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Green routes

While Airbus is betting on hydrogen for its future propulsion system, Boeing has yet to reveal its own sustainable vision

Airbus

Batteries not included

On the face of it, the big two airframers are taking very different approaches to future aircraft designs – and crucially their propulsion systems.

By revealing a trio of concepts, each based on a hydrogen powertrain, Airbus has nailed its colours to that particular mast.

Notably, the company argues that battery technology is not improving quickly enough to support its introduction on commercial aircraft within a 15-year development horizon.

Meanwhile, in Seattle, Boeing has seemingly taken an opposing position, arguing that technological and regulatory hurdles will prevent hydrogen power's uptake in the near term.

In the meantime, the airframer's focus remains on the incremental gains to be researched via its ecoDemonstrator programme.

It could be argued, of course, that these two world views are not mutually exclusive and to some extent depend on the definition of "near term".

Besides, Boeing is right: there are huge obstacles for hydrogen to overcome before it can be rolled out for widespread use: new propulsion architectures and onboard storage systems must be developed; regulators have to be convinced it is safe; and the logistics of providing the fuel at airports needs to be addressed.

And, without a means to produce hydrogen via low-carbon methods, its clean credentials can vanish.

In addition, the benefits from lower noise and small percentage-point improvements in fuel consumption will be felt by airlines today – not decades in the future.

Nonetheless, the fact that Airbus is so clearly championing a new propulsion technology – and attempting to claim the high ground around the decarbonisation of aviation – speaks volumes.

The airframer certainly has its own financial and structural issues to deal with on the back of slumping demand for new airliners, but it is at least attempting to spark debate about the industry's direction.

Boeing, on the other hand, seems paralysed; there are so many fires burning in Seattle – several ignited by its own actions – that management attention seems to be entirely absorbed.

Perhaps the US airframer is working away in the background on its big idea for what a next-generation airliner looks like, but at the moment, those efforts are not at all clear.

While it is tempting to blame Boeing's stasis on the twin blows of the 737 Max and the market, perhaps other factors are also at play.

When it unveiled a multibillion-euro bailout for the aerospace industry in June, the French government was careful to tie its largesse to improvements in environmental performance for fear of angering the increasingly influential green lobby. Meanwhile, the current US administration is led by an arch-climate change denier.

Every organism adapts to its changing environment or ultimately faces extinction. That truism also applies to business: whither Kodak, for instance?

Airbus clearly believes that the world in which it operates is changing and it must change too. Boeing is presumably not blind to the reality of the market, but the question remains whether the blood and treasure required to deal with its immediate crises will leave it hamstrung in the long term.

See p20-21

In focus

Positive outlook: Emirates sees a future for A380 post vaccine

Cover: Honda Aircraft

Features

Tighter regulations set out after Max disasters

US lawmakers submit bill reforming FAA certification process in wake of crashes linked to angle-of-attack control system

David Kaminski-Morrow London

US legislators have unveiled a proposed overhaul of aircraft certification intended to reform and reinforce the process in the aftermath of the two fatal accidents involving the Boeing 737 Max.

The bipartisan bill has been submitted jointly by two Democrat and two Republican representatives, including chair of the House Committee on Transportation and Infrastructure Peter DeFazio.

Featuring 27 sections and running to 85 pages, the Aircraft Certification Reform and Accountability Act seeks to cement new requirements for disclosing safety-critical information, demand reviews of pilot training standards, and underpin protection for whistleblowers.

Human factors analysis forms a key section of the bill, requiring that the US Federal Aviation Administration (FAA) evaluates methods to support human factors assessment and develop a framework to "better integrate" human factors considerations throughout the certification process.

This should be done, it says, with the objective of improving safety by "designing systems and training pilots in a manner that accounts for contemporary knowledge", to reduce the possibility of an accident resulting from pilot interaction with the aircraft.

> "These critical reforms will improve safety and ensure accountability at all levels"
>
> **Peter DeFazio Chair, House Committee on Transportation and Infrastructure**

Boeing and the FAA had been heavily criticised for approving the controversial Maneuvering Characteristics Augmentation System (MCAS), designed to lower the 737 Max's nose upon detection of a high angle-of-attack. Investigation of both the Lion Air and Ethiopian Airlines 737 Max crashes showed the crews struggled with the system's behaviour and countering MCAS's nose-down commands when it received false angle-of-attack data.

Under the proposed legislation, the FAA shall require airframers to provide it with findings and information necessary for crews to be trained on cockpit systems.

The FAA must not only ensure that this information "adequately includes" consideration of human factors, but that each airframer "identifies any technical basis, justification or rationale" for its findings.

Safety-critical data must be submitted to the regulator covering details of any system which "commands the operation" of a safety feature for aircraft control, or otherwise alters the aircraft's airspeed or flightpath, "without being commanded by the flightcrew".

This aspect of the proposal also covers any failure or operating conditions which could result in a hazardous or catastrophic outcome, and any adverse handling quality that would not meet regulatory standards without the addition of software to augment the flight controls.

When establishing any pilot-training requirements, the bill says, the FAA must "independently review" any proposal from the airframer regarding the "scope, format or minimum level" of training necessary to operate the aircraft.

Lion Air 737 crashed in October 2018, killing all 189 passengers and crew

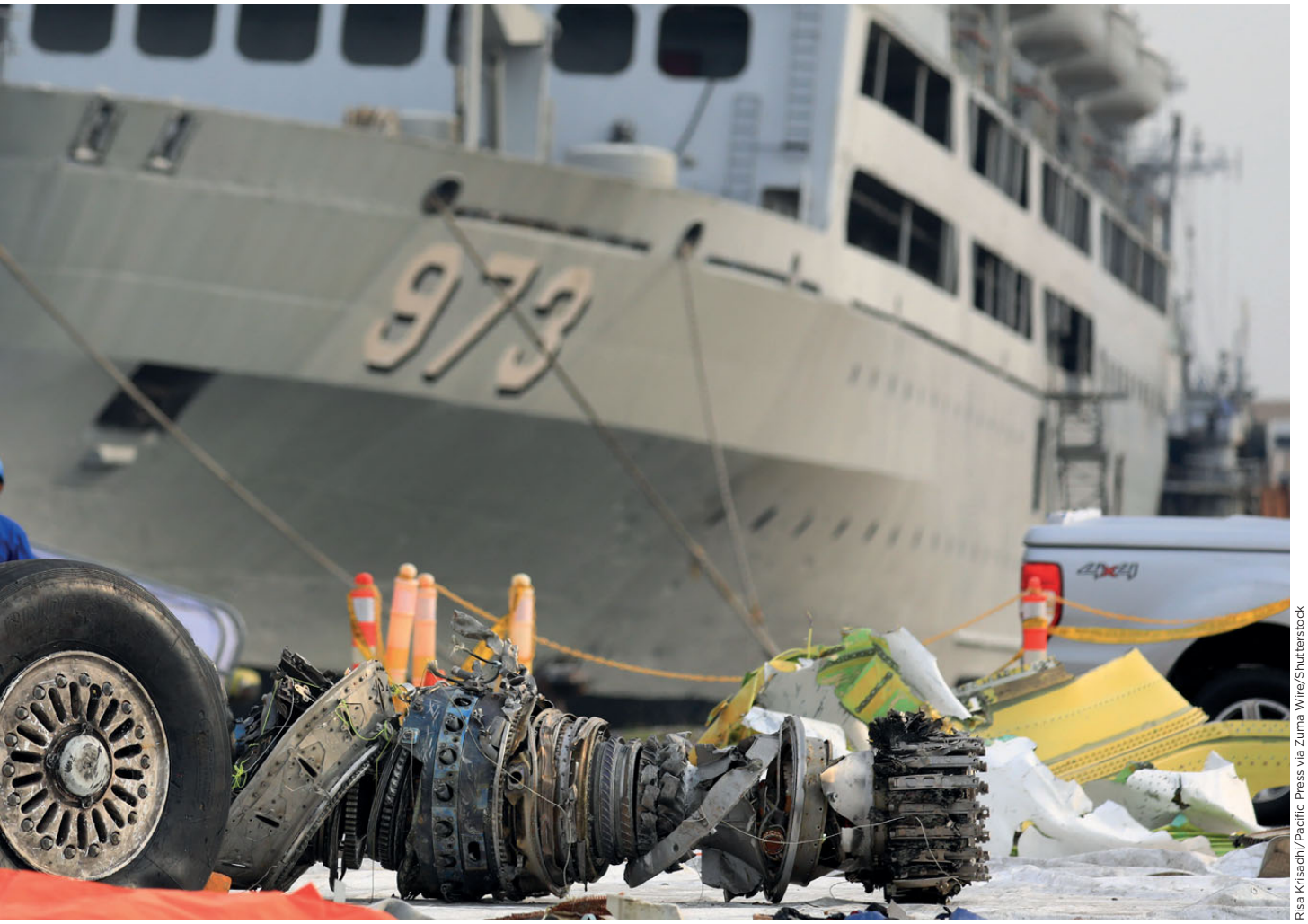
Type certification will not be granted unless the applicant has accounted for "realistic assumptions" with respect to pilot-response times under abnormal conditions, backed up by scientific human factors research, in the design of instrumentation.

Financial incentives

Airframers will not be permitted to make any assurances or provide any kind of financial incentive to potential customers in relation to pilot training for a new aircraft before the FAA has established training requirements.

The proposed legislation states that the FAA will initiate a safety review of assumptions relied upon during aircraft design, including analysis of any possible effects on "pilot competency in basic manual flying skills".

This review will also consider the global nature of the air transport market and the "varying levels" of pilot competency, as well as taking into account differences in pilot training programmes.



Risa Krisadhi/Pacific Press via Zuma Wire/Shutterstock

Under the bill the FAA would have to rethink its assumptions when granting type certification to derivative designs, to establish the extent to which certain revisions and enhancements – such as a new flight-control system, or changes to aerodynamic stability requiring software updates – might preclude the issue of an amended certificate.

US aircraft and aerospace manufacturers will have to adopt safety-management systems and reporting programmes for personnel.

Penalties for regulatory violations will be strengthened, and the bill will extend whistleblower protection to allow employees to report safety concerns without fear of reprisal.

DeFazio says he was "alarmed and outraged" by the recently-published findings from the House Committee's investigation into the 737 Max certification (*see p8).*

But he adds: "I believe history can also show this was the moment Congress stepped up to meaningfully address the gaps in the regulatory system for certifying aircraft and adopt critical reforms that will improve public safety and ensure accountability at all levels."

Meanwhile, the wider process of 737 Max re-certification continues to advance. The FAA on 25 September said that it had met with aviation authorities of other jurisdictions including Brazil, Canada and Europe to complete the Joint Operations Evaluation Board (JOEB) assessment of the aircraft.

The JOEB's findings will be published in the agency's draft Flight Standardisation Board report. That will then inform pilot training requirements ahead of a return to service, while a Technical Advisory Board must evaluate final Max design documents.

American Airlines, which has 24 737 Max aircraft in its fleet and another 76 on order, says its pilots will begin "special training" in November in preparation for the jet's return to service. All of the airline's 737 crews are expected to complete the training by January 2021.

Additional reporting by Pilar Wolfsteller

100

Total number of 737 Max aircraft on order by American Airlines, with 24 received so far

239 pages

Report from US House of Representatives' Committee on Transportation and Infrastructure details 18-month investigation

'Disturbing revelations' of how Boeing escaped scrutiny from FAA in race to deliver profits

Jon Hemmerdinger Tampa

A "culture of concealment" by Boeing and erroneous technical assumptions, combined with insufficient oversight by the Federal Aviation Administration (FAA), contributed to the two 737 Max tragedies.

That conclusion was reached by a broad US congressional investigation into the causes of the 29 October 2018 crash of Lion Air flight 610 and the 10 March 2019 crash of Ethiopian Airlines flight 302, which killed a combined 346 people.

"The Max crashes were not the result of a singular failure, technical mistake or mismanaged event," the report, released on 16 September, concluded.

"They were the horrific culmination of a series of faulty technical assumptions by Boeing's engineers, a lack of transparency on the part of Boeing's management, and grossly insufficient oversight by the FAA — the pernicious result of regulatory capture on the part of the FAA with respect to its responsibilities to perform robust oversight of Boeing, and to ensure the safety of the flying public."

The 239-page report, released by the US House of Representatives' Committee on Transportation and Infrastructure, details findings of an 18-month investigation that included several congressional hearings and reviews of Boeing and FAA internal documents.

House Transportation Committee chair Peter DeFazio and aviation subcommittee chair Rick Larsen led the investigation into the disasters.

"Our report lays out disturbing revelations about how Boeing — under pressure to compete with Airbus and deliver profits for Wall Street — escaped scrutiny from the FAA, withheld critical information from pilots and ultimately put planes into service that killed 346 innocent people," says DeFazio.

"What's particularly infuriating is how Boeing and [the] FAA both gambled with public safety in the critical time period between the two crashes."

Citing a "culture of concealment", the report says "Boeing withheld crucial information from the FAA, its customers and 737 Max pilots, including internal test data that revealed it took a Boeing test pilot more than 10s to diagnose and respond to uncommanded MCAS activation in a flight simulator, a condition the pilot described as 'catastrophic'," says the committee.

Thiago B Trevisan/Shutterstock

737 Max fleet has been grounded since Ethiopian Airlines crash in March 2019

Federal guidelines "assume pilots will respond to this condition within 4s", says the committee.

Boeing equipped the 737 Max with the Maneuvering Characteristics Augmentation System (MCAS), which trims the jet's nose down in certain situations and activates based on readings from a single angle-of-attack indicator.

Potential malfunction

The House report faults Boeing for making "fundamentally faulty assumptions" about the system. It "expected that pilots, who were largely unaware that MCAS existed, would be able to mitigate any potential malfunction", it says.

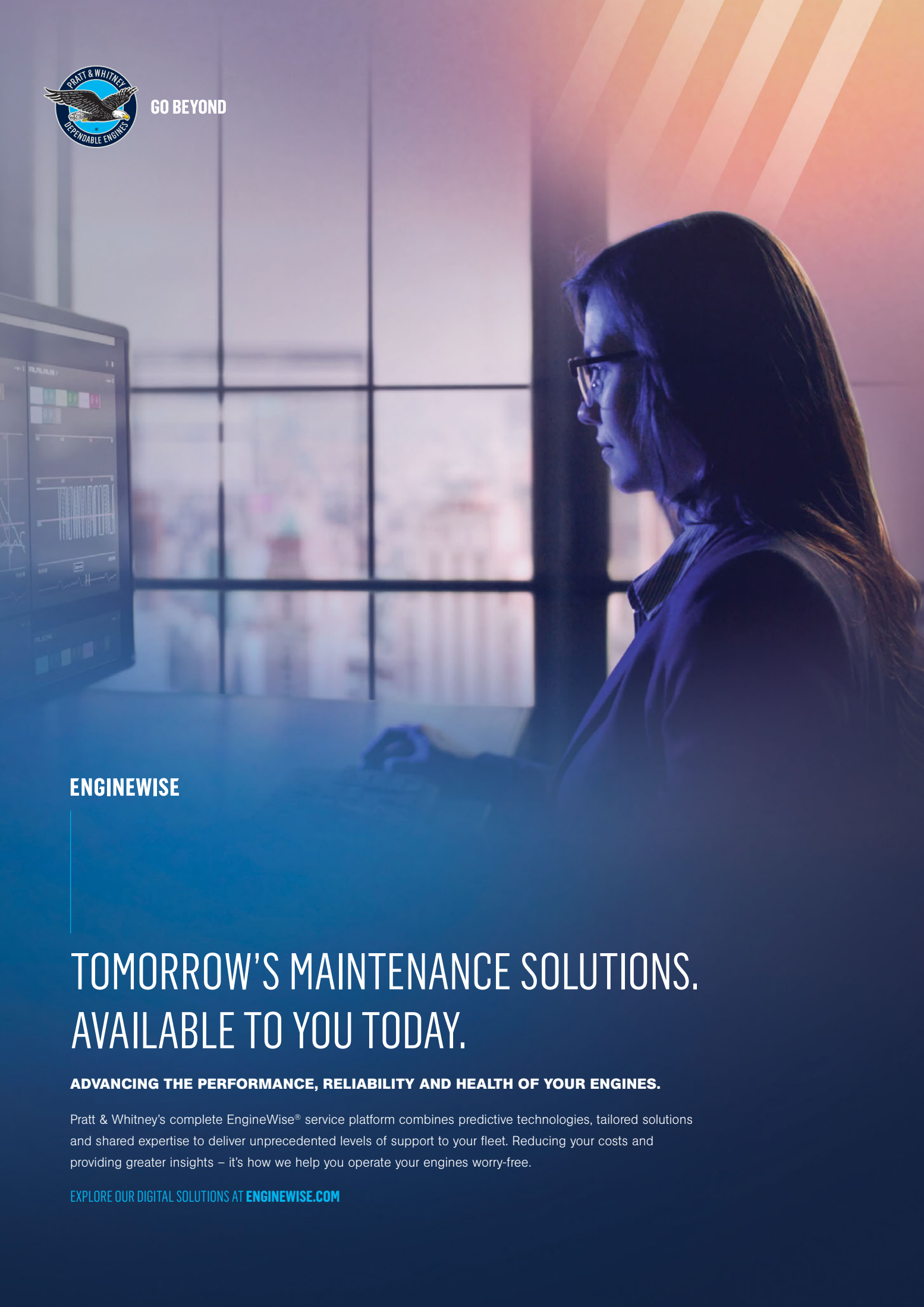
The Max's issues also reflect the "tremendous financial pressure on Boeing and the 737 Max programme to compete with Airbus's new A320neo", which created pressure to cut costs, maintain schedules and avoid slowing Max production despite the jet's issues, the report says.

Additionally, it notes that "multiple career FAA officials" reported examples of the agency's managers overruling its own technical experts "at the behest of Boeing".

The report also cites "conflicted representation" – a factor related to the FAA's oversight structure, which relies heavily on Organization Designation Authorization. Under that programme, aspects of which are common to other countries' certification processes, the FAA delegates large portions of aircraft certification work to manufacturers.

The "oversight structure creates conflicts of interest that have jeopardised the safety of the flying public", says the committee. The report cites "multiple instances in which Boeing employees who have been authorised to perform work on behalf of the FAA failed to alert the FAA to potential safety and/or certification issues".

Responding to the report, Boeing says it has "learned many hard lessons as a company" from the crashes and "from the mistakes" it made. "As this report recognises, we have made fundamental changes to our company as a result, and continue to look for ways to improve."



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Manufacturer has been forced to slash headcount as reaction to downturn

Fears over Boeing's brain drain

A slew of mid-level engineering talent taking redundancy from the airframer raises concerns about depth of cuts

Jon Hemmerdinger Tampa

A slew of departing mid-level Boeing employees has raised questions about whether the company could find itself short of critical expertise needed to advance future commercial aircraft programmes, say aerospace experts.

Bloomberg reported on 26 September that 170 Boeing vice-presidents and other middle-tier staff, including 70 employees from the commercial aircraft division, have taken buyouts – effectively voluntary redundancy. The first of those will depart the company on 2 October in exchange for a year's salary.

Boeing insists the staff cuts will not degrade its ability to compete, but some industry experts express surprise at how many skilled workers are leaving.

"We are witnessing the departure of a critically talented, experienced segment of the Boeing executive workforce that you cannot replace easily," says Michel Merluzeau, aerospace analyst with consultancy AIR.

"The response has reportedly been really strong to the voluntary layoff packages," he adds. "I don't think Boeing expected that many people to respond positively."

Although a new generation of Boeing staff is waiting to step up, Alex Krutz, aerospace consultant with Patriot Industrial Partners, says the transition is unlikely to be seamless. "There's a talented generation in the wings, but there is going to be a learning curve."

Boeing has been working through the dual pressures of the aerospace downturn and the re-certification of the still-grounded 737 Max.

The company is cutting 10% of its workforce, which stood at 161,000 at the end of 2019.

Boeing declines to comment on the scale of the exodus but says: "We are confident that we will have the right team in place to continue to support our customers and the company's business needs."

Competitive advantage

Teal Group aerospace analyst Richard Aboulafia suspects skilled technical and engineering staff members are among the 170 departures, noting that a talent drain could give "Airbus and other US defence primes a big opportunity".

Aboulafia says Boeing already faces "serious technical execution" issues. The company has faced scrutiny for its 737 Max design and production issues with other aircraft, including the 787 and 767-derived KC-46A military tanker.

Boeing's restructuring has also seen the company curtail innovation projects. It has "paused" its NeXt unmanned aircraft division, although the company says it "remains committed" to investing in the urban air mobility sector.

Uncertainty also surrounds Boeing's backing of several other companies, including business jet developer Aerion Supersonic.

Boeing's research and development spending slipped 26% year on year in the first six months of 2020, to $786 million, according to securities filings.

Krutz says the mid-level cuts could see Boeing lose talented workers like supply chain executives, who have strong supplier relationships and understand sourcing challenges. Without those workers, Boeing must take care not to repeat mistakes of the past, he says.

Still, Krutz thinks Boeing will prevail. The company excels at bringing back former staff and consultants to fill skills gaps, and today's cuts will encourage development of "a new generation of leaders", he says.

But analysts say Boeing has no articulated long-term strategy, noting that earlier this year the company shelved development of its New Mid-market Airplane, which was to compete with the long-range variants of the Airbus A321neo.

Aboulafia sees Boeing as treading a road similar to that taken by McDonnell Douglas, which merged with Boeing in 1997.

McDonnell Douglas starved its commercial aircraft business of cash in the years prior the merger. Boeing ended production of the last legacy McDonnell Douglas commercial aircraft – the 717 – in 2006.

"[Boeing] seems focused on the short term," Aboulafia says. "I hope they remember there is a future."

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A380 fan-hub disintegration traced to 'cold dwell' fatigue

French investigators say sub-surface cracking mode that was 'not completely understood' led to uncontained engine failure

David Kaminski-Morrow London

French investigators have traced the serious engine failure involving an Air France Airbus A380 over Greenland to a phenomenon known as "cold dwell" fatigue, which had caused a failure in a fan hub slot which houses the root of the fan blade.

The analysis by investigation authority BEA closes a particularly difficult inquiry that had involved a technically challenging search for fan-hub components from the Engine Alliance GP7200 powerplant, buried in deep snow in remote Greenland. Some parts of these were only recovered 21 months after the 30 September 2017 incident.

Before the retrieval of these crucial components, Engine Alliance had considered that – based on its in-service experience – tool damage from incorrect maintenance was the most likely cause of the failure.

But the inspection of the recovered fan hub "invalidated" this maintenance-damage theory, says BEA, revealing instead that the uncontained failure originated in a macro-zone in the sub-surface of a blade slot. The GP7200 has 24 blade slots in its fan hub, and the fatigue crack was located practically in the centre of slot 10.

BEA believes that a "cold dwell" or "cold creep" fatigue mechanism triggered the fracture. The fan hub is manufactured from a titanium-aluminium-vanadium alloy known as Ti-6-4.

Titanium alloys are vulnerable to creep – a stress deformation – at relatively low temperatures, and the phenomenon was linked to premature fan disk fractures in the 1970s. Dwell fatigue arises from maintained stresses during flight.

Several factors affect the sensitivity of titanium alloys to cold dwell fatigue, says the inquiry, but particular alloys such as Ti-6-4, owing to their chemical composition, were considered to have "little or no sensitivity" to the phenomenon at the time of the GP7200's certification.

Service hours

"This was in part due to the significant number of service hours logged by Ti-6-4 components without any incidents," says the inquiry.

"Although there was in-depth research into this phenomenon with respect to certain alloys, the mechanisms at the origin of the initiation of a cold dwell fatigue crack were still not completely understood."

The inquiry estimates that the sub-surface crack was initiated at about 1,880 cycles, progressing over the course of some 1,650 subsequent cycles before the failure at about 3,500 cycles – about four times earlier than the 15,000-cycle minimum life for the component.

Metallurgical examination of the failure confirmed that no maintenance-induced damage was present when the crack started, and the inquiry points out that no scheduled maintenance action, at the time of the accident, would have detected the fatigue while it was still below the surface of the hub slot.

The failure of the right-hand outboard engine occurred during the aircraft's cruise climb from 37,000ft to 38,000ft while en route to Los Angeles, without a precursor event.

BEA says the fan hub, as a result of the crack, separated into at least three parts. The central fragment stayed attached to the coupling shaft between the low-pressure compressor and turbine, but the two other fragments were ejected – one upwards, the other downwards.

These fragments struck the engine casing, destroying it and causing the entire air inlet to separate and fall to the ground.

Debris hit the wing and airframe, but the A380's flight was unaffected, although the aircraft yawed some 3° to the right in the space of 3s and vibrations were felt in the airframe. The crew initially believed an engine surge had occurred.

The inquiry points out that the high-energy fragments' direction was "random" and that, if they had been ejected laterally, the consequences might have been "catastrophic" should they have penetrated the fuselage or damaged the wing spar or flight-control surfaces.

"This failure was neither anticipated nor prevented by operational or maintenance actions," it says, adding that neither the engine design nor the certification took into account the cold dwell phenomenon.

Examination showed the fatigue originated in a macro-zone of the alloy structure near blade slot 10, where the orientation of the grains was "unfavourable" in relation to the maximum stress direction.

Austin Lines/BEA

Parts of the powerplant were recovered in Greenland 21 months after the incident

This macro-zone, says the inquiry, was "an order of magnitude larger and more intense" than the average micro-texture region observed by the manufacturer, both in other zones of the fan hub and in hubs created from the same alloy billet.

BEA says the "lack of knowledge" regarding cold dwell fatigue, combined with an absence of instructions from certification agencies about taking macro-zones into account with respect to the phenomenon, and an absence of non-destructive means to detect the presence of unusual macro-zones in titanium alloys, contributed to the accident.

"Certification bodies and engine manufacturers are currently considering how to better understand the cold dwell fatigue phenomenon and take it into account in the design of future engines," says BEA.

None of the 497 passengers and 24 crew members on board flight AF066 from Paris Charles de Gaulle was injured. The aircraft diverted to Goose Bay airport in Canada, landing almost 2h after the failure.

Air France crew forced to descend as additional drag 'degraded aircraft's performance'

Such was the extent of damage to the Air France Airbus A380's engine that its crew was forced to descend to a much lower cruising altitude than expected.

The aircraft suffered the failure of its outboard right-hand Engine Alliance GP7200 powerplant as it climbed from 37,000ft to 38,000ft.

Air France procedures for engine failure in cruise require the crew to set power at maximum continuous thrust and to determine the maximum engine-out altitude, which is calculated by the flight-management system.

This maximum engine-out altitude enables the aircraft, at maximum continuous thrust, to maintain level flight at the long-range cruise speed – the Mach number at which the specific flight range is 99% of the maximum flight range.

Air France instructs its crews to descend to this altitude at M0.85, or 300kt (555km/h), and proceed at the long-range cruise speed.

Airbus calculated that the long-range cruise speed of the aircraft, at the time of the failure, was just under 289kt – which would give a maximum altitude of 34,000ft.

But French investigation authority BEA states that the calculation of engine-out altitude assumes the failed engine is windmilling and does not take into account possible deterioration of aerodynamic performance, notably the additional drag resulting from seized rotors or other uncontained failure damage.

The A380's entire fan hub disintegrated during the incident, shearing off the engine inlet.

"Failure of [the engine] being uncontained, the crew were surprised by the additional drag which degraded the aircraft's performance," says BEA.

The descent from 37,000ft was conducted with the intention of holding altitude at 270kt. But BEA says this selected speed "could not be held" with the three remaining engines operating at maximum continuous thrust, adding that the pilots were "not able" to estimate the altitude the A380 would be able to maintain.

In order to avoid demanding excessive power from the engines, the captain opted to descend to 27,000ft at 279kt. It stabilised at this level and subsequently proceeded at this altitude and speed for 45min.

The aircraft was outside of radar coverage at the time of the descent but its course meant no other traffic was in its vicinity.

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Cruz control deflects MPs' ire

British Airways chief emphasises impact of pandemic on aviation as parliamentary body probes carrier's restructure

Dominic Perry London

Speaking over a video link from a nondescript office that looked a little like an interrogation room at a newly built police station, British Airways (BA) chief executive Alex Cruz was in combative yet sombre mood.

Time and time again when pressed by the MPs that make up the UK parliament's transport select committee on whether BA was, essentially, overstating the impact of the coronavirus pandemic on its operation, Cruz swatted back the accusation.

While there were traces of annoyance now and again – accompanied by a facial tic that saw one eyebrow repeatedly raised and lowered as though semaphoring permanent disdain for the questions – there was none of the naked aggression displayed by his former boss, Willie Walsh, in front of the same committee.

Instead, Cruz tried to ram home during his September committee appearance just how much the airline landscape has been upended by the coronavirus pandemic.

His evidence was peppered with superlatives: "the worst crisis", "the biggest impact", "the largest fall"; the airline industry, he said, was now "fundamentally different".

Gloomy outlook

And when MPs attempted to suggest that BA's financial pain would only be temporary, he laid out the bleak reality for them: "I wish I could share your optimism when you make reference to temporary measures. There is no data to support the assertion that this is a temporary measure for the airline industry."

Of course, BA is not immune from that upheaval. But it jarred to see MPs seemingly accusing the airline, which has been burning cash at an average of £20 million ($26 million) per day, of laying off 10,000 staff and ripping up the contracts of the 30,000 that remain as part of a long-planned, ideology-driven restructuring.

"The position we are in is impossible. There is no way we would have pursued this degree of structural change at this pace if we did not have the pandemic," Cruz said, seemingly taken aback by the question.

The political grandstanding was not confined to those with socialist leanings either. "I am no longer proud of our nation's flag carrier," said Conservative MP Simon Jupp, as though BA had threatened the country's first born, rather than chronically bungled its negotiations with unions.

That is not say to that BA's approach was anything but misguided; it chose a nuclear option where subtlety was required. The much criticised threat to "fire and rehire" staff if they did not agree to new terms and conditions was wholly lacking in any sort of corporate responsibility, and Cruz's complaints to the committee that he could not understand why two unions had refused to enter into negotiations rang hollow.

"I deeply regret that Unite and the GMB took 73 days to sit down with us," he said, using much the same phrasing as when apologising for the scale of the lay-offs.

But as Labour MP Sam Tarry noted, a touch acidly: had BA not approached the unions holding a "metaphorical gun to their head, those negotiations might have happened more quickly".

Tarry was one of the few committee members who actually sounded as though they knew what they were talking about, which raises familiar, yet depressing questions about how elected representatives can hope to properly scrutinise an industry about which they understand very little.

By way of an example, take a

British Airways

Cruz came in for particular criticism over airline's handling of negotiations with unions

question from Ruth Cadbury, a Labour MP for the Brentford and Isleworth constituency that sits a handful of miles to the east of Heathrow airport, directly under its approach path.

Having previously said that she understood BA's plight, she later asked Cruz whether he thought it was right that the airline's staff should be paying the cost for €1.3 billion ($1.5 billion) of first-quarter losses at parent company IAG that were attributable to fuel hedging gone awry; a process she characterised as a "gamble".

Cue a clearly bemused Cruz having to painstakingly explain that fuel hedging is very much the industry norm and that over the years it has delivered substantial savings to the airline. No matter also that the fuel hedging losses were triggered by the coronavirus pandemic and its downward pressure on the oil price.

Besides, as he had already pointed out on several occasions, BA is not letting staff go for the fun of it. Put simply, if its operation has shrunk to around one-third of its previous size and the landscape for air travel is irrevocably altered, then something has to give.

> "There is no data to support the assertion that this is a temporary measure"
>
> **Alex Cruz Chief executive, British Airways**

Perhaps she felt that the question was in support of constituents affected by the cutbacks, but whatever the intention, it seemed an odd avenue to pursue.

In the event, Cruz was grilled for a little over 2h and maintained his cool throughout – even when the committee was probing cuts to his own salary.

That said, when asked by Labour MP Grahame Morris on whether, like every other BA employee, his own terms and conditions were permanently changed, Cruz dodged the question with the sort of deft conversational footwork usually reserved for government ministers.

But perhaps what the committee really wanted was another crack at now-retired IAG chief Walsh. His previous pugilistic appearance seemingly won him few friends, with even the committee's Conservative chair Huw Merriman noting that since the departure of "one dominant individual", the company has softened its stance.

It was not a coincidence, Merriman suggested, that now that "Walsh is no longer in the room", a "more reasonable" approach has been adopted.

Cruz, to the surprise of no-one, declined to comment, with the question eliciting barely a twitch of his eyebrow.

Passenger role set to inflate Airlander sales

HAV promotes zero-emission evolution as regional transport that can connect destinations no other aircraft can reach

Craig Hoyle London

Company envisages the aircraft as a 'city connector' over sectors of 135-405nm

While the coronavirus pandemic thwarted an ambition to sell a first Airlander 10 earlier this year, developer Hybrid Air Vehicles (HAV) is using the downturn to promote the giant aircraft's potential in the regional air transport role.

Having previously unveiled a VIP-configured cabin demonstrator suitable for "airborne cruise" applications, HAV last November announced that it was in contract negotiations linked to a four-unit launch order, which it valued at $200 million.

In all, the UK company said it had received letters of intent for a combined 15 aircraft, from "organisations in the tourism and clean technology sectors".

"We were looking for the first contract in the second quarter," says chief executive Tom Grundy, who unsurprisingly notes that HAV has seen a "temporary pause" in leisure-sector business opportunities.

Instead, the Airlander 10's potential as a low-carbon travel option has come to the fore, along with its ability to offer more social distancing for passengers than experienced aboard a conventional airliner.

Grundy says an air transport-optimised cabin would have a weight limit sufficient to accommodate 90 passengers. But with this to be comparable in length and wider than an Airbus A320 fuselage, he says "There will be plenty of space".

"We're used to thinking all aircraft look alike, [but] it won't feel like getting on an aeroplane," he says.

HAV is promoting what it calls a "fast ferry" concept, where the Airlander could serve as a point-to-point "city connector" for sectors of 135-405nm (250-750km).

Examples could include Oslo-Stockholm and Singapore-Kuala Lumpur, while he says that such a service linking Liverpool and Belfast would prove "much quicker" than travelling by car and a ferry.

Connecting the Norwegian and Swedish capitals with an Airlander would involve a roughly 6h 30min flight, but avoid the need to visit an airport, as the type can land on water. But Grundy says the environmental impact of such a journey would be markedly lower, with a claimed 4.5kg (10lb) of carbon dioxide emissions per passenger, versus over 64kg for a comparable trip by airliner.

HAV says the four kerosene engines used by its prototype Airlander demonstrated a 75% reduction in fuel burn against a conventional large aircraft. But it has already plotted a path through hybrid propulsion to offering a fully emission-free product within a decade.

> "There are a lot of parts of the world that Airlander can open up"
>
> **Tom Grundy Chief executive, Hybrid Air Vehicles**

The company is working with Collins Aerospace and the University of Nottingham to develop a 500kW electric propulsor, via an activity named E-HAV1. A full-scale prototype powerplant will undergo bench testing from next year.

HAV's product evolution should involve delivering initial production Airlander 10s powered by kerosene motors, before replacing the forward pair of engines with electric units and also adding a hydrogen fuel cell from 2025.

"We will show that cutting 90% of emissions is a viable thing," Grundy says of the hybrid version. Describing fuel cells as "the sensible solution from the start, due to volumetrics," he adds that HAV "will be a trailblazer" by working to incorporate the technology.

A fully electric and fuel cell model should be ready for service by 2030, the company says.

Meanwhile, Grundy notes that the 500kW motors being developed for the Airlander 10 could be adapted to power conventional regional aircraft.

Another potential application for the type could be in serving as a military surveillance platform – the role for which it was originally designed, to meet the US Army's subsequently axed long-endurance multi-intelligence vehicle requirement.

HAV claims that an Airlander 10 could operate for up to five days continuously while carrying a 3t sensor payload; characteristics worthy of an unmanned variant.

With the UK recently experiencing a spike in the number of migrant boats illegally crossing the English Channel from France, assets employed to monitor the activity have included Royal Air Force Beechcraft King Air 350 Shadow R1 and Boeing P-8A Po-

Hybrid Air Vehicles

seidon MRA1 surveillance aircraft and British Army Thales UK/Elbit Systems Watchkeeper unmanned air vehicles. Why not, HAV argues, employ an adapted Airlander to provide more persistent coverage in such circumstances?

It also is partnered with Vertex Aerospace to pursue potential new opportunities with the US military.

Internet connectivity

Separately, the company in August signed up to the Telecom Infra Project, which aims to provide internet connectivity to under-served regions. It believes that the aircraft could become an ideal platform to carry communications equipment where there is a lack of terrestrial infrastructure, or during major events or in the aftermath of natural disasters.

In advance of signing its first contract, HAV has given much thought to the likely concept of operations and support requirements, and recently signed a pact with the UK's 2Excel Aviation.

"2Excel will work with HAV to develop efficient operations for Airlander's early adopters in mobility, travel, logistics, and surveillance and communications roles," the companies say.

Grundy also notes that HAV has "been though a lot of conversations" with the UK Civil Aviation Authority, European Union Aviation Safety Agency and US Federal Aviation Administration "regarding the overall certification" process.

The redesigned Airlander 10 is expected to make its debut flight in 2023, with HAV eyeing a production ramp up in the 2025-2027 period. Grundy says manufacturing will be scaled to deliver 12 examples per year, with a production site yet to be selected. The company left its original Cardington airfield home in Bedfordshire in 2017, following the completion of prototype flight testing.

Far from being discouraged by the current aviation downturn, Grundy still sees a potential market for 600 Airlanders over the life of the programme. He is keen for the first buyer to be a UK operator, so that work can begin to support the domestic supply chain.

"Covid delayed investors, but we are working hard to get that investment in, and seeking those partners who are going to come on that journey with us and get Airlander into service in 2025," he says. A recent crowdfunding drive secured around £1.9 million ($2.4 million) from 1,600 new backers, enabling the company to bridge the gap to a production launch.

A larger Airlander 50, with a 50t payload capacity, is still on the horizon, with HAV eyeing the outsize cargo and remote region logistics sectors as holding strong potential from 2033.

With the design capable of carrying up to six shipping containers, "There are a lot of parts of the world that Airlander can open up, as well as going point-to-point," Grundy notes.

He points out that global trade relies on "cheap and slow" goods delivery by sea, or "fast and expensive" by aircraft. "Airlander 50 sits right in the gap," he says.

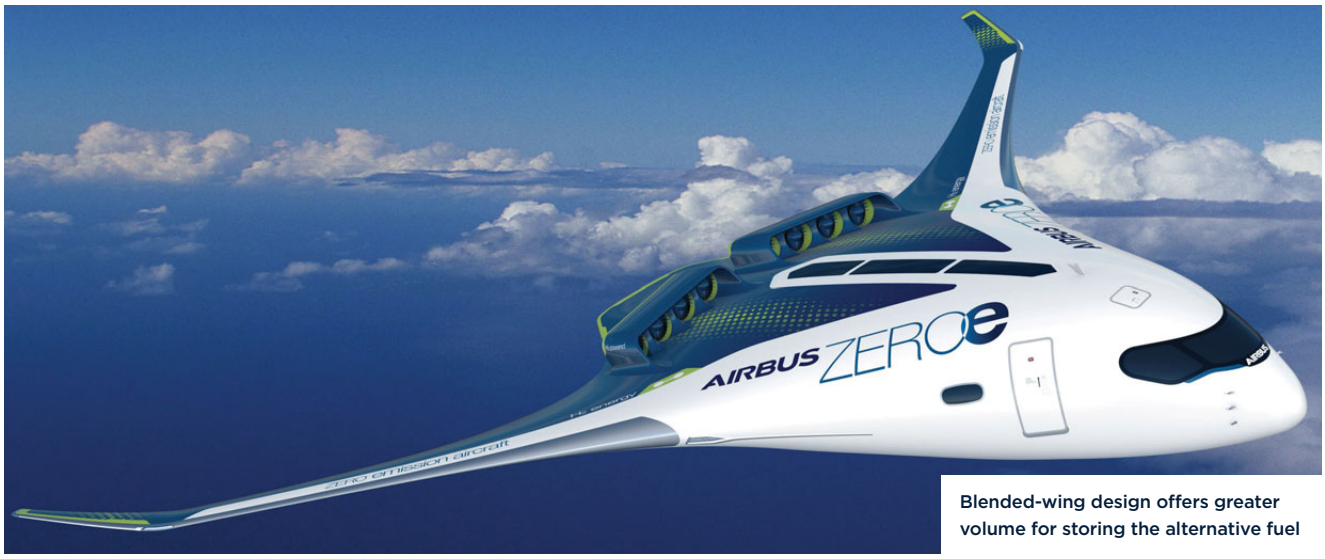
Overcoming adversity

Operational disruption affecting some of the company's roughly 65 staff since March has included some being furloughed – a mechanism that Grundy says was "very helpful" at the peak of the crisis.

"We've kept going," he says. "We have made sure that we are coming out of our flight-test programme looking to leverage every bit of data." The company also has been working to mature relationships with potential future customers, he adds.

With HAV having spent in the region of £120 million over a 13-year period, Grundy is convinced that the giant airship has a bright future. "We are ready to go now," he says.

"It will be a huge success story to deliver 12 aircraft per year – and carbon-free."



Airbus

Blended-wing design offers greater volume for storing the alternative fuel

Hydrogen fires Airbus imagination

Airframer sees gas-powered engines as best placed to meet energy density and emissions goals for commercial aviation

David Kaminski-Morrow London

Airbus is considering hydrogen as a primary propulsion source for future aircraft development, because of concerns that battery technology will not advance rapidly enough for adaptation to large airliners.

The airframer unveiled three conceptual designs in mid-September – two based on conventional twinjet and turboprop airframes and the other featuring a blended-wing fuselage design – and committed itself to exploring a hydrogen-based zero-emission aircraft for potential service entry in 2035.

Glenn Llewellyn, the company's head of zero-emission aircraft, says Airbus has seen a "decoupling" between the speed of battery technology progression and this 15-year timeframe.

"Batteries are not improving at the rate needed to achieve that ambition," he says.

As the coronavirus-driven air transport crisis forced a rethink on investment priorities earlier this year, Airbus curbed its E-Fan X hybrid-electric demonstrator programme, before the modified BAE Systems Avro RJ100 made its first flight.

While batteries are "still interesting" for smaller vehicles, such as urban air mobility platforms, hydrogen has a far greater energy density than even the best batteries – and is closer to the levels demanded by commercial aircraft, Llewellyn says.

He adds that a transition to a hydrogen ecosystem is necessary to provide the power to generate liquid synthetic fuels, and points out that Airbus aircraft are already certificated to take fuel blends with a 50% synthetic component. Such "e-fuels", he says, provide a "very big lever" for reducing carbon dioxide emissions, and have "a lot of potential".

Integration flexibility

The propulsion model involves a gas turbine combusting hydrogen in a similar manner to the combustion of jet fuel. This turbine would have an electric motor, driven by fuel cells, capable of injecting power into the shaft of the turbine.

"Concepts show we can do this with rather conventional aircraft configurations," says Llewellyn. "But we know from our analysis [that] we may achieve a better performance with a more disruptive aircraft design."

Airbus's blended-wing fuselage proposal has more volume, he notes, since one of the challenges of using hydrogen is its greater volume per unit energy compared with jet fuel.

"Blended-wing bodies inherently have more volume," he says. "[They're] already adapted to that."

The "ZEROe" aircraft designs envisaged will remain "in the realms" of current types in terms of passenger capacity, but will possibly feature higher maximum take-off weights, given the need to accommodate larger-volume tanks.

Llewellyn says the "race is on" between the different aircraft concepts, with Airbus yet to select the most likely candidate for a hydrogen-powered airframe.

The company is aiming to reduce the number of conceptual models to fewer than the three unveiled by around 2022-2023, and – depending on the level of readiness – have a mature technological proposal by 2024-2025, opening the way to a potential programme launch.

Llewellyn says the airframer wants to have demonstrators for different kinds of hydrogen propulsion system flying before 2025, but that a full prototype is not likely to emerge until the end of the decade.

He stresses that the hydrogen production would be sourced from renewable energy, mainly wind and solar power.

"What we're already seeing in 2020 is the beginning of exponential growth in terms of those energy production methods," he says. The cost of such processes has "gone down significantly", with less subsidy and increasing

competitiveness against fossil fuel, he notes.

Airbus is "encouraged" by efforts from the transport sector and heavy industry to bring down emissions, he says, and renewable hydrogen power will become a "bigger part" of daily life.

"We're going to see trucks, parts of shipping, buses, running off hydrogen," he says. "There's no other means for society to meet the [Paris agreement climate-change commitments] without hydrogen."

However, the technological advancement and parallel overhaul of the ecosystem required to shift to hydrogen-based aviation will pose substantial challenges.

"It's very unusual for Airbus to be talking about a programme ambition, a commercial aircraft entry-into-service 10 or 15 years before we plan to do it," says Llewellyn. Unveiling its proposal is "not only about Airbus", he adds, but about "driving change" in the energy and aviation sectors.

A hydrogen-based aviation strategy will need to develop regulatory and safety procedures alongside the infrastructure, transport, and storage capabilities.

Llewellyn is confident that the industry will be able to cope with the specific safety considerations for hydrogen fuel, through such technological modifications as double-walled insulated tanks for storage. "[That's] quite different to the way we store kerosene," he says.

"We, as an industry, have essentially created engine designs, fuel system designs, refuelling operations and usage which make kerosene – which is not inert – have an incredible safety record, one which, as an industry, we can be extremely proud," he says. "We need to achieve the same sort of level of safety, or better, when talking about introducing hydrogen on board."

Boeing

US manufacturer is making incremental progress via ecoDemonstrator tests

Driving change will pose a big challenge, Boeing cautions

Jon Hemmerdinger Tampa

Boeing's top product developer doubts that hydrogen-powered airliners will be viable in the near future, because of technological uncertainty and regulatory hurdles.

Speaking the day after rival Airbus had unveiled a trio of hydrogen-powered future airliner concepts, Boeing's commercial vice-president and general manager of product development, Michael Sinnett, expressed doubts about the short-term prospects for the fuel, despite its "unique promise".

Sinnett says hydrogen fuel production and storage challenges will take significant time to work through, and that government regulators must be able to work at a pace matching such technological development, which he does not consider to be a sure bet.

"I don't think it's something that's right around the corner," he adds.

While the aerospace industry has many decades of experience in understanding the use, storage and transportation of kerosene fuel, he notes that the same cannot be said of hydrogen.

"We have to ensure there [is] no back-pedalling on those levels of safety," he says. "That means there is a lot to learn."

Sinnett points to short-term improvements being assessed via Boeing's ecoDemonstrator programme activity.

A recent series of test flights involving an Etihad Airways 787-10 trialled optimised flight routing, acoustic research – including tests to measure noise-reducing nose- and main-landing gear enhancements developed by Safran Landing Systems – and the use of a 50:50 sustainable fuel mix.

US Air Force

Artist's rendering of future fighter may not resemble the prototype just flown

NGAD demonstrator makes debut

US Air Force official credits digital technology for rapid pace of progress on next-generation combat aircraft programme

Garrett Reim Los Angeles

With attention increasingly turning to the US Air Force's (USAF's) Next Generation Air Dominance (NGAD) requirement, the service surprised observers on 15 September by revealing it has already designed, built and flown a full-scale demonstrator in secret.

"NGAD has come so far that the full-scale flight demonstrator has already flown in the physical world. It's broken a lot of records in the doing," Will Roper, assistant secretary of the air force for acquisition, technology and logistics, said in a video presentation during the Air Force Association's virtual Air, Space & Cyber Conference.

"A lot of the mission systems that we require for Next Generation Air Dominance have been flown on test articles, so they are coming along very well," he adds.

Roper declines to say anything else about the NGAD demonstrator, or to describe the scope of the test activities conducted so far. It is not clear if the aircraft was built by the USAF or a contracted aerospace manufacturer, or if released artist renderings bear any resemblance to the design flown.

NGAD is the air force's programme to develop a next-generation fighter to follow on from the Lockheed Martin F-22 and F-35.

While details about the test aircraft have not been revealed, Roper credits digital engineering with allowing the USAF to move quickly from designing, to building and flying the NGAD demonstrator. "Digital engineering seems to accelerate everything," he says.

Digital engineering

Many of the development tasks that previously had to be handled and figured out in the physical world, such as systems integration, can now be almost entirely simulated in the virtual world, allowing for a prototype to be rapidly assembled.

"NGAD now is designing, assembling, testing in the digital world, exploring things that would have cost time and money to wait for physical world results," says Roper.

The NGAD, Boeing's T-7A advanced jet trainer and Northrop Grumman's Ground Based Strategic Deterrent ballistic missile system are all examples of USAF programmes extensively using digital engineering techniques, he says.

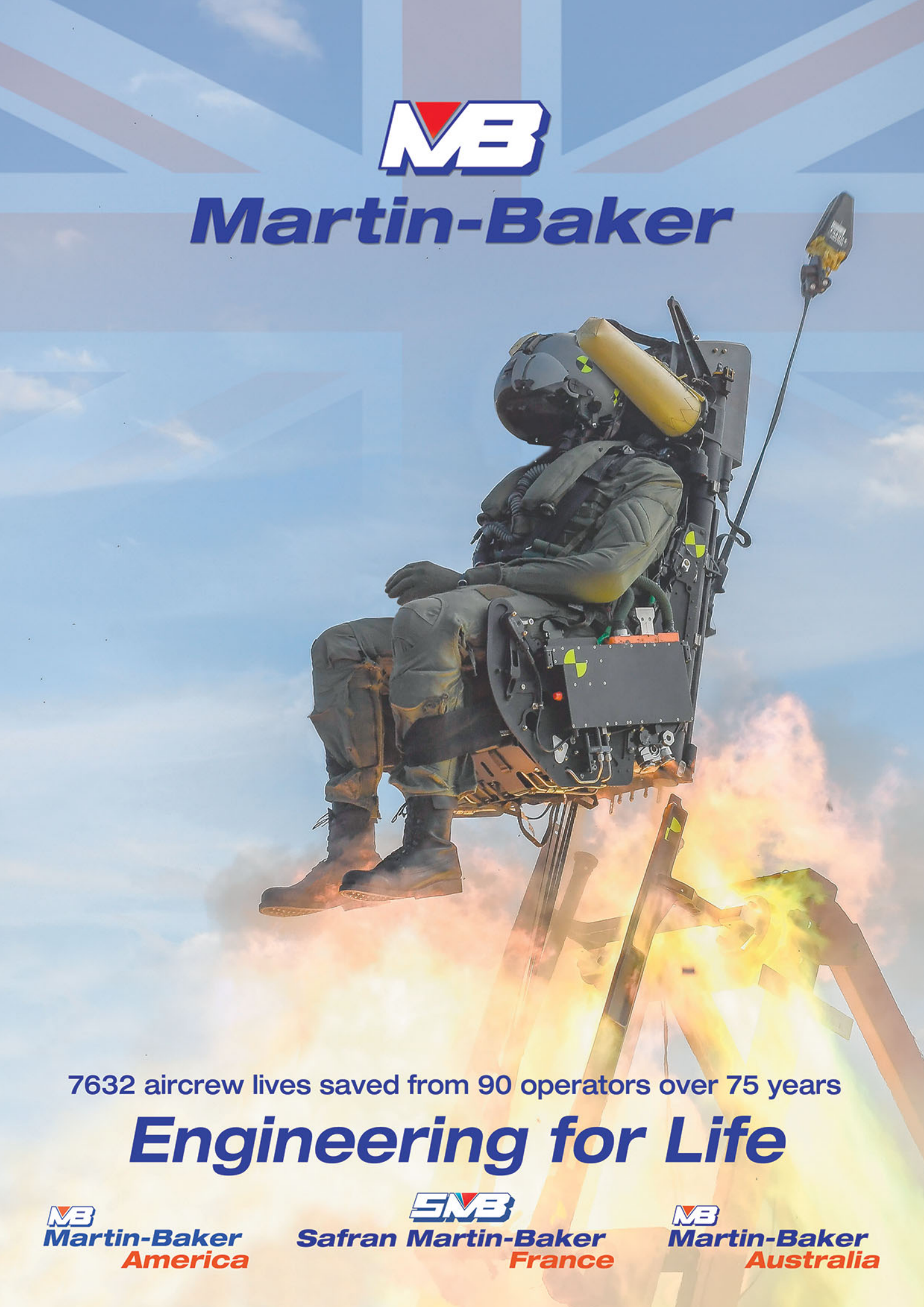
Secretary of the air force Barbara Barrett had a day earlier used the same conference to announce that any of the service's programmes which employed digital engineering would receive the prefix "e" during the development phase, for example, the eT-7A Red Hawk.

Roper says he decided to disclose the NGAD demonstrator's flight status in order to dispel doubts about digital engineering's ability to speed up manufacturing.

"The whole idea of what you can digitally engineer is in question," he says. "I've had people in the Pentagon and elsewhere say 'I see how you could apply that approach to a trainer, like T-7, but you could not build a cutting-edge warfighting system that way'."

Roper also says he wants greater investment from private industry in digital engineering. "We're going to drill on it until every new programme begins by building an e-system," he says. "It's truly magical."

The USAF in 2019 established a new programme executive office to oversee its NGAD and Digital Century Series fighter initiative. Other key focus areas include agile software development to enable future platforms to keep pace with evolving threats.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Will twin-aisles ever bounce back?

With demand for widebody airliners at an all-time low, **Richard Aboulafia** considers the potential for a resurgence

There's a twin-aisle demand drought. Even in the middle of what is likely the worst jetliner market bust ever, the sudden drop in widebody demand is notable.

Between 2012 and 2017, twin-aisle deliveries by value outpaced single-aisles; today, the twin-aisle backlog is just 1,880 aircraft worth $261.8 billion (in realised prices) out of a total backlog of 12,812 aircraft worth $821.6 billion. Twin-aisle output is plummeting and new larger aircraft like the Airbus A350-1000 and Boeing 777-9 are struggling for viability.

This drought reflects a secular shift in fleet planning: increasing numbers of smaller, medium-range aircraft connecting more city pairs, a process known as route fragmentation. But this situation could change, and twin-aisles could even regain parity with their thinner cousins. Specifically, there are four factors that could bring the widebodies back.

First, Asia might grow again. Reflecting slower economic growth and slowing global trade growth, Asia-Pacific air travel demand growth fell to just 3.6% (year on year) in October 2019, from 7.6% in October 2018, according to IATA. The Covid-19 pandemic, unrest in Hong Kong, and decoupling between China and the West have made this problem worse.

But if these macroeconomic and geopolitical horrors are reversed and demand growth resumes at the historical 7-10% pace, twin-aisles would be the big beneficiaries. Asia generally requires longer-range jets, and single-aisles max out at under 5,000nm (9,260km).

Second, if world trade resumes growing at its historical rate, particularly if China's decoupling from the West is reversed, then belly cargo will have a higher premium attached to it. Asian routes in particular typically make more use of belly cargo, which twin-aisles can accommodate and single-aisles generally cannot.

Third, some route fragmentation is driven by new, smaller international carriers, such as AirAsia X or Norwegian. Yet these airlines are the ones most at risk of downsizing, or bankruptcy, as a result of the pandemic. They are not flag carriers, and governments therefore have little reason to support them, particularly since they seldom play a vital role in any country's domestic transportation infrastructure. Similarly, if governments wind up taking a greater stake in their largest national airlines (through last-ditch bailouts), these carriers would benefit at the expense of the private sector upstarts.

Market concentration

If the eclipse of the new international low-cost carriers means that we head back to an era of large, global network carriers, with greater levels of market concentration, that would also argue for larger jets, particularly if hub and spoke networks come back into vogue as a result.

Boeing

Larger aircraft such as the 777-9 are currently struggling for viability

Richard Aboulafia

Fourth, one day, these new international fragmented routes will thicken, along with broader system growth. For example, Air Canada is planning a new Montreal-Dublin route, to be flown by a 737 Max 8. A decade of growth at historical transatlantic growth rates implies demand for a widebody on that route. These new thin, fragmented routes, in short, are like seeds planted today for thicker widebody routes tomorrow.

But at a time like this, a return to robust international air travel market growth seems like a distant prospect. Most forecasts do not even call for a return to 2019 air travel levels until late 2023 or 2024, with slower growth for years afterwards. Airlines are understandably wary about adding larger jets to their fleets. In fact, they are mostly focused on replacing older twin-aisles with new, more capable single-aisles, particularly the A320neo family.

Thus, twin-aisles will stay eclipsed by smaller aircraft for the next six or seven years at least. And the world's four surviving widebody passenger jet families – the A330neo, A350, 777X, and 787 – will need to survive on thin numbers.

Richard Aboulafia is vice-president of analysis at Teal Group

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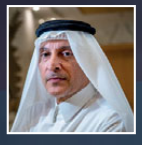

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Rivals target MQ-Next with family approach

General Atomics, Lockheed Martin and Northrop Grumman set out proposals for operational need beyond 2030

Garrett Reim Los Angeles

Several of the rivals eyeing a US Air Force (USAF) requirement to replace the General Atomics Aeronautical Systems MQ-9A Reaper unmanned air vehicle (UAV) have outlined their early proposals for next-generation intelligence, surveillance and reconnaissance (ISR) and strike platforms.

"We're embracing ultra-long endurance, to keep our next-generation ISR [and strike UAV] in the fight for longer periods than many ever imagined possible," says General Atomics Aeronautical Systems president David Alexander. The company's flying-wing design will have the "ability to stay engaged in the fight far longer than current generation" systems, he adds.

"Our advancements in propulsion technology will give commanders a longer reach than ever before," says Alexander, without revealing what sort of engine its new aircraft would use.

In addition to having a better lift-to-drag ratio, the flying-wing design is also inherently stealthy, with an artist's rendering showing only small slits for engine inlets, set behind the leading edge.

The USAF released a request for information in June calling for ideas to replace its current fleet with an MQ-Next capability after 2030. The service is worried that the Reaper, which was designed for use against terrorists and insurgents, is vulnerable when operated near the sophisticated air-defence systems fielded by China and Russia.

Expanded role

General Atomics says it also wants its next-generation UAV to be a highly reliable node in the USAF's battlefield network.

"We believe it is imperative that future unmanned systems are able to communicate, share information, and collaborate – together, and intuitively with their human counterparts – across systems and domains in record time," says Alexander.

"Our focus on automation and autonomous capabilities stems from an understanding that the increased speed and intensity of future warfare requires a similarly agile and intelligent set of systems – not just to reduce manpower and enable operations with minimal personnel, but also to reduce the burden on the tactical data transport network in contested communications environments," he says.

SG-2 concept is heavily based on Northrop's experience with X-47B

Lockheed Martin says its proposed family of MQ-Next systems is likely to include "expendable" aircraft, reflecting the USAF's interest in so-called attritable UAVs. Costing roughly $2 million-$20 million each, these would be cheap enough to be expendable during combat.

"Our operations analysis shows us when it comes to [UAVs], the optimum force structure consists of a mixture of very high-end, very highly capable vehicles, coupled with low-cost, high-volume expendable systems, which are the vehicles that are bringing mass to the fight," says Jacob Johnson, intelligence, surveillance, reconnaissance unmanned air systems director at Lockheed Martin Skunk Works.

Lockheed believes it would be more economical to field a large number of expendable UAVs costing less than $2 million apiece.

"I think of an expendable system

General Atomics Aeronautical Systems

General Atomics' flying-wing design incorporates stealth characteristics and advanced communication capabilities

Northrop Grumman

being a very smart, capable system [that] maybe has some of its heritage based back in cruise missiles," Johnson says.

Meanwhile, if Northrop Grumman's proposal for MQ-Next looks a lot like its earlier X-47B, that is because the new SG-2 flying-wing concept draws many features from the demonstrator.

Along with the outer resemblance, the company says what really binds the two are its Distributed Autonomy/Responsive Control (DA/RC) software. This enabled the X-47B's aircraft carrier landing in 2013 and autonomous in-flight refuelling demonstration two years later.

Northrop is promoting a family of autonomous systems, with an operator able to manage multiple vehicles simultaneously.

"Instead of using a stick, rudder and yoke, [and] a mouse to click waypoints, you just define what objectives you want to have," says Richard Sullivan, Northrop's vice-president of advanced programmes for future combat unmanned air systems.

The DA/RC program would coordinate a group of UAVs to make the most of their collective sensor resources and provide human operators with the most accurate and well-rounded picture of a situation, says Sullivan. Were communications interrupted, the vehicles would use their autonomous capabilities to proceed with their mission, within certain constraints, he adds.

"We can scale to whatever is needed – there is no hard limit," Sullivan says. "The company has done simulation with up to 100 systems involved, and in real-world testing has used 10."

The 7,700kg (17,000lb) SG-2's projected 1,000nm (1,850km) range is less than the 2,100nm reach of the X-47B, but Northrop says it has ideas for longer-range aircraft within the MQ-Next family.

"The USAF appears to be shifting emphasis from permissive environment-only ISR/strike to land- and sea-based systems capable of staging operations from a long-range sanctuary and holding targets at perpetual risk throughout the depth and breadth of highly-contested battlespace," Sullivan says.

ARES deal means Reaper could arrive sooner

General Atomics Aeronautical Systems has been awarded a US Air Force (USAF) contract that will enable it to pre-price the MQ-9A Reaper unmanned air vehicle for export customers.

In a deal that is similar to a recent arrangement covering the Lockheed Martin F-16, the Agile Reaper Enterprise Solution (ARES) framework will enable General Atomics to conclude Foreign Military Sales contracts worth up to a total value of $7.4 billion over five years.

It is set using a pre-negotiated "price-quantity-curve", and also includes mobile ground control stations, as well as related equipment.

"This curve allows the air force and Foreign Military Sales partners to unilaterally order between four and 36 aircraft in a single year," says the USAF Life Cycle Management Center's MQ-9 programme office.

The new approach will "stabilise costs and reduce the time it takes to deliver the aircraft to operational units by approximately 35%".

"Prior to ARES, the standard contract award timeline was roughly 380 days," says Alicia Morales, aircraft production manager with the air force's Medium Altitude Unmanned Aerial System programme office.

"Now we can award in just a couple of days and field the aircraft in 26 months."

Geopolitics keeps Motor Sich stuck

Chinese interest in Ukrainian engine maker is well known, but Kiev may block much-needed takeover for fear of US reaction

Greg Waldron Singapore

China-backed firm Skyrizon is making a renewed push in its long-running effort to acquire Ukrainian aircraft engine manufacturer Motor Sich, with vocal support from a new local partner.

Last month, Beijing Xinwei Technology, Skyrizon's parent, told the Shanghai Stock Exchange that its subsidiary is resubmitting an application to the Ukrainian competition authorities regarding the acquisition, which originated in 2017.

The renewed effort follows a recent agreement between Skyrizon and Ukrainian conglomerate Development Construction Holding (DCH). Should Kiev bless the deal, DCH will control over 25% of Motor Sich's shares and Skyrizon an unspecified number; media reports suggest that Skyrizon has already amassed a stake of around 80% in the engine maker.

Skyrizon's interest in Motor Sich has generated controversy because Washington DC is concerned that the firm's aircraft engine capabilities will fall into the hands of Beijing. In late August, US Secretary of State Mike Pompeo raised the issue in a phone call with Ukrainian president Volodymyr Zelensky. Former US National Security Advisor John Bolton has also written that China's interest in Motor Sich was a significant issue in his discussions with Ukrainian officials.

Several key Chinese military aircraft, such as the Chengdu J-20 fighter and Xian Y-20 strategic transport, rely on Russian engines, while in the commercial space, US-built equipment dominates.

In addition to other industrial products, Motor Sich manufactures a full range of turboprops, turbofans, turboshafts, and auxiliary power units, working closely with Ukraine's Ivchenko-Progress design bureau and airframer Antonov.

Delaying tactics

Ukrainian officials have held up the Skyrizon deal for three years, during which time the company's shares have been suspended at the behest of the country's security services. Competition authorities have also withheld their blessing for the Skyrizon takeover.

In addition to pressure from the USA, Kiev may also be concerned that Chinese ownership will see the company's technology siphoned off. Skyrizon and DCH, however, deny this suggestion.

In August, Skyrizon chairman Wang Jing said the company was determined to invest in the engine maker and keep it in Ukraine. Having DCH as a partner will help Motor Sich "maintain its Ukrainian characteristics", he says, adding that Skyrizon will use "all legal means to protect our investment".

None of the three key parties in the potential deal – DCH, Skyrizon, and Motor Sich itself – responded to requests for comment.

Following news of the Skyrizon partnership, DCH published a series of statements condemning Kiev for its handling of the Motor Sich affair.

It contends that not only has the long share suspension been unfair to stockholders, but that domestic jobs are being lost and the country's technological edge is being eroded through lack of investment. It alludes to Ukrainian officials being pressured by outside entities, but stops short of naming the USA.

DCH says that should the joint bid with Skyrizon win approval, the first major opportunity would be China, where the company's products are well known and where there is a ready market.

"However, we do not plan that the promotion of goods of Motor Sich will be limited to China," says DCH. "With a serious approach to the modernisation of production, there are wide market opportunities, of course, taking into account the restrictions on the supply of goods and services to the Russian Federation, North Korea and Iran."

Washington has not shied from airing its concerns about Motor Sich's possible sale to China. But it cannot provide a market for the manufacturer's aero engines.

Kiev is in a difficult position. Thousands of Ukrainian jobs and a core industrial capability could be at risk, but this must be weighed against its relationship with the USA, an important ally against Russia.

Should the Skyrizon/DCH deal go ahead, Chinese capital could provide a new future for Motor Sich. Unfortunately, the geopolitical reality of Sino-US relations, coupled with Kiev's concerns about Moscow, could keep it in limbo for some time yet.

Real Life Studio/Shutterstock

Acquisition target works closely with airframer Antonov

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Low-flying FARA will smash enemy defences

US Army says data fusion technology and speed will give next-generation helicopter an edge in penetrating role

Garrett Reim Los Angeles

The US Army believes it has found a weak spot in the lower-tier air defences of Russia and China, and intends to exploit this using its Future Attack Reconnaissance Aircraft (FARA).

During a conflict, so-called "kick-in-the-door" missions are typically handed to the US Air Force (USAF) and its fleet of stealthy aircraft. The US Army usually follows, after the enemy's air defences, communications networks and air force have been destroyed.

However, the army believes it should play a leading role in the future suppression of enemy air defences, contending that new rotorcraft technologies will give it an advantage that the USAF lacks.

"The lower tier of the air domain is, in fact, decisive," says Brigadier General Walter Rugen, director of the US Army's Future Vertical Lift cross-functional team. "We don't have a problem that the high flyers do. We can hide in the clutter, and show up at a time and place of our choosing to really create chaos in the enemy's decision cycle."

By using innovative flight controls that automate parts of nap-of-the-earth flight, the service believes it can fly its FARA at higher speeds and lower altitudes than previously thought possible or safe.

"We're being very innovative on how low we can get, how fast we can get," says Rugen. "And so far, it's working out. We've done a ton of runs."

Using army rotorcraft to attack air defence systems is not unprecedented: at the outset of 1991's Desert Storm operation to liberate Kuwait, Boeing AH-64 Apaches flew in low and destroyed Iraqi radar sites.

Low-observable strike aircraft such as the US military's Lockheed Martin F-35 face increasingly sophisticated and lethal air defences. Specifically, they could be vulnerable to the Russian-built S-400 Triumf surface-to-air-missile system, which can hit aerial targets at ranges up to 135nm (250km), and has claimed anti-stealth capabilities. According to the Center for Strategic and International Studies (CSIS), a future missile upgrade could extend its reach to 216nm.

Stealth compromised

After Turkey acquired the S-400 system from Moscow in 2019, Washington ejected its NATO ally from the F-35 programme, saying the stealth fighter could be compromised.

The S-400 is optimised for hitting high-flying aircraft, and needs protection from low-level threats such as loitering munitions, cruise missiles or helicopters, says Ian Williams, deputy director of the CSIS Missile Defense Project. The Russian military typically surrounds the type with shorter-range systems such as the Pantsir-S1 (SA-22) for protection, he notes.

"In the penetration phase for Future Vertical Lift, we're certainly going after SA-22s with our advanced ingress tactics, techniques and procedures that we're developing," says Rugen. "We then go after command and control vehicles. We then go after enemy long-range fire capability."

Scheduled to be fielded by 2028, the US Army wants FARA to be a nimble "knife fighter". With a cruise speed of at least 180kt (333km/h) and a rotor diameter no greater than 12.2m (40ft), it is expected to not only hide behind hills, but between high-rise buildings within cities.

Also designed to fly low to avoid detection during nuclear strikes against the USSR, the USAF's Boeing B-1 bomber fell out of favour when it was discovered in the late 1970s that Moscow was developing a look down/shoot down radar. This would allow a higher-flying aircraft to spot incoming threats against the backdrop of the Earth, without confusing them with objects on the ground.

Sikorsky's Raider X candidate would be optimised to mount surprise attacks using terrain masking for cover

Sikorsky

The US Army believes its next-generation scout helicopter will be able to conceal itself by using terrain masking. Rugen declines to say how low and fast it will be able to fly, citing classification restrictions.

Cluttered view

"It's very anecdotal to say that they can look down and shoot down," he says. "I've not seen any model or test that has been able to show that they can do that as routinely as they can with people who operate in the upper-tier air domain."

Rugen adds: "There's a lot of clutter – some of our stuff is flying as slow as a milk truck. There's a lot to sort out. I don't know that anybody's got an algorithm to do that."

The danger to FARA is that pilots might accidentally step out from the radar shadows and alert the enemy to their presence. "If we poke our head up too high, we're in trouble," says Rugen. "But that's where a lot of the cognitive offloading work we're doing [comes in], to make sure we can fly as fast as we possibly can, as low as we possibly can."

The army's Holistic Situational Awareness – Decision Making development programme, which is to launch in fiscal year 2021, is looking for data-fusion technologies to make it easier for pilots to make decisions, according to a request for information posted in April.

Bell's 360 Invictus and Sikorsky's Raider X candidates for the FARA requirement are fly-by-wire rotorcraft that the companies say can be optionally piloted.

To avoid short-range missiles, "rotorcraft would operate in relative sanctuary just outside the enemy's weapon engagement zone and flood the zone with air-launched effects pushing forward to detect, identify, locate and report [the most-dangerous] threats, that would then be targeted and engaged using long-range precision munitions," says Rugen.

Launched from its FARA rotorcraft and General Atomics Aeronautical Systems MQ-1C Gray Eagle unmanned air vehicle (UAV), air-launched effects will provide intelligence, surveillance and reconnaissance, conduct electronic warfare tasks, act as decoys or serve as loitering munitions. They will also be networked together to pass back information.

"We've had our air-launched effects 'daisy chained' out to about 61km," says Rugen of Area-I drones employed during a demonstration in Yuma, Arizona, named Project Convergence.

Once a threat has been spotted, the army wants any soldier, helicopter pilot, artillery personnel or UAV operator with a weapon in range to strike. During Project Convergence, the service passed targeting information around the battlefield using TrellisWare software-defined radios and ruggedised tablet computers.

An artificially intelligent program named Firestorm is even capable of automating Lockheed AGM-114 Hellfire air-to-surface missile shots from the MQ-1C. "If determined to be the best shooter, Gray Eagle is assigned the fire mission, software on board automatically calculates the route and munitions needed and sends this back to the ground commander, who must approve," says Rugen. "Then, the Gray Eagle flies itself into position and executes the fire mission with no further inputs."

Ultimately, the army believes this sort of automation will give it an edge.

"It's really refining our kill chain down, taking it from minutes to seconds," says Rugen.

Bell

Bell 360 Invictus could fly safely at altitudes and speeds previously thought impossible for an army rotorcraft

Carriers join Airbus on fello'fly trial

French Bee and SAS named as airline partners, with three air navigation service providers supporting fuel-saving initiative

Dominic Perry London

Airbus has revealed that it has signed up A350 operators SAS and French Bee, alongside three European air navigation service providers (ANSPs), to help advance its fello'fly vortex-harnessing fuel-saving initiative.

The move follows a series of test flights earlier this summer that proved it had been able to successfully automate the system.

Unveiled at the Dubai air show in 2019, fello'fly is designed to deliver fuel savings – and emissions cuts – of 5-10% by enabling a trailing aircraft to benefit from the "smooth updraft" of air created by the wake of another large jet flying around 1.6nm (3km) in front.

Airbus says it has taken inspiration from the energy-saving formations flown by migratory birds to develop the concept, which it previously tested in 2016 using a pair of A380s.

Nick Macdonald, head of the fello'fly demonstrator programme, points out that those jets were hand flown to maintain the required separation.

But the process has since been automated, with the autopilot now able to maintain the correct distance between the two aircraft to "capture and track the vortex". Airbus successfully demonstrated the revised system over three flights performed in French airspace in the final week of July using a pair of test A350s – a -900 as the lead aircraft, followed by a -1000.

"The performance measurements were in line with our predictions," says Macdonald. "It's a good endorsement for the project."

Macdonald declines to elaborate on the technology, and notes that the "final solution is something we are still working on". However, he stresses that the eventual product will need to be as light as possible.

Collaboration needed

Airbus hopes to certificate fello'fly by 2025, but says this can only happen if the entire industry gets behind it, in part to develop the new regulatory framework required.

Working with its partners, Airbus will now develop a concept of operations for the new technology.

SAS and French Bee will "bring their knowledge of day-to-day operations" to the programme, says Macdonald, enabling insights on topics such as flight planning and crew workload.

Additional input from the ANSPs – DSNA in France, NATS in the UK, plus Eurocontrol – will help understand how aircraft could be paired, he says, and how procedures might need to change.

Airbus intends to perform another round of internal test flights next year to ensure the maturity of its technology before it conducts a "final demonstration" over oceanic airspace with its partners "to prove all the bricks of the system fit together perfectly".

Lars Andersen, head of sustainability at SAS, says the airline has been involved in the project since late last year, but notes that its participation has been limited by the coronavirus crisis.

SAS will provide an A350 to act as a lead aircraft for the demonstration flight, to be conducted over the Atlantic, with one of the airframer's A350 test fleet in the trail.

Transoceanic flights are required for the demonstration because they involve well-defined corridors and long periods of stable flight.

While Andersen points out that considerable regulatory changes are still required, SAS could adopt fello'fly in the future.

"This is one step in a longer journey, but if the efficiency gains are worth the investment in the technology, possibly we will see this kind of methodology used on longer flights in future," he says.

French Bee has so far provided Airbus with a year's worth of operational data from its transatlantic services to inform the development of a concept of operations. The airframer will now begin work with the airline's crews so that both parties "understand the appropriate training for commercial pilots", says managing director Muriel Assouline.

She describes the initiative as an "amazing project" and stresses that the airline is "actively working to reduce carbon emissions".

French Bee will also provide an A350 for the demonstration flights next year.

Assouline says that if the tests prove successful and the required regulatory changes are obtained, French Bee would be keen to adopt the fello'fly system.

"We like innovation and we like to be first," she says.

SAS

Scandinavian operator will provide one A350 for transatlantic demonstration flight

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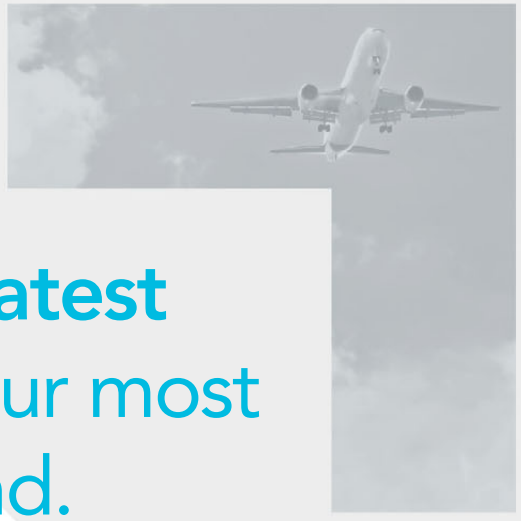

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Bombardier

Bombardier saw deliveries fall to 20 in the period, against 35 in April-June 2019

Second quarter gives GAMA cheer

Trade body figures show shipments edged down as crisis escalated, but sector could benefit as travel habits change

Murdo Morrison London

Manufacturers of business and private aircraft avoided the worst of the turbulence endured by their commercial counterparts during the height of the coronavirus crisis. Shipments in the second quarter of 2020 were down by less than 25% on the same period last year, according to the latest figures from the General Aviation Manufacturers Association (GAMA).

While the drop is marked – several OEMs were forced to make job cuts as international flight bans and stay-at-home orders took effect around the world – the numbers suggest the industry has so far had a relatively soft landing compared with Airbus, Boeing and other airliner manufacturers, which have seen deliveries fall sharply as passengers stop flying and airlines ground entire fleets.

GAMA's third-quarter figures, scheduled for publication on 17 November, may reveal more about the sector's resilience and medium-term confidence – many operators will have already committed to deliveries in the second quarter that were hard to cancel or defer as the pandemic took hold. Nervousness might have more of an impact on deliveries in the second half – traditionally the busier part of the year for shipments – as well as new aircraft orders.

However, the number of deliveries in the second quarter – 489, compared with 626 in 2019 – and their billed value, down from $5.58 billion in the same period in 2019 to $4.55 billion, show that the industry has managed to keep the revenue taps running. For the first half of the year, deliveries fell from 1,137 units in 2019 to 893, while billings were down by 20.2%, at $7.9 billion.

Proportionally, jets – the highest-value segment by far for manufacturers – decreased the most, with 130 deliveries in the second quarter, compared with 192 in the same period last year. That follows a 15% increase in jet deliveries to 809 for the whole of 2019. Turboprop shipments were down 28 at 81, while 278 piston aircraft were handed over, compared with 325 in the second quarter of last year.

Mixed picture

While it is misleading to read too much into a single quarter's delivery totals, particularly when travel restrictions vary from country to country, among the big-jet manufacturers, Gulfstream had a solid April to June – its 32 shipments were actually one up on the same period in 2019. Canada's Bombardier, on the other hand, saw its deliveries fall from 35 to 20, while Dassault – which reports only every six months – managed 16 shipments in the first half, one unit down versus the same period a year earlier.

Embraer reported 13 deliveries, compared with 25 in 2019, while Textron Aviation – which includes the Beechcraft and Cessna brands and whose numbers include small pistons to the super-midsize Citation Longitude jet – saw a modest drop, from 117 units to 98. Honda Aircraft, which delivered 10 HondaJets in the second quarter of 2019, shipped just two of the light twins between April and June this year.

GAMA president and chief executive Pete Bunce says it "should come as no surprise" that the pandemic badly hit the general aviation industry in the second quarter as harsh limits on travel were imposed. He praises the work of manufacturers and their suppliers in implementing new production protocols that have "resulted in very few virus transmission incidents".

Bunce notes that US domestic business aviation flight activity is now at 85% of pre-pandemic levels, while piston, turboprop and rotorcraft movements have increased. He attributes this to travellers "[exploring] the utility of general and business aviation for the first time, which we hope will translate into future customers for the incredible and versatile products our industry has to offer".

See p58

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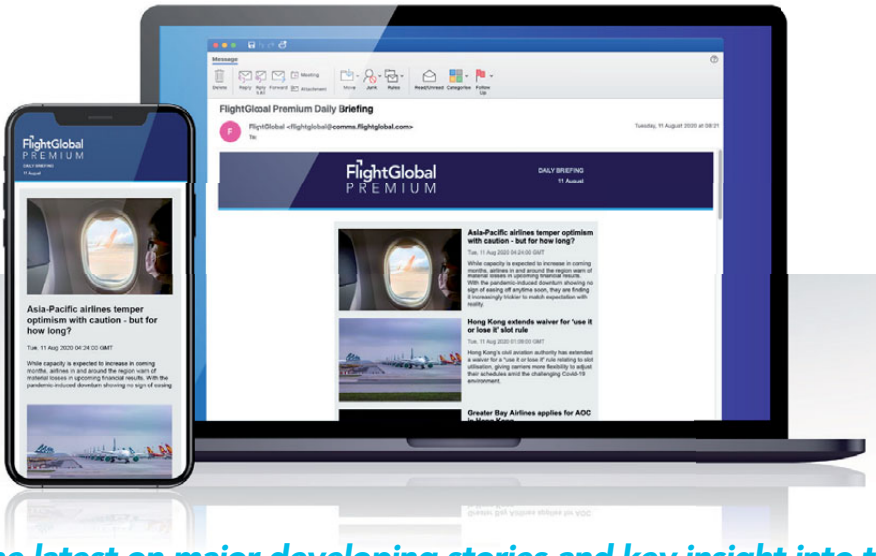

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Can China sustain its recovery?

Nation's big three airlines have all seen rising passenger numbers on internal routes – a return to profit could follow

Alfred Chua Singapore

Despite – or perhaps because – of the fact it was the epicentre of the coronavirus pandemic, the health of China's big three airlines is seen as a bellwether of the wider economy.

That trio of carriers – Air China, China Eastern Airlines and China Southern Airlines – while battered initially by the Covid-19 lockdowns and widespread travel restrictions, are now showing signs of recovery, on the domestic front at least.

Analysis of the three airlines is broadly upbeat, with several reports forecasting a return of both domestic traffic and, crucially, profitability by the end of September.

However, the picture is not as simple as it was pre-pandemic. Much of the revival in domestic traffic has been spurred by heavy discounting, with some airlines throwing in all-you-can-fly "unlimited passes" that allow passengers to travel as often as they like over a set period. In addition, while traffic is at levels seen in January, it is still lagging pre-Covid-19 totals.

Nonetheless, the efforts have seemingly had an impact. Since bottoming out in February, when the coronavirus pandemic forced several Chinese cities and provinces into lockdown, domestic air travel capacity has seen consistent month-on-month increases.

China Southern and Air China both experienced a slight plateau in traffic rebound in May-June, due to the discovery of a Covid-19 outbreak in Beijing, where both carriers have bases. That wave of infections led to the suspension of a significant number of domestic flights in and out of the capital's two major airports.

Since then, however, both carriers have seen continued growth in domestic passenger traffic.

While traffic has yet to return to pre-pandemic levels, the recovery is continuing apace.

Figures for August, the most recent available, show that the big three recorded new highs in domestic passenger traffic for the year, continuing the summer's upward trend.

In fact, China Eastern and China Southern carried more passengers than they did in January, right before traffic bottomed out.

China Southern actually carried more passengers than it did before the pandemic struck, setting a new high for the year, although this is not a like-for-like comparison.

Fleet storage

China Eastern carried 8.5 million domestic passengers for the month, a touch higher than January's figure of 8.3 million. The total is also an 18.2% increase over the previous month, although the figure is about 15% lower than the same period in 2019.

China Southern, meanwhile, carried 10.3 million domestic passengers, which was 8% higher than in January. The figure represents a 14.3% increase month on month, but is about 16% lower than last year's performance.

On international flights, the picture is grimmer, however. Both airlines recorded tiny numbers of international passengers for August: China Eastern around 30,000 and China Southern 73,500, respective declines of 98% and 96% against the same month in 2019. These contributed to year-on-year falls across both airlines' total operations of 28%.

10%

Increase this year in Chinese domestic passenger capacity compared with 2019, according to Cirium data

36 million

Number of domestic passengers carried by China's big three in August

As for Air China, it carried 7.27 million domestic passengers in August, down 0.9% compared to January's high of 7.33 million.

While August's domestic passenger numbers represent a 25% month-on-month increase, the figure was 14.2% lower than the same month in 2019.

Overall, Air China carried 7.32 million passengers across its network for the month, about 30% lower year on year.

While still down on the same month a year earlier, the passenger numbers are heading in the right direction and are continuing on an upward trajectory.

Cirium schedules data indicates that by the end of September, domestic passenger capacity is expected to be about 10% higher than the same period last year.

Examining fleet storage data for the same airlines reveals patterns of recovery. Cirium fleets data shows that the number of stored aircraft has largely tapered off in recent months, a possible indication that carriers are moving full steam ahead with the reintroduction of capacity.

The three carriers had the highest number of aircraft in storage in March, in the immediate aftermath of strict lockdown measures imposed in several parts of China.

Looking at China as a whole, a similar trend in aircraft storage rates emerges, peaking in February and March and tapered down by May when China announced it had largely got the pandemic under control.

In July, China moved to allow travel agencies to operate group tours across provincial borders. Beijing's culture and tourism ministry also eased restrictions on tourist attractions, allowing them to operate at 50% of their capacity, up from a limit of 30% imposed in April.

The move is intended to tap into pent-up demand, and comes just in time for the peak travel period in October, during China's National Day holidays.

Markus Mainka/Shutterstock

China Eastern carried 8.5 million domestic passengers in August

An HSBC report released in September points out that the upcoming 'Golden Week' holiday that runs from 1-8 October will "likely stimulate domestic travel demand", noting that several airports in mainland China have already recorded month-on-month increases in flight movements as part of a domestic recovery.

Industry watchers believe the Chinese domestic air travel market is experiencing a post-pandemic rebound, and think that the trend should continue.

But with demand stimulated by heavy discounting, it is a question how profitable the operations are.

Luya You, transportation research analyst at Bocom International, tells FlightGlobal: "The reasons for this are the high airfare discounts, which continue to eat into revenue at a time when many planes are still flying close to, or just below their break-even loads.

"All of this means domestic carriers won't be [breaking] much ground in terms of moving into positive profits, but they can stop the bleeding better than in [the first half of the year]."

Ascend by Cirium head of consultancy Asia Joanna Lu adds that the steep discounts and unlimited passes offered by Chinese carriers "will not necessarily allow them to earn more, but to lose less".

"Chinese carriers are much less reliant on international demand than most other airlines in [Asia-Pacific], so the impact of plunging international demand is much less overall," she says.

The HSBC research report states that the Chinese carriers will now begin to shift their focus towards improving yields, especially from October, after experiencing a strong domestic recovery.

Still, airlines should be cognisant of another spike in coronavirus cases in the country, which could trigger fresh lockdowns.

Potential risk

Rob Morris, Ascend by Cirium head of global consultancy, adds: "[An] increase in Covid-19 cases in China would cause this recovery to derail. There is no sign of that to date, but this must remain a real – and potentially increasing – risk."

You notes that the volatility of the pandemic means airlines will have to be as flexible as possible.

"It is very hard for domestic carriers right now to plan ahead like they used to pre-Covid. Carriers must be prepared to rapidly redeploy capacity from one route to another if [the coronavirus] impacts a region.

"As a result, these small hindrances can still add up to become much larger obstacles. At the moment, it appears domestic carriers are doing well to cope with this new reality, but we expect slimmer margins as a result," she adds.

Nonetheless, HSBC predicts that the big three will report profits for the quarter ended 30 September, largely driven by the recovery in domestic traffic.

This, together with an appreciation of the Chinese yuan against the US dollar, will help push the carriers back into the black.

That would be an impressive reversal of their financial performance in the first six months of the year, where each posted a substantial operating loss.

"We continue to believe that there is significant pent-up demand for travel that will emerge during the upcoming Golden Week holidays, especially with substitution of overseas tourism with domestic destinations, which should provide airlines with an opportunity to improve yields," the HSBC report adds.

With stability achieved on the home front, China's carriers can now turn their attentions to the wider regional market. As You notes: "Given the distressed state of major carriers throughout [Asia-Pacific], Chinese carriers have a rare window to make significant moves on global market share given their strong liquidity and months of domestic recovery.

"Simply put, they're in a fantastic position – in both financials and fleet – compared with their regional peers to take advantage of the Covid lull."

Try not to panic – we have been here before

In our latest report from the flightdeck, we hear from two anonymous pilots recently released by Middle East carriers

In July, aviation seemed doomed, with airlines either going bankrupt or laying off most of their workforces. My employer, a large Middle East carrier, was no exception and let go of 400 pilots, including myself, a 38-year-old Boeing 777 captain.

My colleagues were quick to set up a WhatsApp group. Their first reactions consisted of lots of yelling and screaming. Many were caught by surprise, not least that the selection process seemed to have been entirely random: redundancy was seemingly not based on seniority or merit, simply on whoever's name came out of the hat first.

Of course, the reaction in some cases was dictated by the individual's financial position. Lots of colleagues had personal loans, a fancy car, expensive school fees and a great apartment with superb views – and associated hefty monthly payments. A few did not even have a place to go to back in their home country, or had not set up any kind of replacement income.

While I had been counting on a few more years of salary to fund some real estate projects, I was prepared – or at least as prepared as one can be for something of this magnitude. Seven years ago, I made it my mission to be free of any employer, and to fly for money only if I wanted to, since my passion for flying had long been extinguished.

One or two more years of salary would have been great, but I'm lucky to be in a more comfortable situation than many of my peers, not that my almost decade-old, beaten-up car would offer any clue.

For those in a less fortunate position, who might think their world is ending, I offer these words of comfort: if you have been in aviation for a decade or two, you have already been through some serious shocks.

Chances are, to get that first jet job, you had to jump through a few hoops: working in the supermarket or McDonalds; paying off costly flight hours; begging every pilot you met socially for a flying job; finally getting an aviation-related role, only to find yourself carrying bags, making coffee, or doing flightplans for the "real" pilots.

Inauspicious start

My flightpath started in 2001. That's right: at the very beginning of my training, terrorists were deliberately flying airliners into buildings – horrific images that everyone still remembers. Two months later, the national airline of my country went bankrupt, while I was in its cadet school. And then, two short years later, aviation was hit again, this time by the SARS outbreak.

Even though the obstacles these events presented seemed insurmountable at the time, a few years later, most of the cadets I studied with had a flying job.

> Countless times in our careers, we have seen colossal catastrophes

Fast forward to 2008-2009 and then came the world financial crisis. Airlines were firing pilots en masse – again – stock markets were crashing, and many people lost their homes or much more. But within four years, IATA reported that traffic had returned to its trend level. No pilot I know was unemployed a few years after the crisis, even though many had initially lost their jobs.

Keep your eyes on the horizon and don't look back

Since then, we have witnessed: the eruption of the Eyjafjallajokull volcano in Iceland in April 2010, which closed European airspace for a full week; 2014's twin tragedies for Malaysia Airlines; and the grounding of the Boeing 737 Max fleet after a pair of fatal accidents.

Countless times in our careers as pilots, we have seen colossal catastrophes. This one seems to be the biggest, but we thought that in 2008, and in 2001. A few years later, it's usually just a bad memory.

Things may be bad now – and they are likely to stay like this for a while – but if, as a furloughed pilot, you have a burning desire to get paid to fly once again, you will achieve that goal. You have dealt with situations like these as a pilot for your entire professional life, and you are a fighter.

In the meantime, let's breathe, focus on family, hobbies we never had time or energy for, enjoy that sabbatical year, or redirect our focus to other projects. But this time, maybe rethink the retirement plan: that big mansion and shiny sports car can probably be ignored.

Arjan Veltman/Shutterstock

Redundancy process sees overseas flightcrews and their families uprooted

It is a strange feeling, seeing colleagues you have known and worked with for decades suddenly scattered to the four winds, disappearing back to their own countries.

While flightcrew across the globe have been made redundant in their thousands, any pilots working outside their home country have faced a particularly brutal time, and none more so than those employed by one of the Middle East's big three.

When you are a resident in a country such as the United Arab Emirates, you have precious few rights once your job disappears, particularly in regard to your continued stay. As soon as that redundancy notice lands, the clock is ticking on your visa, which expires on your final day of service.

Pilots faced a desperate three-month scramble to move their families back home, in some cases liquidating decades of life in the desert in a matter of weeks. If you were lucky, you rented a house and owned cars that sold quickly.

But for those who had bought a house or apartment financed via a local bank, the picture is not so rosy: you cannot leave the country until you pay the loan back, but good luck with making that sale.

The redundancy process felt like an entirely random affair: you were either in – or you were out. In addition, the sheer scale of the redundancies seemed to overwhelm HR departments who were dealing with thousands of pilots, plus cabin crew. Colleagues recently had to queue for 3h to hand back their IDs and cockpit computers.

The greatest sympathy should be reserved for those who come from countries where the borders are still closed: after the last day of service with my former employer, they will be put on "hardship allowance": just 25% of basic salary.

For those pilot colleagues who remain, many are on short-notice unpaid leave, on top of a salary that has been cut in half.

Of course, we all signed up with our eyes open: we knew that working in the Middle East meant no union, no social protection and no seniority, but with a decent financial reward.

There are countless posts on social media from former staff suggesting that they understand why they had to be laid off – in other words, thanks for sacking me!

They might want to reflect on the fact that despite the crisis, their ex-employers are still able to find enough spare change to sign large, multi-year sponsorship deals with European football clubs.

Singapore Airlines

SIA is considering offering to fly passengers around the region – simply to enjoy the view

Asia-Pacific airlines go nowhere

Scenic flights can deliver some passengers – when for now at least, resumption of international travel is a long way off

Greg Waldron Singapore

So-called "flights to nowhere" are smart public relations for Asia-Pacific airlines, but that such operations are even under consideration underlines the immense challenges they face.

Reports recently emerged that Singapore Airlines (SIA) is considering such a service: passengers would board in Singapore, fly around for a few hours enjoying the in-flight service, and land again at Changi airport.

One report suggested that upon landing passengers would go not to their homes, but to a hotel – just as they would after a "real" flight.

SIA has yet to confirm the initiative, which would involve careful planning and extensive dealings with various aviation authorities. A low-altitude scenic flight with one of the airline's Boeing 787-10s over Sumatra's Lake Toba, for example, would require Jakarta's blessing.

Should SIA move forward, it will follow Taiwan's EVA Air, which has operated a few scenic flights from Taipei Taoyuan, and Qantas, which is selling a "Great Southern Land" scenic flight.

The Qantas service will operate from Sydney with a 787-9, selected for the mission owing to its large windows.

In addition to enjoying some great sights, passengers will have plenty of personal space: only 134 of the jet's 236 seats are available for purchase.

Against the collapse in Asia-Pacific air traffic, of course, the value of such flights is entirely in public relations. Getting back to even something resembling profitability requires passengers to return en masse. This is a non-starter while regional governments drag their feet about reopening the region's international travel markets.

There are tentative signs, of course. Vietnam announced that it will allow the resumption of six international routes to Guangzhou, Phnom Penh, Seoul, Taipei, Tokyo and Vientiane. Unfortunately, there will be no more than two flights a week, and only Vietnamese nationals and foreigners who meet set requirements can travel.

A week earlier, a Hong Kong official said that "travel bubble" talks with several countries were under way, but only a handful had expressed interest. At issue were coronavirus tests before departure and upon arrival.

Singapore, meanwhile, took a relatively bold step in late August, lifting quarantine for passengers from Brunei and New Zealand, two countries that are deemed to have handled the pandemic well. Travellers from both countries can take a Covid-19 test upon their arrival, with no need for a 14-day quarantine.

According to IATA's Covid-19 travel map, however, Brunei does not allow passengers to enter or transit, apart from Brunei nationals. Similarly, passengers are not allowed to enter New Zealand.

But apart from activity in countries with large domestic markets, namely China, the recovery the region's airlines desperately need seems as remote as ever.

An effective vaccine is seen as a panacea to the industry's problems. Unfortunately, it is unlikely to be that simple.

Multiple vaccines are being researched globally, but their efficacy is likely to vary – not to mention the gargantuan task of inoculating billions. It is entirely possible, even likely, that governments will acknowledge the value of some vaccines, while casting doubt on that of others.

Passengers could end up navigating a maze of "good" and "bad" vaccines. Such a situation does not an airline recovery make, although anything that offers a ray of hope is to be desired.

Airlines in the Asia-Pacific and globally need to brace for this possibility. For the time being, though, they remain on a flight to nowhere.

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Out of the blue

Max Kingsley-Jones/FlightGlobal

While Post-Covid outlook for A380 is tough, Emirates Airline president Tim Clark is optimistic for superjumbo once vaccine is found

21,970
Global in-service airliner fleet, down by one-quarter on the 29,530 in the 2019 census

56%
Decline in mainline active Airbus and Boeing inventory from January to May 2020

2024
Forecast date for traffic to return to 2019 peak level, according to IATA

Max Kingsley-Jones London
Data research by **Antoine Fafard** London

The *Flight International* annual airliner census has tracked the industry's many booms and busts over the several decades it has been published, but never one on a scale seen in 2020. The change in headline numbers, according to Cirium fleets data, provides a simple illustration of the coronavirus effect: the global in-service airliner fleet has declined by 25% from 29,500 jet and turboprop aircraft when last year's report was published in mid-2019 to just under 22,000 this August (see pie chart 1).

The scale of this decline in the active fleet caused by the coronavirus pandemic is of course unprecedented. The highly fluid situation with regards to the status of the operational fleet called for a change to our usual method of analysis. The census traditionally focuses on the in-service operational airliner fleet, but with such high proportions of each type in temporary storage this year the parked aircraft are being included as part of the analysis.

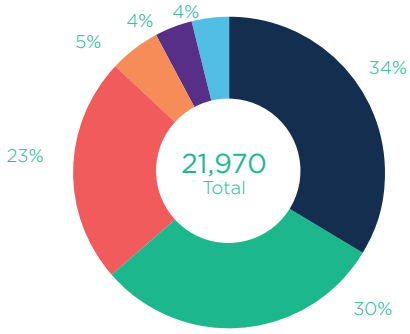
The first nine months of 2020 have been extraordinary for the airline sector as measured by so many metrics. The active fleet has plummeted and deliveries of new aircraft have all but stalled amid the collapse in demand for air travel, combined with the complications caused by lockdowns and quarantines hampering the delivery process.

Until 2020, the active global airliner fleet had been steadily increasing each year through the 2010s, before growth began trailing off in 2019. Evaluation of the global mainline airliner fleet – that is the

31%

Proportion of total mainline fleet in storage at end-August, versus a historic 6-8% average

Pie chart 1: Airliner in-service fleet by region

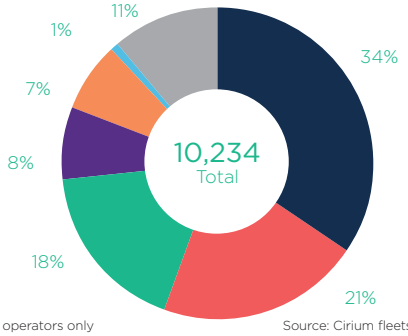


In-service active jets and turboprops with commercial operators only

Source: Cirium fleets data (August 2020)

● Asia-Pacific – 7,427 ● North America – 6,593 ● Europe – 5,134
● Latin America – 1,117 ● Middle East – 864 ● Africa – 835

Pie chart 2: A320/737 families – order backlog by region

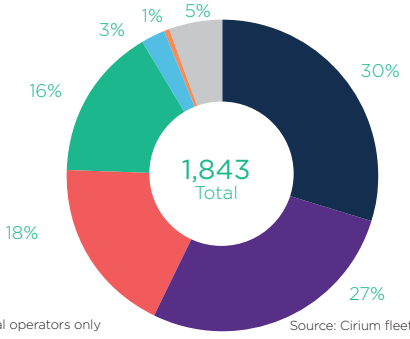


Commercial operators only

Source: Cirium fleets data (August 2020)

● Asia-Pacific – 3,534 ● Europe – 2,154 ● North America – 1,820
● Middle East – 791 ● Latin America – 729 ● Africa – 73 ● Unassigned – 1,133

Pie chart 3: Widebody order backlog by region



Commercial operators only

Source: Cirium fleets data (August 2020)

● Asia-Pacific – 552 ● Middle East – 503 ● Europe – 339
● North America – 292 ● Africa – 45 ● Latin America – 14 ● Unassigned – 98

single-aisle Airbus A320 and Boeing 737 families, along with Airbus/Boeing widebody types – reveals the comparative effect of the crisis on the number of aircraft in active service.

Traditionally, the number of stored aircraft equates to about 6-8% of the total fleet. Graph 1 illustrates the year-end situation over the past five years and in August 2020. The active fleet had been steadily increasing, from 18,400 aircraft in 2016 to 20,900 last year, before declining to 15,600 in August 2020.

The effect of Covid-19 had resulted in the stored fleet ballooning to around 31% of the total fleet.

Graph 2 shows the evolution of the A320/737 active/stored fleet over the same period and graph 3 illustrates the situation with widebodies.

A closer look at 2020 reveals the dynamics that have played out in changes to the active fleet. As graph 4 shows, this provides some interesting insight into the impact of the virus.

Steep fall

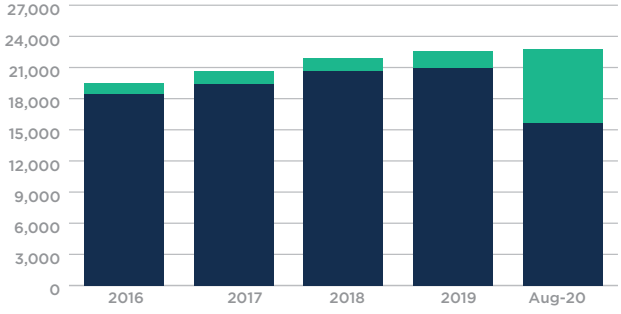
At 1 January 2020, the mainline Airbus and Boeing fleet in active service with commercial operators totalled 20,900 aircraft. The active fleet began an immediate decline in January, falling to a low of around 9,000 aircraft (a 56% drop) in the April/May period. By September, this figure had increased to almost 16,300 aircraft, but was still down by over one-fifth on the size at the start of the year.

It is evident from the recovery profile that the active single-aisle fleet is rebuilding faster than that of the widebodies. By September, the A320/737 fleet was within 20% of its size at the start of the year, while widebodies were still down by 28%, highlighting how short- to medium-haul operations have been recovering faster than longer-haul services.

There will be casualties in both the single- and twin-aisle sectors but it is already clear that the four-engined widebodies are most at risk. The size of the 747 passenger fleet has been irreversibly reduced, and the outlook for the A380 is tough – with several airlines having decided to permanently retire some or all their aircraft. Other operators have no short-term plans for a return to service.

The pace of recovery of the active fleet to its pre-coronavirus size is tough to judge, given that there are so many dependable factors, says Ascend by Cirium's

Graph 1: Global mainline fleet, active/stored – 2016-2020



A320/737 and Airbus/Boeing widebodies. Commercial operators only
Column totals are combined values for each year
Source: Cirium fleets data (Year-end/August 2020)

● In service ● Stored

Max Kingsley-Jones/FlightGlobal

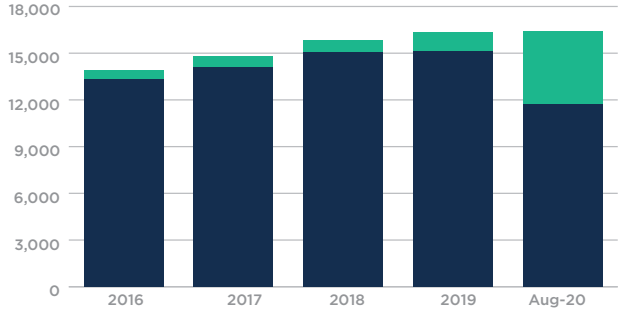
787 has the highest share in active widebody fleets, based on its relative youth and fuel efficiency

head of global consultancy, Rob Morris: "There is no single panacea for any of this, but I suspect that the key is implementation of a successful vaccination programme on a global scale."

And the size of the fleet is only one metric by which to measure the industry's gradual return to the old normal, with the others being the utilisation of the fleet and of course the load factors. Morris points out that the former is currently down significantly, compared with the start of 2020.

The consensus across the industry is that a full recovery will only be possible once a vaccine is introduced to allow social distancing and travel restrictions to be relaxed, making the short- to medium-term outlook difficult to forecast. Emirates ›

Graph 2: A320/737 fleet, active/stored – 2016-2020



Commercial operators only
Source: Cirium fleets data (Year-end/August 2020)

● In service ● Stored

Max Kingsley-Jones/FlightGlobal

Newer-generation narrowbodies have recovered most rapidly, with A320neo having the highest proportion of flying fleets

Airline president Tim Clark describes social distancing on aircraft as "an economic catastrophe. Airline business models are not built on 50% seat factors for no segment of the business. So that can't work."

Clark says that a vaccine "must be found" for the industry to recover fully, but he is "100% confident" that it will be. Clark also believes that once a vaccine is found there should be a bright future for the A380, of which Emirates has 115: "The A380 has proven to be a hugely successful aircraft and if fuel prices were forever to stay at today's levels, this aircraft is hugely potent," he says. "The thirst for travel will come back."

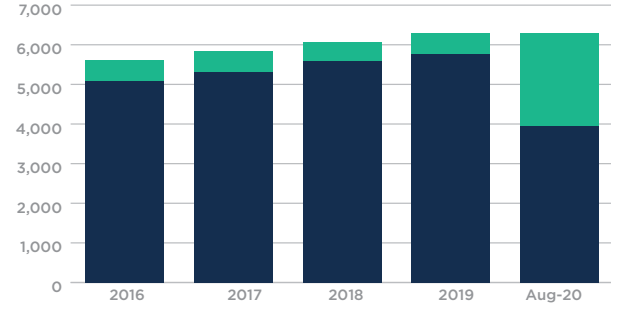
"We aren't expecting traffic to return to the 2019 peak until late 2023 – in fact IATA now says 2024. And, until there's a vaccine next year – we hope – the traffic recovery will be a bit anaemic," says Richard Aboulafia, vice-president of analysis at Teal Group. "So, since the fleet is coming back faster than traffic, it's clear that the result will be financial pain for the airlines, particularly if more government aid isn't forthcoming.

"In short, the best-case scenario is that the fleet stabilises at around this level for the next six to 12 months, and it's also possible that more planes are grounded, depending on traffic and aid packages."

Partial rebound

Morris says the in-service fleet (defined as aircraft tracked flying – single-aisle and twin-aisle in passenger and cargo operations) has recovered to some extent

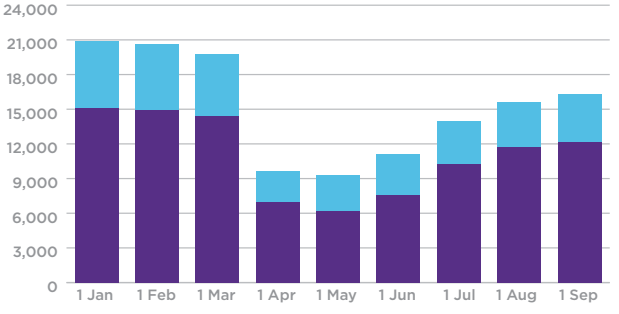
Graph 3: Widebody fleet, active/stored - 2016-2020



Airbus and Boeing types. Commercial operators only
Source: Cirium fleets data (Year-end/August 2020)

● In service ● Stored

Graph 4: Active fleet evolution - 2020



Airbus and Boeing types. Commercial operators only
Source: Cirium fleets data

● A320/737 ● Widebody

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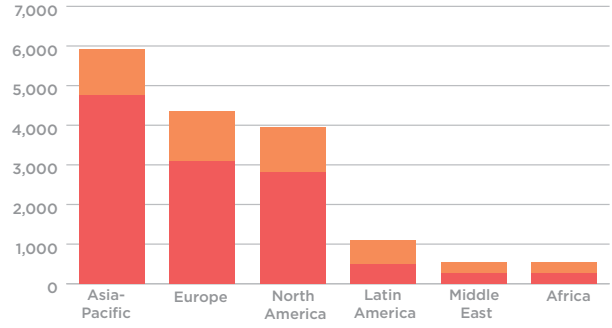
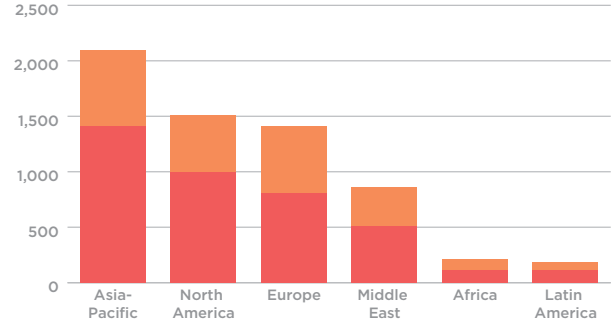
Graph 5: A320/737 fleet distribution by region



Total fleet: 16,426 (11,694 in service; 4,732 stored). Commercial operators only
Source: Cirium fleets data (August 2020)

● In service ● Storage

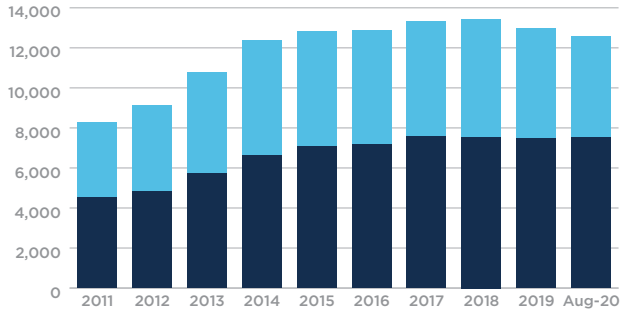
Graph 6: Widebody fleet distribution by region



Total fleet: 6,283 (3,944 in service; 2,339 stored). Airbus and Boeing types
Commercial operators only
Source: Cirium fleets data (August 2020)

● In service ● Storage

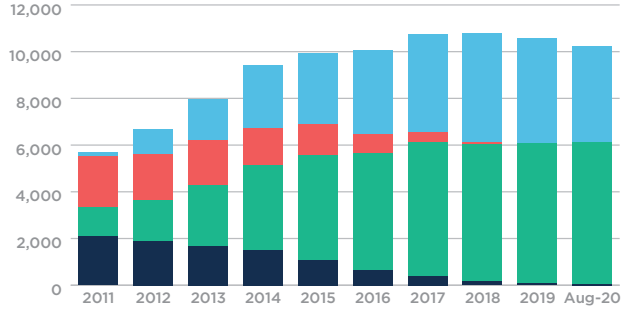
Graph 7: Airbus/Boeing order backlog - 2011-2020



Commercial operators only
Source: Cirium fleets data (Year-end/August 2020)

● Airbus ● Boeing

Graph 8: A320/737 order backlog - 2011-2020



Commercial operators only
Source: Cirium fleets data (Year-end/August 2020)

● A320ceo ● A320neo ● 737NG ● 737 Max

Lufthansa

Parked aircraft inventory increased sharply early in 2020 before beginning gradual recovery

"The best-case scenario is that the fleet stabilises at around this level for the next six to 12 months"

Richard Aboulafia Vice-president of analysis, Teal Group

but has reached only around two-thirds of that flying at the start of 2020. "The recovery has stabilised around this level and as we now head into the northern autumn and winter, it is hard to see further significant recovery in 2020," he says.

Morris and Aboulafia concur that the "two-speed recovery" being witnessed in the mainline fleet sector will continue.

"Twin-aisles are much more vulnerable to prolonged parking, and Airbus is generally in better shape, since the A321neo and A220 would appear to be relatively well positioned."

Morris says that, based on the assumption that narrowbodies typically serve domestic and regional markets while widebodies are deployed internationally, fortunes will be affected by the different speeds at which these markets recover.

"At present we are seeing around 70% of the global single-aisle passenger fleet back in service but only around 40% of the twin-aisle," he says.

"Looking further forward, our current most likely recovery scenario (which projects global passenger demand to recover to 2019 levels in 2023 – which may itself prove optimistic) has the global single-aisle fleet recovering to end-2019 levels at some point in late 2022, with twin-aisle not recovering to those levels before end-2023 at the earliest, and potentially later."

Ascend by Cirium's projection comprises many assumptions, including recovery of demand itself, of passenger load factors and aircraft unit utilisation, as well as a change in the mix between twin-aisle and single-aisle aircraft. "Clearly, these variables will alter the timing. But overall it is abundantly clear that single-aisle will recover ahead of twin-aisle," Morris states.

Graphs 5 and 6 show the geographic breakdown in August of the mainline types – A320/737 and widebodies, respectively. The split between active and stored aircraft varies between region, but this has been an ongoing dynamic situation throughout 2020 and will continue as such.

Top 10 fleets: mainline aircraft

Type	In service	Storage	Total	Active share
Airbus A320ceo family	4,919	2,279	7,198	68%
Boeing 737-600/700/800/900	5,072	1,420	6,492	78%
Boeing 777	1,006	509	1,515	66%
Airbus A330ceo/A340 family	731	747	1,478	49%
Airbus A320neo family	1,152	225	1,377	84%
Boeing 737-200/300/400/500	551	425	976	56%
Boeing 787	700	265	965	73%
Boeing 767	528	272	800	66%
Boeing 757	465	250	715	65%
Boeing 747	324	173	497	65%

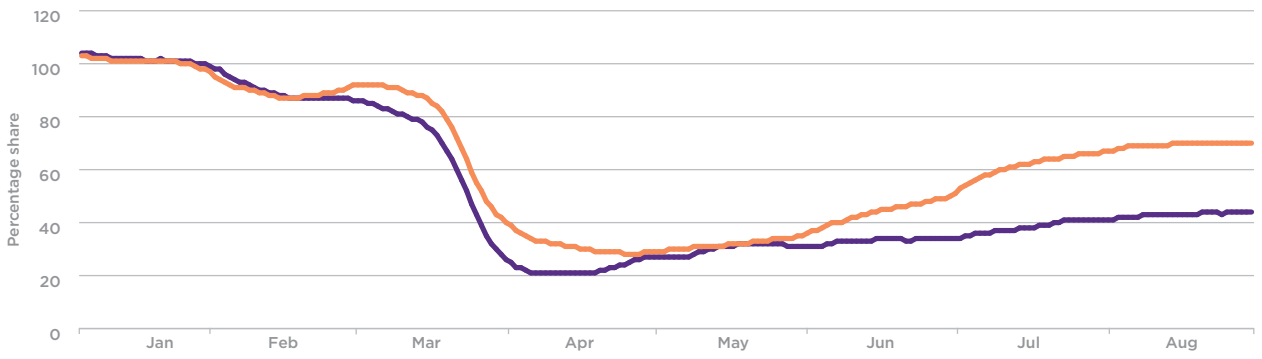
Source: Cirium fleets data (August 2020). Commercial operators only

Change at the top

The top 10 fleets rankings from Cirium are also revised this year. Normally the metric is based on active aircraft. However, this year, the stored totals are included as they account for such large numbers, along with the share of the fleet that is active.

The A320ceo is ranked first in the mainline group by total fleet – although notably there are currently more 737NGs in active service, even though the total fleet is smaller. The 737 Max had been on course to break into the top 10, but deliveries were suspended in March 2019 following the fleet grounding. The uncertainty around when the 737 Max will be cleared to return to service and resume deliveries is another factor in the difficulties over forecasting the pace of the fleet recovery.

Ascend by Cirium evolution of 2020 active mainline fleet



Seven-day moving average proportion of active fleet at 1 Jan 2020. Source: Ascend by Cirium (Cirium fleets data)

● Twin-aisle ● Single-aisle

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Max Kingsley-Jones/FlightGlobal

Size of 747 fleet has been irreversibly reduced, with UK flag carrier having permanently retired the type

The highest proportion of any fleet flying is the A320neo – at 84%, with the 737NG a close second on 78%. In the widebody arena it is the 787 that is the most numerous proportionally – at 73%. This highlights how airlines are favouring the youngest, most efficient types as they gradually restore the fleets to service. The Embraer E-Jet again tops the regional aircraft fleet ranking, with the ATR turboprop family in second place.

Top 10 fleets: regional aircraft

Type	In service	Storage	Total	Active share
Embraer 170/175/190/195	1,034	457	1,491	69%
ATR 42/72	763	446	1,209	63%
Bombardier CRJ700/900/1000	595	248	843	71%
Embraer ERJ-135/140/145	320	366	686	47%
Bombardier CRJ100/200	288	389	677	43%
De Havilland Canada Dash 8-400	337	216	553	61%
Bombardier Dash 8 Q100/200/300	275	160	435	63%
Beechcraft 1900	283	101	384	74%
De Havilland Canada Twin Otter	235	133	368	64%
Fairchild Swearingen Metroliner	218	44	262	83%

Source: Cirium fleets data (August 2020). Commercial operators only

Graph 7 highlights the slowdown in orders for Airbus and Boeing types that began last year after the backlog peaked in 2018. This was also a factor of the increasing output across assembly lines that had been continuously breaking industry records until the 2019 Max grounding sent Boeing's shipments tumbling.

Orderbook restructuring has been an ongoing theme, partly linked to the Max crisis and also the wider industry downturn. The effect on the Max orderbook is already clear to see in graph 7, which highlights its declining backlog – against zero deliveries for the last 18 months, compared with a static situation for the A320neo.

The intake of new orders at Airbus and Boeing has also slowed dramatically but so have delivery levels, so it will be interesting to see where the backlog finishes up at the end of 2020 once all the pieces slot into place.

Orderbook pie charts 2 and 3 illustrate the breakdown by region of the A320/737 and widebodies for commercial operators. As ever, Asia-Pacific is the lead region with a 34% and 30% share of the orderbooks, respectively. Europe is the second-largest region in the single-aisle sector, while the Middle East is in the equivalent position for widebodies.

P *Flight International* and FlightGlobal Premium subscribers have exclusive access to a full listing of the World Airliner Census. Visit: FlightGlobal.com/Census2020

Gulfstream made clear its ambition with the G700: to surpass its flagship and tackle its competitors head on. But how is the coronavirus crisis affecting its certification and flight-test programme?

Gulfstream

Latest model has a range of up to 7,500nm at M0.85

Space craft

Jon Hemmerdinger Tampa
Cutaway **Tim Hall**

Gulfstream continues to fly ahead with development of its G700 large-cabin business jet, an aircraft the company insists will give it a firm footing in the highest echelons of the business aircraft market. In launching the programme at the National Business Aviation Association convention in October 2019, the Savannah-based airframer underscored its intentions: to go one better than its current G650ER flagship and take on rivals such as Bombardier's Global 7500.

Towards that end, Gulfstream gave the ultra-long-range G700 new engines and advanced cockpit, flight control and cabin technology. But much can change in a year, as the coronavirus downturn has shown.

Even as the industry adjusts to plunging profits, and with companies including Gulfstream slashing staff, development and flight testing of the 19-passenger, Mach 0.925 G700 remains on schedule, the company insists.

"We didn't miss a beat during Covid," says Gulfstream senior vice-president of innovation, engineering and flight Colin Miller. He notes that the company has adopted remote working policies amid the pandemic. "We are on track for an [entry into service] and customer deliveries in 2022."

Gulfstream is bringing the Rolls-Royce Pearl 700-powered jet through flight testing close on the heels of the G500 and G600 development programmes, and incorporating many of those aircraft's enhancements into the latest model. Gulfstream delivered the first G500 in September 2018 and the initial G600 in August 2019.

Qatar Executive, also a G500 and G650ER operator, has thrown its support behind the G700 as launch customer, with 10 orders. Gulfstream has also secured G700 orders from Flexjet, making the Cleveland-based fractional ownership company the first North American G700 buyer. The G700's list price is $78 million, perhaps a hair more than competing jets.

Prior to the G700's 14 February first flight, Gulfstream logged some 22,000h of G700 lab

tests. The company makes heavy use of a "systems-integration bench", where staff perform the heavy lifting of meshing the jet's advanced electric systems, which include its Honeywell Primus Epic-based Symmetry flightdeck and a GE Aviation-made data concentration network (DCN).

"Integration is never easy, especially for these complex designs," Miller says. "We have taken it upon ourselves to be the integrator."

The company also makes use of a "cabin integrated test facility", where it evaluates cabin systems.

"A big message for our customers is [that] we test the cabin as thoroughly as we test the flightdeck," Miller adds.

Growing line-up

The test fleet now stands at six G700s, with one more yet to join the programme, and the aircraft have together logged some 600h. The work of envelope expansion testing has fallen to the first test article, with serial number 87001.

"We are starting to validate our take-off and landing performance and we are testing the airplane to make sure that it's fully safe in the event of an engine failure," says Gulfstream senior experimental test pilot Jake Howard.

The second test jet first flew on 20 March and has since been subjected to rig testing, which involves bending and stressing the aircraft to "make sure it can take the loads", he says.

Gulfstream has been performing in-flight-load tests with the third test jet – work that is about 75% complete – and has assigned environmental control and icing evaluations to test jet four.

Jet five and a yet-to-be produced seventh test jet will handle avionics trials, and Gulfstream will use the sixth G700 as a demonstrator and production-test aircraft, Miller says.

The company has completed flutter and aerodynamic stall tests, and earlier this year wrapped up cold-weather testing at Eglin AFB in Florida.

There, the team subjected a G700 to a 10h "cold soak" at -40°C (-40°F): "Just as if you were in Deadhorse, Alaska, and you walk out and crank it up," says Miller.

Pilots have also flown a G700 to the breakneck speed of M0.99 while at 54,000ft – higher than its 51,000ft maximum cruise altitude.

Gulfstream has been running the test programme amid the triple stresses of the coronavirus pandemic, the aerospace industry downturn, and broad criticism of Federal Aviation Administration (FAA) certification processes following two Boeing 737 Max crashes.

Though Gulfstream closed 2019 with its strongest backlog in 10 years, neither it nor its competitors have been spared hardship from the pandemic-driven aerospace downturn, despite suggestions that business-jet demand might inch higher amid the pandemic as flyers shy from commercial air travel.

News broke in May that Gulfstream was cutting 700 jobs. Its parent, Virginia-based General Dynamics, reported that its aerospace business profit fell by 52% year on year in the second quarter of 2020, to $159 million.

Covid-19 has required Gulfstream to proceed cautiously by socially distancing staff and shifting to remote flight briefings.

Although the airframer reviewed its test programme in the light of criticism against the FAA following the 737 Max issues, the agency has permitted it to proceed with its original test plan. The FAA has also adjusted to coronavirus by permitting "virtual witnessing" – meaning regulators can view some G700 tests remotely via webcams, says Miller.

He insists that the various aerospace-industry stresses have not thrown G700 work off track. "There haven't been any major shifts," says Miller.

He ticks off the G700's technical features, noting the cabin systems, advanced avionics and DCN, which he says ease pilot workloads and improve safety and reliability.

R-R designed its 18,250lb-thrust (81.2kN) Pearl 700s specifically for the G700 – a costly but worthwhile effort because "you can't hot-rod an airplane without developing an engine to go with it", Miller says.

The Pearls have "straight and isotropic" aerodynamic air flows and more-optimised combustors, giving them at least 3-5% better fuel efficiency than the G650's 16,900lb-thrust R-R BR725s, says Miller.

"It is at the point where there is no wasted flow,"

Gulfstream

Honeywell Primus Epic-based Symmetry flightdeck with sidesticks, touchscreens and head-up displays

Miller says of the Pearls. "[Rolls-Royce] developed an engine that perfectly matched the airplane."

Combined with drag-reducing "shark fin" winglets, the Pearls contribute to the G700's extreme range – an advertised 7,500nm (13,900km) at M0.85 and 6,400nm at M0.9. Gulfstream continues to evaluate whether it can "do better", Miller says.

The G650ER can also fly 7,500nm, but the competing Global 7500, according to Bombardier, can fly slightly further, to 7,700nm.

Room with a view

However, Gulfstream has said large-cabin jet buyers value additional space more than extra range, noting that jets in the G700's class can already connect extraordinarily distant cities and essentially reach anywhere with one stop.

And cabin space is where the G700 shines, says Gulfstream, describing the jet has having the "tallest, widest and longest" cabin in the industry.

At 17.4m (56ft 11in) long, the G700's cabin is about 3m longer than the G650's and slightly longer than the Global 7500's. The G700's cabin is 1.91m high and 2.49m wide – the same as the G650 and bigger in both measurements (but only by few centimetres) than the Global 7500. The G700 has a 48,800kg (107,600lb) maximum take-off weight and can carry a payload of 2,900kg plus 22,400kg of fuel.

The cabin has 20 of the large, 71.4cm (28.1in)-wide windows found on the G650, providing what Miller calls "a tremendous amount of natural light". Gulfstream will also equip the jet with a lighting system composed of "20,000 LEDs that can simulate any phase of the sun".

"We recognised early on that getting someone that represents customer support in the design and engineering phase is very important"

Mitch Choquette **Vice-president, customer support, Gulfstream**

The G700 has the same Symmetry cockpit as the G500 and G600. It includes 10 touchscreen displays and BAE Systems-designed active-control sidesticks, which are linked so each pilot feels the other's commands, says Miller.

"They allow us to open up the cockpit and allow us to provide pilots with situational awareness," he says, noting that accidents have been attributed to unlinked sidesticks. "The fact that they move together is a first for civil aviation."

Thales is responsible for the G700's flight control computer and Parker Aerospace makes its fly-by-wire control system. The jet has a "predictive landing performance system" that during approach determines where on the runway the aircraft will likely stop, and warns pilots of possible overruns.

The G700 has an enhanced flight vision system based on infrared technology, that presents images of the outside world to pilots, and permits authorised pilots to descend below instrument-approach minimums.

It also has a synthetic vision system (SVS), which displays computer-generated images of the outside world. But while the G500, G600 and G650 have SVS presented on cockpit primary flight displays, the G700 is the first Gulfstream aircraft that has SVS presented on head-up displays (HUDs), says Howard.

Gulfstream is also working on an update that would present combined synthetic-infrared views – a "combined vision system" – on HUDs.

The G700's flight systems, like those on the G500 and G600, feed into the DCN. That network shares data between systems and helps complete some actions previously performed by pilots, such as checklist items.

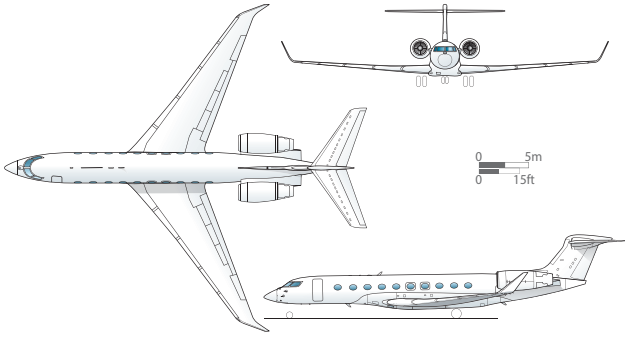
"Our flightdeck philosophy is to make it simple and intuitive... error resistant," Miller says. "We put a tremendous amount of technology into the airplane."

The company produces G700s in the same Savannah Main Plant Campus that houses G650 and G650ER production and uses techniques introduced with the earlier jets.

With the G650, Gulfstream replaced thousands of rivets with bonded stringers, and aerostructure suppliers adopted new induction-welding processes used to construct thermoplastic components.

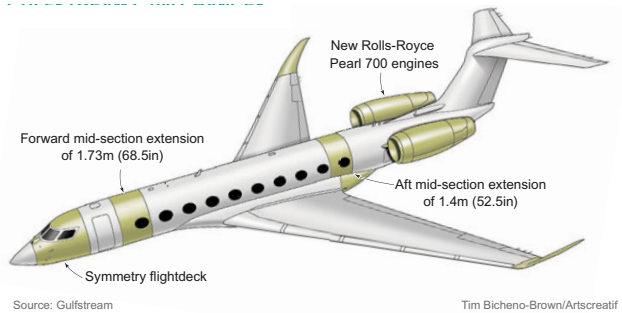
The G700 has a composite and aluminium

Gulfstream G700



Tim Bicheno-Brown/Artscreatif

Gulfstream G700 changes versus G650



Source: Gulfstream

Tim Bicheno-Brown/Artscreatif

Gulfstream

Type made its maiden flight on 14 February 2020

airframe, with composite horizontal stabilisers, pylons, engine nacelles and winglets, says Greg Collett, Gulfstream senior vice-president of manufacturing and completions.

Interior structures such as furniture and cabinets are made from honeycomb composites. The company performs large-jet completion work – which includes cabin installations – at its Savannah site and at company-owned facilities in Brunswick, Georgia; Appleton, in Wisconsin; and Long Beach, California.

Major G700 suppliers include Honeywell, which makes the avionics, touchscreens, auxiliary power units and environmental control and cabin-pressure systems. Collins Aerospace manufactures the jet's horizontal stabiliser trim actuators, power generation and landing-gear systems, while GKN unit Fokker produces the empennage, bonded-fuselage panels and floorboards.

GE provides the G700's health and trend monitoring system and electrical power distribution system. Meggitt makes the wheels and brakes, Nordam supplies wing-to-body fairings and main landing-gear doors, and Safran the fuel distribution system. Gulfstream now manufactures wings for most of its large jets, including the G700, having recently taken over that work from Triumph Group.

Integrated process

A Gulfstream customer support specialist team has been deeply embedded in the G700's development and will play a central role in the aircraft's service entry, says Mitch Choquette, Gulfstream vice-president, customer support.

His department runs a 24/7 technical-support call centre – even supplier representatives are on hand – and has access to two G150s, which are ready at short notice to fly customer support missions. The company began enmeshing customer support staff with development teams as it brought to market the G650, and used the model in developing the G500 and G600.

"The 650 was a game-changer," says Choquette. "We recognised early on that getting someone that represents customer support in the design and engineering phase is very important."

The support team's broad goal is for the G700 to be "maintainable" from the day it enters service. That means ensuring that the aircraft's components are durable and easily accessible, that technicians understand how to repair the jet and that Gulfstream has the right tools on hand. Choquette's team has been involved "in all the design meetings" and has "an equal seat and voice, to share concerns".

Gulfstream will train two "core" customer support employees to be experts in the G700's systems and its "nuances", and will cycle customer service staff, including technical and field representatives, through G700-specific training.

Some staff will get the same flight-safety training the company offers to customers, including reviews of maintenance, engines, avionics and European Union Aviation Safety Agency maintenance licence requirements, which differ from FAA standards.

Gulfstream

'Shark fin' winglet helps make the jet 3-5% more fuel efficient than the G650

Gulfstream

Aircraft has the tallest, widest and longest cabin in the industry, says Gulfstream

"When the airplane does go into service… those people have been exposed to it," Choquette says, noting that Gulfstream aims to be able to complete maintenance and part replacements within 30min.

Customer-support staffers have use of G700 "iron birds" – physical replicas of the aircraft's systems that provide "the opportunity to exercise the airplane in the lab environment".

Gulfstream has also embedded technical operations experts and field service representatives with the G700 flight-test programme. Those employees will validate the jet's maintenance manual, develop "troubleshooting techniques" and document all maintenance equipment required for the G700.

A separate cabin systems team under Choquette's department is responsible for validating the quality of the G700's cabin and the cabin systems' performance. Those technicians and customer representatives participate in cabin reviews and flight tests.

The increasing sophistication of cabin technologies requires Gulfstream to have the specialised cabin division, Choquette says. "This is taken very seriously," he adds.

"The last thing you want to do is go out with an aircraft, the systems are not right, [and] you are not able to support it."

Choquette's team is developing a G700 "material strategy" that aims to ensure sufficient replacement components are available and in the right location, when the aircraft enters service. The company has completed about 85% of the work of compiling a "recommended spare parts list" that will eventually include some 1,400 unique items. About 80% of the G700's parts will be common to other Gulfstream models, with 20% being G700 specific.

Gulfstream has in recent years built up its service network to include facilities in Amsterdam, Appleton, Atlanta, Beijing, Brunswick, Dallas, Farnborough, Hong Kong, Long Beach, Palm Beach, Savannah, St Louis, Van Nuys, and Westfield.

Supporting deliveries is among the customer support team's most critical functions. Before handing over new aircraft, representatives travel to customers' facilities, where they review capabilities and expectations. Gulfstream sends three-strong support teams with aircraft during deliveries. They include a cabin systems specialist, customer operational readiness representative and entry-into-service (EIS) pilot.

The cabin specialists, who ensure customers understand the systems, and the operational-readiness representatives, who review the aircraft, its systems and paperwork, may stay for up to 10 days with customers. EIS pilots, who help customers transition to operating new jets, typically stay for around five.

"It helps [customers], and it helps us to make sure they are going to be successful," Choquette says.

This issue should contain a cutaway poster of the Gulfstream G700. If yours is missing or damaged, please contact ***flight.international@flightglobal.com***

Gulfstream

Manufacturer argues that customers care more about space than extended range

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Coronavirus has been gentler on the sector than its commercial counterpart, but corporate clients are subdued and for many, Zoom calls have replaced the personal contact that drives private air travel

Flexjet

A Flexjet Phenom 300: the operator grounded 40% of its 156-strong fleet early in the crisis

Selling sanctuary

Kate Sarsfield London

The National Business Aviation Association (NBAA) convention was first held in 1954 and has taken place against the background of numerous national crises, from social unrest in the 1960s to the ugly aftermath of 9/11. But this year, in common with every other such event around the world since early March, the industry's main annual get-together, scheduled for October in Orlando, fell victim to the coronavirus crisis.

Despite some evidence that the sector has benefited from the airlines' problems – with executives and high net-worth individuals new to business aviation choosing the security of private cabins and exclusive terminals, rather than risking crowded commercial aircraft and airports – the industry has faced the same pressures as the rest of aviation.

Flight restrictions, quarantine and social distancing rules and a general reluctance by businesses to engage in air travel have all put the brakes on a sector that – in North America particularly – was enjoying impressive growth in 2019. Even so, there are signs that business aviation may be set for a faster recovery than the wider airline industry.

NetJets, the world's largest business aircraft operator, with a fleet of more than 750 jets across its fractional, charter and management units, points to Friday 13 March as a "turning point" in the industry's fortunes.

"Nobody in the United States will ever forget that day," says Patrick Gallagher, president of sales, marketing and service for the Columbus, Ohio-headquartered firm. "Covid-19 was really taking hold and I remember very clearly sitting in my office and every state started to put its shelter [lockdown]

30
Number of Embraer Legacy 450-to-Praetor 500 conversions on order by Flexjet, with one delivered so far

$700m
US government grant funds for Part 135 operators to use on recruitment and training, to be wound down in October

90%
Proportion of people who can afford to fly privately but do not, according to a 2020 survey by McKinsey

rules in place. We had been operating very, very freely throughout the USA up to that point and then everything changed."

He says coronavirus hit NetJets' business "to a greater extent than any event since we were founded in May 1964".

In North America, the company's average daily flights fell by 90% from 400 in mid-March to mid-April 2019 to 40 in the same period this year. Meanwhile, its European sister company experienced a similar decline, from 100 to 10 departures a day. "We were largely offering repatriation and repositioning flights with clients deciding to relocate for the lockdown to their second or third homes in the country," Gallagher notes.

Sharp drop

This drastic decline in flight volumes forced NetJets to ground much of its fleet, cancel half of the 60 planned new aircraft deliveries for 2020, and cut employee numbers by one-quarter at both its European operation and US-based Executive Jet Management subsidiary. "We had to act quickly and these weren't easy decisions to make," says Gallagher.

At rival Flexjet, the impact was similar. "Business was normal for us until mid-March, then it hit a brick wall," says chief executive Mike Silvestro. Like NetJets, much of Flexjet's activity involved repatriation and medical flights. "But daily volumes were at about 20% of what we usually expect in March," says Silvestro. Flexjet grounded 40% of its 156-strong fleet, although it has retained its workforce.

The abrupt fall in flight activity in March was not felt by all operators, however. Luxury charter provider VistaJet describes the early stages of the crisis as "very fruitful" for its business.

"We were probably one of the last companies to feel the effect of lockdown and revenue-wise March was the best month we have ever had, climbing year on year by 15%," says chief operating officer Ian Moore.

He attributes this buoyant period to VistaJet's "truly international" customer base and strong support infrastructure. "We watched globalisation at work, flying customers and their families, largely on repatriation flights, to every continent. It was a lot of hard work but we were uniquely placed to take those flights, due to our global footprint and high-end business jet fleet," says Moore.

The Malta-headquartered company operates an all-Bombardier fleet comprising 73 Challenger 350s and 650s, as well as Global 5000s, 6000s and a flagship Global 7500, which VistaJet took delivery of in February.

However, the buoyancy did not last. Flight activity tailed off in late April as customers largely "stayed put", says Moore. "This was a tough month and we grounded some of the fleet due to a lack of demand." Instead, VistaJet focused on government, medical and specialist cargo flights, which accounted for the bulk of requests, although there was a trickle of repatriation flights. "There was a lot of one-way flying, so we created an empty-leg offering to fill the gap," he says.

VistaJet took the view that this lull would last about six weeks and that recovery would quickly follow. "We made a decision to keep our 1,500 staff on board, so we would be ready when the rebound came," he says.

The decision was vindicated, as from mid-May, when lockdowns eased globally and borders opened up, demand for business aircraft travel resumed in earnest, driven by private and leisure travel.

"Our 73 aircraft are now back in service and we are busier than ever," Moore says. "With international travel on the rebound, we plan to add a second Global 7500 in the fourth quarter and five more examples within 15 months."

So can business aviation continue to exploit the limitations of commercial aviation when it comes to making travel as Covid-proof as possible? "There is an overwhelming desire from today's travellers to minimise their exposure to the virus and for those who can afford it, business aircraft have become the curb-to-curb solution," says NBAA president Ed Bolen.

"Flying privately significantly reduces the number of touch points, compared with airline travel, not least because of the high standards of cleanliness both on the aircraft and at the VIP terminals, which cater for a small, niche customer base," he says.

The industry is successfully capitalising on these public health fears, with many operators reporting a large rise in new entrants to the market.

"We're back to about 80% of our normal demand in the USA and almost at full capacity in Europe," says Gallagher. He notes that travel patterns have changed significantly since the pandemic struck in line with the nature of the flights. "We are seeing a huge increase in the amount of personal and leisure travel, from the swathes of wealthy people who want to see their families and visit the places that they love, but aren't willing to do so commercially," Gallagher says.

Demand is driven not only by NetJets' existing fractional and charter customers but by those new to business aviation, he says. Particularly pitched at this demographic is NetJets' Marquis Card, which it sells in 25h blocks and offers what Gallagher calls "a great introduction to [the] benefits of private aviation".

He says the ultimate luxury is the "absence of worry". High net-worth individuals who previously viewed private aviation as an extravagance that they didn't need, now regard it as a necessity that they can't live without, Gallagher asserts. "There's nothing like a pandemic to make people realise there is a better way to travel," he says.

Despite the slow performance early in the second quarter, NetJets recorded a 50% hike in new customer signings to the Marquis Card in the seven and a half ›

NBAA

Flying privately significantly reduces touch points for passengers, says Bolen

months to mid-August, says Gallagher.

"These customers are making a six-figure investment to have access to our outstanding fleet and service, and we have 25h to convince them to stay," he adds.

His view is echoed by Silvestro. "More than 80% of our fleet has now returned to service and we are adding new customers all the time," he says. As with NetJets, the block charter programme is the "big seller" among customers new to the market, offering access to Flexjet's light-cabin Embraer Phenom 300 and super-midsize Challenger 350s.

Flexjet is also adding Embraer Praetor 500s to its fractional programme this year, along with the first examples from the Legacy 450-to-Praetor 500 conversion programme. "We recently took delivery of the first of 30 upgraded aircraft from Embraer and will take the remainder at a rate of two aircraft a month," says Silvestro.

Gaining Lift

Flexjet made "a smart move in March", he notes, to launch an internal shuttle using Phenom 300s to transport flightcrews to and from their assignments, thereby minimising their exposure to coronavirus "which could ultimately impact our customers", says Silvestro. "The initiative, called Project Lift, has also insulated Flexjet crews from the vagaries of airline travel during the pandemic, including reduced service, elimination of routes and delays, ensuring that Flexjet crews are sure to be at their aircraft when Flexjet owners want to travel," he says. "Project Lift has been a worthwhile investment and we have transported over 4,000 pilots."

The small boost to leisure travel has sustained many business aircraft operators in the past few months, but certainly not all. The wholesale retreat of business flyers has had a devastating impact on many firms as senior executives – a key client base and revenue stream for many operators – are now working from home, substituting face-to-face meetings with virtual exchanges. "Business travellers were the staple of many operators before Covid hit and now they are largely locked down as a result of the pandemic," says Bolen.

He argues that many operators in the USA have been forced to accept assistance from the government. "Congress has made $700 million available in grants to Part 135 [charter] operators so they can continue employing and training staff, but this is winding down in October and economic conditions are currently looking very mixed," he says.

"Business travel hasn't returned for us in any meaningful way," says Gallagher. Prior to the coronavirus outbreak this sector accounted for around half the flight volume across the firm's fractional and charter fleets, he notes, "but since mid-March people are working from home, and only leaving the house when they absolutely have to".

It is a similar picture at Flexjet. "Our business was split equally between leisure and business travel before Covid-19 struck, but the latter market has fallen away, mainly because firms are concerned about employee wellbeing," it says.

That said, corporate flying has resumed within a small group of industries, notably automotive, pharmaceutical and information technology. "Even during a pandemic, executives have to visit their facilities," says Gallagher.

He believes that there has been a marked shift in travel patterns. "Before Covid-19, typically trips would take a couple of days and involve a hotel stop-over

and dinner with clients. Now, senior executives are fitting the itinerary into a one-day trip, which tells you that people are still a little fearful of being exposed [to the virus]. It could be like this for some time," he says.

Commercial stimuli

Lack of confidence may be a major obstacle to the resumption of corporate travel, but market forces, driven by the need to create new business opportunities, will eventually drive demand, says Gallagher. "You can't go visit a facility via Skype, you can't go look at a piece of land via Skype, and you can't hold a roadshow or close a multimillion-dollar deal by Skype. These interactions are far more effective in person," he states.

In a recent blog post, Sheryl Barden, chief executive of business aviation recruiting firm Aviation Personnel International, expressed her concern at the reluctance of companies to resume business travel and called on corporate flight departments – which often use a mixture of company-owned and third-party aircraft – to actively engage with their organisations to stress the important benefits of flying privately in the current environment. They need to offer "an end-to-end solution that focuses on safety – one that delivers significant value to your corporation," says Barden.

This is particularly important as corporate legal executives remain concerned about "duty of care" for their employees, she continues, noting that flight department executives can stress that business aviation has much lower risk, with only about 20 touch points versus 700 for commercial travel.

"It's unrealistic and unfeasible for a Fortune 500 company to ban travel altogether," Barden says. That is why "you've got to get creative".

> "You can't hold a roadshow or close a multimillion-dollar deal by Skype. These interactions are far more effective in person"
>
> **Patrick Gallagher** **President of sales, marketing and service, NetJets**

While the business community mulls a return to private flying, operators continue to tap the high-end private and leisure travellers to help plug the gap. "This market represents a great long-term growth opportunity for our industry," says Moore.

He is confident the industry has only dipped its toe in the pool of well-heeled entrants. He cites a 2020 study by management consultancy McKinsey revealing that more than 90% of people who can afford to fly privately do not.

"The potential for our market is huge," says Moore. "Private air travel is well positioned for a continued rebound and growth."

Bombardier

VistaJet predicted that recovery would begin roughly six weeks after initial lockdown

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The latest iteration of Honda Aircraft's innovative small jet sets new standards in range, fuel efficiency, performance and comfort – and is a pleasure to fly. We put it through its paces

A class apart

Michael Gerzanics San Jose

The lower end of the light jet market, once termed the entry jet segment, has three main contenders: Textron Aviation's Cessna Citation M2, Embraer's Phenom 100EV, and Honda Aircraft's HondaJet Elite.

A strong case can be made that Cessna popularised the small business jet field, with the prolific success of its Citation and Citation Jet models. Embraer, which has been manufacturing aircraft for more than 50 years, first delved into business jets in the late 1990s.

The Honda Motor Company, meanwhile, traces its roots to the period after the Second World War in Japan, where its founder, Soichiro Honda, built motorised bicycles. It advanced to produce motorcycles, and in 1964 became the world's largest manufacturer of them.

Next, Honda moved into the automotive market, where its precision and technical expertise allowed it to produce one of the world's most reliable automobile lines. For a number of years, the company honed its engineering talent by participating in Formula 1, first with its own car and engine but later solely as an engine manufacturer. Honda also is now one of two engine suppliers to the IndyCar racing series, and can be rightly proud of its recent victory in the 2020 Indianapolis 500.

Meanwhile, Honda Aircraft chief executive Michimasa Fujino developed the concept for what would be the company's first commercial offering, the HondaJet.

I have now been fortunate enough to fly all three of the highly capable but different leading aircraft in the light jet sector.

Each sports two medium-bypass turbofan engines and can carry four occupants in comfort to destinations at least 1,130nm (2,090km) away. All three have Garmin flightdecks and are certificated for single-pilot operations – an essential trait, as a good percentage of them are flown by owner operators. Yet once past these broad strokes there is one offering that is clearly different: the HondaJet Elite.

Under Fujino's guidance, Honda Aircraft has deployed notable innovations that by several

Honda Aircraft

Type is optimised for single-pilot operation, and has a maximum reach of 1,438nm

Honda Aircraft

Reduced take-off distance is one of several major improvements in updated model

measures elevate its design to the top of its class.

The most striking feature that differentiates the type from its classmates is its overall configuration. The HondaJet has its engines mounted like no other business jet. Termed over-the-wing engine mount (OTWEM), the company says the distinctive look brings measurable benefits.

Conventional wisdom holds that mounting anything above a wing carries a drag penalty compared with an underwing configuration. From an aerodynamic standpoint, however, the OTWEM configuration increases fuel efficiency by reducing wave drag, which is the result of shock waves generated at transonic speeds. By carefully evaluating wave patterns, Fujino's team determined the optimal location of engines and pylons to harness favourable interference patterns.

The location is defined by its chord-wise, height above, and span-wise location. The first two were determined primarily by aerodynamic factors, expressed as ratios of engine inlet size to chord length and vertical from wing upper surface, respectively. Span-wise location – distance outboard from the fuselage – was largely dictated by structural and aeroelastic considerations. Remarkably, at some points in the flight envelope the engine/wing combination has less drag than the bare wing itself would have.

OTWEM also brings other benefits, especially with respect to passenger comfort. The engines do not encroach on the fuselage, allowing for a larger cabin and tail-cone baggage compartment. Additionally, engine vibrations are dissipated through the wing structure rather than a short fuselage-mounted pylon.

> The most striking feature is its overall configuration. The HondaJet has its engines mounted like no other business jet, with measurable benefits

Innovative design

The wing itself also highlights the HondaJet's technological prowess. It has a natural laminar flow (NLF) aerofoil developed specifically by the company. Typical NLF wings allow laminar flow to about 25% of the chord, but Honda Aircraft says its wing maintains laminar flow to 44% on the upper surface and 60% on the lower surface. The aerofoil's cross section is also thicker than typical NLF designs, allowing for increased fuel tankage in the wings.

Another innovation employed on the HondaJet is an all-composite fuselage. Composites allow the fuselage's shape to be optimised for laminar flow and attendant drag reduction. Since composites are stronger and stiffer than metal construction, cabin interior volume can be maximised for a given exterior profile, while composite structures can also typically be lighter than ones constructed with aluminium.

A back-of-the-envelope calculation, however, shows that a typically equipped HondaJet has a structural weight fraction on a par with the Phenom 100EV and greater than the Citation M2. Finally, composite structures are less susceptible to corrosion, with lower scheduled maintenance costs.

The original HondaJet received US certification in 2015, with the improved Elite model following three years later. Major improvements added with the update include reduced take-off distances, along with increased range and payload capacity.

I accompanied Peter Kriegler, HondaJet's North America sales director, as he performed the pre-flight walkaround inspection of our preview flight aircraft – Elite model serial number 42000141, registered N256BB.

Ken Hall

Cockpit features a Garmin G3000-based avionics system and has an uncluttered feel

Visually, the OTWEM layout does take a moment or two to get used to. To my eye, the engines were mounted lower, more forward and more outboard than a conventional tail-mounting scheme would have dictated.

High quality

During the inspection, I marvelled at the superb fit and finish of the aircraft's exterior surfaces. The wing's polished heated leading edge glistened in the strong sunlight. Few if any fasteners protruded from the upper surface of the wing, having been milled from a single piece of aluminium. These two facets no doubt help to maximise laminar airflow.

As we neared the empennage, Kriegler highlighted the numerous holes drilled in the engine inlets, which reduce noise and vibration in the cabin. A single-point gravity fuelling port is mounted below the vertical stabiliser high on the tail cone. Part of the 213nm range advantage offered by the Elite over the prior model is gained by its tankage of an additional 61 litres (16USgal) of fuel. Rounding the tail, Kriegler pointed out the enlarged horizontal stabiliser and elevator, critical to the Elite's 135m (443ft) shorter take-off distance (sea level, standard day). While slightly lagging the competition at sea level, the HondaJet Elite turns the tables under hot and high operating conditions – 5,000ft and 25°C (57°F) – where it requires significantly less runway than its rivals.

Once on the left-hand side of the tail cone, Kriegler opened the external baggage compartment door. The opening was at a comfortable height, as there was no engine pylon to contend with.

With the walkaround complete, I entered the aircraft and surveyed the passenger cabin, which had a club four configuration and optional galley. As could be expected, the quality of the furnishings was very high. The HondaJet's cabin is longer than those of its rivals, with the length used to increase space between the facing seats. According to the manufacturer, they provide 200mm (8in) more leg room than the Phenom 100EV and 360mm more than the Citation M2. The enclosed lavatory was well appointed and featured skylights to provide an airy feeling. Uniquely for its class, it has a sink and is externally serviced.

Like the Phenom and M2, the HondaJet has a Garmin G3000-based avionics system. While all three types benefit from having three large 14in displays and two 6in touchscreen controllers, I found the HondaJet's flightdeck was a step above its rivals. Overall, it was clean and uncluttered.

Pre-start flows consisted primarily of ensuring all switches were in the NORM/ON position and rotary knobs placed at the 12 o'clock position. Kriegler guided me through the flight management system (FMS) initialisation process, as well as loading of weight and balance information. One nice feature was the take-off/landing distance management function, which combines FMS and XM weather information to compute and display performance data.

Ensuring all pre-flight steps were completed was facilitated by the electronic checklist and its yoke-mounted control, with a combined scroll wheel and select button.

As is typical for most FADEC-controlled engines, starting the two GE Honda Aero Engines HF120-H1As was a snap. During the taxi to San Jose International airport's runway 30L for departure, I found the steer-by-wire nose wheel steering (NWS) sensitive at slow ❱

Ken Hall

Gerzanics, with the test example

Honda Aircraft HondaJet Elite specifications

Dimensions	
Length	12.1m
Height	4.5m
Wingspan	13.0m
Passenger cabin	
Length	3.69m
Width	1.52m
Height (flat floor)	1.47m
Baggage stowage (nose)	0.25cb m, 91kg
Baggage stowage (tail cone)	1.61cb m, 181kg
Weights	
Maximum take-off weight	4,853kg
Maximum landing weight	4,517kg
Useful load (excluding pilot)	1,645kg
Performance	
Take-off distance*	1,064m
Operating ceiling	43,000ft
Range**	1,438nm
Landing distance***	1,075m

Source: Honda Aircraft *MTOW, SL, ISA **4 occupants, MTOW, NBAA IFR ***MLW, SL, ISA

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Ken Hall

Overwing engines increase fuel efficiency by reducing wave drag

speeds, but it did allow for tight turns on the ramp.

With the flaps set to take-off/approach (TO/APPR), take-off speeds for the 4,345kg (9,580lb) aircraft (including two occupants and 880kg of fuel) were: 104kt (192km/h), 109kt and 116kt. I was able to devote all my attention outside the aircraft when I taxied into take-off position, as the HondaJet has an automatic lighting system. This uses GPS information as well as aircraft speed, altitude and configuration to automatically manage the external lights.

Once cleared for take-off I advanced the thrust levers to the TO detent. Acceleration was predictably brisk as the HondaJet has the highest thrust-to-weight ratio of the aforementioned light jets. The speed-sensitive NWS made centreline tracking easy, with no tendency to over control.

At 109kt, light to moderate yoke forces were needed to establish a take-off attitude of approximately 15°. Once airborne I raised the gear and retracted the flaps passing 130kt. Past the departure end of the runway I turned the aircraft downwind for a visual circuit to what would be a full-stop landing. This short hop was flown for the benefit of our photographer on the ground, but would also allow me to gain a feel for how the HondaJet handled in the pattern.

On an extended downwind I lowered the gear and set the flaps to TO/APPR. Starting the turn to final I set the flaps to LDG, fully extended. I used FMS vertical path guidance to monitor my turning descent to final, allowing me to roll out on a 3° glide path for runway 30L. About 50% N1 on the engines held the fully configured HondaJet at the target speed of 109kt.

Situational awareness

Passing about 50ft radar altitude I retarded the thrust levers to IDLE. After initially over flaring, I lowered the nose and the aircraft settled nicely on to the runway. As I slowed the aircraft for runway turn off, the SurfaceWatch system announced "5,000ft remaining". Even on a long runway in clear conditions, I found the callout helpful. For operations out of short/contaminated runways in adverse conditions, the SurfaceWatch system would no doubt greatly enhance situational awareness; a valuable commodity in a single pilot aircraft.

The second take-off was much like the first, but once airborne, I followed FMS guidance to track the TECKY 3 RNAV departure procedure. With the aircraft cleaned up, I set the thrust levers to the maximum continuous thrust (MCT) detent. I followed the default VNAV guidance, which held 210kt until transition to Mach 0.57.

For the latter part of the climb I engaged the autopilot and familiarised myself with the very capable G3000 system. One really impressive function was the display of active Temporary Flight Restriction areas. There were a good number of these along our route because of uncontrolled forest fires, and had we been lower they would have affected our flight.

On a standard day Honda Aircraft lists a time to 41,000ft at maximum take-off weight (MTOW) of 20min – faster than both the Phenom and M2. While we were about 450kg under MTOW, time from brake release to our levelling at 41,000ft was just over 21min. The longer time was the result of intermediate level offs and hotter than standard (ISA +15°C) conditions for the majority of the climb.

Level at 41,000ft I left the thrust levers in the MCT

Honda Aircraft HondaJet Elite versus competitors

	HondaJet Elite	Phenom 100EV	Citation M2
Cabin (L* x W x H)	3.69 x 1.52 x 1.47m	3.35 x 1.55 x 1.5m	3.4 x 1.47 x 1.4m
Cabin volume	6.29cb m	6.03cb m	5.61cb m
Accomodation	2 flightdeck + 5-6** (4 with optional galley)	2 flightdeck + 4-6**	2 flightdeck + 6 (belted lavatory standard)
Range***	1,438nm	1,178nm	1,302nm
Maximum cruise speed	422kt	406kt	404kt
Maximum operating Mach speed	0.72	0.7	0.71
Engines	2 x GE Honda Aero Engines HF120	2 x Pratt & Whitney Canada PW617F1-E	2 x Williams International FJ44-1AP-21,
Thrust	2,050lb	1,730lb	1,965lb
Take-off distance	1,064m	972m	978m
Landing distance	825m (5 occupants), 1,075m (MLW)	741m (4 occupants), 837m (MLW)	789m (MLW)
Thrust-to-weight ratio	38.3%	32.3%	36.7%
Wing loading, kg/sq m	295.9	259.8	217.8
Price	$5.3m	$4.25m	$5.31m

Source: Manufacturers MLW = maximum landing weight *Including lavatory **Belted lavatory optional ***NBAA IFR, 4 occupants

Honda Aircraft

Ken Hall

Cabin (*top*) and tail-cone luggage compartment (*above*) can be larger without fuselage-mounted engines

detent, and allowed the jet to slowly accelerate. During the acceleration I took off my headset and was impressed by the sound of near silence. Kriegler and I were easily able to converse at normal voice levels. He remarked that the largest contributor to the ambient noise was the environmental control system fan, confirmed by the drop in sound when he turned it down to a slower speed.

Next, I noted the cabin altitude had levelled at 7,580ft. The airframer lists a cabin altitude of 8,000ft at 43,000ft for the 0.59bar (8.56psi) delta p system. After about 5min at (ISA+1°C) with an indicated airspeed of 208kt, total fuel flow was 680lb/h as the jet clipped along at a true airspeed of 405kt.

I then retarded the thrust levers to slow the HondaJet to long-range cruise speed. To ease pilot workload and increase efficiency in cruise conditions the aircraft has a cruise speed control (CSC) function. This uses the FADECs to modulate N1s (+/-5% from engagement condition) to maintain set speed. Once stable at M0.613 (177kt indicated airspeed – KIAS) I engaged the CSC. Total fuel flow of 480lb/h maintained a pace of 352kt true airspeed.

With four occupants, Honda Aircraft lists an NBAA range of 1,438nm, a capability borne out by my preview day observations.

Cruise points complete, we started a descent and allowed the HondaJet to accelerate to VMO; 270KIAS. I performed a series of sharp small control inputs in all three control axes, and the aircraft response was well damped.

The HondaJet's speed brakes are aft tail cone panels that open like clam shells, not the typical wing surface panels. To slow the aircraft below VMO I opened the speed brakes, which slowed us without the airframe buffet typically felt in other aircraft. One reason Honda Aircraft has placed the speed brakes on the fuselage may be to keep the wing's NLF aerofoil unmolested by moving panels and attendant surface gaps.

Next I engaged the autopilot to observe the G3000 system's overspeed protection scheme. In a slight descent I advanced the thrust levers to accelerate the aircraft past 270kt, into the barber pole of the primary flight display's (PFD's) airspeed tape. An audible ditter sounded with "MAXSPD" displayed on the PFD. At 275kt, the protection scheme activated, with the autopilot pulling the nose up to reduce speed below the redline.

Slow-speed safety

Satisfied with the HondaJet's high-altitude and high-speed characteristics, I continued the descent to see how it handled at lower altitudes and speeds. Our Elite was equipped with the optional Stability and Protection (S+P) system, with roll and angle-of-attack functions. This is mechanised through the AP servos and intended to help the pilot keep the aircraft in the optimal flight envelope.

The first function we looked at was designed to enhance roll stability. In level flight at 200kt I rolled the aircraft into a 45° angle-of-bank (AoB) turn. On the PFD, two "whiskers" were displayed on the roll arc, indicating when the roll protection would trigger. Rolling past 45° required increased yoke pressure. Releasing the roll pressure at an AoB greater than 45° caused the jet to roll towards wings level but stopping at 30° AoB. With the S+P turned off I was able to execute 60° AoB steep turns, with no additional roll pressure required.

To summarise, when engaged, the S+P system provides electronically enhanced positive spiral stability at bank angles greater than 45°.

The next mode we investigated was the underspeed protection scheme, active when the autopilot was engaged. In level flight I retarded the thrust levers to IDLE and observed the aircraft slowing. As the airspeed approached 98kt indicated "MINSPD" was displayed on the PFD, while "AIRSPEED" was annunciated. Pretending to be a distracted pilot, I just watched as the autopilot pitched the nose over to maintain a safe airspeed. It does this without regard to the engaged autopilot pitch mode – ALT HOLD in this instance.

These roll, high- and low-speed protection modes will stack the deck in favour of a safe outcome for a distracted pilot.

The final set of manoeuvres we accomplished were two approaches to stall. The first was in a clean configuration. Slowing in level flight at about 1kt/s the stick shaker activated at 106kt to signal an impending stall. In the shaker the wings were steady, with little if any airframe buffet. Smoothly relaxing yoke back pressure and advancing the thrust levers allowed the jet to recover to normal flight conditions.

The final approach to stall was in a landing configuration, gear down and flaps to LND. This time

the shaker activated at 91kt, with the wings rock steady and no observed tendency to roll off. Recovery to normal flight conditions was again effected by lowering the nose and advancing the power.

Area manoeuvres complete, we turned towards San Jose for an autopilot-coupled instrument landing system approach to runway 30L. En route to the field I found the vertical profile display very helpful to comply with the altitude restrictions on the approach procedure. Outside HIVAK, the final approach fix, Kriegler simulated an engine failure by pulling the right thrust lever to IDLE. As we levelled at the glideslope intercept altitude I increased power on the left engine.

The HondaJet has a rudder bias system that uses the yaw damper servo to partially reduce pedal forces needed to compensate for asymmetric thrust conditions. The autopilot remained engaged and I used the PFD's slip/skid indicator to fine tune pedal displacement. Roughly 20kg of left pedal pressure was required to compensate for the asymmetric thrust condition.

The autopilot did a fine job of tracking the localiser and smoothly lowered the nose at glideslope intercept. With flaps set to TO/APPR approximately 50% N1 was needed on the right engine to maintain our target speed of 114kt. The rudder bias system was still active, but I did need some pedal to co-ordinate flight.

While Kriegler had briefed me that this approach would end in a missed approach, to demonstrate the HondaJet's coupled go-around capability, it was still a surprise when he called, "Go-Around" at decision height. I hit the thrust lever-mounted take-off/go-around switch and watched the autopilot smoothly pitch the aircraft to a 12° nose up attitude. As I advanced the thrust lever I fed in left rudder to maintain co-ordinated flight. At the TO detent (92% N1) approximately 35kg of rudder was needed to centre the slip/skid indicator.

The rudder bias system kept the needed force well below regulatory limits and would have mitigated the adverse effects had the pilot been slow in proper application of the rudder. With a positive rate of climb I raised the gear, retracting flaps as we accelerated through 130kt. Once the aircraft was cleaned up, we terminated the single-engined manoeuvres.

Go-arounds are a normal but infrequent manoeuvre. The HondaJet's coupled go-around capability is a definite safety enhancer, automating what can be a very demanding procedure.

Bigger, longer, faster

With a slight sigh of relief, having safely executed a single-engined approach and missed approach, I punched off the autopilot and used both engines to enter a visual downwind for runway 30L. The HondaJet's pleasing handling qualities made the visual circuit to a full-stop landing a joy to fly.

Once on the FBO ramp, shut-down procedures were minimal and rapidly accomplished. My 2h at the HondaJet Elite's controls had allowed me to see first-hand its strengths.

Honda Aircraft has set the standard for light jet cockpits. Optimised for single-pilot operations, the HondaJet Elite's G3000-based flightdeck offers a level of operational integration unmatched in its class, with pilot workload further reduced by the automation of routine tasks. The innovative OTWEM configuration reduces drag and increases range, while simultaneously allowing for the largest cabin in this class.

The NLF wing has a heavier loading than its rivals, helping it to cruise faster and offer a smoother ride in turbulent conditions. The HondaJet Elite's enlarged horizontal stabiliser and elevator have brought take-off distances more in line with those of its rivals, but a few may find landing field performance a concern.

Subjectively, I found the HondaJet Elite the most enjoyable light jet I have flown. Objectively, its large cabin, high cruise speed and long legs push it to the top of its class. For those driven by passion and performance the choice is clear: the HondaJet Elite.

Ken Hall

Steer-by-wire nose wheel actuation allows for tight turns while taxiing

Today's attempts to fly on battery power rely on the same Lithium-ion technology that powers cell phones. To really get off the ground, aviation needs a new kind of energy storage technology

Vertical Aerospace

Vertical Aerospace's VA-1X concept features four tilting motors spread across its wings

Taking charge

Dan Thisdell London

A little over a year ago, Elon Musk waded into a Twitter conversation about electric aviation with the remark, "FWIW, based on calcs I did 10 years ago, cross-over point for Li-ion beating kerosene is ~400Wh/kg. High cycle batteries are just 300Wh/kg today, but probably exceed 400 in ~5 years." This summer, he added: "400Wh/kg *with* high cycle life, produced in volume (not just a lab) is not far. Probably 3 to 4 years."

If the magic 400Wh/kg (watt-hour per kilogramme) capacity from Lithium-ion batteries was really so close, one might expect Musk to have launched an electric aircraft company by now – although between cars, rockets, tunnels and exotic ventures like brain-computer interface implants, even he may have enough on his plate. But whether or not the Tesla and SpaceX magnate intends to join the few dozen existing electric flight projects at various stages of development, his figures highlight the issues that stand in the way of zero-emission flying. Energy storage, rate of output, mass and manufacturing technology all weigh on the feasibility – and economics – of battery-powered flight, so the question is: are today's batteries good enough to do it?

The answer appears to be: yes, sort of.

The business case for what are typically electric vertical take-off and landing (eVTOL) craft capable of operating from small city centre helipads is the dream of avoiding road congestion, hence the generic term "urban air mobility". That vision is summed up in the name given to its project by one of aviation's biggest players: CityAirbus. Far smaller but no less ambitious is Vertical Aerospace, a UK start-up that unveiled its VA-1X design in late August, with a promise to bring an air taxi to market as soon as 2024.

Distributed propulsion

The VA-1X exploits a key appeal of electric designs; the ability to distribute propulsion more widely than is possible with traditional combustion engines or jets. With four tilting motors spread across the wings of an otherwise conventional layout, the machine will take off and land vertically, but transition to more efficient fixed-wing flight for cruise. Vertical Aerospace is not

73-100 miles

Maximum range of 'a vertical-to-fixed-wing transitioning aircraft' powered by current Lithium-ion battery technology, according to the American Chemical Society

2,700Wh/kg

Theoretical energy density limit of next-generation Lithium-sulphur cells, a technology that removes the need for heavy, costly and environmentally damaging nickel and cobalt

commenting on its batteries, but promises to move a 450kg (990lb) payload – a pilot plus four passengers – at "cruise speeds of 150mph [130kt] with a useable range of up to 100 miles [160km]". Critically, Vertical says its "ultimate aim is to make the VA-1X significantly cheaper than helicopter flights, removing one of the major barriers to environmentally friendly air travel".

Dr James Robinson, a senior research fellow in chemical engineering at University College London, sees Vertical's objectives as feasible but "aggressive". Today's Li-ion batteries – the familiar power source for everything from personal electronics to roadgoing vehicles like Tesla cars – reflect a 30-year-old technology, he says. They are well understood, acceptably low cost and can be tailored to deliver an appropriate balance between the raw power output needed to heft an eVTOL off the ground or bring it gently back down, and to propel it forward in the relatively low-power but long-endurance cruise phase.

But while Li-ion batteries can make short flights feasible, and also have reasonably attractive recharge times and charge-discharge cycle lives, range is their weakness, Robinson tells *Flight International*. He points to a 2018 paper from the American Chemical Society's *Energy Letters* journal on the battery performance ultimately needed by eVTOL platforms. There, the authors (including a representative of Airbus's "Acubed" Silicon Valley innovation centre) analyse "a generic vertical-to-fixed-wing transitioning aircraft" and conclude, based on current Li-ion technology, that for an aircraft with a gross take-off mass of 1,000-2,500kg "an operational range of 73-100 miles [40-60km] represents the upper limit".

Indeed, a quick look at automobile specifications underscores the shortcomings of Li-ion for aviation. According to *Car and Driver* data, a Tesla Model S has a range of nearly 650km and curb weight of 2,200kg. A comparably-sized BMW 530i has a range of up to 950km but a kerb weight of barely 1,700kg. The Tesla may pack plenty of performance and feature low-mass and low-maintenance electric motors, but the batteries weigh, literally, a ton.

Shutterstock

The Tesla Model S has curb weight of 2,200kg

As Robinson detailed in a July 2020 paper for the Faraday Institution, a battery technology research group based at the Harwell hi-tech cluster near Oxford, Li-ion technology today can deliver a maximum of about 250Wh/kg, the standard comparative measure of battery energy density. But while there is scope to boost Li-ion energy density – clearly a critical measure for aircraft, which must minimise weight – Robinson describes the technology as "reasonably well optimised" and sitting on a "plateau", with the prospect for only incremental improvements. Moreover, those Wh/kg figures are at the cell level; that 250Wh/kg cell delivers maybe 170Wh/kg when packed into a battery with suitable casing. So what is needed to move aviation away from fossil fuels, he writes in that July edition of *Faraday Insights*, are "batteries that extend performance beyond the limits of Li-ion technology".

Energy density

That next-generation technology may be at hand. Lithium-sulphur cells, says Robinson, are at a "pre-commercial" stage of development but promise a dramatic leap in energy density. Li-S cells have a theoretical energy density limit of 2,700Wh/kg and have already been demonstrated at 470Wh/kg, with 500Wh/kg expected by early 2021.

Li-S cells today degrade rapidly in use and so suffer from low-cycle lifespans, but the technology bypasses Li-ion's need for heavy, costly and environmentally damaging nickel and cobalt; sulphur is one of the most abundant elements on Earth. Li-S cells are also inherently safer, with much reduced likelihood of overheating and fire, and unlike Li-ion can be stored and shipped when fully discharged.

Today, Li-S has two shortcomings for aviation. One is relatively poor power per volume, so Robinson expects the first applications in transport to be in large vehicles like buses and trucks, though the next five years could see them in applications like satellites or drones.

For eVTOL aircraft, the great Li-S drawback is a rate of discharge too slow to deliver the surge needed to get airborne. An early attempt to build an aircraft around Li-S power was announced in July 2020 by UK battery developer OXIS Energy and Texas Aircraft to convert, in Brazil, its high-wing Colt S-LSA into a two-seat trainer, with 2h/200nm range.

Robinson stresses that the transformative power of this new technology will depend on whole-aircraft optimisation, not just better batteries: "Planes will have to be redesigned to accommodate electric aviation." Li-ion eVTOL types flying in the mid-2020s, he reckons, can be a bridge to more ambitious 2030s aircraft built around Li-S technology; hybrids – using Li-ion power to get airborne and Li-S to deliver cruise range – are an attractive idea.

Meanwhile, he describes Musk's 400Wh/kg as "an interesting number. I'd like to talk to him about it."

From yuckspeak to tales of yore, send your offcuts to murdo.morrison@flightglobal.com

The predictions of Mystic Michael

Some of the early predictions about the impact on the industry of Covid-19 proved to be hopelessly wide of the mark – almost on a Trumpian scale – including this one from "Mystic" Michael O'Leary, at the A4E conference in Brussels in early March.

Ryanair, said its chief executive, did not expect the effects to last through the summer, and the crisis might all be over a lot earlier. Demand would dip for roughly three weeks and "then people will get bored with coronavirus", he suggested. A few weeks later, the Irish carrier grounded its entire fleet.

Mind you, his fellow airline boss Willie Walsh's crystal ball was not exactly in full working order either. The since-retired IAG chief executive dismissed the notion that aircraft could be grounded across the globe as happened after 9/11, and forecast that any downturn in traffic "will stabilise in the coming weeks".

Yuckspeak, No. 980

"Corporate purpose as a moral compass in the crisis: Thales has defined its purpose as 'building a future we can all trust'. It is a statement that took six months to write, six months of consultations with almost 50% of the Group's 83,000 employees about our motivations and about the needs of society today and tomorrow. It's the exact transcription of the DNA that has shaped the Group since it was founded more than a century ago. It is crucial for our customers – the people behind the infrastructure that forms the nervous system of our societies – to share and support this vision. We only succeed if our customers succeed. Is our purpose ambitious? Yes, it's tremendously ambitious. And we need to show humility because Thales does not claim to be the be-all and end-all of trust."

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Indonesian Aerospace

Indonesia's twin-turboprop will be a museum piece

From the archive

1920 The man in the street

We have urged on many occasions that there is only one possible way in which the suffrages of the man in the street are to be gained for the cause of aviation and that is by making him practically familiar with all its possibilities. Even though the War made him accustomed to seeing aeroplanes in flight and the reading of their performance may have given him to think that there was rather more in flying than he had been led to believe, aviation is still something with which he has not actually come face to face and he retains to some extent the belief that those who fly in aeroplanes are of the stuff of which heroes are made and not for the ordinary person. He will never believe differently until he has been enabled to test for himself the ease and safety of aviation.

1945 Whittle's achievement

Outstanding interest in turbine jet propulsion was convincingly demonstrated last Friday when Air Comdre. Frank Whittle, C.B.E., R.A.F., read his paper in London. Long before the time announced, the lecture hall was filled to overflowing and a disappointed crowd was shut out unceremoniously, although many had tickets of admission. The paper dwelt mainly upon the historical angle, and as such is a worthy record of the development work associated with Whittle's pioneer efforts with turbine-compressor units for jet propulsion of aircraft. His recount of the many troubles encountered with his original units, and of the measures taken to overcome them, constituted a magnificent example of patience, fortitude, and confidence in the final outcome.

Watch this space

Anyone looking for an adventure in space and time could have done worse than join the press conference that was hosted by Ukrainian aviation bureau Antonov on 9 September.

Its event in Kiev coincided with the 100th anniversary of the founding of a company that became the Antonov plant.

The 'time' part came from the unveiling of a new range of wristwatches, produced under the Kleynod brand in co-operation with the aircraft firm. But to take care of the 'space' bit, Antonov held the conference in the cavernous freight hold of its legendary An-225, the world's largest operational aircraft.

Video records of the gathering indicate that social distancing was easily managed within the empty 6.8m-wide cargo bay – hardly a surprise, given that the colossal six-engined jet, designed to shoulder the Soviet 'Buran' shuttle, has a payload capability of 250t.

That's about 1.2 million watches or 3,300 horologically-minded journalists.

N250: a dream ends

The only surviving prototype of the twin-turboprop airliner that represented Indonesia's ambition to join the elite of aircraft-manufacturing nations in the 1990s – the IPTN N250 – has been handed over to the Mandala Aerospace Central Museum in Yogyakarta.

The N250 was an ambitious development and an icon to many Indonesians. Part of the drive by the region's "Tiger" economies to develop high-tech, competitive industries in the late 20th century, the project was killed by the Asian financial crisis. In 1998, the company told *Flight International* that, with the bankrupt government having withdrawn support, the programme needed overseas funding to survive.

The original 50-seat N250 was announced at the 1989 Paris air show and rolled out in November 1994. It flew for the first time on 10 August the following year, an event of such importance to the nation it was named National Technology Revival Day. A 70-seat stretch followed, and the aircraft was to have been the springboard to a 100-seat passenger jet, the N2130.

Final resting place

More than 200 skeletons of mammoths have been found at an airport construction site near Mexico City. Sadly, it is not the only airport these days where plenty remains of jumbos from another era can be found.

50

1970 Going underground

Mr Masefield said that the proposed rail link from central London to Heathrow—by extension of the Piccadilly line of the London Underground—was not in the authority's view the best solution; the scheme based on extension of British Rail track into the airport, connecting it with Victoria Station, although more expensive, would have been more satisfactory. But the main thing was, that a link should be provided as soon as possible. Mr George Hole, BAA chief executive, said that it did not appear that the rail link could be operational before 1976. The Underground extension has been recommended to the Government by a special steering committee as the preferable method of providing the link; the work is expected to cost £19 million.

25

1995 Astronomical prices

After six years of wrangling, the 14 members of the European Space Agency (ESA) have finally agreed on their financial contribution to the US/Russian-led Alpha international space station. An ESA ministerial meeting at Toulouse on 18-20 October hammered out a substantial compromise which overcame fundamental differences between France and Germany over spending priorities. France can now pursue developments of the new Ariane 5 launcher, will have leadership of the automatic transfer vehicle for the space station, and can begin development of a crew-rescue vehicle, while Germany will lead work on the COF orbital laboratory. An attempt by the UK to cut ESA science programmes by 25% was blocked, leaving the spending plan virtually intact.

Keeping control

I am a long-term reader, and very keen to keep in touch with the industry.

In the late 1960s and 1970s, I was very much involved – initially recruited as a sales engineer for the Panavia Tornado and then working on the Airbus A300's secondary flight-control systems. After selection, I was promoted to contracts manager for what was to be a very exciting ride.

The A300 contract also included its tailplane actuator, which our design team had proposed as a triplex system because of its vital contribution to the aircraft's safety.

Boeing's original fitment of a simplex actuator for the 737 Max is beyond comprehension. Its proposal to modify it to a duplex-signalled actuator is, I believe, totally unacceptable, and should not be awarded airworthiness.

Name and address supplied

High praise

I enjoyed reading Captain R E Gillman's flight-test article again on the Boeing 747 (*Flight International*, September).

He wrote about the cockpit height and difficulty of not cutting corners when taxiing.

In a Douglas DC-10 (covered separately in the same retrospective package) the front wheels were so far behind the cockpit that you really did think you were farming when you made a turn!

John Wallinger
Upton Grey, Hampshire, UK

Maths vs Musk

The "magical" 400Wh/kg output needed to enable electric flight is being touted as the point where batteries can go head to head with kerosene. Elon Musk says so (FlightGlobal.com, 11 September), but I think his calculations are out by a factor of 10.

Batteries are measured in Wh/kg, whereas kerosene is in MJ/kg. The conversion is 1Wh equals 0.0036MJ.

Kerosene is around 43MJ/kg, but as modern turbofans are around 35% efficient we can effectively de-rate its effective energy density to around 15MJ/kg.

Not all of this will be converted into thrust, as some will drive electrical load, the environmental control system and so on.

That 15MJ/kg is equal to 4,160Wh/kg.

If a battery-powered aircraft has a drivetrain (invertors, wires, and other components) that is generously 95% efficient, then a 400Wh/kg battery could be de-rated to 380Wh/kg.

For every 1kg (2.2lb) of kerosene you'd need approximately 10.9kg of battery to generate the same duration of usable thrust, so I am left with the conclusion that the hurdle for directly equivalent long-range larger electrically powered aircraft should be batteries with approximately 4,000Wh/kg.

An electrically driven fan motor, mostly iron and copper, will be heavier than a turbofan, which is mostly air by volume. The electric aircraft will need high altitude-capable wiring insulation and power convertor hardware, but could offset that against lower drag options, such as using a blended-wing body, boundary layer ingestion, wake drag reduction, or flying slower.

By contrast, a kerosene-powered aircraft becomes more efficient in flight, as it burns off fuel and grows lighter. A narrowbody such as an Airbus A320 has a maximum range of 3,000nm (5,550km), but a typical flight might only cover 1,000nm – so perhaps a limited range would not preclude sales of a aircraft while limiting the volume of batteries that need to be carried.

But even allowing for this, the required battery capacity only drops to 1,330Wh/kg: far above what is currently available or envisioned.

Chris Elliott
Coventry, West Midlands, UK

Boeing

Jumbo cockpit made corners a challenge

Well said

Reading that the author of the excellent letter: "Quality counts in the cockpit" (*Flight International*, 11-17 August) chose not to disclose his or her identity, I must confess I was momentarily tempted to claim authorship. I would certainly have taken pride in seeing my name under such a profoundly qualified view.

Piter Kraus
Hamburg, Germany

Air India Express tragedy occurred on 7 August

Shijith Sreedhar/AP/Shutterstock

The scourge of tailwind landings

During my 32 years as a pilot and flight instructor with SAS, the company had three accidents in connection with landing; all in tailwinds. These involved a Caravelle (Ankara), DC-8 (Los Angeles) and DC-10 (New York). In addition, the domestic carrier Linjeflyg had a fatal landing accident in a tailwind, with a Metro II in Angelholm.

I studied psychology at Stockholm University, and have researched and analysed the world's tailwind accidents.

There are two types of aircraft crashes in connection with such conditions.

In Type 1 events, the pilot flies as in "downhill" and enters the runway at too high a speed and slips off at the end of the runway. This is pilot error, as the crew should have aborted the approach as it was not stabilised.

A Type 2 incident involves the pilot reducing the aircraft's speed to the correct value, but as it approaches the ground – where the wind always decreases – the airspeed indicator shows an increase in speed. By reflex, the pilot reduces the engine power and before there is time to correct that error, the aircraft crashes short of the runway.

After an article of mine appeared in the Flight Safety Foundation's monthly journal, Airbus and Boeing reprogrammed their automatic speed controls so that they also register the aircraft's speed over the ground via radar. When these indicate that the air speed decreases when the tailwind lessens, it increases the engine power, even though the pilot's flight speed indicator shows an increase in speed.

Your half-year safety report (*Flight International*, 11-17 August) listed the 5 February crash of a Pegasus Airlines Boeing 737-800 in a 20kt (37km/h) tailwind. On 7 August, an Air India Express 737 suffered a similar fate, with a tailwind of around 10kt.

Both were "Type 1" incidents: ones that cannot be handled by the autothrottle – only the pilot can avoid them.

Gunnar Fahlgren
via email

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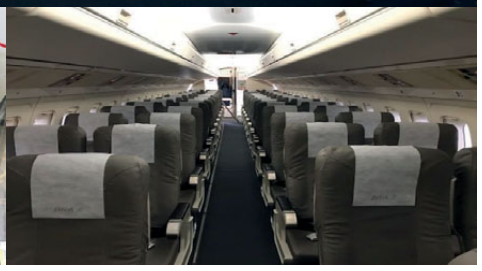

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In the latest of our articles championing the role of women in aviation, we detail the career of Royal Australian Air Force Wing Commander **Marija Jovanovich** – from a pivotal Cessna 152 flight

Don't let doubters shatter your dream

Greg Waldron Singapore

Wing Commander Marija Jovanovich has had a career of high adventure in the Royal Australian Air Force (RAAF), but contends that while careers in aviation are definitely possible for women, they are not always clearly accessible.

Jovanovich's career in the RAAF kicked off as a pilot on the Lockheed Martin AP-3C Orion maritime patrol aircraft (MPA) from 2007 to 2011. Subsequently, she became a test pilot after completing one year of training at the US Air Force Test Pilot School at Edwards AFB in California.

She has flown more than 30 types of aircraft, including the Boeing F-15D and E, and F/A-18F Super Hornet. Perhaps the most exotic model she has flown is the Lockheed F-16 VISTA, or 'Variable Stability In-flight Simulator Test Aircraft'.

"When I flew the VISTA I realised that when I jump into any airplane, you make an unwritten contract... where you tell the airplane that you're going to do your best to keep it inside its flight envelope and not damage it. And the airplane says to you that every time you put an input in, it's going to react more or less the same as it did the last time you put in that input."

On the VISTA jet, however, this contract did not hold, because the backseater can make adjustments that radically change the aircraft's handling. The VISTA can even mimic long-retired types, such as the USAF's Century Series of fighters from the 1950s and 1960s.

Jovanovich is hard pressed to state her favourite aircraft type, but confesses a very strong attachment to the AP-3C. She is in the process of requalifying for the type, as she is set to take command of 10 Sqn, which operates a pair of AP-3C(EW) electronic warfare aircraft – the Boeing P-8A Poseidon has replaced the RAAF's MPA-roled Orions.

Jovanovich did not have a great passion for aviation as a child. Her parents are not pilots, but surgeons.

"As a kid I was a bit of a nerd, and I use that word affectionately," she says. "I had a love for both science and adventure. I wanted something that would satisfy both of those drives. In my mid-teens, aviation started to crystallise as something that would satisfy both."

A life changing event occurred at the age of 17, when Jovanovich attended the Walsh Memorial Scout Flying School, in Matamata, New Zealand. She recalls a Cessna 152 flight from a grass airstrip.

"The first time I jumped into one of those aircraft, I knew that was what I wanted to do. Some people think they want to fly for a living and they jump into a small airplane and take off and realise 'Nope, this is definitely not [for me].' I had the opposite experience."

From then on her focus was joining the RAAF as a pilot. She suggests that young people interested in aviation should get airborne in a small aircraft.

Jovanovich says that her experience with the RAAF has been overwhelmingly positive. She adds that the service has done everything possible to get more women involved both as aircrew and in technical roles, but that it is hard to move the needle. She points out that the RAAF had its first two female pilots in 1988, but that 18 years later when she graduated flight school in 2006, she was only its 13th.

"To me, that's a clear indication that while it was possible for women to do the job, for one reason or another it was not accessible."

One challenge she observes is that a large part of the public is simply not aware that there are female pilots in the RAAF – this despite campaigns to raise awareness. The service even has a section on its website dedicated to female pilots. But as of February 2019, just 38 (5%) of its 752 pilots were women.

Jovanovich believes the challenge goes well beyond the air force, to society at large. Young women can even be discouraged from attempting to start a career in a field that is perceived to be the domain of men.

"Generally as a society we still have quite entrenched gender roles when it comes to employment," she says. "When I talk to high school students, they already have a very good idea of what they can and can't do. When I talk to primary school students, they already have a pretty strong idea of what male and female jobs are."

Jovanovich adds that another big misconception about becoming a pilot is that it requires advanced abilities in physics and mathematics. She is eminently

Commonwealth of Australia

Entrenched gender roles are still a barrier to women entering the industry, says Jovanovich

"If your passion is aviation, follow it, even if that means going against the people who are telling you that you shouldn't do it"

qualified to comment about this, as she studied mathematics and physics at university.

"You need to be able to do some of it, but you're taught the bits you need. Being awesome at math and science is not a requirement... and it should absolutely not be a barrier for getting involved in the field.

"If your passion is aviation, follow it, even if that means going against the people who are telling you that you shouldn't do it," she says. "And this particularly applies to young women, because they are more likely to be the ones that get told that this isn't for you, you can't do this, and you shouldn't do this. My advice would be to back yourself and give it a go anyway."


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