional solution now can easily switch to the permanent STC solution later." Notably, only

> IF, OR WHEN, A VACCINE FOR THE CORONAVIRUS IS FOUND, THERE WILL BE A NEW REQUIREMENT, NAMELY TO DISTRIBUTE AN ESTIMATED 4BN DOSES AROUND THE GLOBE. THAT TASK, SAID HUGHES, WOULD NEED THE EQUIVALENT OF 7,000 BOEING 747 FLIGHTS.

economy-class cabins have generally been used for freight carriage. Highly customised business – and first-class cabins are usually too heavy and complex to easily remove.

Could the A380 find a new niche as a freighter as passenger demand struggles to recover? The answer seems to be 'No', given that extensive structural redesign, notably of the top deck, would be required.

Theoretically, using the A380 for e-commerce – which often means shipping a lot of bulky but light packages – could be feasible. However, any company attempting to do so would find itself up against specialists in the field such as FedEx or DHL, which already have the necessary vast ground infrastructure in place to aid distribution. More likely, said IATA's Hughes, was that elderly Boeings could enjoy a new lease of life: "What's been shown is that the 777 is a tremendous aircraft. You might find that older 777-200s and 300s could be converted."

Older Airbus A330-300s could also go down this route, with airlines potentially getting another 15 years' use from them after leaving passenger service: "The 330, like the 767, has good economics and, going forward, I think there will probably be some demand for that."

Emirates Cargo

Delivering the future

And the future? "This industry's unique selling point is that it must be prepared for anything," said Hughes.

If, or when, a vaccine for the coronavirus is found, there will be a new requirement, namely to distribute an estimated 4bn doses around the globe. That task, said Hughes, would need the equivalent of 7,000 Boeing 747 flights.

Meanwhile, the needs engendered by the pandemic meant that: "Cargo is seen as the hero of aviation," said Céline Hourcade, Transition Director at The International Air Cargo Association (TIACA). However, while it was true that cargo flights had helped bring in a trickle of money to both airlines and airports while passenger flights were suspended, "the air cargo business is still suffering", she said. There had been a few winners – notably pure cargo airlines – but most carriers, ground handlers and airports remained in financial straits, she noted. There seems little doubt, however, that cargo operators will play a more important role in the immediate future.

Helping them will be new equipment, which will particularly appeal to smaller cargo airlines. The ATR 72-600F will build on the success of the Franco-Italian regional airliner, with a large, upward-hinged, forward-fuselage cargo door and the ability to carry both containers and bulk packages. This is scheduled to enter service this year.

Cessna has also begun flight tests of its clean-sheet-of-paper SkyCourier twin-turboprop utility aircraft. This will operate as a 6,000-pound payload capable freighter, a 19-seat passenger aircraft or with a mixed passenger/freight combination. Both types will have ranges of 900nm, making them particularly suitable for feeder cargo operations.

New models, new conversions and a new degree of public recognition for their work may yet bring cargo airlines out of the shadows on that far side of the airport.

Qantas
One hundred not out

On 16 November 1920, Australian flag carrier Qantas was established. Former CEO JOHN WARD looks back at the history of this airline and considers its future challenges in this time of unprecedented turmoil in air travel.

During one hundred years of monumental change, Qantas has provided global aviation industry leadership in product innovation, technical excellence, operational performance and managerial acumen. In doing so, it has survived many dark moments. Periodically reinventing itself, it is a rare exemplar of a successful and resilient Australian business with global reach. Today, it is confident in both its capability and in its economic and social relevance and another reinvention is in prospect.

In the beginning...

The story behind the formation of Qantas began in March 1919 just after Paul McGinness and Hudson Fysh arrived in Hobart, having sailed from Egypt, their First Word War military flying days over. It culminated when the papers formalising the establishment of the airline were signed at the Gresham Hotel in Brisbane on 16 November 1920. Shortly thereafter, Qantas commenced domestic operations in Queensland, initially carrying mail and then passengers. Its network expanded and it began international operations in 1935.

It was an active participant in many theatres during World War II and kept supply lines open between Australia and the UK by operating the 33 hour 'Double Sunrise' flights between Perth and Ceylon to break the Japanese blockade of the Indian Ocean. It was acquired by the Australian Government in 1947, at which time it ceased domestic operations.


Qantas

John Ward, former Qantas CEO.

Below from left to right: Qantas founders, Paul McGinness and Hudson Fysh; early Qantas Empire service; John Travolta takes part in celebration of Qantas' past in 2014's use of retro livery, pre-war Qantas advertising poster.

For the next 45 years Qantas remained uniquely an international airline without a domestic network. While this had its challenges from a business perspective, it necessitated a global outlook and a focus on growing foreign markets.

By the 1970s, Qantas had become an Australian icon by being synonymous with both pioneering and with aspects of the national interest overcoming isolation, developing technological independence and putting in place the air transport infrastructure necessary for trade, business, immigration, family reunion, tourism and cultural exchange with key foreign markets. It also provided airlift capacity for defence and in national emergencies.

Privatisation

By the mid-1980s, Qantas was the most visible overseas manifestation of Australia. However, government ownership support was no longer a political priority. Qantas was starved of equity with $11.50 of debt for each dollar of equity. This had to be addressed.

The resulting privatisation which followed the acquisition of the purely domestic Australian Airlines in 1992 required a commercially sustainable balance sheet and the attainment of globally competitive operating and financial metrics.

Privatisation also meant that, unlike the situation with many of its foreign competitors, it was largely the appetite of the capital markets that would henceforth be the ultimate determinate of the size and shape of Qantas.

Realised merger synergies resulted in a substantially lower post-merger domestic cost base and its potential for high profit generation. Qantas' initial post-privatisation focus was therefore on maximising the returns from its domestic network while strengthening its international competitiveness through co-ordination with its domestic network.

Intrinsic to Qantas' historical success has always been taking a long-term perspective with careful and early investment in new technology to secure competitive advantage in both product and operating costs. This remains true and is now augmented by the need for capital market support, requiring healthy cash generation and a continuing investment grade credit rating.

Leadership

No retrospective on Qantas would be complete without some commentary on leadership.

At Qantas, leadership has always been the art of listening to a broad range of stakeholders while determining what is best for the long-term future of the company and then gaining the support of key constituencies by providing them with the knowledge base to embrace the company's conclusions and accept its strategies.

While shareholders' interests were never subordinated to those of other groups, it was always accepted that stakeholder considerations were part of a strategy to promote company sustainability and maximise value over the longer term. Indeed, this embodiment of what are now known as environmental, social and governance (ESG) principles has been a feature of leadership at Qantas throughout its 100 year history.

During this time, when making strategic decisions, Qantas has often needed to balance a range of often complex and competing stakeholder interests in concluding what actions are in the best interests of the company. At various times these different stakeholder interests have been accorded different weightings. Profitably serving the national interest was a key criteria

Doug Nancarrow

Left: Six Qantas CEOs – from left Alan Joyce, Geoff Dixon, the late James Strong, John Ward, John Menadue and the late Ron Yate.

Below: Qantas Boeing 707 in Seattle in 1959.

under government ownership while delivering a competitive return has become key post-privatisation.

Historically, regular direct, consistent and open employee and political communication has been necessary to gain trust, secure engagement and have stakeholders develop sufficient appreciation of business reality to mitigate shortsighted political and industrial agitation.

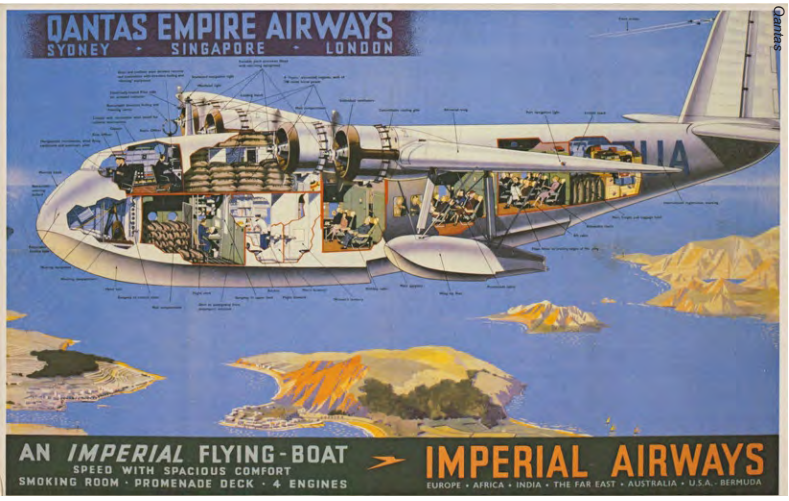
The lesson of history is that, for these audiences, spin is counterproductive. It dilutes the credibility of the real message and breeds cynicism which is neither conducive to an engaged and motivated workforce, nor to government support. Hubris must be avoided.

Until the 1990s, economies of scale were a prime source of competitive advantage. Since then, the balance between economies of scale and scope has shifted. Many economies of scale have been mitigated by technology and by outsourcing. While this reduced some of Qantas' resilience and domestic competitive advantage, from a group perspective, it has had positive, albeit painfully achieved, results.

As economies of scope became the increasingly potent source of competitive advantage, these have underpinned Qantas' recent success. Examples are its superior network alliances, its customer loyalty programme, the reach of its differentiated dual-branded manifestations and the defence of its 'line-in-the-sand' 65% domestic market share.

Not since foreign hub operations began in earnest in the 1970s has Qantas been able to overcome its structural geographic disadvantage as an 'end-of-the-line carrier' and have some semblance of control of its own destiny in the

Qantas



Qantas

Qantas

Europe end-to-end market. This may now be in sight.

The longest haul

For the Australian East Coast, finally the aircraft technology is arriving to allow a broader fight back against geography with an extended long-range variant of the Airbus' A350 selected as the aircraft best suited for viable non-stop services to the UK, Europe and New York, demand for which could become increasingly strong in the post-pandemic years.

The intermediate hub-based carriers cannot offer equivalent non-stop products without securing traffic rights to operate without landing in their country of designation. This is unlikely. Moreover, the European and US competitors which could offer equivalent products do not consider Australia or ultra-long-haul flying to be a strategic priority. Indeed, the introduction of such services by Qantas is simply not going to provoke a raft of airlines to follow. That, no doubt, is just how Qantas would like it.

In the future, Qantas will also have to compete with restructured competitors and new entrants. It will face continued volatility associated with recessions, fuel prices, currency fluctuations, industrial disruption, wars and pandemics. Then there is the ever-present potential of technological disruption. There is, however, a serious emerging threat: that of dealing with aviation's contribution to greenhouse gas-driven global warming.

So far, heavy industry and energy generation have played the most significant role in meeting emission reduction targets. With greater ambition to further reduce emissions there will be a need for other emissions-generating sectors to have a much larger role.

The emissions challenge

Qantas recognises that, between now and 2050, as other sectors contract, aviation will make up an increasingly significant share of remaining positive emissions with its highly uneven distribution of emissions on a per capita basis, raising equity concerns. It has announced its ambition to reduce its emissions to net zero by that date and to contribute to the funding of research into alternative low emission fuel sources.

There are sound business reasons for this. Unless low-carbon aviation technology becomes technically feasible, there will be increased pressure to restrain demand. The imposition of a frequent-flyer levy, escalating with the distance travelled by an individual within a defined period, would spare the large majority of travellers significant extra cost. This has been proposed along with a ban on frequent-flyer programmes that are seen as incentivising excessive flying. The impact on Qantas of such globally induced moves to encourage behavioural change would be massive.

Accordingly, successfully avoiding such an outcome through the development of low-carbon aviation fuel technology is becoming a key priority. While an offsets program might be useful during a transitionary period, some carbon-offsetting schemes stand up to scrutiny little better than the Catholic Church did in the Middle Ages when it sold indulgences for the forgiveness of sin. Ultimately, aviation will need to reduce its carbon footprint in ways it can control, not by relying on middlemen offering to absolve guilt over polluting if they are paid to offset carbon, often by planting trees. While this will not be easy, as the 100-year history of Qantas demonstrates, overcoming new challenges never was easy.

Above; left: A Qantas flying boat promotional poster, right: In July 2020 Qantas retired the aircraft most associated with it, the Boeing 747.

The long road to recovery starts here

PAUL ADAMS, Head of Aerospace and Defence, at consultancy Vendigital looks at how the aviation and aerospace sector can recover from its biggest-ever crisis.

Spirit Aerosystems

The aerospace industry could never have predicted the crisis that has unfolded this year in the shape of the Covid-19 pandemic. With airlines grounded and international travel restrictions only now beginning to lift slightly, demand for replacement aircraft has plummeted and could take several years to recover.

Data released recently by the International Air Transport Association (IATA) for Q2 shows that global airline revenues fell by almost 80% compared to the same period last year. With many borders still closed, airlines have been unable to operate commercial flights and they have been rapidly burning cash as a result. According to IATA, the industry burned $51bn in cash in Q2 and the situation is expected to continue through 2021.

IATA's Director General and CEO, Alexandre de Juniac, has commented that "the crisis is growing longer and deeper than anybody could have imagined". It is clear that even where restrictions on international travel have begun to ease, with the UK Government announcing 'air bridges' for example, uncertainty about the impact of a 'second wave' and further country-specific restrictions will continue to peg back demand for replacement aircraft and have a limiting effect on passenger numbers for some time to come.

While it might be too early to talk of green shoots, a small increase in domestic traffic is evident as the airline industry re-emerges from its enforced hibernation. However, with reduced numbers of passengers onboard each aircraft, operators will be prioritising the use of newer aircraft, due to their enhanced operational efficiency. Reduced international traffic also means most of the aircraft taking to the skies are narrow-bodied, rather than their wide-bodied counterparts that are mainly used for long-haul flights. These factors will have a knock-on effect on demand for replacement aircraft and reduce MRO volumes. The short term cash and profit

impact of this second factor in particular cannot be understated.

Effect on the supply chain

As aircraft manufacturers and major OEMs react to these dramatic market changes by scaling back production and announcing job losses, the full impact on the supply chain is only now becoming apparent. The vast majority of suppliers in the UK and mainland Europe are small and medium-sized businesses, many of them producing parts for the commercial aviation sector alone. Many of these businesses will be pushed to the brink of insolvency by cuts further up the chain.

While reports suggest that some major programmes will be cut by more than half for the next two years, aircraft manufacturers and major OEMs know that the key to survival lies in keeping supply lines open and ensuring they are ready to ship when needed. To achieve this, they will need to take intelligent sourcing decisions and keep a close eye on the Covid-19 risk landscape. For example, they need to understand what parts they are buying from where and consider whether any are coming from high-risk territories, where the infection rate is still rising sharply.

A good example of this is the surge in cases in India in recent months, a country that plays a critical role both in the provision of parts but just as crucially, engineering services, that enable the rest of the supply chain to operate effectively. They should also keep a close eye on where the pandemic could hit next, and consider how they might respond to localised outbreaks, which could force more temporary shutdowns. Since March, the Covid-19 risk map has shifted considerably. While Wuhan was the source of the outbreak, China and some other Asian countries, such as South Korea, were among the first to restart production, which is now restored to pre-pandemic levels. With the number of new infections in decline, production in many parts of mainland Europe has also restarted. For the US, the outlook is less certain as the pandemic continues to cause problems and some states have re-introduced restrictions.

As well as understanding the risk profile of the territory where parts are being sourced, OEMs will need to consider how goods are being transported between countries. With airfreight volumes significantly reduced, many parts are being shipped or transported by road and rail. Making sure logistics solutions providers are able to operate, and understanding the constraints affecting their services, could help to minimise unwelcome delivery issues or breaks in supply. OEMs should also take steps to reconfirm their order book to ensure they have a good understanding of the probability that each will be fulfilled on time and in full.

Co-ordinating an industry response

Having studied their supply chains and assessed all relevant risk factors, some OEMs have already taken action by re-allocating orders, supporting suppliers and, in some cases, they have even decided to bring work in house. Practical steps need to be taken to support supplier cashflow however and a cross-sector task force has been established with the support of industry body, ADS, and the Aerospace Growth Partnership, spearheaded by former Airbus Executive, Tom Williams. This national task force has a key role to play in co-ordinating the industry response and the UK Government must now step up to provide specific support to the industry, as the French and German Governments have already done.

This support will be imperative to allow the industry to recover strongly from this crisis. Indeed, history shows that businesses that invest early in a recovery are best placed to secure a strong future market position. A good example of this is digital readiness, which has already become an important factor in increasing supply chain resilience. Manufacturers that have put in place a well-structured digital infrastructure that gives them access to accurate real-time data will be better placed to react to market volatility on the road to recovery. Investment in automation to facilitate the remote fixing of machinery, for example, could also improve operational efficiency and protect business continuity. Much of this technology is now considered 'off the shelf' in other industries and, as such, it represents a relatively low-risk investment. Such investments will be key to building a long-term, competitive UK supply chain.

> MANUFACTURERS THAT HAVE PUT IN PLACE A WELL-STRUCTURED DIGITAL INFRASTRUCTURE THAT GIVES THEM ACCESS TO ACCURATE REAL-TIME DATA WILL BE BETTER PLACED TO REACT TO MARKET VOLATILITY ON THE ROAD TO RECOVERY.

Airbus

National fighter aircraft: **The recurring dream**

For countries seeking to climb up the aerospace technology ladder – a national combat aircraft programme may seem the perfect way to do this. But, as RICHARD ABOULAFIA explains, beware the pitfalls of developing your own fighter.

These are boom times for new combat aircraft from emerging producers. Right now, four new combat jets are being developed by aspiring fighter manufacturers, in addition to the latest round of new initiatives from traditional producers in Europe, the US, Russia, and China.

This emerging producer boom echoes a similar period back in the 1980s. In fact, some of the players, and even some of the airframes, are identical. Back in the 1980s, the emerging players were Japan, India, Taiwan, South Africa, Israel, Romania, Yugoslavia, and Brazil. Today, the emerging fighter manufacturers are Japan, India, South Korea, and Turkey (plus a reborn trainer variant of Taiwan's Ching Kuo). These new producers face difficult but not impossible odds.

Motivations

There are six primary rationales for an emerging producer nation to develop its own combat aircraft:

1. **Economics** – Fighter jets cost hard currency, the thinking goes; why not keep as much of this funding as possible in-country? For export-minded countries like South Korea, why not try to tap into a strong global market for fighters?
2. **Specialisation** – Designing an aircraft with unique national requirements in mind is tempting for some countries. Israel's cancelled Lavi fighter, for example, was aimed at the country's specific operational needs. Since most global fighters available in world markets are multi-role designs, building something with a more specific mission set can be tempting.
3. **Sovereignty/Last resort** – Some countries want to ensure that their fighter industry stays under national control, for security reasons. For countries like Israel or Taiwan, or pre-1991 South Africa, the fear of an arms cut-off in the event of a conflict served as further motivation to keep their fighter manufacturing capabilities purely domestic.
4. **National pride** – For some, a national fighter is a sign that the country has achieved great or near-great power status. The Mitsubishi F-2 (originally FS-X) was created during Japan's seemingly unstoppable rise to geopolitical greatness in the late 1980s and, in the minds of many observers, the two were readily equated.
5. **National technological development** – Japan, India, and other countries have viewed combat aircraft as part of a broader industrial and technology development

Below: A HAL Tejas in flight.

Below right: A model TF-X at The Paris Air Show, Le Bourget 2019.

Premshree Pillai / Flickr

> CHINA'S AIR FORCE HAS HUNDREDS OF SUKHOI SU-27S, SU-30S AND THE J-11, THE LOCAL SU-27/30 COPY. IN THESE CIRCUMSTANCES, GIVEN THE THREAT AND OPERATING CONDITIONS, AN LCA PILOT WOULD BE WELL-ADVISED TO STAY AWAY

strategy, with possible knock-on benefits for other industries. This driver is closely related to national pride, only with a technocratic roadmap.

6. **Low mix product creation** – For countries with a more complex air power force structure, the thinking goes that they can import on first-rate design for day one combat operations (ie, something with stealth and penetrability), that can 'kick down the door' of enemy air defences. However, for day two and beyond, something less capable would be a more efficient way of delivering ordnance. This explains South Korea's first fighter, the FA-50. The country's follow-on KF-X, while more of a medium/heavyweight product, will primarily handle less challenging missions than the Republic of Korea Air Force's F-35s, at least on the first day of a conflict.

These motivations are far from mutually exclusive; usually, new national fighter concepts are the result of a combination of these. Many of these motivations are looking a bit dated, particularly as national power is increasingly evaluated in more economic and cultural terms.

The difficult India LCA paradigm

The best way to understand the appeal, and, more importantly the drawbacks, of a national fighter is to look at the one design that spans both the 1980s surge and the 2020s surge: the Hindustan Aeronautics Ltd. (HAL) Light Combat Aircraft (LCA). From the standpoint of programme survival, it is a remarkable success story. From the standpoint of proving its worth for national security, it is an unmitigated disaster.

First conceived in 1978, the LCA programme was launched in July 1983 by the newly created Indian Aeronautical Development Authority (IADA). After numerous delays, the LCA made its first flight in January 2001 with (partial) initial operational clearance granted in January 2011. Final operational clearance slipped to late 2016 and then slipped again but was finally awarded in February 2019.

However, in 2009 HAL announced that it would develop a new MkII LCA variant after the first 40 production Mk1 planes were delivered, largely since the Mk1 was viewed as marginally effective. In addition to a new engine, the MkII will have a larger fuselage and wings, and greater payload. Plans call for procurement of 240 MkIIs.

Today, after 37 years, just 16 Mk1 LCAs are in operational service. That is a remarkable record of failure but the knock-on consequences are worse. National fighter programmes are inherently protectionist. The theoretical likelihood that the LCA would be available kept India from importing anything near its size class. For years, India evaluated the F-16 and Gripen for a light fighter requirement but the LCA always seemed to be right around the corner.

As a result of this protectionism, the country kept operating hundreds of MiG-21s many years beyond the point they had lost any operational effectiveness. Remarkably, over 130 of these half-century old relics remain in service today. The damage continues to be done. In August, India's government announced a list of 101 defence products that could not be imported. Predictably, light combat aircraft are on the list. The Indian Air Force, still expecting to receive 220 LCAs, will continue to wait, unable to consider alternatives.

The biggest problem with the LCA, and with national fighters in general, is that it is tough to change the programme, and indeed the aerospace industry roadmap, when the strategic environment changes. In the LCA's case, that may be catastrophic for India.

In the 1980s and 1990s, the biggest security threat to India was Pakistan. That called for a relatively light aircraft, since Pakistan's Air Force was small and equipped largely with old and marginally effective aircraft. The central front in any conflict would have been at sea level, directly on India's border. The LCA,

JohnNewton8/Wikipedia

if available, could have been useful, even if it caused serious trouble if it ran into Pakistan's small number of F-16s. Many countries viewed the prospects of a nuclear confrontation between the two countries with alarm and the US even enacted an arms embargo against India for a time. Looking at ways of maximising self-sufficiency, in this context, made some degree of sense.

Today, the biggest threat to India comes from China, in the Himalayas. That is an extreme operating environment, where range and engine power are hugely important. China's Air Force has hundreds of Sukhoi Su-27s, Su-30s and the J-11, the local Su-27/30 copy. In these circumstances, given the threat and operating conditions, an LCA pilot would be well-advised to stay away.

It was also not possible to reconsider the LCA programme, as the very nature of defence production itself changed. Before the LCA's birth in the 1980s, the economic value and effectiveness, of an aircraft, revolved around the airframe and engine. It was relatively easy to design and build some kind of airframe. While engines were more complex creations, they could be built in-country based on someone else's design. The first Soviet engines were built as copies of British jet engine designs from the 1940s. In fact, in the 1960s and 1970s, India built the Marut, a light supersonic fighter. While not a success in terms of performance, India was able to build 147 of these, using British-designed engines.

Yet, by the 1980s, the spiralling cost and complexity of fighter systems, including engines, meant that no one country could really go it alone. The old days, when a country could replicate basic system capabilities on national production lines, were gone.

The result is that much of an LCA, in terms of its economic value and in terms of combat enablers, needs to be imported. For example, production LCAs were to be powered by the GTX-35VS Kaveri, an indigenous turbofan under development at the Gas Turbine Research Establishment (GTRE) in Bangalore. This project persisted for almost as long as the LCA, despite abundant indications that it was not performing as planned. Remarkably, in January 2013 the Kaveri engine was definitively cancelled. GE's F404 was selected as a replacement, with the F414 specified for the Mk II variant.

Similar hopes for other domestic systems also faded, replaced by imported ones. The upshot of all this foreign, imported content means that the LCA is no longer any kind of insurance policy against an arms embargo. While India could build the LCA airframe in-country, everything else, including the General Electric F414 engines, BAE Systems flight controls, Elta radar, and Thales displays, would still need to be imported.

The LCA works best as a cautionary tale of what can go wrong with national fighter aircraft and the damage a country's pursuit of them can do to its national security. In fact, the IAF's light fighter requirement is best seen as a battle between people in lab coats and people in flight suits. With the LCA's survival, the lab coats won and the flight suits definitely lost.

What will persist?

Examining the list of six motivating factors behind national fighters above provides a limited degree of guidance for the future of the latest crop of jets. Will these motivations provide sufficient reason for governments to fund these programs? Are these motivations based on consistent logic? In addition, the motivators driving a new national fighter may be countered by any or all of these three possible headwinds:

1. **National wealth and priorities** – Can the country's defence budget afford the development of an all-new aircraft or can it be viewed as a bill-payer for more pressing requirements in the event of budget cuts? Brazilian defence budget cuts in the 1990s, for example, helped kill the dream of a national combat aircraft, particularly after the Italo-Brazilian AMX combat jet ended production.

> JAPAN'S TECHNOLOGY BASE IS ARGUABLY THE MOST ADVANCED IN THE WORLD, AND ITS ECONOMY IS THE THIRD LARGEST IN THE WORLD. WHAT BENEFITS WOULD A NATIONAL FIGHTER BRING?

Yosan/Japanese MoD

Concept design of Japan's F-X fighter.

> SOUTH KOREA'S DEFENCE INDUSTRY IS FAR MORE EXPORT-ORIENTED THAN JAPAN; WHILE JAPAN HAS LEGALISED DEFENCE EXPORTS IN RECENT YEARS, IT HAS YET TO SCORE ANY SIGNIFICANT SALES.

2. **Competition from imports** – Are imported fighters from traditional producers in the US or Europe more competitive? This is not just a question of value for money but also offsets and industrial workshare. For example, Japan has established an F-35 final assembly line in-country for its 147-F-35 buy, so switching to a new national fighter means the loss of those jobs and facilities. In the case of Taiwan, all it took to derail the AIDC Ching Kuo national fighter programme was US and French approval for F-16 and Mirage 2000 sales. When these were made available, Ching-Kuo procurement plans were cut by around 50%.
3. **Changing threats** – In some cases, the nature of the threat changes, making a national fighter less of a priority or shifting resources to other defence priorities. But there is also the possibility that increased threats change national fighter procurement cost calculations. For example, if China poses a growing threat to Japan in the coming decade, will Japan decide that spending $20bn on developing a new national fighter makes less sense than spending the same money on actually acquiring fighters off-the-shelf, thereby directly strengthening the country's military? Similarly, if South Korea and Japan continue with plans to deploy aircraft carriers and to grow their naval aviation presence, they might need to shift resources to acquiring the F-35B short take-off vertical landing (STOVL) aircraft.

Looking at all these factors, of the four possible new fighters, Turkey's TF-X would appear to be the most vulnerable. The country's fighter systems development capabilities are minimal, so the aircraft would be heavily dependent on imported equipment. National pride, a key driver behind President Erdogan's defence industry development initiatives, would be gravely undercut by the large contracts that the country would need to award to foreign systems providers on TF-X. Since another driver behind TF-X is a rift between Turkey and NATO, it would be particularly awkward for the government if these contracts were awarded to NATO-country defence firms.

Japan's Next Generation Fighter (NGF, or F-X) is expected to fly in 2028, with first deliveries in the mid-2030s. While this is set to be more of a new, largely Japanese design than the F-2 (derived from the F-16), Japan has also made it very clear that it still expects to work with foreign partners. That is not a problem but what is not clear is the motivation behind NGF. Japan's technology base is arguably the most advanced in the world and its economy is the third largest in the world. What benefits would a national fighter bring? Still, the country has prioritised sustainment of its national defence champions and this programme might be another way of keeping them healthy.

South Korea's KF-X is expected to enter service in the second half of the 2020s. This too will be very heavily dependent on imported technologies and South Korea's economy, like Japan's, is probably too advanced to really benefit much from the development of a national jet. On the other hand, South Korea's defence industry is far more export-oriented than Japan; while Japan has legalised defence exports in recent years, it has yet to score any significant sales. By contrast, South Korea has exported over 60 T-50/FA-50s, the first time any emerging fighter producer has actually succeeded with exports. Thus, the KF-X might go ahead just because of the export business case.

Finally, there's India. The LCA would, in a theoretical sense, appear to be most vulnerable to cancellation; after all, the three headwinds against national fighters all strongly work against it and none of the six motivators really still apply. After 37 years, who would bet against this project?

RAeS Air Power Virtual Conference – 7-8 November 2020, Online, London

Alvis Cyrille Jiyong Jang

Side view of a KAI KF-X fighter model.

Taking charge of electric aircraft

In the years to come, it is predicted that electric and hybrid-electric passenger aircraft will be developed to replace jet-powered regional aircraft. BILL READ FRAeS asks how airlines can be persuaded to invest in this new technology and how they might make money from their operation.

Within the next decade, it is predicted that the first fleets of non-polluting commercial electric-powered passenger aircraft will begin to enter service. But how realistic are these predictions? Part 1 of this two-part report into the economics of electric aircraft looked at the commercial challenges of selling commercial electric aircraft to operators and the implications for airport operators and service providers. Part 2 now considers how airlines could be persuaded that there is money to be made in game-changing new e-aircraft designs and how they might be operated in commercial service.

Acquisition

It is now time to consider who might actually acquire and operate electric aircraft. Let us imagine that you are a CEO of an airline planning future aircraft acquisitions. The development of larger regional electric aircraft has now reached a point where you are considering ordering some to add to your aircraft fleet.

Although it will look good for the airline's public image to fly non-polluting 'green' aircraft, you will only acquire electric aircraft if you think you can operate at a profit. Not only does there have to be a demand from the air-travelling public to fly on e-aircraft (and an assurance that they are safe) but also a commercial advantage in using e-aircraft over conventionally-fuelled regional jets and turboprops.

As any economist will tell you, the cost of operating an aircraft is more than just the initial purchase cost. Once in service, the aircraft will need to be stored, maintained, recharged, and repaired. People will need to be paid to operate the aircraft – pilots, cabin crew, maintenance staff and airports. An

THE CUSTOMER HAS TO CONSIDER WHICH SUPPLIER IS THE MOST LIKELY TO STAY THE COURSE AND REMAIN IN BUSINESS TO SUPPORT AND UPGRADE THE AIRCRAFT DURING ITS LIFETIME

airline will also only operate e-aircraft if the airports it flies into have the necessary ground infrastructure to handle them.

Another element is that of 'vision'. It is a well-established fact that developing a new aircraft takes time and money. Currently, a new aircraft can take from 5-10 years to design. The time taken between an airline ordering a new aircraft and the aircraft entering service can also take between 3-5 years and the aircraft will then remain in service for 20-30 years. A decision taken now to buy new aircraft will have a long-term impact across the airline's fleet. This could make airlines hesitant to invest in the first generation of less efficient hybrid-electric aircraft, as operators might prefer to wait until the technology matures and then buy a more advanced second generation of all-electric aircraft. If there are a number of competing e-aircraft manufacturers in the market, the customer has to consider which supplier is the most likely to stay the course and remain in business to support and upgrade the aircraft during its lifetime.

There is the issue of training. Pilots will need training to fly the new hybrid or electric aircraft, possibly also having to learn how to be the sole pilot if airlines take the opportunity to move to single-pilot operations. Training providers will have to develop new e-aircraft simulators for all the different types available. Training may be different for operating hybrid and pure electric designs. There may have to be a new e-electric aircraft pilot certificate.

Heart Aerospace

Swedish start-up, Heart Aerospace, has revealed more details of its proposed 19-seat all-electric-powered ES-19 regional airliner, including its propulsion system. The ES-19, aimed to be in service in 2026, would use automotive batteries to power four propellers with an initial range of 217nm. Eight airlines, including SAS, have already placed letters of intent (LoI) for 147 ES-19s.

Operation

Now – a few years further on into the future, let us now assume that you are the Chief Operating Officer of an airline with a newly acquired fleet of electric regional aircraft. How can you best operate them to make a profit?

The business case for electric aircraft is dependent on three factors: operating costs, passenger demand and meeting the carbon emissions standards demanded by regulators. For an airline, costs will include such elements as staff wages, airport charges, insurance, storage, maintenance, batteries and the cost of battery charging. Some of these may be less than a conventional aircraft; according to electric aircraft developer Ampaire, e-aircraft could offer a 90% reduction in fuel costs, and a 50% reduction in maintenance. However, if you are operating hybrid-electric aircraft which require liquid fuel, some of these pure-electric cost savings may no longer be valid. The batteries used to power the aircraft will also lose their recharging potential over time and will have to be replaced.

The generation game

One of the major elements in every airline's cost calculations is that of fuel and this will be no different when operating electric aircraft. The price of hydrocarbon fuel fluctuates depending on the demand and supply of oil and many airlines use fuel pricing hedging to bring more certainty into their calculations. The economic advantage of e-aircraft would depend on the difference between the price of electricity and the competing price of oil. Just as current airlines have to keep an eye on changes in the price of fuel, future operators of electric aircraft will also have to watch the price of electricity.

This could vary depending on where the electricity comes from. It may be important for airlines to know the source of the electricity used to charge their aircraft batteries. Does it, for example, come from a national grid or a local power scheme? Would it make economic sense for airports to fit, for

example, solar power panels to the roofs of airport buildings or on unused land around the airport that could then be used not just to power the airport but also to sell electricity to airlines to recharge their batteries?

In discussions about future aircraft designs, there has also been debate about the potential of aircraft powered by hydrogen cells. Such aircraft would not emit polluting gases but come with their own set of challenges in how to safely store the low temperature liquid hydrogen in an aircraft and to operate such an aircraft economically, given that the fuel cells will account for a large amount of the aircraft's interior space and payload. One suggestion has been that the hydrogen fuel cells do not need to go into an aircraft at all but could be used to generate electricity on the ground.

If the electricity comes from outside the airport, it may become important to know how it is generated. Supporters of electric aircraft are keen to emphasise that they are non-polluting and do not emit CO_2, which is true of the aircraft but not necessarily of the power station, located somewhere else, which generated the electricity and may have relied on coal or nuclear power (as is already the case with electrified railways).

Sweat those assets

As low-cost airlines have demonstrated, the key to making money on short-haul routes is to use your aircraft as intensively as possible – flying the aircraft over the same route several times a day with as short a turnaround as possible. However, when using electric aircraft, this business model runs into difficulties. Electric aircraft will be fitted with propellers and will therefore be slower than those fitted with jet turbines. This will not only mean that passengers will have to spend more time aboard an aircraft to get to their destinations but also that aircraft will not be able to fly so intensively on short-haul routes.

There is also the question of how quickly electric aircraft could be turned around to be ready for another flight. There is currently no consensus on whether it would be faster to recharge on-board batteries (which would be less labour-intensive) or to physically swap out exhausted batteries and swap in fully charged ones – which might be quicker but is likely to need more manpower to accomplish.

Passenger power

This seems a good moment to introduce the most important element in making money from electric aircraft – the airline passenger. Role-playing once again, suppose you are a passenger wishing to fly on a regional airline for a holiday or for business – will it make any difference to your choice whether or not you fly in an electric aircraft?

There will, of course, be several factors influencing your decision to fly. An obvious one will be ticket price. Would you be willing to pay more or less for flying in an electric aircraft compared to a jet-powered aircraft?

Another factor could be the time taken to complete your journey. Speed is normally a key selling point to passengers but e-aircraft will not be as fast and may not be able to operate in particular weather conditions adverse to electric flight – such as high winds, snow or storms.

There is also the issue of confidence in the safety of e-aircraft. As with all new forms of transport, electric aircraft will have to create a track record of trouble-free operations to encourage passengers to use them. There is already debate over whether passengers would be happy flying in an aircraft (electric or otherwise) with just a single pilot or even no pilot at all. If the new generation of e-aircraft develops a history of unreliability and flight delays, this could dent its potential market. Even worse, a single accident caused by a battery failure or power loss to an e-aircraft flown by any airline could set back the cause of electric aviation for everyone by years.

SPEED IS NORMALLY A KEY SELLING POINT TO PASSENGERS BUT E-AIRCRAFT WILL NOT BE AS FAST AND MAY NOT BE ABLE TO OPERATE IN PARTICULAR WEATHER CONDITIONS ADVERSE TO ELECTRIC FLIGHT – SUCH AS HIGH WINDS, SNOW OR STORMS.

The green factor

Then there is the green factor. How important is the environment to passenger choice over which airline to fly with? One of the key selling points of electric aircraft is that they are non-polluting and carbon-free. However, one of the key selling points used by developers of new supersonic passenger aircraft concepts is that they are faster. Which factor is going to be more important to prospective passengers?

As discussed earlier, airlines might be keen to introduce e-aircraft, not just to save money on jet fuel but also because it will give their brand a positive

NASA

Above: NASA's X-57 Maxwell aircraft is its first all-electric X-plane.

image with reduced noise and zero emissions. While some airline passengers may be unaware or not interested in what aircraft they are flying in, environmentally-aware customers may also have a wish to travel in an electric aircraft because it is (or even just perceived as being) more environmentally friendly. Would 'flight shaming' end if airlines introduced electric aircraft?

Returning to the question of price, will an airline have to charge a lower price for all-electric flights to compensate customers because their travel time will be longer or will they be able to set a higher price, hoping that passengers will be willing to pay a 'green supplement' for an environmentally-friendly flight? In theory, the future price of tickets for e-aircraft flights should be less than those of conventional flights, as electric flight does less harm to the environment. However the economic reality might mean that e-aircraft tickets cost more, as e-aircraft are expected to be (at least initially) more expensive to operate.

Making e-aircraft pay

In conclusion, it is obvious that there are still many unknowns about the operation of electric aircraft. It is not certain yet what they will look like, their capabilities in terms of speed and endurance and what types of companies will make and service them. It is not known whether they will replace existing aircraft or create a completely new market for pollution-free regional transport.

However, this situation may change if there are more technological breakthroughs – such as the safe and efficient use of hydrogen fuel cells, remote in-flight recharging using laser beams, or even ionic-powered aircraft.

If these clean power systems develop to the stage where they can be used to power large aircraft, then e-aircraft may also be able to be operated on long-haul networks.

While the environmental credentials for e-aircraft look good, there are still some issues to be sorted out, such as the inefficiencies of hybrid-electric aircraft, the power wasted in charging batteries, the potential harm to the environment created by polluting power stations which generate the electricity used to power e-aircraft and the challenge of the disposal of used aircraft batteries. There is also the potential environmental damage caused by the mining of rare minerals and sourcing of other materials used to create the batteries.

The speed of development is also uncertain. To begin with, the market for e-aircraft is expected to be small. A forecast in 2018 from Markets and Markets predicted that this market would grow from its 2018 level of around $99m to around $122m by 2023. Looking further into the future, UBS estimates a market of $178bn by 2040. However, what these predictions did not account for was the onset of the Covid-19 pandemic in 2020 which has inflicted severe damage to both existing aviation demand and to future research. There are now questions being asked as how air transport will operate in the post-Covid-19 world. If the virus becomes a long-term hazard, airlines may have to operate flights carrying fewer passengers to enable social distancing. This reduction in capacity could become a particular drawback for the profitable operation of smaller regional aircraft (jet, turbo-prop and electric) which need to make every seat count.

However, it could also be that this could be the opportunity that electric aviation needs to develop. Given sufficient confidence and investment into new technology, 'success will breed success' and the e-aviation market may expand more rapidly than expected, as manufacturers and airlines see that money is to be made and airports invest in new infrastructure to meet that demand. While this article has focused on passenger e-aircraft, there are other potential markets in which e-aircraft could also be used, including air cargo and military transport applications.

All this and Covid-19

However, all these predictions about the future assume that the aviation market in the future will operate much in the same way that it does today. After Covid-19's radical shake-up of the world economy all bets may be off as to how air transport may look in the future. Although aviation is expected to recover after a few years, it may not be in the same form as it was before. If 'social distancing' becomes a new norm, it may be more difficult for operators of smaller aircraft (and airports) to make a profit if they have to carry fewer passengers.

Electrifying the future

Despite the setback of Covid-19, the future for electric aviation still looks rosy. There is a demand for a cleaner form of aviation from operators, regulators and passengers. Given sufficient commitment from all interested parties working together, possibly supported by government financial incentives, then the dream of electric aviation could become a profitable reality. However, it will take time and companies which invest in e-aircraft will need to be in it for the long-term and keep their eye on the horizon if they are to create a new electric aviation world.

***Climate Change*, RAeS Virtual Conference – 3-4 November 2020, Online, London**

The first part of this report (*AEROSPACE,* October 2020) into the economics of electric aircraft looked at the commercial challenges of selling commercial electric aircraft to operators and the implications for airport operators and service providers.


ESA

Safeguarding the final frontier

Battleground, natural resource or orbital commons? Outer space is all these things and more. TIM ROBINSON reports from the Royal Aeronautical Society's first ever virtual conference – 'Safeguarding Earth's Space Environment' held online on 9-10 September 2020.

Space may be vast but, like any real estate, there are more desirable locations than others. For space that tends to be low-Earth orbit (LEO), which is rapidly filling up with satellites and debris and thus presenting a number of challenges to both commercial and government operators.

The virtual conference, organised by the RAeS Space Group, drew top-level speakers from around the globe, from ESA, the UN's Outer Space Office, the Royal Air Force, Japan's JAXA, UK Space Agency, academia, space law, space start-ups, tracking companies, Lockheed Martin and the brand-new US Space Force to discuss and address these issues.

It is getting crowded up there

The conference heard that the rapid growth of megaconstellations is increasing the number of objects in orbit exponentially. Only in the past 12 months, SpaceX's Starlink constellation has now reached a total of 700 satellites in orbit – and plans to expand that to 12,000 – with proposals for a follow-on system of 30,000. Other megaconstellations are also on the drawing board, such as OneWeb (48,000), Kuiper (3,200) and potentially a Chinese LEO (12,000) network. In comparison, since the dawn of the space age in 1957, humans have only put 10,000 objects in space.

> PROXIMITY OPERATIONS MIGHT BE SEEN AS THE ORBITAL EQUIVALENT OF HAVING A NUCLEAR BOMBER FROM AN UNFRIENDLY STATE FLY ABOVE A VITAL POWER PLANT, SERVER FARM OR TV STATION JUST WAITING TO STRIKE.

This is now having implications for other operators. Only recently, Peter Beck, founder of Rocket Lab launch company, warned in an interview to CNN that the number of satellites is now making launches increasingly difficult: "This has a massive impact on the launch side, Rockets "have to try and weave their way up in between these [satellite] constellations."

To avoid 'conjunctions' or collisions in orbit you need early warning and enough fuel in your satellite to move trajectories. But the growing number of satellites in orbit means that there has been a significant shift from even 15 years ago, said Dr Holger Krag, ESA, where the vast majority of avoiding actions were taken against space debris, to today, where 15-20% now involved conjunctions with other controlled satellites. This means that operators need to contact other operators to deconflict – taking time and resources. Krag also noted that, despite the space object catalogues and ability for observers on the ground to track many objects in orbit, this was not yet precise enough. A lot of avoiding actions are therefore probably unnecessary and are thus wasting valuable fuel, decreasing the lifespan of satellites.

There is thus a growing requirement for a Space Traffic Management system where a functional equivalent of an airliner's TCAS collision avoidance system could automatically issue traffic awareness warnings, collision alerts and pass on information about what manoeuvres the other operator is taking to increase separation.

Space as a battleground

The increase in commercial satellites is only one half of the challenge. The other is that space is becoming increasingly a military battleground. This, of course, is not new, as spy satellites were a part of the Cold War from almost the start – but today peer rivals are becoming increasingly bold in challenging the 'unwritten norms' of responsible behaviour and good practice – with China's ASAT test in 2007 a wake-up call in the vast amount of space debris it produced.

This year saw a Russian satellite attempt 'proximity operations' – with Western satellites (see p 14). As Air Marshal Harvey Smyth, Director Space, UK noted at the conference: "You wouldn't tolerate this sort of behaviour in any other domain". While Russian aircraft, ships and submarines are known to probe NATO defences to test reaction times and awareness, there is no 'orbital QRA' that can scramble and gently shepherd rogue satellites away from friendly objects. The speed of satellites in orbit and conjunctions means that these can be threatening 'Sword of Damocles', your critical infrastructure with few options to defend against them. Proximity operations, then might be seen as the orbital equivalent of having a nuclear bomber from an unfriendly state orbit above a vital power plant, server farm or TV station, just waiting to strike.

Regulations and laws

Responsible use of space also extends to countries as well as private operators. The conference also heard that international regulations and treaties (most notably the UN's Outer Space Treaty of 1967), crafted at the height of the Cold War, where there were only two superpowers and the threat of nuclear war extending into orbit was the primary concern, are now becoming increasingly outdated in this multipolar world of commercial operators, new spacefaring states and the dependency of modern life on space-based information. 'Space debris', for example, is not mentioned explicitly, although it could be covered by 'harmful contamination'.

These then need updating badly and this summer the UK diplomats had proposed a new resolution at the UN to govern the responsible use of space. Although the UK is still very much a minor space power, it is now seeking to play a larger role in establishing international agreements on the new norms of behaviour in space. The UK was the first international partner to join the US-led Operation Olympic Defender – an effort to build closer co-operation between allied nations in securing and protecting space.

The new virtual platform

This conference was notable in that it was also the first fully virtual event put on by the Royal Aeronautical Society – as it adapts to the Covid-19 environment. While, as to be expected for the first attempt, the event experienced a couple of minor technical teething troubles, this digital platform highlighted the incredible potential for future RAeS online events. Delegates could ask questions to speakers and panels but there was also a side-bar where general chat was encouraged. The digital platform also allowed for sponsor 'virtual' lounges, packed full of information and videos from the sponsors, as well as human representatives to connect with. Most importantly, the conference platform also provided for that vital aspect that is missing elsewhere – networking. Those that added details (company/organisation, location) to their delegate profile could request one-to-one personal meetings via an inbuilt schedule organiser. Once the conference was over, attendees could also access the entire day's presentations via their own personal dashboard – allowing delegates to build up their own back catalogue of easy-to-access conference presentations and proceedings in one place (aerosociety-events.com) to revisit and watch at their leisure.

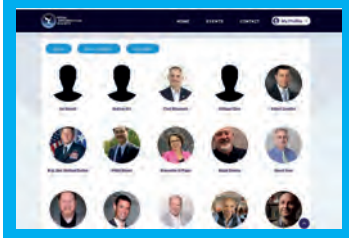
Summary

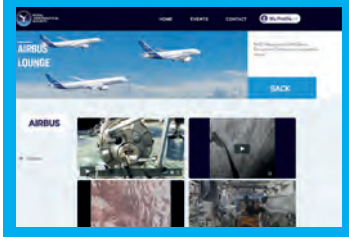
This conference then comes at an extremely topical time as space becomes more 'cluttered, complex and contested' while society becomes more dependent on space-based services. The formation of the US Space Force and the growing interest of other nations' militaries to protect this valuable shared resource above our heads that enables much of modern civilisation is thus no accident. Yet, commercial, scientific, governmental and military operators will all need to work together if humans are to continue to reap the benefits of our space-based services. Pollution or rogue behaviour on *terra firma* may be bad but, in orbit, the actions of a very few (or maybe even the one) have the potential to cascade further and affect billions on Earth.

It is thus also highly appropriate that this conference on the 'final frontier' would also break new ground in becoming the first ever RAeS virtual conference – bringing together speakers and delegates from almost every time-zone from Japan to the US to consider this complex and fast-moving topic.

ROYAL AERONAUTICAL SOCIETY

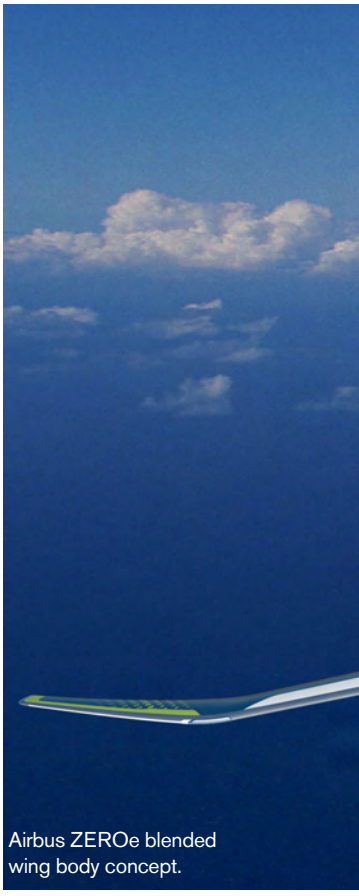
RAeS makes history with its first virtual conference





Airbus spearheads zero-carbon Moonshot

Liquid hydrogen may blast rockets off into space but, in 2035, it could be powering zero-carbon aircraft if Airbus' ambitious plans to lead the decarbonisation of aviation come to fruition. TIM ROBINSON FRAeS reports.


Airbus ZEROe blended wing body concept.

Earlier this year, proponents of green aviation were disappointed when Airbus, in conjunction with partner Rolls-Royce, axed its modified BAe 146 hybrid-electric E-FanX demonstrator before it had even flown. Yet, what seemed to be at the time a setback for progress in sustainable aviation, has now turned out to be just a small bump in the road to the launchpad of a far more ambitious aim – to develop a zero-carbon airliner by 2035.

One might think that, given the grave existential crisis that aviation currently finds itself in due to the Covid-19 crisis, the pressure from the environmental lobby would have eased and aerospace manufacturers would have breathing space to focus on just surviving. Yet, ironically, the opposite has happened. With clearer skies, less pollution and better air quality, the mass grounding of the world's airline fleets has given people a glimpse of what a zero-carbon, cleaner future might be like.

While the world's airlines are in deep crisis and delaying deliveries of current-generation aircraft, some argue that this is the perfect time for the aerospace industry to look even further ahead and rethink and reset itself for a zero-carbon future – ready for when demand returns and the inevitable growth in air travel comes back.

Airbus pivots to hydrogen

Indeed, this seems to have informed Airbus' thinking when, on 21 September, it unveiled three ZEROe concepts for hydrogen-powered airliners, ranging from a regional turboprop, turbofan and a blended-wing body (BWB) design – which, it says could be in service by as soon as 2035. Airbus CEO Guillaume Faury described the unveiling as: "a historic moment for the commercial aviation sector as a whole and we intend to play a leading role in the most important transition this industry has ever seen."

The hydrogen-powered turbofan ZEROe airliner, looking conceptually like a scaled-down A350, would seat 150-200 passengers, with a range of nearly 2,000 miles. Liquid hydrogen would be stored in the rear fuselage. Another ZEROe concept is for a hydrogen-powered turboprop, for 100 passengers and a range of up to 1,000 miles. The final concept is for a 200-seat BWB design, based on the company's Maveric testbed revealed at the start of this year. Its range would be approximately 2,000 miles but the volume of the fuselage would open up multiple options for cabin layout and storage of hydrogen. All these aircraft would use hybrid-electric architectures, leveraging Airbus' knowledge on E-FanX, with electric motors embedded in the gas turbines and powered by fuel cells.

It is important to note that, while these are CGI concepts, this represents a firm product development plan by the company. Airbus aims to downselect from these three in 2022-23 and officially launch the programme in 2025, ahead of a ten-year plan to bring a zero-carbon airliner into service in 2035. A flight demonstrator programme will also support this effort which Airbus aims to fly before 2025. The company hints that the BWB concept may already have an advantage, says Glenn Llewellyn, Vice President, Zero Emission Aviation, Airbus, speaking at a media roundtable: "We know from our analysis we may achieve a better performance with a more disruptive overall aircraft design. One of the challenges associated with hydrogen is that it has more volume than kerosene per unit of energy

> "ALL THESE AIRCRAFT WOULD USE HYBRID-ELECTRIC ARCHITECTURES, LEVERAGING AIRBUS' KNOWLEDGE ON E-FANX, WITH ELECTRIC MOTORS EMBEDDED IN THE GAS TURBINES AND POWERED BY FUEL CELLS

Airbus

and, therefore, the blended wing body flying wing approach is fairly adapted to that", adding: "the race is on between those different concepts."

Being this transparent about future product development to rivals, customers and media is highly unusual, as Llewellyn stressed: "It is very unusual for Airbus to be talking about a programme ambition, a commercial aircraft entry into service 10-15 years before we plan to do it. The reason that we're doing it is because we recognise that this programme is not only about Airbus; it's also about driving change in the energy and aviation ecosystem," adding: "We're here as a call for action, to ask for help, to ask for these companies, these players to join us on this ambition to deliver a zero-emission aircraft. We will not do this on our own and that's probably as significant as the technology challenge".

This then, is not just an Airbus CGI of sleek future airliners but the company launching a commercial aerospace 'moonshot' that has the potential to touch almost every part of civil aviation as we know it.

Moonshot or incremental approach?

Of course, moonshots can fall short. Concorde, for example, though an engineering masterpiece and aeronautical work of art, never broke through into mainstream success. Airbus' previous 'moonshot', the A380, also offers a cautionary tale of hubris and trying to bend the market to your will. Over at Boeing, the combination of composites and a new outsourced production model almost did for the 787 Dreamliner.

A clean slate? The Covid-19 crisis has opened up the opportunity for aviation to reinvent itself as a zero-carbon form of transport.

The incremental approach then, can also offer firm advantages getting green technology into service faster. Boeing, for example, has since 2012, test-flown sustainable technology on its annual ecoDemonstrator programme – which sees an in-service airliner modified to trial advances such as drop-in-sustainable aviation fuels, recycled carpets, laminar flow aerodynamics and optimised flight routing. This year it partnered with Etihad Airways to test new technologies on a 787-10 Dreamliner. These included sustainable aviation fuel, quieter landing gear, and the biggest-ever noise research project in partnership with NASA – as well as an anti-Covid-19 UV flightdeck disinfectant lamp that is now being fast-tracked into production.

Over the past eight years, one third of ecoDemonstrator sustainable technology projects have already made it into service, with another third still being researched and the last third being judged not ready yet, says Boeing's Mike Sinnett, Vice President, Product Development. Boeing's ecoDemonstrator then provides an approach where incremental advances can be quickly tested and adopted.

Airbus

However, Sinnett was sceptical about Airbus' ambitious plan for hydrogen-powered airliners in the next 15 years saying: "I don't think it's something that's right around the corner" and noting the vast experience that the industry and operators had built up with Jet-A1-fuelled airliners over decades.

Nearer than we think

ZeroAvia

Yet hydrogen-powered aircraft are now already with us. The same week as Airbus' announcement also saw a historic aviation milestone in UK skies with the first flight of ZeroAvia's hydrogen fuel-cell-powered six-seat Piper M demonstrator at Cranfield, UK, on 25 Sepember. "One of the most historic flights in decades" said new UK Aviation Minister, Robert Courts, MP of the flight.

This achievement, the first flight of a 'commercial grade' hydrogen-powered aircraft is thus a major milestone for zero-emission flight – ZeroAvia CEO and founder Val Miftakhov saying: "It's hard to put into words what this means to our team but also for everybody interested in zero-emission flight. While some experimental aircraft have flown using hydrogen fuel cells as a power source, the size of this commercially available aircraft shows that paying passengers could be boarding a truly zero-emission flight very soon."

ATI-backed ZeroAvia now plans to demonstrate longer range (200-300nm) flights with the Piper M before the end of the year, before turning its attention to offering its hydrogen powertrain to convert existing 19-seat class aircraft, such as the Dornier 228 and Cessna SkyCourier, to zero-carbon flight in the next three to four years. With ZeroAvia aiming its powerplant to be in ubiquitous PT6 turboprop-class, it could have wide applications.

Even though this six-seater is at the small end of the zero-carbon scale compared to Airbus' plans, Miftakhov reveals that it has already attracted big commercial interest with over 30 discussions with operators, ten letters of interest (LoI) and seven talks with aircraft OEMs.

Thinking further out of the box

Finally, there may be even more radical ideas to harness hydogen as a potential zero-carbon aviation fuel. Earlier this year, ex-Airbus and UTC Chief Technology Officer, Paul Eremenko, revealed his latest project – Universal Hydrogen, which aims to turn hydrogen into separate mini-fuel cell tanks that could be loaded onto aircraft, cargo container-style, removing the need for cyrogenic refuelling at airports. Universal Hydrogen aims to have its technology ready by 2024.

Meanwhile, hybrid-airship specialists Hybrid Air Vehicles is already working on a future electric version of its Airlander airship, in partnership with Collins. CEO Tom Grundy also notes that Airlander could be perfect for pulling through new green technologies like these – as the airship already gives a 70% reduction in CO_2

Above: CGI formation flight of ZEROe concept aircraft under consideration. The turbofan concept would feature a 'chimney' on top of the fin to vent hydrogen in the event of any emergency.

Left in text: ZeroAvia's hydrogen fuel-cell-powered six-seat Piper M demonstrator.

Right: Airbus ZEROe turboprop concept.

Airbus

emissions compared to conventional aircraft. With a hydric-electric configuration this would increase to a 90% reduction and 100% with an all-electric power. Perhaps most interesting of all, the giant internal volume of airships would potentially allow for easier storage of hydogen than conventional wings and tube airliners where, as the volume of hydrogen increases, so does the drag. HAV is now proposing that Airlander could find a new role as a point-to-point 90-seat regional aircraft – with 'fast ferry' style speeds as the world shifts to a zero-carbon future.

However, like hydrogen-powered airliners and electric flight, widespread adoption of airships as regional transports will need big changes and adjustments in flight operating procedures, infrastructure and customer expectations. Will passengers accept flying slower (in the case of electric/hybrid-electric aircraft and airships) but greener in the future? (See *Taking charge of electric aircraft*, p 32)

Challenges

In order for commercial aviation to pivot to hydrogen, there still remain significant challenges – both from a technical standpoint and from logistics and scaling up this alternative fuel. Some critics also point out that, while hydrogen is 'zero-carbon', burning it as a fuel is not zero-emission – it does produce NO_x and water vapour. Water vapour may seem harmless but can contribute to the formation of contrails and radiative forcing which is linked with climate change and the greenhouse effect. Water vapour contrails then may have to be paired with advanced air traffic management to steer clear of contrail formation areas. Research done by the Royal Aeronautical Society's Greener by Design Group suggests that this could be quite easily achieved with today's space-based real-time weather surveillance and with minimal operational and economic impact on airlines. Tactical military aircraft already avoid the contrail layer, if possible to prevent giving away their position to enemies within visual range – could civil airliners do the same?

There is also the issue that hydrogen may not scale well – unlike kerosene fuel. Paradoxically, the bigger the aircraft, the more weight and volume that cryogenic tanks for liquid hydrogen and its associated systems take up – undermining seat-mile economics. It may be then that A320-sized aircraft with a range of 1,500-2,000nm could be the upper limit, before the cryogenic fuel tank weight and volume (and thus drag) spirals up and makes it unprofitable. Says Llewellyn: "With the technology that we are targeting for 2035, we see that sort of passenger numbers, 200, maybe a bit more, being the upper limit for the technology. We expect that subsequent generations of hydrogen-powered aircraft could potentially start moving upwards of 200 passengers but probably not for the first iteration of large commercial hydrogen aircraft." Sustainable aviation fuels (whether biofuels or synthetic E-fuels) will thus still have a part to play.

Another factor to consider is how the hydrogen is made. A true zero-carbon supply chain would see the 'green hydrogen' produced by renewable energy – such as wind or solar power. However, that still remains a fraction of energy consumed. 'Grey hydrogen', with the fuel produced by electricity from coal, oil or gas power then might have to do for the forseeable future but can that be called fully zero-carbon? However, there is cause for positivity here for, as Llewellyn notes, the economics of renewables are shifting fast: "What we already see in 2020 is the beginning of exponential growth in terms of those energy production methods that is driven primarily by the fact that the cost of those production methods have gone down significantly over the last few years."

There is also the immense logistics, infrastructure and supply chain aspect of introducing a whole new

> IN VERY SIMPLE TERMS, THERE'S NO OTHER WAY FOR SOCIETY TO MEET THE PARIS CLIMATE AGREEMENT COMMITMENT WITHOUT HYDROGEN
>
> **Glenn Llewellyn**
> Vice President, Zero Emission Aviation, Airbus

fuel – as one person once described it: 'turning Heathrow into Cape Canaveral'. Airports would need to be upgraded all around the world, with cryogenic fuel supply and storage on a scale that is difficult to fathom – especially if narrowbody aircraft, which make up the bulk of the airliners in the world's fleet, will be the first to be converted to hydrogen. It is worth pointing out that this will include those airports where hydrogen-powered aircraft might have to divert to as well.

Finally, there is the certification aspect. Recent events have shown in stark detail what happens when an aviation regulator is gutted of expertise and companies practise self-regulation. It is thus clear that, for a new fuel and propulsion system, and with the public's, politicians' and the media's minds jumping to the *Hindenburg* whenever hydrogen and flight are mentioned, regulators will need to be ultra-cautious when approaching certification.

There are thus significant challenges – both from a technical standpoint and the logistics. However, these are not insurmountable.

multiple stakeholders and sectors, from airlines to energy producers. It will also require understanding and education on the part of consumers, the media and politicians on the limits of certain types of technology and how zero-carbon air travel could alter traditional business models and passenger experience. For example, would communities near small airfields welcome a huge increase in movements of electric or hydrogen-powered commuter aircraft if that would facilitate cheap, zero-carbon point-to-point travel?

What is different this time around is that the push for this new greener technology is coming from society itself, rather than as a side-effect of ever more efficient engines, lighter materials and reduced drag that aviation engineers have always aimed for since the Wright brothers first flew.

There is thus a huge opportunity for the aviation industry, which has been fighting a rearguard action in trying to convince policymakers it is serious about reducing its carbon footprint, to embrace this wholeheartedly and run with it.

Airbus

In the UK, zero-carbon aviation has been given a high priority, with the formation of the industry/government JetZero Council partnership to focus and help channel development in this area with the goal of zero-emission transatlantic flight in a generation. This is also a priority elsewhere in Europe – with the French government's €15bn bailout to the aerospace and aviation sector coming with the understanding that sustainable green projects should be fast-tracked.

This then represents a huge opportunity to reset the sector that will allow people to travel again, guilt-free, and airlines to grow, while massively reducing the impact on our planet. Airbus' Llewellyn says: "In very simple terms, there's no other way for society to meet the Paris Climate Agreement commitment without hydrogen. Hydrogen is here with us to stay, and it's something that will have infrastructure developed for it, will have a reducing cost curve, and we are sure that aviation needs to be positioned to take advantage of that. "In the end, if aviation is to meet the challenge of sustainable green growth, then this is a moonshot worth aiming for".

Summary

Make no mistake – this is a gigantic undertaking which Airbus itself admits it cannot hope to achieve by itself – commercial aviation's equivalent of the Apollo Lunar programme. Even the introduction of the jet age in the 1950s perhaps was not as significant, as jets had been in service since WW2 and fuel was still oil-based. Hydrogen and the related electrification of aviation will thus need support and buy in across

Afterburner

www.aerosociety.com

Diary

16 November 2020

Electrifying General Aviation II

Online Light Aircraft Design Conference 2020

An artist's impression of the Rolls-Royce ACCEL approaching Buckingham Palace, London. ACCEL aims to gain the all-electric air speed record. Rolls-Royce.

Message from RAeS

OUR PRESIDENT

Prof Jonathan Cooper

In these are difficult and uncertain times, it is good to see that a lot of the Society's activities are continuing to function making use of digital platforms. In many cases this has enhanced the reach of a lot of our events.

In September I chaired the latest in our series of 'Academic Summits' and was very pleased that attendees from all the Society's 30+ accredited universities were able to attend. Universities have very much been in the focus in the news since the start of the new academic year but attendees were able to report that they are continuing to deliver courses in a 'blended' format of digital and in-person delivery to the same high standards, meeting the learning objectives required for accredited degree courses. The forum considered a number of very timely issues in the current climate: the implementation of mixed mode curriculum delivery, lab teaching, group design projects, tutoring (particularly of first year students) and assessment. I was impressed by some of the innovative solutions that have been implemented to deal with the ongoing situation and the feedback from the meeting confirmed that sharing experience between institutions is incredibly useful for all concerned. With on-site accreditation visits not being possible, the Society has completed our first virtual professional development scheme accreditation visit in October and will also be undertaking two virtual academic accreditation visits in November. The latter will be followed up with a shortened site visit at some later date in order to award the full accreditation period.

> ONE OF THE SOCIETY'S STRATEGIC AIMS IS TO DISSEMINATE AND FACILITATE IMPARTIAL AND AUTHORITATIVE KNOWLEDGE AND INFORMATION TO A BROAD AUDIENCE

One of the Society's strategic aims is to disseminate and facilitate impartial and authoritative knowledge and information to a broad audience and, as part of this goal, some of our Specialist Groups have been busy recently. I was able to participate in the seventh RAeS Aircraft Structural Design conference, hosted using our new conferencing tool, both as a technical paper presenter and, also, as a participant in the panel session held at the end of the conference. The quality of the presentations, and the internationally renowned keynote speakers, was as good as in previous editions. It was interesting to hear how advanced structural designs and manufacturing methods will be required to help enable the march towards zero-emissions flight; such environmentally friendly designs will not be achieved by simply replacing kerosene with batteries or hydrogen-based powerplant. Congratulations to the Structures and Materials Specialist Group for putting on this excellent event.

The Rotorcraft Specialist Group organised a 'Hovering Ambition' panel event where the discussion was focused on the future of rotary-winged aircraft. The aim of the evening was to enthuse and excite a wide audience about the opportunities that the rotorcraft industry has to offer and to provide some insight as to where the industry may be heading. The discussion covered a wide range of fascinating and timely topics, including: reducing emissions and noise, automation and novel configurations. This is the sort of event that all Specialist Groups should consider putting together using the digital medium, attracting a broad audience and not just technical specialists in their particular discipline.

Readers of this column will remember that in the summer I signed a MoU between the Society and the AIAA to work together in areas of mutual interest, which includes a remit to facilitate the generation of knowledge. I was pleased to hear that the Aerodynamics SG have been working with their counterparts in the AIAA to organise a Drag Prediction Workshop (you'll have to wait until 2022 though for it to happen) aiming to improve the Prediction of Shock Induced Separation in Transonic Conditions. This activity will consist of a series of test cases to be circulated between participants and the workshop will consider the results obtained using a range of different computational approaches.

Finally, I am pleased that the Society's Autumn recruitment fair, now entering its 14th year, will take place in the beginning of November. The event will be held virtually, enabling attendees from all over the world to engage with the industry companies and representatives to explore the vast opportunities available in aerospace and aviation. This annual event is a great example of how we can bring together our strong industry partnerships and thriving network of members to interact with students and graduates seeking apprenticeships and graduate employment, and also more experienced professionals and service leavers looking to make their next career move.

OUR CHIEF EXECUTIVE

Sir Brian Burridge

- With increased Covid restrictions across Europe, there is little solace for airlines as they continue to burn through cash at a predicted total rate of £230,000 per minute. Meanwhile, IATA pointed out that '*the crisis is growing longer and deeper than anybody could have imagined*.' The peak summer period when European airlines score most of their profits saw industry revenue levels at just 25% of those in 2019 leaving little in reserve for the normal winter slowdown. Air navigation service providers will likewise suffer several lean months.
- In response, the UK Government is shortly to publish an aviation recovery strategy in recognition that the sector is recovering from an unprecedented shock and facing an uncertain future. The Government says that it is committed to maintaining a thriving and competitive aviation sector. To that end, the strategy is likely to cover: the return to growth of the sector; workforce and skills; regional connectivity and freight; innovation and regulation; consumer issues; climate change and decarbonisation; health, safety and security; and the critical role that aviation plays in retaining the UK's global reach. A tall order perhaps but vital, nevertheless.
- Related to this, our recent consultation response to the Government's Comprehensive Spending Review (CSR) contained ten key asks. We seek financial support to the sector through the Covid-19 crisis, increased funding for a National Space Programme and a range of financial measures to improve apprenticeships. We also helped shape the response of The National Engineering Policy Centre which included a call for investment in Sustainable Aviation Fuels. You can read both documents on the Society website at **www.aerosociety.com/policy**. Similar points were included in our letter of welcome to the new Aviation Minister, Robert Courts MP, a former member of the Transport Select Committee and a member of the Air League Council.
- Meanwhile, we have been climbing-up the learning curve of our virtual conference platform with considerable success. More akin to running a TV station than a traditional conference, the format is so much more inclusive. In the first three events, we have drawn international expert contributors and global audiences. The innovative platform allows networking with fellow delegates with sponsors positioned in a virtual lounge where visitors can interact directly with the companies. You can also catch-up on anything you missed from the recordings (see 'Safeguarding space virtual conference report' p 36). Worth attending soon will be the Climate Change conference on 3-4 November and the President's Conference on 25-26 November entitled Digital Technologies to Enable the Future Aerospace Industry. The Branches, too, have been very successful in adapting to the virtual lecture environment, adding much value to our learned output.
- As for careers events, Yeovil Branch graduates and apprentices from Leonardo Helicopters are organising a 'live broadcast' Cool Aeronautics event in November. It contains an ambitious programme of STEM talks, experiments and hands-on activities from its site, going live to over 450 primary school pupils in the local area. Our thanks go to Leonardo and the programme sponsor, AAR, for their continued support. Also, our annual careers and recruitment fair goes virtual for the first time on 4 November, supported by our Club Class partner Boeing.
- For Corporate Partners, we have online briefings coming-up by Professor Sir Charles Bean on 30 November entitled, 'Covid, Brexit and the UK's Economic Prospects' and, on 14 December, Professor Michael Clarke's whose title is: 'The Integrated Defence and Security Review: Grasping or Missing Generational Change?' We are also now well advanced on the creation of the 2021 programme. All members will wish to note in diaries that the 2020 Wilbur and Orville Wright Lecture will take place virtually on 2 December. The speaker is Michele Evans, Executive Vice President Aeronautics at Lockheed Martin.
- It is a sad fact that, given the difficult times which confront us, we lost a number of staff on redundancy at the end of October. You will see elsewhere in this edition that among them are three who have given particularly long and highly-valued service: Gail Ward (Events), Steve Smith (Venue) and Brian Riddle (Chief Librarian) (see p 52). Overall, we have lost 14 staff since March some of whom were on temporary contracts covering maternity leave, which now leaves a staff cohort of 36 posts. We wish all those who have left our best wishes for the future, particularly those who have served the Society for an extended period.
- Finally, Council nominations are upon us. Members interested in standing for Council in the 2021 election to be held next spring can now find the details at **www.aerosociety.com/councilelection**. At a time of both uncertainty caused by the pandemic and the opportunity for transforming the Society's operations, this is a chance for you to contribute.

> MEANWHILE, WE HAVE BEEN CLIMBING-UP THE LEARNING CURVE OF OUR VIRTUAL CONFERENCE PLATFORM WITH CONSIDERABLE SUCCESS

Book Reviews

AIRLINER MODELS

Marketing Air Travel and Tracing Airliner Evolution Through Vintage Miniatures

By A J Lawler

The Crowood Press, Ramsbury, Marlborough, Wiltshire SN8 2HR, UK. 2019. 336pp. Illustrated. £50. ISBN 978-1-78500-633-3.

The invention of machines has always been accompanied by the creation of smaller-scale models of these machines to help convince people to use them, to buy them, to finance their development and to inspire people to improve them. The headquarters of the great shipping lines contained wonderful models in glass cases of the vessels representing the state of the art of technological development. Over the past 100 years air transport has developed, allowing ordinary people to live their dreams of travel to distant lands and these dreams have been inspired from the outset by beautiful, intricate airliner models visible through travel agents' windows. Such models have also been used to persuade the world's airlines to order aircraft and company boards, bankers and governments to authorise their production.

Anthony Lawler has been inspired by such models since his boyhood and nourished this passion, and his extensive collection, throughout his long and distinguished career in airliner marketing. He is one of a small, discreet group of expert collectors in the world. Although no self-respecting air museum would be complete without a large number of models, they tend to follow the theme of the museum. Hence an original idea to chronicle the development of airliners worldwide in this photographic journey through the models that ensured their promotion.

The models featured in the book were professionally made, primarily from wood or metal, until plastic became a material of choice. The majority are from the author's personal collection, supplemented by those of fellow collectors, former and current model-makers, and those from the historic model collections of the Science Museum, London and the Museum of Transport and Technology, Auckland.

Containing over 800 colour photographs, the book is structured chronologically with a chapter for each decade from the 1920s through to the 1980s, followed by a single chapter covering 1980 to the present day. This structure gives greater place to the wider variety of airliner designs in earlier years as the industry was maturing, without ignoring modern airliners, even if the models are distinguished more by their liveries than fundamental visual differences in their designs.

Anthony Lawler has been inspired by such models since his boyhood and nourished this passion, and his extensive collection, throughout his long and distinguished career in airliner marketing

The discerning reader may find the subsequent chapters even more interesting as they contain profiles of the model makers themselves, listed alphabetically by country. A few of these are large, successful companies with long histories, many smaller ones have fallen by the wayside or been absorbed, and some existed only through the talents of individual craftsmen. A dedicated chapter covers model bases in the broadest sense, illustrating the many different ways in which models were presented. In contrast to today, these were often in the form of ornate ashtrays, for example a sterling silver Trident 1 model originally presented to the Chairman of British European Airways.

Interspersed between the main chapters are a series of 'Treasure Hunts', each of which tells the tale of how a particular model was acquired by the author for his personal collection. These stories are uplifting and will strike a chord today with the many passionate aviation people who try to inspire the younger generation.

The book concludes with an account of how models are used in the marketing of airliners towards airlines, rather than the promotion of air travel. Such models might serve to illustrate a particular feature of a design, such as a swing-opening tail, but equally the models might be of new designs that are never actually built in the same configuration as the one promoted.

Aircraft manufacturers have used models to promote sales since the outset. One particularly remarkable model featured in the book is a 53-inch span Handley Page 0/400 airliner made from wood, metal and fabric by the Handley Page workshops. Many others, particularly from the pre- and immediate post-WW2 era, contain incredible component and interior cutaway detailing.

The models themselves are the true stars of this book, although their stories are interwoven with those of their builders and that of a caring collector sharing his passion with the reader. A choice was made only to identify the ownership of a model where specifically requested. That left me feeling curious and a little hungry as I would have preferred identification, except where the owner did not give permission. Notwithstanding, this is a book to read, to leaf through with pleasure, to leave out in full sight of friends and visitors and to come back to.

In future, airliner models are likely to be commissioned for the niche uses of marketing and specialised trade shows but the heyday of models like those featured here, often works of art requiring so many hours of labour from true craftsmen, are long past, and *Airliner Models* is a fitting tribute to them.

Bob Lange
FRAeS

IN TURBULENT SKIES

British Aviation Successes and Setbacks 1945-1975

By P Reese

The History Press, The Mill, Brimscombe Port, Stroud, Gloucestershire GL5 2QG, UK. 2020. 295pp. Illustrated. £19.99. ISBN 978-0-7509-9302-9.

The decline of the British aircraft industry between 1945 and 1975 is a well-known story and Peter Reese tells it well.

In 1945 Britain was as advanced as the US in the design of fighter aircraft,and possibly bombers, although it had fallen behind in design and construction of commercial transport aircraft. Governments of both colours saw the aircraft industry as a major element of foreign trade and, from at least 1942, were planning to revive the production of commercial transports for a world market, aided by Britain's undoubted head start in gas turbine propulsion.

Sadly, this was not to be. The specification by the Brabazon Committee for a non-stop transatlantic airliner led to an unsuitable aircraft, though the Committee is often not given credit for correctly specifying the Comet, Viscount and Dove, and the Airspeed Ambassador was a good aircraft, even if it did not sell overseas. But the first aircraft to appear, the Avro Tudor, suffered technical problems before two disappeared over the Atlantic. A few years later the promising progress of the Comet was cut short by the fatigue failure of the fuselage that cost two aircraft and their occupants. Development of the Britannia was delayed by engine icing problems so that it was overtaken by the pure jet B707 and DC-8. Cancellation of the V-1000 military jet transport meant that a civil version was not available for the first generation of transatlantic orders.

In military aviation, the British position was weakened by delay in developing a swept wing fighter to match the Sabre and then failure to produce a low supersonic fighter, such as the F-100. Cancellation of the Miles M-52 supersonic research aircraft also set back progress. The 1957 *Sandys White Paper* prioritising missiles over manned aircraft blocked a generation of military aircraft except for TSR-2, which in turn was cancelled in 1964.

Reverting to civil transports, the stories of the Trident and VC-10 have been told by Keith Hayward. Both failed to achieve substantial overseas sales because they were based on specifications too specific to BEA and BOAC. The BAC 111 achieved reasonable sales but only a fraction of the DC-9, partly because of accidents during development and partly because of the delay in producing stretched developments, when compared to Douglas.

Above: Vickers Viscount 802, G-AOHJ, of BEA at London Heathrow Airport in 1964. Behind is a Hawker Siddeley Trident. The Viscount was a response to the Brabazon Committee's Type IIB design for a short-haul, propeller-turbine powered pressurised airliner. Around 445 Viscounts were built between 1948 and 1963. Adrian Pingstone.

The decline of the British aircraft industry between 1945 and 1975 is a well-known story, and Peter Reese tells it well

The final section suggests that part of the decline was a result of poor project specification and management by governments but that there was no wish to run down the aviation industry. Another important factor was the technical ability of the industry to deliver the aircraft specified. Failures of the Tudor and Comet, the deep stall accident of the BAC 111 and engine icing on the Britannia, blighted their prospects. In military aviation, projects such as the Swift were technically unsuccessful.

The author also suggests that "within the UK a sense of misplaced self-confidence and the wish to 'return to normal after the war' served to encourage its aircraft manufacturers to continue with their time-honoured methods of production and for aviation to remain a fragmented industry with its 27 aircraft firms and eight engine manufacturers. Proud owners and their staff, many of whom had been together since the early 1920s, opposed much-needed amalgamations, with Frederick Handley Page, for instance, finding it impossible to unite with another firm and choosing liquidation instead." Above all, the industry faced well-resourced competition from the US with a much larger home market and arguably better technical and project management. There are a few questionable comments in this section. The Brabazon airliner was powered by piston engines but only as an interim measure because the turboprop engines to be used in the Brabazon Mk 2 were not available. In 1945 a turbojet transatlantic airliner would not have been possible.

The book reads well, though there are a number of minor errors. 'USAF' is given as 'USF' throughout; the Blue Streak fuel turbopumps were driven by gas turbines, not batteries (p 116); the Eland in the Rotodyne was 3,000hp, not 300hp (p 192); and more. Most of these will be obvious to the reader, and not detract too much from the book. It provides a good overview of a period that shaped the aviation industry in this country.

Dr Kit Mitchell FRAeS

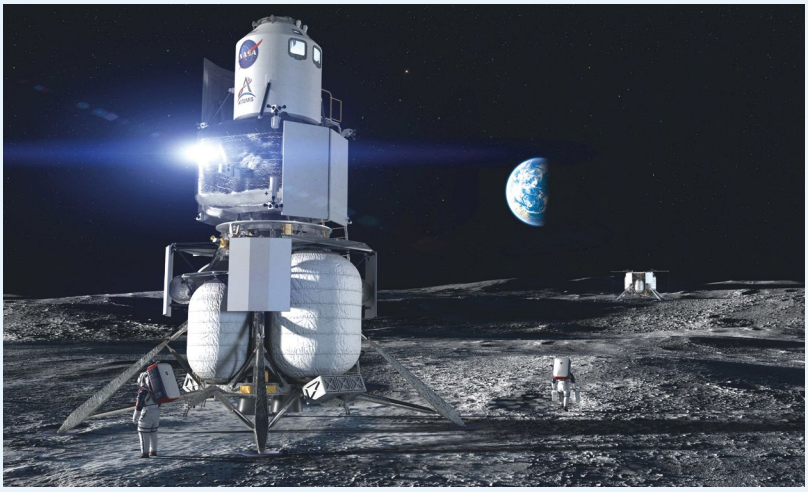
Book Reviews

RETURNING PEOPLE TO THE MOON AFTER APOLLO

Will It Be After Fifty Years?

By P Norris

Springer. 2019. vii; 231pp. Illustrated. £24.99. ISBN 978-3-030-14914-7.

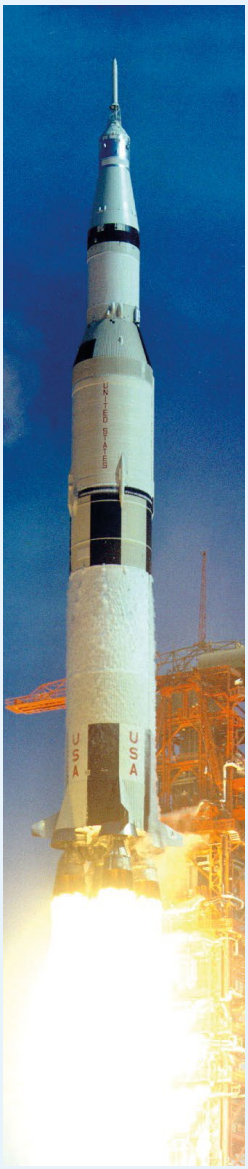


The author Pat Norris is an experienced engineer and writer, having published numerous times (including in this magazine) yet wears his technical knowledge lightly. Writing in a clear and jargon-free style, he modestly makes only the most fleeting of footnotes to his work at TRW (the book is, after all, not an autobiography). But these brief notes remind the reader that this is one of the few books written by one with first-hand experience.

The book opens with a more fundamental question than its title, exploring the political and technical reasons why the US went to the Moon in the first place. An overview of the Saturn V launcher follows. Rocketdyne's development of its gigantic first stage engine – the F-1 – was fraught with combustion instabilities and self-destructing test engines, with the author introducing topics like oxidiser injection and combustion chamber stability to the layman succintly and clearly. The instabilities weren't merely tested experimentally but later induced deliberately; the chamber pressure was already a staggering 80atm, yet was tripled during bomb detonations to ensure that the F-1 was sufficiently trustworthy for human spaceflight.

The second stage was a bigger challenge. It had to be startable in vacuo, where conventional lubricants simply evaporate. Innovative manufacturing techniques were developed to not only build the S-II stage, but to keep its mass down, due to the increasingly heavy spacecraft atop the third stage, which came ready-designed from the Saturn 1B. The description of the spacecraft modules (command, service, lunar) is interwoven into a description of the Apollo 11 mission.

The author is open about the material he omits, such as the Gemini programme and the unmanned lunar probes. The material isn't purely technical and the author gives a brief description of NASA's management approach. There's little description of management tools and processes here, being more a historical account of the techniques used (fast, but high-risk, testing of complete launchers) noting – correctly, it may be argued – that today's NASA is far more risk-averse and cost-conscious but achieves less. The usual spaceflight superstars are mentioned (George Mueller, Sam Phillips, Jim Webb). Unfortunately, the rest of the Apollo missions – 12-17 – are squashed into a mere seven pages. The legacy of Apollo follows, described not just scientifically and managerially but also socially and politically.



A chapter about the Soviet moonshot follows, describing how it failed. Here, Norris is able give a detailed retrospective of the USSR space hardware, which would have been unavailable to 1960s' authors. The failure wasn't simply down to technical inferiority; the USSR had not one but three Moon projects in parallel (robotic sample return, manned lunar flyby and manned landing), all competing for the same scarce budgets and skills. Sergei Korolev may be the most famous but the often overlooked Valentin Glushko and Vasili Mishin are also described in more detail than other authors would.

As a historical account the book is uneven at best but it truly excels in providing an overview of present-day space programmes and their future prospects. The latter half of the book moves beyond the Cold War to the present and near future and explains why no-one has flown to the Moon since 1972. There are substantial chapters on the work of SpaceX and Blue Origin, describing how missions are becoming less governmental and more corporate. There is a sense of a baton being passed from one generation to the next. The F-1's empirically-designed injector plate, which fed the engine with 3t of kerosene and LOX every second, is pictured alongside not Wernher von Braun, but Jeff Bezos of Amazon. There are two photos of the USSR-era R-7 derived launcher, one carrying aloft Yuri Gagarin in 1961, the other the UK's Tim Peake in 2015.

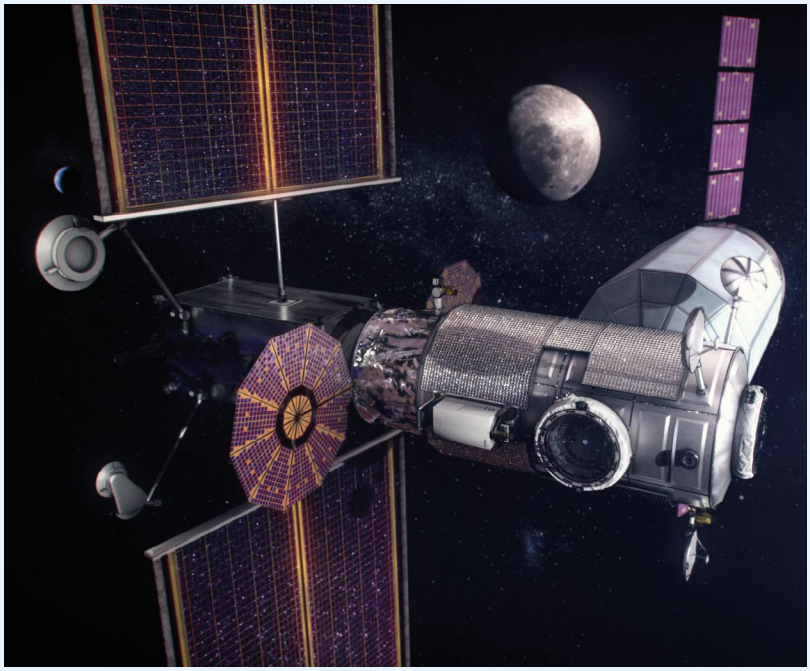
The author doesn't confine himself to the traditional Russian-American space powers, with China's Moon programme deservedly receiving a chapter of its own. Russia is lumped in with 'the rest' in the final chapter (along with Europe, Japan, Canada, India). This, however, is less a reflection of the author's opinions and more of national priority, as these countries have concentrated on unmanned Earth orbital and interplanetary missions.

The book could have benefitted from more

rigorous editing (there's no need to point out the definition of the ton seven times, and the author appears to have confused Apollo 9's Rusty Schweickart with Apollo 13's Jack Swigert) and the author's conversational style – and his fondness for exclamation marks – may irritate some readers. The Apollo 11 landing was doubtless a triumph but the author's praise of the USA borders on hysteria, which may bring his objectivity into question.

Overall, Norris presents a well-argued and readable answer to the titular question, accessible to both technical specialists and enthusiasts alike, which this reviewer will not spoil by revealing. He concludes that somebody may well be on the Moon, perhaps funded by a private company rather than a national government, and much sooner than his readers may expect. The true test of Norris' analysis will be time itself.

Andy Sinharay
MEng ACGI MRAeS



Above: The NASA-led Lunar Gateway is a planned space station in lunar orbit intended to serve as a communication hub, science laboratory, short-term habitation module and holding area for rovers and other robots. It is expected to play a major role in NASA's Artemis programme after 2024. NASA.

Opposite top: On 30 April Blue Origin's National Team, which includes Lockheed Martin, Northrop Grumman and Draper, was awarded $579m to develop an integrated human landing system as part of NASA's Artemis programme to return humans to the Moon. SpaceX and Dynetics were also awarded contracts to develop their landing system concepts. Blue Origin.

Opposite bottom: The lift-off of Apollo 15 atop its Saturn V launcher on 26 July 1971. NASA.

FOUNDATIONS OF AIRLINE FINANCE

Methodology and Practice – Third edition

By B Vasigh and Z C Rowe

Routledge, 2 Park Square, Milton Park, Abingdon OX14 4RN, UK. 2019. xxxv; 642pp. £47.99. [20% discount available to RAeS members via www.crcpress.com using AKQ07 promotion code]. ISBN 978-1-138-36781-4.

Financial management is key to the successful operation of any business and airlines are no exception. This book provides the basis for understanding economic concepts and applying them to make sound financial decisions in the airline industry.

Part 1 examines the key aspects of finance and, as such, creates a foundation from which the book develops. Although it is more finance than airline-oriented in this Part, it still introduces some airline specific aspects. Part 2 is an exhaustive examination of financial statements and accounting practices, and a number of key financial metrics are introduced that are necessary for any airline professional to understand.

Financial management is key to the successful operation of any business, and airlines are no exception

The last two Parts are more airline-oriented dealing with numerous practical applications. Given the capital-intensive nature of aircraft acquisition, the chapters examining capital expenditures are especially useful. Not to be overlooked is the chapter dealing with operating costs and in particular fuel hedging given the recent volatility in the price of aviation fuel. This is complemented by chapters on aircraft leasing and revenue management which are vital components of successful financial management.

The Third edition provides up-to-date information regarding this dynamic industry. This is complemented by numerous global case studies that are relevant, although they are dominated by US examples.

This book provides a comprehensive overview of the financial aspects of airline operations and management. It is of utility to both managers wishing to learn about the unique aspects of airlines and to aviation students wishing to become knowledgeable about financial management.

Frances Kremarik
Lecturer in Air Transport
University of Westminster

NEW MEMBER SPOTLIGHT

Zoe Garstang ARAeS, 20

Location: Preston, UK

Job Title: Airworthiness Engineer – Typhoon Flight Safety Analysis, BAE Systems.

What inspired you into aerospace? I always wanted to pursue something STEM-related at school but had never really considered aerospace engineering as a career; that was until I met a Specialist Engineer during an event run by BAE Systems called 'Bring Your Teenager to Work Day'. It was this insight which opened my eyes to the possibilities within engineering and which has influenced my career path to date.

What is the best thing about your current role? I enjoy how varied my role in airworthiness is. One moment I could be analysing occurrence data for trends, the next I could be reviewing In-Service Tasks for Typhoon operators.

What made you join the Royal Aeronautical Society? I joined the Society while I was a Technical Engineering apprentice as I wanted to develop my understanding of the aerospace industry and also get involved in RAeS activities. I started attending my local Branch lectures and was asked to join their committee as the Young Persons Representative. Since then, I've also supported the Society's outreach activities and most recently I've been elected onto the Young Persons Committee.

What do you hope to get out of your membership? I hope to further my professional development and become professionally registered. I would also like to continue my involvement with my local Branch and the Young Persons Committee to encourage more young people to consider engineering as a career.

What three items would you take with you to the space station? My camera, a LEGO set of the International Space Station (although astronaut Satoshi Furukawa has already beaten me to that one!) and my iPod with audiobooks/ music.

What's your favourite aircraft and why? That's a tricky one but I'd have to go with the Avro Vulcan. I'll never forget XH558's farewell tour back in 2015 and seeing the aircraft fly straight over our heads!

Who is your biggest inspiration? Many people have had a big impact on my life, from the Specialist Engineer who sparked my interest in engineering, to the people I've worked with throughout my apprenticeship and beyond. I've found it's often the small things that make the biggest difference.

Piece of advice for someone looking to enter your field? I'd say make the most of opportunities that are out there and be proactive in seeking out opportunities that you believe will add value – not every opportunity will be easy to come by. Also, remember that you can enter engineering in so many different ways – apprenticeships, graduate schemes and direct entry roles to name a few. Take time to research the different routes and follow the path that feels right to you.

Obituary

PROFESSOR MICHAEL 'MIKE' JOHN GOODYER

CEng FIMechE AFAIAA FRAeS
1934-2020

Michael John Goodyer, age 86, of Chandlers Ford, Hampshire, Professor of Experimental Aerodynamics and Freeman of the City of Coventry, passed away in the family home on 6 September 2020.

Born to George Robert and Eva May Goodyer on 9 June 1934 in Coventry. After attending King Henry VIII grammar school 1945-50, he was accepted as an apprentice to Armstrong Siddeley Motors Ltd studying Automobile and Aeronautical Engineering. He gained his HNC in Mechanical Engineering in 1954 and was awarded a scholarship to the College of Aeronautics, Cranfield, in 1956. With a specialisation in aircraft propulsion he gained his MSc in 1958 and returned to now Bristol Siddeley Engines Ltd in Coventry as Section Leader of the performance section.

In 1963 his long association with Southampton University began with his appointment as a Research Fellow to the Department of Aeronautics and Astronautics. Promoted to Lecturer in 1966, he gained his PhD in Experimental Aerodynamics in 1968 and remained in this post until his promotion to Senior Lecturer in 1978, Reader in Experimental Aerodynamics in 1985, Deputy Head of Department in 1993 and ultimately held the Acting-Head of Department position at his retirement in 1995.

In the late 1960s discussions were taking place around the accuracy of data gleaned from wind-tunnel testing of aircraft. Interference from the model support and tunnel sidewalls along with the issues of aerodynamic scale were causing significant differences between test and flight data. NASA Langley Research Center in Virginia, US, was working on a proposal for magnetic suspension of the model to eliminate the interference from the support structure but the costs and technical challenges associated with scaling up this proposal were proving prohibitive. In 1969 Robert A Kilgore from NASA Langley visited Southampton University to complete his PhD. The two men talked at length about possible solutions. Prof Goodyer was aware of a proposal from a textbook published in 1952 (*Wind-tunnel Techniques*) where the gas in the tunnel would be cooled cryogenically to help rectify aerodynamic scale issues. He suggested a small wind tunnel with a magnetic suspension system and cryogenically cooled working fluid. NASA became very excited by the proposal and a consultancy offer was made, a collaboration that lasted from 1970-1991.

Professor Goodyer's inspirational work with the practical application of cryogenic cooling for high Reynolds number aerodynamic testing won him a NASA Special Achievement Award in July 1973 and a second in October 1973 'For the conceptual studies, engineering, design, fabrication, assembly and initial operation of the Langley pilot cryogenic high Reynolds number transonic pressure tunnel'.

In addition, during January 1974, he was awarded a NASA Certificate of Recognition for his inventive work on a stagnation pressure probe and received a Group Achievement Award in November 1975 again, 'for outstanding scientific achievements related to the cryogenic wind tunnel concept'. A paper co-authored by him won the Outstanding Publication within the Aeronautics Directorate at Langley in October 1983. Ultimately, in 1984, he was awarded the NASA Medal for Exceptional Scientific Achievement and the NASA Space Act Award in 1990 for his scientific contribution to the development of the National Transonic Facility (NTF), the world's largest pressurised cryogenic wind tunnel, located at NASA Langley.

Despite numerous trials and studies the magnetic suspension of models has yet to see many practical applications. However, several cryogenic wind tunnels have been constructed both in the US, Europe and the wider world. Data from NTF and the European Transonic Wind-tunnel (ETW) have been used in many legacy programmes and are still in use advancing the design of military and commercial air vehicles.

Throughout the 1980s and 1990s Prof Goodyer was in high demand for his expertise. Numerous lecture tours took him all over the world visiting, among others, Japan, Taiwan and Australia. He was one of the first western scientists to be invited to post-Mao China, in 1983 visiting the Beijing Institute of Aerodynamics, Northwestern Polytechnical University (NPU) in Xi'an and the Chinese Aerodynamic Research and Development Center (CARDC) in Mianyang. In 1986 he visited the Nanjing Aeronautical Institute and he made two further visits to NPU in 1991 and 1994. He was appointed Honorary Professor at NPU in 1994 and selected by Shaanxi Education Commission as Model Foreign Teacher (Expert) of Higher Education in Shaanxi Province in 1993-4. He also acted as consultant to many companies and institutions, including British Aerospace, Vickers, the Royal Aircraft Establishment and, of course, the ETW group.

In 1990 he was elected Associate Fellow, American Institute of Aeronautics and Astronautics and in 1994 as a Fellow of the Institute of Mechanical Engineers and of the Royal Aeronautical Society.

In retirement he used the wind tunnel located in his garage loft at home to design, calibrate and sell yawmeters through his company, Consultant Engineering Associates.

He married Pauline Brookfield on 8 September 1956 spending many happy years with her until her death from leukemia in December 2011. He is survived by his daughter Anne and son John. He has four grandchildren and four great-grandchildren. He had a strong sense of family and an intelligent, quick and cheeky sense of humour.

John Goodyer

STAFF RESTRUCTURING

Having now completed the Society's restructuring programme, several members of the team departed the Society at the end of October. We regret the loss of colleagues such as these who represent so much talent and experience and who have contributed so much to the Society, some over an extended period including Brian Riddle, Steve Smith and Gail Ward.

Brian Riddle

Following a Royal Aeronautical Society staff reorganisation, the staff role of Chief Librarian was made redundant at the end of October 2020, thus bringing to an end over 36 years of continuous service of Brian Riddle to the Society, having originally joined the Library staff in August 1984.

During this time Brian has arranged reviews and compiled abstracts of thousands of books, researched enquiries, catalogued numerous books/journal articles, compiled over 100 articles about the Library's collections for the Society's publications, arranged for the archival conservation and digitisation of many of its treasures (including the 'Adopt-a-Picture' and 'Adopt-a-Book' projects), arranged the loan of historic material to exhibitions, curated the 2003 Pioneers of Flight exhibition and co-edited *Letters of the Wright Brothers: Letters of Wilbur, Orville and Katharine Wright in the Royal Aeronautical Society Library* (Tempus Publishing. 2003).

The following years witnessed the major relocation of the Library to Farnborough that occurred from 2004 onwards, culminating with the opening of the National Aerospace Library in December 2007.

The **www.aerosociety.com/movies** site launched at the end of May this year which showcases historic aviation films held in our archives was the latest of the Library's digital projects which have been developed in recent years using today's technology to share material from the Library's archives with the rest of the world – attracting a number of favourable comments/interest via social media from around the world – and include the web-based catalogue (**www.aerosociety.com/catalogue**) [2013], images collection (**www.aerosociety.com/printsandposters**) [2012], heritage collections (**www.aerosociety.com/heritage**) [2015] and the National Aerospace Library Sound Archive (**www.aerosociety.com/podcast**) [2017], all of which Brian originated.

Steve Smith

Steve has been a stalwart of the No.4 Hamilton Place team, providing venue support for over 20 years, by setting up meeting rooms, solving technical and logistical issues and catering to the needs of our members, clients and staff. Those of our members with long memories may even recall being served a drink or sandwiches in the Members' Bar by Steve.

Above: Gail Ward with the Master of Ceremonies at the 2018 RAeS Annual Banquet she had organised.

Top left: A 2007 photograph of Steve Smith.

Middle left: Poster for the 1935 International Aircraft Exhibition which was displayed at the 2012 'Flight and the Artistic Imagination' exhibition at Compton Verney.

Bottom left: Oil in board by Cyrus Cuneo, the restoration of which was sponsored by Dr I C Perry FRAeS under the Library's 'Adopt-a-Picture' programme and now displayed on the staircase at No.4 Hamilton Place.

RAeS (NAL).

Gail Ward

Gail joined the Events Team as a Conference Co-ordinator in 1994 and has served the Society and its members for over 25 years, most recently as the Event Manager for all our Corporate and Society events. During this time Gail has organised hundreds of events for members and our Corporate Partners and played a key role in celebrations for 100 years of powered flight, the Centenary of British Aviation and the Society's own 150th anniversary activities. With her outstanding customer service skills and event management, some of the highlights of her work have included a Gala Dinner at the Science Museum with HRH The Duke of Edinburgh, the Centenary Gala Dinner at Farnborough Aerodrome where Lesley Garrett CBE entertained guests and the RAeS 150th Anniversary Gala Banquet at the Guildhall with our Guest Speaker, Per Lindstrand and Guest of Honour, HRH Prince Michael of Kent.

We thank all the staff for their hard work, dedication and loyalty over the years and wish them well for the future.

RAeS 2020 Virtual Conference Programme

Join us from wherever you are in the world to experience high quality, informative content. Book early for our special introductory offer rates.

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RAeS Climate Change Conference

DATE
3 - 4 November 2020
TIME
13:00 - 17:00

SCAN USING YOUR PHONE FOR MORE INFO

RAeS PRESIDENT'S CONFERENCE

Digital Technologies to Enable the Future Aerospace Industry

DATE
25 November 2020
TIME
13:00 - 17:30

SCAN USING YOUR PHONE FOR MORE INFO

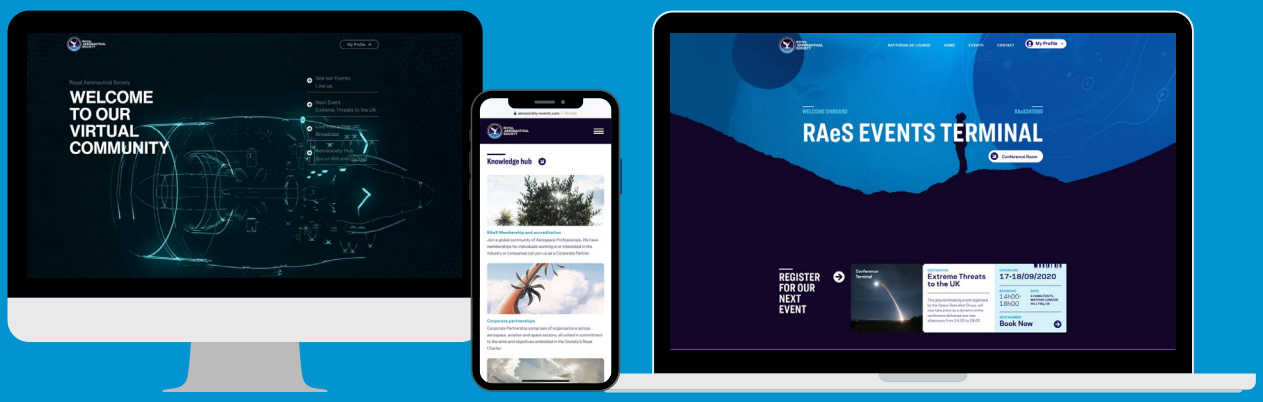
AIR POWER

RAeS Air Power Conference

DATE
7 - 8 December 2020
TIME
13:30 - 18:00

SCAN USING YOUR PHONE FOR MORE INFO

Embark on your virtual learning journey with the RAeS



- Connect and interact with speakers and ask questions live
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For the full virtual conference programme and further details on what to expect visit aerosociety.com/VCP

Left: Wg Cdr J A Kent in the cockpit of the 1910 Deperdussin belonging to the Shuttleworth Collection at the 1949 Royal Aeronautical Society Garden Party. Below: A screenshot from the film of the Sikorsky Hoverfly I. Bottom: Dr Harold Roxbee Cox, Royal Aeronautical Society President 1947-1949, leaves the Garden Party in a hydrogen balloon flown by Charles Dollfus. RAeS (NAL).

A window in time

The National Aerospace Library has digitised its collection of films, many of which had been in storage at Hamilton Place for 50-60 years (see *AEROSPACE*, May 2020, pp 50-51). Although many were in labelled cans, there were also those that were unlabelled and are now being reviewed for identification and cataloguing before being made accessible to a wider audience via the Society's website. It was among these that Tony Pilmer, the Society's Librarian & Archivist, found a 5min 20sec colour film whose sole credits declared it to be a 'Royal Aeronautical Society Garden Party', but which one?

With a rough date deduced from the aircraft featured in the film, I was able to reference the Garden Party photographs I had sorted and digitised in 2015 to quickly come to the conclusion that it was the Society's Garden Party held at White Waltham Aerodrome near Maidenhead on Sunday, 8 May 1949. This was held to mark the year in which the Society had been granted a Charter of Incorporation.

The emphasis of the day was on light aircraft and the displays featured aircraft from the previous 40 years, both statically and in the air. Around 5,000 members and their guests witnessed spirited displays by the Shuttleworth Trust's Blériot XI, Deperdussin and Sopwith Pup, while more modern aircraft were represented by Cierva Skeeter and Sikorsky Hoverfly I helicopters. Also present were a number of Miles, de Havilland, Avro and Hawker types.

The highlight of the day was the flight of a 12,000ft^3 hydrogen balloon. Inflated by the Royal Air Force Balloon Unit from Cardington, with scant regard to modern-day health and safety considerations, and piloted by the well-known aeronaut Charles Dollfus. With the RAeS President, Dr Harold Roxbee Cox (later Lord Kings Norton) also on board, it ascended at 6pm travelling five miles across country before landing at Foliejon Park, Winkfield, 22 minutes later.

Among the music performed by the Fairey Aviation Works' Band that afternoon was 'March for the Flight of Mr Lunardi's Air Balloon' composed by Samuel Wesley around 1784, a copy of which had been found in the Library's Hodgson-Cuthbert Collection.

Chris Male
MRAeS

The film may be viewed at:
https://www.aerosociety.com/gardenparty

ROYAL AERONAUTICAL SOCIETY

Renew your membership for 2021

At the Royal Aeronautical Society we understand the challenges that the industry has recently been facing and the impact this has had across our membership and the industry.

We have adapted our range of membership benefits to suit a digital environment. In 2020 we have launched a new *AEROSPACE* app, expanded our e-library of resources and launched a virtual conferencing platform to hold a variety of events online.

Through renewing your membership at the Society, you will continue to have access to a range of exclusive membership benefits, developed to ensure you have access to the resources, support and tools, whenever you require them.

Get involved with specialist groups and your local branch by updating your preferences. Log in to your account on the Society's website to ensure your preferences are up to date:

www.aerosociety.com/login

You will shortly receive an email which provides further information on how to renew your membership with details on how to make payment.

If you require any further assistance regarding your membership renewal or would like to make payment over the phone please contact the Subscriptions Department on:

+44 (0)20 7670 4315 / 4304

subscriptions@aerosociety.com

Your membership benefits include:

- Use of your RAeS post nominals, as applicable
- Subscription to the monthly *AEROSPACE* magazine through the post and the app
- Access to the National Aerospace Library resources which includes e-books, podcasts and films
- Discounted rates for a variety of online conferences and webinars through our new virtual conferencing platform
- Access to Society news and blogs online
- Engage with your local Branch through events and networking opportunities
- Support gaining Professional Registration
- Recognition of achievement through the Society's Medals and Awards
- Free online access to *The Aeronautical Journal* and its 123 year old back catalogue
- Exclusive 20% discount on 30+ Cambridge University Press books on the topic of Aerospace Engineering
- Coming soon... Aeroversity, the Society's new Learning Management Platform with access to online courses, resources and CPD recording tool

... and much more! Find out more ways to get involved and utilise your membership benefits:

www.aerosociety.com/membership

membership@aerosociety.com

Thank you in advance for renewing your membership!

With your support, the Royal Aeronautical Society remains the world's foremost professional institution dedicated to the entire aerospace and aviation industry.

Elections

FELLOWS

David Blenkinship
Leonard Bouygues
James Cemmell
Andre Du Plessis
Philippe Guidi
Ricky Hart
Itor James
Andrew Lees
Steve Luczynski
Kevin Palmer

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Bert Buyle
Andrew Campbell
James Chase
Vanni Da Ronco
Luis De La Torre
Mark Galle
James Goodwin
Kyle Hannah
Ranga Herath
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Fraser Johnston
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Scott Francey
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Hamish Rutherford
Georgia Smith

AFFILIATES

Richard Macauley
Mansoor Shar

STUDENT AFFILIATES

Maiza Babar
Murat Duran
Moataz Hassan
Linge Liu

WITH REGRET

The RAeS announces with regret the deaths of the following members:

Frank Ernest Behennah CEng FRAeS 95
Paul Hermon MRAeS 59
Boel Elisabeth Norman MRAeS 78
Marc Shawn Polivnick ARAeS 48
John Aubrey Ridler IEng AMRAeS 91
Raymond Barry Searle CEng FRAeS 83
Stuart Sendall-King LdH CEng FRAeS 98
Norman Sharp CEng FRAeS 100

Handley Page Lecture 2020 – Online

The National Flying Laboratory Centre, Cranfield University In-Flight Measurement and Research

Professor Nicholas Lawson CEng FRAeS
Chair in Aerodynamics and Airborne Measurement and heads the National Flying Laboratory Centre at Cranfield University

6pm, 19 November 2020

To book:
https://www.cranfield.ac.uk/events/events-2020/handley-page-lecture-2020

Handley Page Jetstream, G-NFLC, flight mechanics laboratory. Cranfield.

COUNCIL ELECTIONS 2021

Would you like to help guide the Society?

NOMINATIONS FOR THE 2021 RAeS COUNCIL ELECTIONS ARE NOW OPEN

The Society would like to hear from members who are interested in standing for the Council in the 2021 elections to be held next spring. Only by having a good number of candidates from all sectors of the aviation and space community can the Council benefit from a variety of backgrounds and experience.

As members will be aware, the Council now concentrates on the outward facing aspects of the Society's global activities. Indeed, as the Society becomes ever more global, it is critically important that our offerings to members, to Corporate Partners and especially to the public are of the highest quality. To lead output of the highest quality we need members of Council from every part of the aeronautical community and this is where you come in.

Please give serious thought to whether you could serve the Society in this most important role. If you are interested, or require further information, please visit our website at **www.aerosociety.com/councilelection** or contact Saadiya Ogeer, the Society's Governance and Compliance Manager, on +44 (0)20 7670 4311 or saadiya.ogeer@aerosociety.com

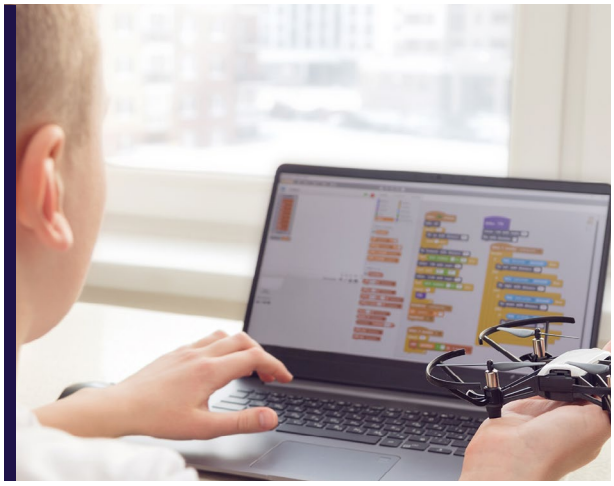
Please note that all nominations must be submitted no later than 31 January 2021 at 23.59 GMT.

24 November

Final closing date for 2020

ROYAL AERONAUTICAL SOCIETY

Apply now for Membership and Professional Registration



Do you need guidance on applying for membership, upgrading or professional registration with the Engineering Council?

Join us for a webinar, a one-to-one support appointment or contact the membership team for guidance on:

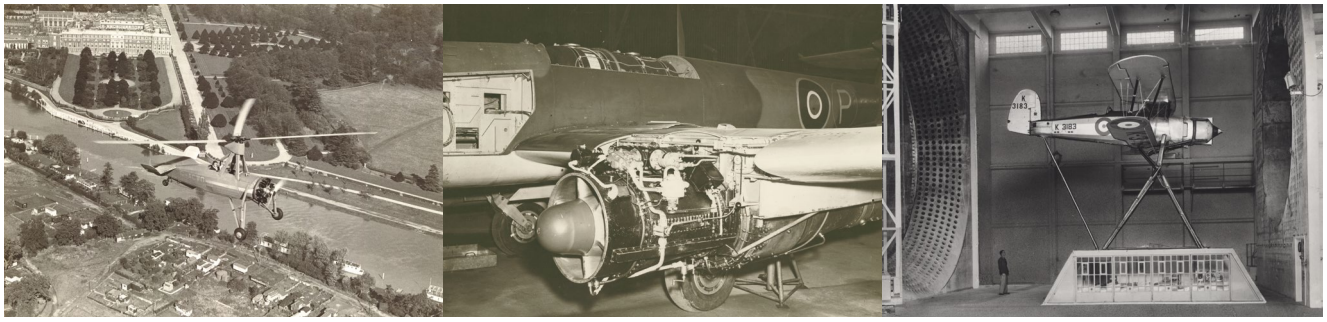
- Requirements for membership grades or **CEng**, **IEng** & **EngTech** registration
- Information on benefits and the Society
- How to apply and documents required

Find out more: **www.aerosociety.com/support**

To apply login here: www.aerosociety.com/login

Contact us: membership@aerosociety.com or +44 (0)20 7670 4384 or 4400

Journal of Aeronautical History



The first four *Journal of Aeronautical History* papers of 2020 have been added to the Society's website and are FREE to view or download:

https://www.aerosociety.com/news-expertise/journals-papers/papers-of-the-journal-of-aeronautical-history/

Reginald Brie – Pioneer of Autogyros and Helicopters
Compiled by David Gibbings MBE FRAeS

Farnborough and the Beginnings of Gas Turbine Propulsion
By Frank W Armstrong FRAeS

The Royal Aircraft Establishment Farnborough: 100 years of Innovative Research, Development and Application
By Dr Graham Rood

Alcock & Brown's Competitors
By Peter Elliott

The Last Word

Commentary from

Professor Keith Hayward
FRAeS

Airlines are suffering more than a fever

> WE ARE LOOKING AT LOSSES IN THE REGION OF $84BN THIS YEAR WORLDWIDE AND A SUBJECTIVE SET OF SURVEYS THAT ONLY 41% OF POTENTIAL PASSENGERS FEEL CONFIDENT ABOUT FLYING THIS YEAR

For a while this summer, European traffic levels were around 60% of 2019 numbers – a recovery of sorts. The recent resurgence of Covid-19 in Europe and the knock-on effects on tourism underlined the brittleness of the recovery. Things are not going to get much better as the industry moves from shoulder to winter traffic. The outlook for long-haul carriers, especially those who depend on transatlantic business, is looking even worse.

A long haul for long haul

Symbolic of the lost business, airlines are retiring early the mighty and iconic Jumbo. The Boeing 747 in many respects was the vehicle of democratised long-distance travel – and in some luxury if you went upstairs to the bars sometimes on offer. While several Gulf airlines are getting their Airbus A380s into the air again, many of the large Airbus' may be joining prematurely their more veteran wide-bodies in retirement.

IATA data, or its forecasts, show the depth of the problem. We are looking at losses in the region of $84bn this year worldwide and a subjective set of surveys that only 41% of potential passengers feel confident about flying this year. The experience of Zooming and other online conferencing and business transactions is also an ominous sign of a long-term depression of demand for vacation and, more significantly, for airline yields and business traffic.

Both LCCs and the legacy carriers on both sides of the Atlantic are cutting capacity. Virgin Atlantic and BA have dug deep into reserves and into shareholders' pockets to keep airborne. Some airlines, primarily in Europe, are getting direct aid from governments, or at least access to soft loans. Nevertheless, large numbers of staff, pilots and cabin crews are being furloughed, given their notices or put onto poorer contracts – not perhaps the industry's finest human relations hour. Worse still for UK airlines (and airports), there is yet no sign of on-site testing to aid out- or in-bound traffic recovery. Off-on air quarantine has also done nothing except load emergency outbound flights from sunny places.

Open the Blue Ribbon route – please!

There is now an appeal to governments to relaunch transatlantic services. Given that the US is at the top of the worst Covid-hit countries, it is hardly surprising that authorities on this side of the Atlantic are leery of allowing unrestricted travel again.

The airlines are proposing private testing regimes to limit, if not to avoid, the two-week quarantine requirement. Despite this and other precautions, such as well-filtered air, flying long haul with the measures needed to avoid infection is hardly likely to be much fun either.

This is the route that counts in terms of revenue. It might not have the growth rates of other parts of the world network but yields are amongst the best available. The London airports, especially Heathrow, are badly missing this traffic.

Will this traffic return once there is a vaccine, or the virus has been otherwise tamed? There has been speculation for many years that cyber connection will remove the need or will to travel, particularly for business. The current crisis has introduced many to the much-improved quality of cyber conferencing – and the joys of avoiding the downsides of modern air travel – queues and crowds. Optimists will cite the human urge to connect physically, to enjoy different experiences, especially if the company is paying for it.

With Covid surging again in Europe and the US outbreak showing little sign of lessening, getting back to anything like normal will be a struggle. Even optimists are looking at 2024 before things begin fully to improve. The Blue Ribbon route is likely to remain in deep depression for some time yet.

Going virtual on 4 November 2020!

Register now for the RAeS careers and recruitment fair dedicated to supporting **current and future aerospace and aviation professionals**

Covid-19 has had a huge impact on the aerospace and aviation industry and this year our event will be very different. To keep people safe, we will be hosting our annual careers fair online using new technology to retain interaction between exhibitors and visitors, with competitions and a fantastic programme of insight talks for all career levels, from early talent to the experienced.

Despite the challenges many employers currently face, we hope to highlight opportunities in the industry including future tech, emerging aviation and space tech, as well as career transition roles and training opportunities to capitalise on the incredible skills and knowledge that our people can offer.

Help us come together to support the future needs of the industry and ensure we are ready for future technological challenges and recovery.

Our thanks to Club Class partner, Boeing, for their support in moving the event online.

For visitor registration please contact: **careers@aerosociety.com**
For exhibitor packages please contact: **rosalind.azouzi@aerosociety.com**

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