FlightGlobal.com December 2020

FLIGHT INTERNATIONAL

INSIDE

Uncle Roger's fiendish quiz

High fliers

Our World Air Forces review details the global fleet p40

Saab thrives with new boss p20

Are jet packs ready to take off? p70

Awkward union
Why China still needs USA for development
p16

Gulf power
UAE given nod after targeting F-35A purchase
p18

£4.99

A WORLD OF SUPPORT

Wherever your destination, Gulfstream Customer Support has you covered. With an extensive force of experts around the world, we offer responsiveness matched only by our devotion to detail. It is our pleasure to serve you.

Gulfstream™

A General Dynamics Company

Surprise strike

The UAE's unexpected approval for an F-35 buy can be seen as just part of a US strategy to support its allies in the region

Even after the most turbulent of years had taught us all to expect the unexpected, Washington's snap announcement of a planned stealth fighter sale to the United Arab Emirates (UAE) still came as a big surprise.

Add to that the fact that the proposed first transfer of Lockheed Martin F-35s to an Arab state had received tacit support from Israel.

The UAE has of course long been seeking to add the fifth-generation fighter to its already impressive combat fleet. But the USA's underpinning of Israel's comparative military advantage in the Middle East meant there was no Lightning II on the ground at the Dubai air show in November 2019 – although an example made a debut flying appearance at the event.

While previously unable to gain approval for an F-35 acquisition, Abu Dhabi had dallied with Dassault on the Rafale, eyed the Eurofighter Typhoon and also considered adding to its existing Lockheed F-16E/F inventory with more capable Block 61 examples. Ultimately, it chose to bide its time – to good effect.

While it waited, other Gulf Cooperation Council members moved to strengthen their fleets around it. For Saudi Arabia, this meant taking new Boeing F-15SAs, while Bahrain is to field 16 new F-16Vs and Kuwait 36 Typhoons.

Meanwhile, Qatar – now isolated by the UAE and its allies because of Doha's alleged leaning towards Tehran – is making the most marked step. It has so far fielded 23 of an eventual 36 Rafales, with the same number of F-15s and 24 Typhoons also to join its ranks.

The timing of secretary of state Mike Pompeo's announcement of a prospective broader $23.4 billion arms package for the UAE – amid the political turmoil following the contested outcome of the US election – only added to its surprise nature.

In what now looks set to be a final flurry of defence sale approvals before the Trump administration makes way for US President-elect Joe Biden in January, Washington had just weeks before drawn China's ire by backing the sale of new F-16s and General Atomics Aeronautical Systems MQ-9B unmanned air vehicles to Taiwan.

But what directly advanced the prospect of 50 F-35As and related weapons, plus 18 armed MQ-9Bs boosting the UAE's military capability, was its recent normalisation of relations with Israel. Brokered via the USA, this development has already seen the commencement of direct commercial flights between the nations.

The strengthening of another US ally in the Middle East region is seen as good news for pretty much everyone but Iran. As Washington turns its attention to preparing for potential future conflicts with China and Russia, arming its friends elsewhere with the best equipment it can offer spares its assets for the bigger battles to come. Job creation at home is a further bonus.

With stealthy F-35As, plus its Saab GlobalEye surveillance aircraft, the UAE will have a highly capable air force fleet – more than able to address the threat posed by Iran's military.

As for Israel, its air force now operates 23 F-35I Adirs from a planned 50-strong fleet of the type. While it already has this technological head start on the UAE, it also retains a unique status in being able to update the aircraft with its own systems. As such, it won't be getting outmanoeuvred by its neighbours any time soon.

See p18

Mo Azizi/Shutterstock

Towering ambition

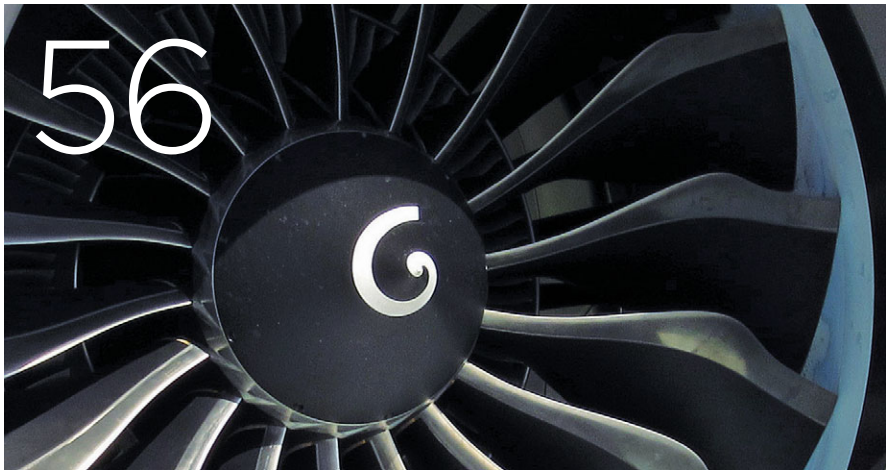
In focus

Cover: Jamie Hunter

Regulars **Comment 3 Straight & Level 74 Letters 76 Jobs 81 Women in aviation 82**

Features

Strength in numbers:
World Air Forces review



The return of the Max

FAA takes lead in re-approving Boeing's flagship narrowbody, as airframer works through updates to existing aircraft

Jon Hemmerdinger Tampa

US regulators have cleared the Boeing 737 Max to fly again, a move that came 20 months after the jet was grounded following two crashes that killed a combined 346 people.

The Federal Aviation Administration (FAA) on 18 November rescinded its 13 March 2019 "Emergency Order of Prohibition" – the document barring US airlines from operating Boeing's latest 737 iteration.

"The design and certification of this aircraft included an unprecedented level of collaborative and independent reviews by aviation authorities around the world," says the agency. "Those regulators have indicated that Boeing's design changes, together with the changes to crew procedures and training enhancements, will give them the confidence to validate the aircraft as safe to fly in their respective countries and regions."

US airlines can now operate the Max again – but only after the jets receive specific modifications, and only with pilots who complete new training related to the narrowbody's Maneuvering Characteristics Augmentation System (MCAS). Before flying, the jets will also have several other alterations, such as changes to horizontal stabiliser wires to comply with the latest FAA regulations.

Pilot training

The FAA must also approve US-based Max operators' pilot training programmes, and the agency has retained authority to issue the airworthiness certificates that clear each specific new 737 Max to fly. Previously, Boeing had that ability.

"Airlines that have parked their Max aircraft must take required maintenance steps to prepare them to fly again," says the FAA.

"We will never forget the lives lost in the two tragic accidents that led to the decision to suspend operations," says Boeing chief executive David Calhoun. "These events and the lessons we have learned as a result have reshaped our company and further focused our attention on our core values of safety, quality and integrity."

With the FAA having acted, attention now turns to other regulators, who must also clear the jet before it can be operated more widely.

Boeing says it had already started making the wire changes to stored Max aircraft. But only now, with the FAA having cleared the jet, will it begin the MCAS-related updates, it says.

How much time will pass before the Max returns to revenue service remains unknown. But American Airlines has scheduled 737 Max flights for the end of December.

Other US airlines with the Max in their fleets include Southwest Airlines and United Airlines.

3,365

Boeing's current backlog for the 737 aircraft, according to Cirium data

Globally, airlines have 391 Max in storage, including 86 in US airline fleets, Cirium data shows. Boeing's backlog includes 3,365 737s.

Resuming deliveries should give Boeing a critical influx of cash, as customers typically pay the majority of a jet's cost upon receipt, analysts have noted.

In addition to rescinding the grounding order, the FAA on 18 November published an airworthiness directive (AD), laying out required changes to the jets. It mandates various updates, including notable changes to MCAS, the flight-control system that played a central role in the two crashes.

MCAS will now receive input from both the jet's angle-of-attack (AoA) indicators, and flight-control computers will disable MCAS if the AoA data disagrees, the AD says.

MCAS activates based partly on AoA data and previously had received input from only one sensor.

David Ryder/ZUMA Wire/Shutterstock

Control column

Also, MCAS can now activate only once per "sensed high AoA event" – not multiple times, as happened during the accidents, when the nose of the each aircraft was repeatedly forced down. In addition, pilots will always be able to override MCAS by pulling back on the control column, says the AD.

The AD also mandates that the jets must have cockpit AoA disagree alerts.

Boeing has also updated software to prevent "a theoretical combination of faults that could lead to a runaway stabiliser" – a condition when the trim system makes uncommanded stabiliser adjustments, it says. Likewise, new software prevents the "remote possibility" of autopilot disengagement.

Additionally, horizontal stabiliser wires must be separated to ensure they meet FAA requirements. And all 737 Max will be checked for foreign object debris, Boeing says.

Max pilots must complete new MCAS-specific training and experience MCAS activation in simulators. New training also addresses manual trim issues and "runaway stabiliser" events.

The FAA recertification follows an unprecedented and remarkably

American Airlines plans to have the type back in service by the end of December

turbulent chapter in Boeing's 104-year history. The Max's troubles began with the crash of Lion Air flight 610 on 29 October 2018, killing 189, and was followed a little under five months later when Ethiopian Airlines flight 302 went down on 10 March 2019, causing the deaths of all 157 on board. Both jets were 737 Max 8s.

Investigators believe the crews could not keep their aircraft in the sky after faulty AoA inputs caused MCAS to repeatedly activate.

Boeing equipped the Max with MCAS to address aerodynamic changes resulting from the jet's CFM International Leap-1B engines, which are larger than the 737NG's CFM56 powerplants.

The Leaps can make the Max pitch nose-up in certain circumstances. MCAS counters that tendency by trimming the horizontal stabiliser, pitching the nose down.

Boeing took heat for not fully disclosing the existence of MCAS to customers, and for a software glitch that made AoA "disagree" alerts inoperable on some jets.

The crashes spurred investigations that shook Boeing to its core; documents surfaced that raised troubling questions about its inner workings. Critics accused the airframer of dismissing internal concerns about the Max's safety, of wrongly denying the need for Max-specific pilot training, of having too much influence on FAA inspectors, and muscling the Max through the FAA's certification process.

Boeing's executives, including Calhoun, insist the company's top priority remains safety. Since the crashes, Boeing has created a new internal safety division and shifted its structure so engineers report to the chief engineer, not to business unit heads.

The crashes also prompted widespread criticism of the FAA's certification process and its delegation of huge chunks of certification work to aircraft manufacturers.

Why recertification of latest 737 variant is only the start of airframer's troubles

Although the US recertification of the 737 Max removes a significant blockage to the resumption of deliveries, it is in some senses only the beginning of Boeing's troubles.

The move comes at a point of uniquely depressed demand, when many airlines have little need for new aircraft.

Additionally, the pace at which other regulatory agencies – notably the Civil Aviation Administration of China – re-approve the Max will also have a bearing on when shipments can restart to all carriers.

The situation is made more complicated by the fact that Boeing is sitting on a huge stockpile of built but undelivered 737 Max jets – around 450 aircraft, according to most estimates. It must work through that inventory before any significant production ramp-up can take place. And bear in mind that many of those aircraft no longer have a customer – through cancellation or bankruptcy – and will need reconfiguration before delivery.

How quickly Boeing can do that has knock-on consequences for its suppliers as they plan for future rate rises. Indeed, in its most recent forecast – at the end of October – the airframer has materially reduced the number of stored 737 Max types it expects to deliver in 2021, cutting the figure to about 225, with the majority following in 2022.

Previously the bulk of the undelivered inventory was due to ship in 2021.

"We expect to have to re-market some of these aircraft, and potentially reconfigure them, which will extend the delivery timeframe," says Boeing chief financial officer Greg Smith.

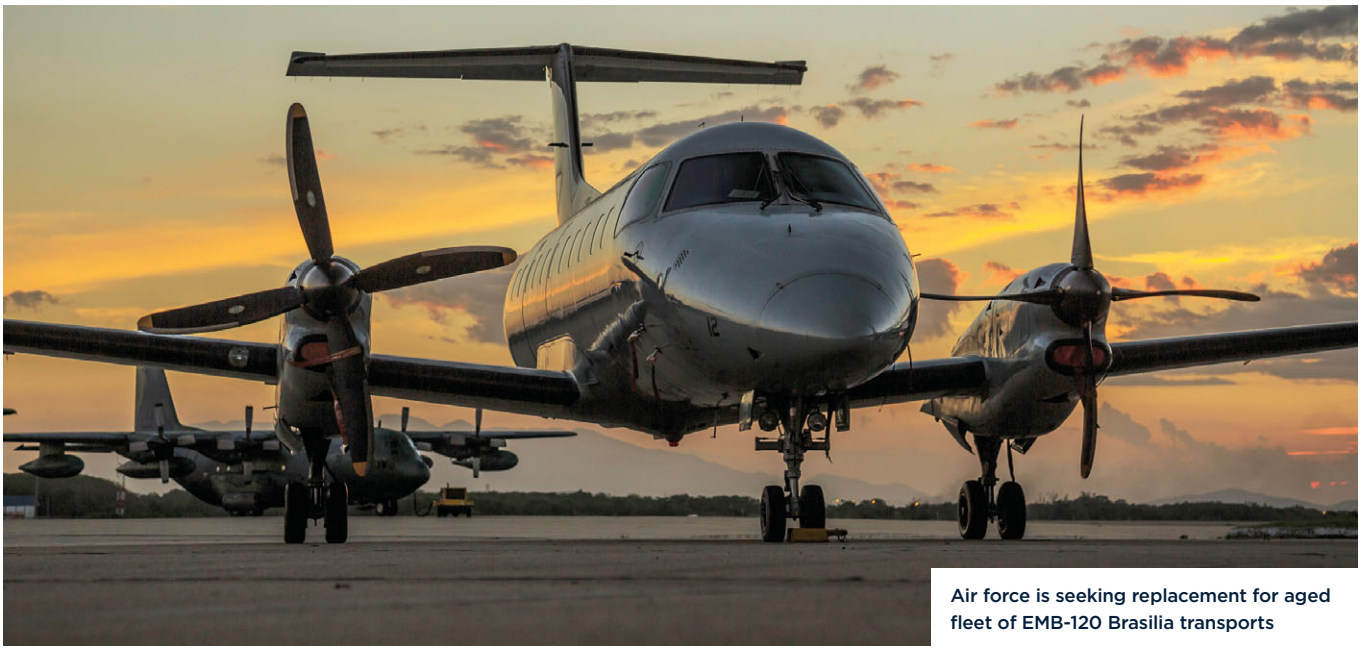
In October, Boeing lost another 12 orders for the 737 Max through cancellations, and removed another 25 aircraft from its backlog to comply with accounting standards.

Although the company retains contracts for those jets, it has less confidence sales will close.

In the 10 months to the end of October, Boeing lost 1,043 737s from its backlog: 448 cancellations and 595 axed owing to the accounting regulations.

Boeing's decisions on any production ramp-up will have an impact on its supply chain. Spirit AeroSystems intends to produce 737 fuselages at a rate of 10 monthly, starting in January 2021, in part to allow it to reduce its own inventory of 128 units.

The airframer has not detailed its target for 737 Max output in 2021, but anticipates a rate of 31 units per month by early 2022.



Brazilian air force

Air force is seeking replacement for aged fleet of EMB-120 Brasilia transports

Embraer spins up new designs

Brazilian airframer teases pair of turboprop concepts as it appears to move closer to launching aircraft development

Jon Hemmerdinger Tampa
and **Garrett Reim** Los Angeles

Embraer appears to be gearing up to launch at least one new turboprop development in the coming years, although whether this will be a civil or military aircraft – or even both – remains to be seen.

The Brazilian airframer has dropped numerous hints over the past few years about the potential for a new turboprop airliner to take on products from ATR and De Havilland Canada.

However, its interest in the segment appeared to have waned – until the end of October, when the manufacturer and its commercial aviation chief executive, Arjen Meijer, tweeted digital renderings of a conceptual civil turboprop design.

And, in a recent podcast for *Airfinance Journal*, vice-president of marketing Rodrigo Silva e Souza says Embraer continues studying a potential new turboprop aircraft. He adds that the company seeks "business partners" in the project.

The concept images show an aircraft with a fuselage seemingly identical to an E-Jet – perhaps an E175 – and twin turboprop engines mounted above the low-wing, while further aft a T-tail configuration is preferred.

Embraer says it tweeted the image "for illustrative purposes only" and declines further comment.

But the sense that new designs are being worked on was reinforced a month later, when the Brazilian air force previewed renderings of a proposed hybrid-electric short take-off military and commercial transport aircraft.

Embraer and the Brazilian air force signed a memorandum of understanding in December 2019 to develop a new light military transport. Embraer acknowledges that the hybrid design is the product of that agreement, but declines to provide further detail.

Doubling up

Called STOUT – or Short Take Off Utility Transport – the aircraft would have two turboprop engines that double as turbogenerators powering a pair of wing-tip-mounted electric motors.

The STOUT is intended to replace the Brazilian air force's Embraer EMB-110 Bandeirante and EMB-120 Brasilia fleets, of which it has respectively 64 and 19 examples in service.

According to the presentation, the STOUT is designed to have roughly the same external dimensions as the EMB-110 and EMB-120.

The aircraft is intended for "serving remote locations with short, narrow and unpaved runways", says Brazilian aviation publication *Poder Aero*. It must be capable of "transporting cargo and personnel in jungle areas, reaching major airports in South America, launching parachutists, extracting pallets and transportation of the sick".

In addition, it must be able to take off from a 1,200m (3,940ft) runway and operate in an "Amazonian environment".

Range would be 1,310nm (2,420km) with a maximum payload of 3t. Unlike the Bandierante and Brasilia, it would come with a rear ramp for loading and unloading cargo and passengers.

The STOUT aircraft would be capable of carrying 24 paratroopers or 30 soldiers.

Embraer and the Brazilian government intend to use the country's need for a new military transport to jump-start hybrid-electric aircraft development. The new propulsion architecture is thought of as promising for regional or commuter commercial passenger service owing to lower fuel and maintenance costs, as well as a lighter environmental impact.

GO BEYOND

PRATT & WHITNEY
GTF

THERE IS NO COMPARISON. NO EQUAL. THERE IS ONLY ONE.

THE COMMERCIAL JET ENGINE IN A LEAGUE OF ITS OWN.

Powered by an industry-first geared architecture – and more than 40 other groundbreaking innovations – the **Pratt & Whitney GTF**™ is unlike any engine that's come before it.

EXPLORE THE FUTURE OF FLIGHT AT **PRATTWHITNEY.COM**

Modesty worth shouting about

As he prepares to step down as boss of Safran, Philippe Petitcolin is reluctant to take credit for the company's success

Dominic Perry London

Charisma and leadership: two qualities that are hard to measure but on which the success or failure of a company can hinge.

At least, that is the contention of Philippe Petitcolin, who, at the time of writing, was counting down to the end of his five-year tenure as chief executive of French aerospace giant Safran.

He is due to hand over to Olivier Andries in January and while hesitating to proffer any counsel on the group's future direction, Petitcolin does give this piece of advice.

"Just be yourself. I think when running a company like Safran you need leadership and charisma. So this is what I am going to tell him.

"I'm not going to try to give him some ideas of how to run the company. We are all different, so let him run the company the way he thinks he should."

Those two qualities are vital, he says, because "we are established in so many countries" and "people in Thailand or Morocco see the company through the management".

But in Petitcolin's case, you might also add humility and modesty to the list. He is, he says, "not the kind of person who wants to be on the highlights and recognised for things, especially things I haven't done."

Safran has demonstrated steady growth since his appointment in April 2015 – revenue rose from €15.7 billion ($18.5 billion) in 2016 to €24.6 billion in 2019, and income followed a similar course, growing from €2.4 billion to €3.8 billion last year. (Clearly that growth trajectory has not continued into 2020, where pandemic-hit revenues will be down by about 35%.)

Positive outcomes?

But in further evidence of that modest streak, Petitcolin declines to take much, if any, credit for that sustained period of success, noting the long lag in aerospace between deciding on a course of action and an eventual outcome.

"When you make a decision the results or the consequences of your decision [don't appear] in the following three months or six months – sometimes it takes five years or 10 years.

"I did well over the five years because my predecessors did extremely well. I didn't do anything to launch the CFM56 with GE – that had been done in the 1980s – but I have all the profit from what they did," he says.

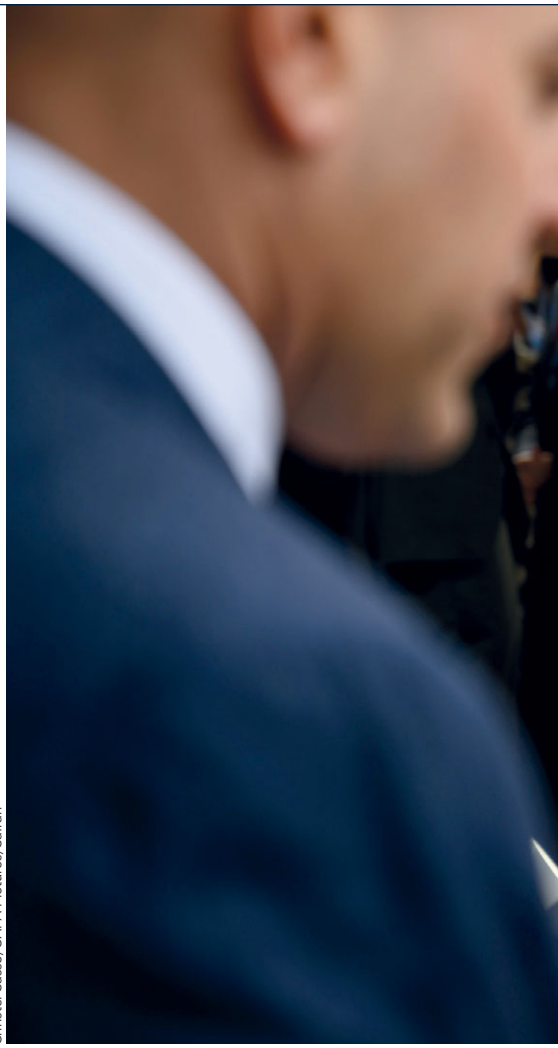
At a broad strategic level, one of Petitcolin's earliest decisions was to shift Safran's focus to laser in on commercial aerospace. That defined what the group would – and, crucially, would not – do in the future.

But that altered course spelled the end for the security business unit that his predecessor, Jean-Paul Herteman, had painstakingly built up. "If you look at what I did – the change of strategy – it was not that easy to decide the segment that my predecessor had invested in, the security business, was the one I wanted to sell."

But, he argues, "security was not our business. We had nothing to do in it".

"You cannot invest in everything," he says, noting that the belief was that "consolidation in the aerospace industry would come and we needed to conserve our resources.

"We didn't have the resources to be able to do both – so we had to make a choice."



Christel Sasso/CAPA Pictures/Safran

"Consolidation in aerospace would come and we needed to conserve our resources"

Philippe Petitcolin
Chief executive, Safran

Raphael Sorel/Safran

Safran is already looking at technologies for successor to Leap powerplants

One of Petitcolin's biggest strategic moves was to abandon Safran's security unit to focus on commercial aerospace

But those divestments – the detection business went to Smiths Group for €710 million, and the identity and security unit to Advent International for €2.4 billion – helped to bankroll the near €10 billion acquisition of troubled French interiors manufacturer Zodiac Aerospace.

That move helped to cement Safran's position as a top three aeronautical supplier (behind only Raytheon Technologies and GE Aviation) and reduced its reliance on revenue from propulsion. However, it was not without its headaches.

Takeover worries

At the time the acquisition was announced, Zodiac was in a mess: industrial issues across several sites meant that deliveries to the big airframers, particularly Airbus, were late, slowing the ramp-up of crucial programmes.

Indeed, mid-negotiation over the terms of the merger, Zodiac released a new profit warning, which took Safran by surprise.

Petitcolin points out there are ups and downs in every negotiation – moments "where you think it is going to be extremely difficult or impossible" – and the talks with Zodiac were no exception.

While he never thought Safran would be unable to get the deal done, "there were moments where I didn't know any more if the acquisition would be a good fit for us".

But the process went ahead and the deal was completed in March 2018. Although the turnaround has been derailed by the current crisis in aerospace – the interiors business unit remains the worst afflicted of Safran's divisions – Petitcolin says by the end of 2019 "we were really on track".

But propulsion continues to be the biggest source of revenue for Safran: at €12 billion, it represented just shy of 50% of group turnover last year. Bearing in mind its joint ownership with GE Aviation of CFM International, the company is preparing the ground for the next generation of commercial engines on a timetable that foresees the launch or pre-launch of a new narrowbody airliner in the 2025-2027 period.

"We are working very hard with our partner GE in order to find an engine that would save a lot of fuel – whatever the fuel is – a saving of around 20% over the Leap," Petitcolin says.

There is no decision on the fuel type yet, with biofuel, sustainable aviation fuel and hydrogen all vying for consideration. "We are working on all these options but only by 2025 will we be able to tell our potential customers what is likely for service entry by 2035."

However, he stresses that there is no new engine in development, merely research on the technologies to support it.

Curiously, of the four Western propulsion specialists – GE, Pratt & Whitney, Rolls-Royce and Safran – the French firm is the only one that does not make its own civil engine, be that for an airliner or business jet.

Yes, it has the hugely successful CFM partnership with GE to fall back on, plus a 65% share of the more modest PowerJet SaM146 programme on the Sukhoi Superjet, but there its commercial engine interests end.

Safran's last venture into the space was the ill-fated Silvercrest business jet engine for the Dassault Falcon 5X, the failure of which led to the cancellation of the aircraft programme.

€12bn

Turnover in 2019 generated by Safran's propulsion division

Although he did not launch the Silvercrest, Petitcolin was in charge of what was then Snecma – now Safran Aircraft Engines – during its development phase; in fact, he signed the deal with Dassault to equip the 5X with that engine.

And while he is reluctant to admit any regrets from his time at Safran – a career that encompasses stints at virtually every division – the failure of the Silvercrest clearly rankles; it was, he says, "something we did not manage very well".

"Maybe we should never have tried to get into this market. I didn't stop it. I didn't launch it, but I didn't stop it; maybe I should have done.

"I could have stopped it but I'm not sure I would be in this job

Adrien Daste/Safran

Acquisition of interiors specialist Zodiac was not without issues

today because I would have been pushed to the side," he says.

Despite the scars, Petitcolin thinks that "in the long run we will have to rethink what we tried to do with Silvercrest."

That does not mean challenging the main players, "but I think that it makes sense for us to rethink what we could do in regional or business jet engines". At some point, he says, a successor to the SaM146 will be required.

In the meantime, Safran will have to content itself with revenue generated from CFM. As previously noted, Petitcolin was not responsible for the founding of the joint venture, but he was in the hot seat at Snecma for the launch of the Leap engine, one of his biggest achievements, he says.

75%

Share of narrowbody market achieved by CFM International Leap engines

But the achievement was not the launch alone – attaining the same 75% market share in the narrowbody segment as previously gained with the CFM56 was just as important. "With GE we have been able to maintain this market share. It is not easy at 75%: the only thing you can do is lose share."

But even here, that stubborn streak of modesty is at play. The lock-in with Boeing was always likely to continue, he says, and the 60% share on the Airbus A320neo is "basically what we had on the CFM56".

"I don't know if it is impressive – it is what it is," he says; only by increasing the figure to 70-80% would it be noteworthy, he argues.

One of the tasks – arguably chores – a chief executive must perform every three months is to run financial analysts through the company's quarterly results.

The latest grilling took place on 30 October, and featured, as you would expect, interrogation on the coronavirus crisis, the 737 Max and so on. But having received an answer to his questions – the last of the day – one analyst took a moment to acknowledge that it was the outgoing chief executive's ultimate appearance on a results conference call.

He wanted, said the analyst, to take "30 seconds" and thank Petitcolin for the "incredible contribution" he has made to Safran over the past five years.

The response? "Thank you, that's very nice of you," said Petitcolin, modest to the last.

Why automotive industry drives supply chain harder

Philippe Petitcolin's career with Safran began in the automotive filters business of what was then Labinal. That division was then sold in 1998 to French firm Valeo, taking him with it.

A three-year stint outside Safran followed, before he rejoined the company in 2001, leading to a perhaps surprising conclusion: Petitcolin contends that automotive "is ahead of us in terms of the maturity of supply chain, on time delivery and in terms of quality".

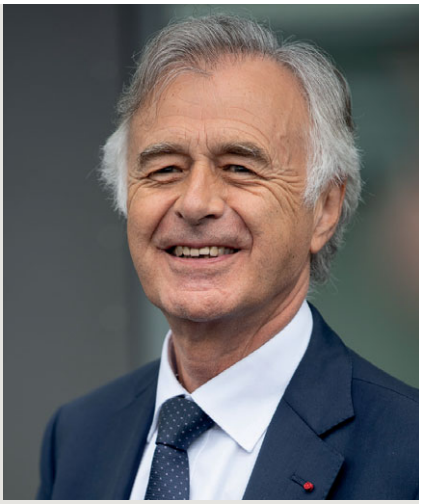
For anyone that has owned a car that appeared to have been put together late on a Friday afternoon, an argument about quality control may seem counterintuitive, particularly against aerospace's reputation for tiny tolerances and precision engineering. But Petitcolin insists that, given the volumes being dealt with, it cannot be any other way.

"When you are building 3,000 or 4,000 cars per day, if you have a quality problem it takes you three or four weeks to discover – by that point you have 30,000, 40,000 or 50,000 cars to inspect. In our business, we are talking about a few engines."

The automotive supply chain has been "totally rationalised", something which is yet to happen in the aerospace sector, partly because of the speed at which programmes are developed.

That overdue consolidation process may be accelerated by the current crisis, but he questions whether the relationship with the supply chain will be fundamentally altered.

"There is not a resistance [to change] but it is the way that people have been working for years. They do not see yet the need for huge change. On-time delivery does not exist in our industry; within 48h, it's good. In the automotive industry... if you are one hour late it can stop the assembly line."



Laurent Pascal/CAPA Pictures/Safran

That will change as new programmes arrive, but it is "too difficult and too costly" to implement changes on current products. "It is better to fix the supply chain than to replace it with another one," he says.

Berlin inks deal for 38 Eurofighters

Quadriga replacement programme will include 'most modern European-built combat aircraft' with AESA radar technology

Craig Hoyle London

Tranche 4 jets will be mostly single-seaters

Airbus Defence & Space

Airbus Defence & Space has received a contract to build a Tranche 4 batch of 38 Eurofighters for the German air force, following recent parliamentary approval for the Project Quadriga acquisition. The deal was formalised on 11 November, during a signing event involving officials from the Eurofighter consortium and NATO Eurofighter and Tornado Management Agency.

Berlin's new assets will be a mix of 30 single-seat and eight twin-seat fighters, Airbus says. This will include a trio of instrumented test aircraft, to be used in support of further enhancements to the type.

New equipment to be integrated with the Quadriga jets will include an active electronically scanned array (AESA) radar, currently being developed by Hensoldt, plus what Airbus refers to as "future-proof hardware and software". This sensor suite will provide "unlimited multi-role capability for engaging air and ground targets", it claims.

Germany had separately signed a contract in June to acquire 110 Captor-E Mk1 AESA radars for use with its existing Tranche 2- and 3-standard combat aircraft.

"This makes Germany the largest ordering nation in Europe's biggest defence programme," Airbus notes of the new deal. The three other Eurofighter industrial partner nations are Italy, Spain and the UK.

Cirium fleets data records the German air force as having 137 Eurofighters in active use, aged between one and 17 years. This total includes 31 Tranche 1 production examples, it shows.

Airbus Defence & Space chief executive Dirk Hoke describes the new Tranche 4 standard as "the most modern European-built combat aircraft, with a service life well beyond 2060".

"Its capabilities will allow full integration into the European Future Combat Air System," Hoke adds.

Confirmation of the follow-on order from Germany – which will use the new aircraft to replace its Tranche 1-standard Eurofighters – "secures production until 2030 and comes at an important time for the programme", says Airbus.

Delivery of the final example to Italy on 23 October had marked the end of production for the partner nations. However, the Typhoon is currently being built for export customers Kuwait and Qatar, and the Eurofighter consortium is also anticipating a potential repeat purchase from Spain, which is seeking replacements for its Boeing F-18s. Germany has also indicated that it will acquire 55 examples as a partial replacement for the Luftwaffe's Panavia Tornado fleet.

Airbus notes both Finland and Switzerland are due decide on their future fighter acquisitions during 2021, with the Typhoon in contention in both competitions.

See p40

leonardocompany.com

Helicopters | Aeronautics | Electronics, Defence & Security Systems | Space

LEONARDO

China and USA remain locked in 'bad marriage'

There is very little that Beijing can do to harm foreign aerospace interests without hurting its domestic aviation industry

Garrett Reim Los Angeles

Despite opposition from the Chinese Communist Party, in the past year and a half the Trump administration has approved billions of dollars in potential arms sales to Taiwan.

China, which claims the island democracy as its own, has vowed to retaliate.

But so far the response from Beijing is mostly a symbolic shot across the bows: denunciations from the foreign ministry; angry and dismissive opinions in state-run papers such as the *Global Times*; and sanctions for US aerospace firms and defence subsidiaries, none of which do substantial business in the country anyway.

More pain could be caused to US industry by taking aim at commercial aerospace, but that would largely be a self-defeating policy, analysts conclude. That is because China is reliant on Western suppliers and expertise, particularly from the USA, to further its development of domestically built airliners.

Moreover, if Beijing were to block US-made passenger aircraft from being sold in China it would make operations expensive and difficult for Chinese airlines, which would be put in a tough negotiating position with rival Airbus for the majority of their jet requirements. Alternatives such as China's own Comac C919 or the Russian-built Irkut MC-21 will not match the maturity of the Western aircraft, or be available in any significant quantity, for a number of years.

Ultimately, unpicking the links between the US and Chinese aerospace industries would be a "nightmare scenario", says Richard Aboulafia, vice-president of analysis with the Teal Group.

Although it "would be difficult to execute," it is "not impossible", he says, but stresses the huge upheaval such a move would cause.

"Not only would supply chains, financial portfolios, and customer buying patterns need to be sorted out, the entire China-US political and trade relationship would be impacted too," he says. "Or, an aerospace decoupling would both reflect and contribute to a much broader political and economic decoupling."

Right now, Chinese airlines are reliant on US-built jets – or, in the case of Airbus, those made in Europe or assembled locally in Tianjin, China, where it has an A320-family final assembly line.

"Chinese aircraft development, predictably, has taken many years longer than hoped," says Aboulafia. "After nearly 20 years, they are just delivering a useless regional jet."

That regional jet is Comac's ARJ21, a 78- to 90-seat aircraft that has hardly set the world alight since service entry in 2016. In total, 38 examples have been delivered, with another 316 aircraft on order, according to Cirium fleets data. The user base will be entirely Chinese, apart from a few examples potentially finding their way to the developing world.

"The C919 is the jet that really matters, and that won't be available in large numbers until the end of the decade," says Aboulafia. "It might not be available in even small numbers until 2025."

> "Chinese aircraft development has taken many years longer than hoped"
>
> **Richard Aboulafia Vice-president of analysis, Teal Group**

Domestic aircraft development would take even longer if Beijing tried breaking the industry's reliance on US engine and systems suppliers, he adds. For instance, the C919 narrowbody is powered by Leap-1C engines made by CFM International, a joint venture between GE Aviation and Safran of France. Or, consider the communication and navigation systems for the C919, which is made via a joint venture between China Electronics Technology Avionics Company and Raytheon Technologies' subsidiary Collins Aerospace.

Joint ventures

Similarly, Aviage Systems, which produces the C919's avionics, is a joint venture between GE and AVIC. Beijing, like many other governments, has tried to advance domestic industries by requiring foreign companies to give up technology or form joint ventures with local firms in order to do business within its borders. Western firms and governments also accuse Beijing of using espionage to steal intellectual property in order to reverse-engineer critical technologies.

But those tactics can only take an industry so far, says Alex Krutz, managing director at Patriot Industrial Partners, an aerospace consultancy.

2025

Probable date for first deliveries of Comac's C919 narrowbody

AirTeamImages

Comac remains reliant on US manufacturers for C919 development

"The hardware will come easier for them through partnerships, through learning and forced intellectual property transfers. Some things they will design on their own. They have some very smart people that have gone to [Massachusetts Institute of Technology] and other places," he says. "But generally, there's some secret sauce when it comes to software, coatings or aerodynamics of certain parts.

"For example, one of the golden nuggets of an engine are the coatings within the hot section. Pratt & Whitney has proprietary coatings that they keep very close to the vest... They don't even let suppliers coat certain parts."

Even if certain aspects of an engine were reverse-engineered, making all the parts work together efficiently requires considerable know-how. "Making it work at sustained hours, it's a whole different story," says Krutz.

International outlook

That kind of knowledge makes China beholden to Western manufacturers.

"There's dependent and there's totally dependent. If they want functioning aircraft with a significant gap in performance with the rest of the world, they could get there by the early 2030s," says Aboulafia. "But no country, even the USA, can rely purely on national systems, unless they want inferior jets. If China goes down this path, even when they got there they would merely be repeating the horrible Soviet experience of having inferior national copies of globally-built aircraft."

In theory, Chinese manufacturers and airlines could rely solely on European suppliers, though that might make their negotiating position difficult, says Krutz.

"Airbus has been increasing its market share, but it's hard to sort out what's due to geopolitical tensions and what's simply the 737 Max's problems," says Aboulafia. "But I suspect we'll see the answer, with any [Civil Aviation Administration of China] delays to Max recertification."

Ultimately, it appears the leadership of the Chinese Communist Party knows its aerospace industry can't break free of US manufacturers just yet. That shows in the largely toothless sanctions against US companies selling weapons and aerospace subsystems to the Taiwanese military.

In response to a $1.8 billion deal for missiles, rocket artillery and reconnaissance pods, Beijing in October announced plans to levy sanctions on suppliers Boeing, Raytheon and Lockheed Martin.

However, China's sanctions seemed to be only against the defence units of Boeing and Raytheon Technologies; Boeing Commercial Airplanes and Collins Aerospace were not mentioned. For its part, Lockheed does relatively little commercial business, most of which is limited to its helicopter subsidiary, Sikorsky.

"The best way to think about the relationship is that it's a bad marriage, but divorce would be worse," says Aboulafia.

Lightning strikes for UAE

US Air Force

Current F-16s will be bolstered by $10.4 billion-worth of stealth fighters

Gulf nation secures initial US approval to acquire 50 F-35As, following September treaty normalising relations with Israel

Garrett Reim Los Angeles

After years of uncertainty about its future combat aircraft options, the United Arab Emirates (UAE) finally appears close to acquiring its first choice candidate – the Lockheed Martin F-35A.

The US Department of State announced on 10 November that it had approved a potentially $23.4 billion weapons package for the UAE, including 50 F-35As valued at up to $10.4 billion.

The proposed deal also covers the provision of 18 General Atomics Aeronautical Systems MQ-9B unmanned air vehicles, worth $2.97 billion, plus $10 billion of air-to-air and air-to-surface weapons.

Typically, Department of State-endorsed arms sales are passed to the US Congress for clearance, but in this case secretary of state Mike Pompeo declared that the sale would be approved.

"I directed the department to formally notify Congress of our intent to authorise the UAE's proposed purchase," he said. "This is in recognition of our deepening relationship and the UAE's need for advanced defence capabilities to deter and defend itself against heightened threats from Iran."

Armaments to be supplied with the Lightning IIs would include Raytheon AIM-120C8 AMRAAMs and AGM-154C/E Joint Standoff Weapons, plus Joint Direct Attack Munition guidance kits, the US Defense Security Cooperation Agency says. A deal would also cover training, spare parts and support services.

Israeli advantage

Selling the stealthy F-35 to the UAE is a controversial step, because US policy has historically sought to give Israel a qualitative military edge over other nations in the Middle East. Cirium fleets data shows that the Israeli air force currently operates 23 F-35I Adir fighters, from a planned 50-unit acquisition.

However, Israel and the UAE agreed to normalise relations in September, as part of a treaty negotiated via the USA. Israeli prime minister Benjamin Netanyahu subsequently said that he would not oppose the sale of "certain weapon systems" to the UAE.

"The proposed sale will make the UAE even more capable and interoperable with US partners in a manner fully consistent with the USA's longstanding commitment to ensuring Israel's qualitative military edge," says Pompeo.

An existing user of Lockheed's F-16E/F, the UAE has long sought a next-generation fighter capability. Following protracted negotiations, it had appeared poised to choose between the Dassault Rafale and Eurofighter Typhoon during the 2013 Dubai air show, but backed away from acquiring either type. It also failed to progress with a proposed follow-on buy of 30 F-16s in an enhanced Block 61 configuration.

Cirium data shows that the UAE air force has 78 F-16s in active use, aged up to 16 years. It also uses 59 Dassault Mirage 2000-9s, including 15 trainers.

Meanwhile, the potential MQ-9B package would include Leonardo Seaspray 7500 maritime search radars, anti-submarine warfare mission kits and 515 Lockheed AGM-114 Hellfire air-to-surface missiles. The capability would enhance the UAE's ability to spot and track Iranian diesel-electric submarines.

It is unclear whether US President-elect Joe Biden will back the sale of such an arms package.

See p40

Additional reporting by Craig Hoyle in London

The Courage to Meet Tomorrow's Challenges Today

IAI draws on innovative solutions and proven technologies to meet today and tomorrow's challenges.
We've been creating exceptional solutions since 1953.
IAI offers tailored interconnected and interoperable solutions within and across domains.
Leap into the future together with us.

www.iai.co.il • corpmkg@iai.co.il

Gripen E will enter service with Swedish air force and export customer Brazil

Saab

Developing secure relationships

Saab's chief executive Micael Johansson explains how the company's successes are sustained with its customers

Craig Hoyle London

After spending just over a year at the helm of Sweden's aerospace, defence and security champion, Saab chief executive Micael Johansson is happy with the company's performance, despite the challenges presented by the coronavirus pandemic.

With the health crisis having largely not affected its domestic operations – Sweden has imposed no workplace lockdown measures since the global outbreak – the company has enjoyed notable successes with two of its most important programmes during 2020.

All but "a couple of hundred" of Saab's 14,000 employees in Sweden have been working at its sites as normal, albeit with increased hygiene measures in place. "We have been careful," Johansson says, noting that the approach has actually resulted in staff absences due to sickness falling this year.

On 29 April, the first of three GlobalEye swing-role surveillance aircraft ordered by the United Arab Emirates (UAE) touched down in Abu Dhabi. A second example of the heavily adapted Bombardier Global 6000 followed in September.

The UAE in November 2019 announced an intention to increase its GlobalEye fleet to five aircraft. "Negotiation has been progressing – that's still absolutely in play," Johansson says.

Meanwhile, Gripen E deliveries into the Swedish and export buyer Brazil's joint verification and validation programme are ongoing.

Lone examples of the new-generation fighter were handed over to each customer in late 2019 to support test activities in Sweden, and Brazil's first locally-designated F-39E was recently shipped to and flown in the country.

36

Initial order for the new-generation Gripen E from Brazilian air force, including eight two-seat F models

While his volume of overseas travel has been impacted by global travel restrictions, Johansson made two trips to Brazil inside a week in late October. The first was to attend a high-profile ceremony in Brasilia welcoming the F-39E, also attended by Brazilian President Jair Bolsonaro and air force leaders, and he then returned to speak at a conference about the development of the nation's aerospace industry.

A further four aircraft will be transferred to the Brazilian air force in 2021, including to its Wing 2 at Anapolis air base late in the year. It has 36 examples on order, including eight two-seat F models, and follow-on purchases are anticipated over the coming years.

"The programme is a real success," Johansson observes. "It brings something substantial to the country.

"We have done extremely well when it comes to partnerships in Brazil," he adds, referring to its largest-ever transfer of technology, including to Embraer. "You must have something to build upon – that's why this has been so successful," he says.

An in-country Gripen design and development facility and flight-test centre have already been established, along with a local capability to produce subassemblies. Brazilian companies also are now feeding its supply chain.

Brazil's purchase – which sees the nation leading development work on the Gripen F – also could open the way for further sales in Latin America.

Saab is already targeting Colom-

bia's combat aircraft needs, working in conjunction with Embraer. The nation's air force is due to complete an evaluation process during December, as it looks to replace its aged Cessna A-37s and Israel Aircraft Industries-built Kfirs.

"I don't think we can win a Gripen E contract in Colombia if we do not do that from Brazil to a large extent, with the support of the Brazilian air force and Brazilian industry," Johansson says.

Johansson, who succeeded Hakan Buskhe in his role in September 2019, sees strong potential for multiple further sales of both the Gripen E/F and GlobalEye.

Finland has been offered both types for its HX requirement to replace ageing Boeing F-18s. A selection is expected next year, with rivals being the F/A-18E/F Super Hornet and EA-18G Growler, Dassault Rafale, Eurofighter Typhoon and Lockheed Martin F-35A.

The Gripen E is also on offer to Canada, where he says Saab has tabled "the most comprehensive response we're ever delivered". Other opportunities exist with Austria, along with existing C/D-model operators the Czech Republic and Hungary, while the earlier standard is currently being pitched to Croatia.

Competitive offers

"We have very competitive offers in all campaigns," he says.

Sweden, meanwhile, is expected to define a need to replace its pair of Erieye airborne early warning radar-equipped Saab 340s when it publishes its new defence bill in December 2020.

Johansson says there is also strong interest in the Erieye ER-equipped GlobalEye in the Asia-Pacific region, and Europe. He believes the type could also potentially provide a "gap-filler" capability for NATO, whenever the Alliance begins replacing its Boeing E-3A airborne warning and control system fleet.

The GlobalEye's sensors are capable of simultaneously performing surveillance of airborne, land and maritime threats. The technology also can determine a swarm of drones from a flock of birds, find low-flying or hovering helicopters, and as new threats emerge, Johansson says "we can look at new functional modes".

Elsewhere, Saab in the process of establishing an aft fuselage manufacturing facility in West Lafayette, Indiana, for the US Air Force's Boeing T-7A Red Hawk advanced jet trainer. It launched engineering and manufacturing development production work at its Linkoping site in Sweden in January 2020.

Another opportunity exists with the UK's Tempest future combat air system (FCAS) activity, which is also supported by Italy and Sweden. Saab is to invest in an FCAS centre in the UK to support the project.

A trilateral memorandum of understanding should be signed late this year or in early 2021.

"We will definitely support that avenue and we will invest," Johansson says. "We want to be part of this, preferably at an OEM level, being part of the system of systems, and also at the platform level.

Saab

Johansson has spent his entire career with Saab

"Exactly to what extent and how big of a portion will be related to Sweden when it comes to the business case, and how much will be invested – that's still to be seen," he says.

"We have a great working relationship with BAE Systems and the British industry. On the industrial side, despite the Covid[-19] situation things are done extremely well. Let's see what governments sort out in terms of funding, and focus on the next phase. It is a really important programme for us."

More immediately, faced with supply chain disruption, Saab in October announced a potentially SKr1.5 billion ($170 million) impact to its Aeronautics unit, in part due to the need to bring some work back in-house, or to qualify alternative suppliers on the Gripen E programme.

Johansson explains that the measure – intended to protect production as it ramps up over the next several years – relates to some single-source suppliers within its global network, and includes "items affecting functionality growth".

Johansson has spent his entire career with Saab, having joined in 1985 as a systems engineer working on image processors, after studying mathematics and computer science at university. That early work involved using "racks of computers, with the power of an iPhone", he notes. Immediately prior to becoming chief executive, he headed Saab's surveillance business area.

He sees making regular visits to the company's sites as an important part of his role in charge of a broad product portfolio. This ranges from command and control equipment to sensors, guided weapons, remote tower technology and the A26 submarine.

"You have to understand what you are trying to lead," he notes. This requires what he describes as a continuous process of learning and upskilling. "I don't want to – just because I've been here 35 years – be the one that says 'do it the way we did it earlier'," he says.

Sustained investment

"We will always be a company working heavily on R&D and innovation. To sustain that is an important area for me – especially seeing the pace of technology development today," he notes.

"Our focus is to be more multi-domestic, in terms of where we have our operations: that is a good way of growing the company." Countries where he would like to see its capabilities develop further include Australia, Finland, Germany, the UAE, the UK and the USA.

"I am happy to have an organisation with quite a lot of people in different countries during this pandemic – otherwise it would have been extremely difficult," he says. "We have seen the effect of that [strategy] on or order intake, which has been better than last year, despite this situation."

Summing up his first 12 months, Johansson concludes: "This is a fantastic job, to get to meet so many stakeholders around the world, and I'm so proud of the company and our employees.

"We bring a lot of good capabilities and technologies to the marketplace, and I believe a lot in trying to protect and create secure societies."

Sun sets on 777 Classic in Japan

After being involved in Boeing's widebody programme from the very start, Japanese carriers ANA and JAL have both been forced to bid farewell to their oldest examples

Greg Waldron Singapore

In their recent half-year results, both All Nippon Airways (ANA) and Japan Airlines (JAL) announced measures to mitigate losses from the coronavirus pandemic, including plans to phase out more aircraft than originally intended.

One thing stood out: both carriers addressed the fate of their Boeing 777 fleets, which have long formed the backbone of their domestic networks.

JAL will retire up to 24 777s over the next three years. These comprise 11 777-200ERs used in its international network which will be retired by March 2021, although an unspecified number will be moved to domestic operations.

It will also retire all 13 777s currently used on domestic flights – comprising nine 777-200s and four -300s – by March 2023.

Essentially, JAL is removing its entire complement of 777 'Classics' – give or take those -200ERs.

JAL's announcement came after compatriot ANA disclosed the retirement of 35 aircraft – 28 more than originally planned in the current financial year. Of these, 22 are 777s, though the Star Alliance carrier does not provide more detail.

While the news of premature retirements was not entirely surprising given the industry's malaise, it still marks what could be the end of an era – one made more significant considering that the two carriers were launch customers for the 777 programme.

In fact, their association with the programme dates back nearly 30 years, when they placed their initial orders for the 777-200.

The two Japanese carriers were also involved in the development of the widebody twin, underscoring its importance to their strategies. For both, the 777 would replace older, high-density 747s used on domestic routes.

ANA will phase out 22 of its US-built twin-aisles in FY2020

Air TeamImages

As a 1995 FlightGlobal report stated: "The 777 will play a critical role in ANA's defence of its domestic market share," with the carrier wasting no time in making clear to Boeing what it needed from the new aircraft programme.

JAL took delivery of its first 777-200 in 1996, while the initial -300 followed two years later. ANA's lead -200 arrived in 1995, and its first -300 in 1998.

Both carriers would end up operating almost every passenger variant of the 777, save for the ultra-long-range -200LR, culminating in the -300ER, which both operate extensively on mostly long-haul routes.

Only ANA has committed to the latest variant of the family – the 777-9, with 20 examples on order.

The mass retirement means, aside from the handful of retained -200ERs, JAL will in future operate only relatively young 777-300ERs.

It is a similar story at ANA, where the 22 retirements will almost certainly be drawn from its 26 777 Classics, leaving just the 28 -300ERs. In both cases, removing the older aircraft will reduce the airlines' 777 inventories to levels not seen since the 2000s.

As the backbone of the modern Japanese domestic fleet makes its exit, both carriers provide mixed pictures of what the next generation will look like.

For JAL, some of the higher-density domestic operations have been taken over by the Airbus A350. JAL has also made it clear that the domestic fleet will largely remain the same size in the short term, owing to the introduction of more examples of the European widebody, of which it has 25 on order.

ANA's 777-300s will be tough to replace on a one-to-one basis, however, because they offer extremely high density: configured with more than 500 seats, they can accommodate more passengers than any other aircraft in its fleet. The carrier has not explicitly outlined any replacement for the widebody yet, but has a significant number of 787-10s and A321neos on order.

Still, it is clear that the days of the 777 'Classics' are numbered. This trend has been accelerated by the global pandemic, which has also forced other carriers in the Asia-Pacific region to dispose of their older aircraft – such as Qantas with its 747s, and Singapore Airlines, with its elderly 777s.

It is also evident that the two Japanese carriers, which have seen the programme from its infancy to global fame, have made a final decision about the 777's role in their fleets. When the pandemic clears and air travel picks up again, the 777 will no longer be the domestic flagship for either airline.


E2 PROFIT HUNTER
A different animal
for a different world
• Rightsize your fleet
• Match capacity with demand
• Rebuild business profitability
• Achieve true sustainability
#E2ProfitHunter
E2ProfitHunter.com
EMBRAER
CHALLENGE.
CREATE.
OUTPERFORM.

Lack of Max delivers boost to NG

With the latest 737 variant out of action, values and utilisation levels of previous model have held up better than Airbus rival

Dominic Perry London

Although the grounding of the 737 Max has been a disaster for Boeing, its absence has had the effect of propping up utilisation levels and values for the earlier-generation 737-800.

That means that the older variant of the Seattle airframer's best-seller has avoided the fate of its Airbus narrowbody rival, the A320ceo, according to analysis from Ascend by Cirium.

Fleet utilisation data for the two types during 2020 reveals that while both have declined significantly from pre-pandemic levels, the 737-800 fell by 44% year on year, while the A320ceo dropped by 57%.

That difference has been driven by several factors, says Thomas Kaplan, senior valuations analyst at Ascend.

While the continued absence of the 737 Max means that all-Boeing operators have little choice but to continue using the 737-800, that is not the case for those with all-Airbus fleets.

If an A320-family operator has both the Ceo and re-engined Neo variants – which Airbus has continued to deliver through the pandemic – the latter will be preferred on fuel-efficiency grounds, says Kaplan.

In fact, says Ascend's global head of consultancy, Rob Morris, a new-generation aircraft like the A320neo "even in the current fuel environment" and with relatively low utilisation, will "still save an airline about $900 per day".

VDB Photo/Shutterstock

Boeing has backlog of built but undelivered Max jets

Scaled up across a carrier with 50 examples in its fleet, that could amount to an annual saving of $16.2 million. In addition, the average value of the A320ceo has fallen steeply this year. In fact, it has shown one of the sharpest declines of any popular aircraft type, dropping by an average of 31% across the entire fleet. In contrast, the 737-800's value has fallen by around 10-15%, says Kaplan.

Cargo conversion

Other factors helping maintain the 737-800's value are a "desirable freight conversion programme", the uniformity of the fleet given the lack of engine choice on the type, and the fact that surplus inventory from restructuring carriers such as Virgin Australia or Norwegian has yet to hit the market.

However, Ascend predicts that once deliveries of the 737 Max resume at pace next year, values for the 737-800 will begin to decline more sharply as airlines remove them from service in favour of the newer jets.

"As the Max returns to service, we will see negative pressure on values and lease rates," says Morris.

Before any significant production ramp-up can happen, Boeing must first deal with around 450 737 Max aircraft which are already built but undelivered.

In its most recent forecast, the airframer predicts that it will hand over around half the total in 2021 and the majority of the remainder in 2022.

Complicating the picture is the fact that some of those 450 Max jets no longer have a customer – through bankruptcy or cancellation – which means that Boeing has to remarket and reconfigure the aircraft prior to any delivery.

Airbus

Manufacturer is currently building 40 A320neo-family jets per month

Airbus has eye on production rise

Airframer looks at increasing narrowbody output next year, but supply chain cautions demand must support ramp-up

David Kaminski-Morrow London

While Airbus has begun planning for a possible narrowbody production increase in the second half of next year, key suppliers insist that demand must be real and sustained to avoid future disruption.

Airbus is currently building A320neo-family aircraft at a rate of 40 per month, down from a pre-coronavirus pandemic figure of around 60 per month.

But the airframer says that although the timeframe for any potential ramp-up has shifted from the second to the third quarter of 2021, it sees enough demand, supported by contracts currently in place, for raising output next year.

Chief executive Guillaume Faury says the company wants to "make sure the supply chain is prepared" for any increase, but it is "not calling it a ramp-up expectation".

"It's important to stress the crisis is far from over," he adds.

Faury says the reduced single-aisle production rate of 40 aircraft per month has proven to be "robust".

"So far it has played out correctly for us," he says, adding: "We plan to maintain rate 40 until at least summer next year."

Any increase in rate beyond that point, to meet customer contracts, would be "gradual and modest", Faury says, confirming to analysts that the current "improved" production planning shared with suppliers features a monthly figure of 47 aircraft for the second half.

"It's backed by the backlog," Faury stresses. "It's not speculative, it's robust."

While key engine suppliers to the A320neo programme believe they will be able to meet Airbus's demands, their support for any rate rise is conditional.

Philippe Petitcolin, chief executive of Safran, which is a part owner with GE Aviation of the CFM International joint venture, says discussions with Airbus over the supply of Leap-1A engines to support the potential ramp-up have been "extremely good".

Material requirement

"I believe we should be in line with the requirements of our customers in the coming days or weeks," he said in late October.

But he adds that the "requirements must materialise" and cautions against a scenario where the supply chain is forced to increase production, only to see output slashed again several months later.

Fellow European propulsion specialist MTU is also confident that it can cope with any Airbus narrowbody production rate increase next year without needing additional investment.

Reiner Winkler, MTU chief executive, says the company is "well prepared" for any potential output rise in 2021.

"We are coming from a rate above 60 down to around 40, so there's enough flexibility in the system with no additional capex or working capital pressure from that," Winkler says.

MTU is a risk-sharing supplier in the Pratt & Whitney PW1100G engine, which is an option on A320neo-family aircraft.

Faury says the financial pressure on the supply chain is still an "area of concern" and that Airbus and its suppliers need to "navigate the situation together".

Although Airbus is preparing suppliers for potential ramp-up next year, Faury says this is limited to single-aisle output. "We don't anticipate ramp-up [of long-haul production] as on the single-aisles in the foreseeable future," he adds.

The A350 monthly rate remains at about five aircraft, which, says Faury, "underpins what we think about recovery of traffic on long-distance flights" – adding that it is "not unreasonable" to believe such a recovery will begin only once a vaccine to address the coronavirus outbreak is in place.

Although Airbus was caught "off-guard" as the crisis emerged in March, he says, the current situation is "much different", with "lots of specific and dedicated organisation" in place to deal with the complexity of production and customer deliveries.

Additional reporting by Dominic Perry

F-35 misses latest full-rate production target

US Air Force

Protracted IOT&E activity must conclude before multi-year orders can take off

DoD defers March review into maturity of Lightning II, with outcome of simulation-based assessment key to success

Garrett Reim Los Angeles

Lockheed Martin's Lightning II stealth fighter will not complete its initial operational test and evaluation (IOT&E) process by next March as previously planned, according to the F-35 Joint Program Office.

Confirming the development in late October, the US Department of Defense (DoD) said a full-rate production decision review is to be further delayed until later next year.

The DoD had expressed confidence as recently as August that the F-35 programme's IOT&E phase would conclude by its March 2021 target, after experiencing multiple delays since the process started in December 2018. It has not disclosed the reasoning behind the fresh slip.

Reaching a full-rate – or so-called Milestone C – production decision is required by the US Congress before it will clear the DoD to negotiate multi-year contracts with Lockheed. Such deals will secure future revenue for the company and enable it to pass back bulk discounts to its F-35 customers.

The formal launch of full-rate production would also be a symbolic victory for Lockheed and the F-35, the development of which has been repeatedly delayed because of design deficiencies with the three-variant aircraft.

In a January 2020 report, the DoD's Office of the Director of Operational Test and Evaluation said that the F-35 had 873 unresolved deficiencies, and that new problems were being discovered regularly. The DoD says progress has been made with resolving issues, but has not disclosed the current number of outstanding problems.

To finish its IOT&E phase and advance to a full-rate production review, the F-35's capabilities and vulnerabilities need to be assessed in a Joint Simulation Environment. The DoD plans to use this activity to test the Lightning II against hypothetical air and surface threats, including those it expects to appear within the next 10 years.

Updated schedule

While the Joint Simulation Environment work is scheduled to conclude during 2021, the DoD says it will not occur soon enough to allow a Milestone C decision by the end of the first quarter.

"The F-35 [Joint Program Office] is preparing an updated project schedule based on measured progress to date," says the DoD. "[The Joint Simulation Environment] evaluation will inform the beyond [low-rate initial production] report, a statutory requirement for full-rate production decision review. Until the completion of the review, production of the F-35 will continue in low-rate initial production, in accordance with Congressional authorisation and appropriation."

Lockheed is producing aircraft this year as part of the programme's low-rate initial production lot 12. It plans to deliver between 120 and 125 examples in 2020; a coronavirus disruption-driven reduction from an original goal of 140.

Releasing its third-quarter results in late October, the company said that a total of 78 aircraft were delivered by the end of September – a reduction of five from the same period a year earlier. Output during the three months to the end of September totalled 31 units: three more than in the third quarter of 2020.

The company has previously projected peak production of the stealth fighter as reaching 180 aircraft in 2024.

Cirium fleets data shows that there were 501 F-35s in operational use at the end of September, including 175 examples dedicated to training duties. The type is in service with the US armed forces, plus Australia, Israel, Italy, Japan, the Netherlands, Norway, South Korea and the UK.

See p40

LITEF

Ensuring Safety and Performance for Today and Tomorrow

With light weight, small volume, outstanding environmental robustness and unmatched performance LITEF's certified Inertial Systems deliver value to the operators of all types of aircraft including the most challenging fly-by-wire and tilt rotor applications.

For more information, please contact info@litef.de
Northrop Grumman LITEF GmbH, Loerracher Strasse 18, 79115 Freiburg, Germany

No respite for troubled SpaceJet

A fresh round of budget cuts has seen the in-development Mitsubishi regional aircraft forced into a period of hibernation

Alfred Chua Singapore

Where now for the SpaceJet programme, Mitsubishi Aircraft's bid to break into the regional jet market?

Already serially delayed before the coronavirus pandemic struck, the SpaceJet M90 – formerly the MRJ90 – now appears to be firmly in hibernation.

Despite assurances from parent Mitsubishi Heavy Industries (MHI) that it will only "temporarily pause" development of the regional jet, the effort now appears frozen to all intents and purposes.

Releasing the medium-term business plan for its 2021-2023 fiscal years, MHI revealed it is to apply the brake more firmly.

"Given the current development status and market conditions, we have no choice but to temporarily pause the majority of SpaceJet activities, except for [type certification] documentation.

"We will work to review where we stand, make improvements, and assess a possible programme restart," it says.

While it notes that the coronavirus pandemic is "temporarily depressing [the] market", it is hopeful that long-term demand will return.

MHI says it will continue to minimise costs relating to the regional jet programme, as it seeks to save more than Y120 billion ($1.1 billion) over the three-year period. To this end, the group will "shift investment away from SpaceJet" into other areas of new growth, such as mobility and logistics.

Already handed a budget cut of 50% early this year, the SpaceJet programme will now see a further reduction in the capital allocated from 1 April next year, with MHI allotting only Y20 billion for FY2021.

That is a far cry from the Y370 billion annual budget allocated in its previous three-year business plan.

Earlier this year, MHI halved the 2020 SpaceJet budget to Y60 billion, a move in response to the coronavirus crisis that also saw all non-Japanese SpaceJet locations closed and development of its 76-seat M100 variant shelved.

But if the programme is essentially in hibernation until April 2024, the prospects for its reanimation are not great.

Launch customer All Nippon Airways and fellow Japanese carrier J-Air have not announced any change to their respective 15- and 32-unit commitments for the M90 and, if the SpaceJet is restarted, will probably still take delivery of the domestically built jets, observers believe.

> "We have no choice but to pause most SpaceJet activities"
>
> **Mitsubishi Heavy Industries**

However, Cirium data lists the total firm backlog as just 163 aircraft, with US regional airline SkyWest accounting for the vast majority with an order for 100 examples. While the delay to the M90 is theoretically long enough to allow a relaxation in US pilot scope clauses to be negotiated, that would also benefit the rival Embraer 175-E2, in which SkyWest still has an interest, despite an earlier order cancellation.

> Y120 billion
>
> **Savings targeted by Mitsubishi Heavy Industries in three years covered by new business plan**

Utah-headquartered SkyWest, it should be noted, is already an operator of the current-generation E175 and has 189 in its fleet and 24 more on order.

The carrier says its position on the M90 orders has not changed: "Our Mitsubishi agreement remains contingent on partner flying agreements," it states.

Timing may also be key. If little or no work is being carried out on the jet over the next three years, particularly flight tests, there would seem only the vaguest prospect of it entering service much before the tail end of the decade.

By that time, of course, the M90's Pratt & Whitney PW1200G engines will not be the cutting-edge differentiators they were when the programme was launched in 2008. While they might have stood out had the MRJ90 arrived in 2013 as initially planned, given the presence of other geared turbofan variants on types including the Airbus A220 and A320neo, plus Embraer's E2 series, that is no longer the case.

Meanwhile, with service entry no closer, the SpaceJet programme continues to burn through cash.

For the six months ended 30 September, the programme chalked up a loss of more than Y82 billion, nearly six times the loss it made during the same period last year.

First-half SpaceJet development costs were Y30 billion, against a full-year forecast of Y60 billion.

The aircraft, defence and space unit, in which the SpaceJet programme resides, made a half-year operating loss of Y66 billion, reversing the Y13 billion profit it made in the same period last year.

Still, MHI notes that the impact of the pandemic has eased since bottoming out in the three months ended 30 June, when the company was hardest hit.

On a quarter-on-quarter basis, both order value and revenue more than doubled, to Y206 billion and Y336 billion, respectively.

MHI forecasts a full-year operating loss of Y95 billion for the unit.

It is not clear that the regional jet programme will ever take off again

AirTeamImages

While the SpaceJet programme confronts an uncertain future, MHI will expand other parts of its commercial aviation business.

Having acquired the CRJ programme from Bombardier earlier in 2020, MHI states that it will from FY2021 expand the MRO business area and "secure synergies" across various parts of its commercial aviation division. As well as seeking to leverage its position as type certificate holder for CRJ-family aircraft, MHI intends to expand its maintenance offer outside of the Canadian-built jet.

MHI believes that faster recovery of regional and narrowbody operations will translate into a more rapid pick-up for its CRJ support and aero-engines business, including its participation in the PW1100G programme for the A320neo.

Area-I proves effective for US Army

Start-up has become a key defence contractor in just 10 years, thanks to a focus on refined engineering and aerodynamics

Garrett Reim Los Angeles

There was one company US Army Brigadier General Walter Rugen wanted to "brag on" after the service's Project Convergence exercises in the Arizona desert: start-up Area-I.

Founded in 2009, the small, Georgia-based company has emerged as a key supplier for the US Army's experimental war plans. In particular, it is developing so-called air-launched effects: small unmanned air vehicles (UAVs) that will be deployed from aircraft or other UAVs to perform scouting missions behind enemy lines.

The service is leaning on such small drones to help it remain relevant in an era when surface-to-air missiles threaten to shoot down its traditional way of fighting. Unable to safely approach enemy forces too closely with its attack and scout helicopters, it wants to probe from a distance with air-launched effects and then fire long-range missiles at key targets.

Launch options

Area-I's Altius-600 has become a focal point of the US Army's futuristic warfighting exercises. It has been launched from a Sikorsky UH-60 Black Hawk utility helicopter and a General Atomics Aeronautical Systems MQ-1C Gray Eagle UAV.

The company has worked closely with the service over the past couple of years to pioneer the air-launched effects concept. It has air-launched its Altius-600 more than 40 times within the past six months, and has lost only two of the aircraft to accidents.

With these recent successes under its belt, the company is expanding its ambitions. It is developing an even larger air-launched effect, called the Altius-900, which will be capable of more than 15h of flight time and have a range of 540nm (1,000km). Efforts are also under way to repurpose the Altius-600 for launches into the eyes of hurricanes as part of a National Oceanic and Atmospheric Administration (NOAA) mission to better understand extreme weather.

Area-I's UAVs are able to air-launch into a variety of conditions because of the company's long-term focus on refined engineering and aerodynamics, says chief executive Nicholas Alley.

Alley noticed that the finer points of aeronautical engineering had been overlooked by the first generation of drone manufacturers while touring their facilities in 2006.

540nm

Range of the Altius-900, under development for an unnamed client

"I'd say, 'Hey, where's your aero guy?'" he recalls. "Inevitably, the story was 'We had a guy who was pretty interested in RC airplanes and we use the spreadsheet we found online [to design our UAV].'

"I don't want to name any names, but these are big-time UAVs that were turned into probably billion-dollar companies," says Alley, who saw an opportunity to increase the performance of UAVs.

That sort of thinking influenced the design of the Altius-600. In order for the UAV to have the slender, elongated wings needed to achieve up to 4h of flight endurance while still fitting inside the US military's Common Launch Tube, Area-I had to engineer the drone into "a flying, transforming robot", he says.

The Altius-600's wings telescope outward from within themselves, and spring-loading their expansion creates room for more batteries. Its wings also have a much higher aspect ratio than other tube-launched UAVs, such as the AeroVironment Switchblade and Raytheon Coyote, claims Alley: those types use a dual set of shorter, folding wings.

This emphasis on aerodynamic efficiency also resulted in the Altius-600 having a "very slippery airframe" with few protrusions, says Alley. The UAV's pusher propeller also was designed in-house.

"Most UAV manufacturers draw from the RC hobbyist market when selecting propellers. This greatly limits the design space, especially when it comes to folding propellers that can be stowed in a tube," says Alley. Instead, Area-I used "proprietary aerodynamic tools" to design the propellers to improve its performance, reduce its acoustic signature, and allow them to be folded.

But perhaps most importantly, Alley says Area-I has figured out a way to consistently achieve stable flight after the Altius-600 is ejected from its launch tube. That can be incredibly difficult when deploying from a fixed-wing aircraft such as a Lockheed Martin AC-130J Ghostrider gunship.

Area-I

The larger type is designed to be dropped from 450kg-class bomb rack units

Area-I

Black Hawk helicopter has been used as a launch vehicle for the Altius-600

"You can imagine you're sitting nice and happy in this little tube. And then, all of a sudden, you get jetted out to the free stream. You could be going hundreds of knots," says Alley. "Every launch is unique: tumbling, spinning, trying to stabilise the aircraft, ensure that it knows where it is, and where [or] how it's oriented, and then allowing it to get on wing without exploding itself."

This ability to stabilise the Altius-600 is the company's secret recipe, he says, declining to explain how the UAV rights itself.

Target practice

Area-I reached this point via small business innovation research contracts issued through the US Air Force Research Laboratory, starting in 2011. Those initially funded development of the Altius-600 for deployment from the Air Force Special Operations Command's (AFSOC's) AC-130Js. Previous reports state that the Altius-600 was flown below cloud level to find targets during tests.

More recently, the company has supported the army's vision for air-launched effects – a concept that Alley says was pioneered in co-ordination with the Aviation Technology Development Directorate at Fort Eustice in Newport News, Virginia.

> "Every launch is unique, trying to stabilise the aircraft to get on wing"
>
> **Nicholas Alley Chief executive, Area-I**

During Project Convergence, the Altius-600 was launched from a UH-60 at as little as 100ft above ground level, with the Black Hawk acting as a surrogate for the service's next-generation armed scout, the Future Attack Reconnaissance Aircraft.

The army wants to prove that a small drone can be launched from a low-flying rotorcraft and hunt for targets while its host aircraft hides in the radar shadows. Several possible missions have been identified for air-launched effects, including intelligence, surveillance and reconnaissance, electronic warfare, decoy applications, communications relay work and loitering munition strikes.

In addition to its work with AFSOC and the US Army, Area-I has three other air-launched effects efforts: a NOAA variant of the Altius-600, the US Navy's (USN's) Altius-500 and the Altius-900.

The Altius-500 was designed to be deployed from A-size sonobuoy launch canisters aboard the Boeing P-8A Poseidon maritime patrol aircraft. Because the 737 derivative does not have magnetic anomaly detection equipment to sense the presence of a submarine below the surface of the water, the USN was considering using the Altius-500 to perform the task. Alley says the project is on hold while the service decides whether to proceed.

Storm force

A variant of the Altius-600 in development for NOAA is likely to start flights into hurricanes next year, with the company having demonstrated safe launches from the Lockheed WP-3D Orion. The drone will carry a suite of weather and communication hardware, including temperature, pressure and humidity sensors, as well as downward-looking infrared sensors, a datalink with a 150nm range and a satellite modem.

NOAA plans to launch the Altius-600 into the eye of a hurricane, and have it transition through the wall of the storm. Area-I believes that its UAV should be able to survive for 3-4h in such conditions, depending on turbulence.

"There are provisions in the Altius flight controller to recover from severe upsets [tumbling], but we have done extensive flight simulations utilising NOAA-provided wind models, and we are confident we should be able to stay upright," says Alley.

The company's Altius-900 work is being conducted for a mystery customer. Weighing 36.3kg (80lb), it is designed to be hung and dropped from 14in, 450kg-class bomb rack units, like those used by the US Air Force's General Atomics MQ-9A Reaper.

The company's largest UAV has 6.1m (20ft)-long telescoping wings, and could also be deployed in-flight from the rear ramp of a cargo aircraft, says Alley. Its range and endurance stem from the use of a hybrid-electric engine that runs on heavy fuel. The aircraft is at a relatively low technology readiness level, with Area-I planning to conduct additional flight testing soon.

Alley declines to say what the Altius-900's application is, but says its payload can include electro-optical and infrared sensors.

Beyond Boeing

Despite its history as a 737-only operator, Southwest Airlines is looking elsewhere for its next narrowbody purchase

Pilar Wolfsteller Las Vegas

Southwest Airlines, an all-Boeing operator since its inception almost 50 years ago, is again flirting with the idea of buying aircraft from a competing airframer.

And with a hot new Airbus family – the A220 series – proving its mettle, analysts say such a move may be long overdue.

"The A220 is the logical follow-on for Southwest," says Mike Boyd, president of airline consultancy Boyd Group International. "It is a leap ahead of the A320 series, and it will be years and years before Boeing has a clean-sheet 737 replacement on the ramp."

Southwest executives have in recent years expressed interest in the idea of branching out beyond operating only 737s, a discussion that has gained traction following the 737 Max grounding, which hit Southwest particularly hard.

The airline is among Boeing's top customers for the 737; it has 34 Max in storage and 260 jets on order.

Amid the coronavirus pandemic and its effects on the air transport industry, the idea of acquiring new aircraft seemed to have been put on Southwest's back burner, until the company's third-quarter earnings call on 22 October.

"If there were ever a scenario for us to consider making a change in aircraft, it would be now, because we're not desperate to grow the airline, and may not be for a long time," Southwest's chief executive Gary Kelly said. "We do need the smaller airplane. We have a ton of 737-700s that are coming up for retirement in the next several years."

As of 23 October, Southwest had 421 737-700s in service, including more than 60 that are at least 20 years old, plus another 72 in storage, according to Cirium fleets data. Southwest equips the variant with 143 seats, all in economy class.

Strong attraction

But which mid-range aircraft will be the bride that Southwest takes to the altar? Until recently, a Boeing product – the 737 Max 7, for which the airline holds 28 orders – seemed most likely.

But perhaps no longer.

"The A220 is a new variant – [a] younger, more fuel-efficient aircraft than the 737-700," says Helane Becker, analyst at Cowen Securities.

She also notes that the 737 Max 7, unlike the clean-sheet A220, is based on a decades-old design.

Boeing has secured relatively few orders for the smallest member of the Max family: the current firm backlog stands at just 52 aircraft, comprising 30 for Southwest and 22 for Canadian discounter WestJet, according to Cirium.

Airbus acquired the A220 programme from Bombardier in 2018. As of end-September, Airbus had delivered 123 A220s and had another 516 on order.

A220-family aircraft are the smallest in Airbus's product line: in a two-class layout, the -100 can hold 100-120 seats and the -300 120-150. Boeing says the 737 Max 7 can accommodate 138-153 seats in a two-class configuration.

While the Max has around 300nm (555km) more range than either A220 model, that is not the only metric under consideration.

"The A220 is flat-out the most advanced single-aisle airliner in the world," Boyd says. "[It has] far better economics than even the Max, the cabin is superior in comfort and the A220-300 can do Providence [Rhode Island] to Washington DC, and Providence to London [Ontario], profitably."

And for an airline rebuilding following the pandemic – Southwest reported a record $1.2 billion loss in the third quarter – efficiency and profitability are top of its mind.

"We will need [a smaller aircraft] to fly shorter to medium-haul markets, with economics that will serve us well," chief financial officer Tammy Romo says. "We have long been an all-Boeing carrier and there are certainly efficiencies that come with that. All that [will be] factored into that evaluation."

But the single-manufacturer argument only goes so far, analysts say. Southwest has previously operated various 737 variants concurrently with differing training, maintenance, parts and support required.

However, Becker says that if a two-type fleet is pursued, the airline will "have to work harder to maintain their low-cost advantage" since new aircraft would add complexity.

She adds that another possible contender to replace the -700s could be Embraer E-Jet E2s, though the airline has not disclosed discussions with the Brazilian airframer.

Southwest says it plans to make a fleet decision within the next year, with potential deliveries of new jets from 2025.

Carrier has flown 737 variants for all of its 50-year history

Jeramey Lende/Shutterstock

WE SHARE YOUR PASSION FOR FLIGHT

Airside from CAE is the new digital platform created for pilots, by pilots during the COVID-19 pandemic.

Designed using feedback from thousands of pilots around the globe, Airside supports you with the tools to prepare you to fly again. Find pilot jobs, update your CV with our resume builder tool and browse pilot training articles from experts across the industry. Create an account today to take advantage of an experience tailored to you.

airside.aero

AIRSIDE

From CAE

Dutch researchers probe CO_2 riddle

Study suggests rise in cargo operations and sharper fall in short-haul passenger services are responsible for emissions failing to track overall reduction in flights during pandemic

Dominic Perry London

Researchers in the Netherlands believe that an increase in long-distance cargo flights, combined with steeper reductions in short-haul passenger services than for long-haul operations, are responsible for carbon dioxide (CO_2) emissions failing to fall in line with the overall drop in flights.

Analysts from the Royal Netherlands Aerospace Centre (NLR) looked at movements to and from Schiphol airport from March to September 2020. They found that although total flights dropped by 67% year on year, CO_2 emissions fell by only 55%.

That differential was widest in May and June: although 85% fewer flights were recorded, CO_2 emissions dropped by just 64% – a 21 percentage point difference; during the July-September period, that gap narrowed to less than five percentage points, the research shows.

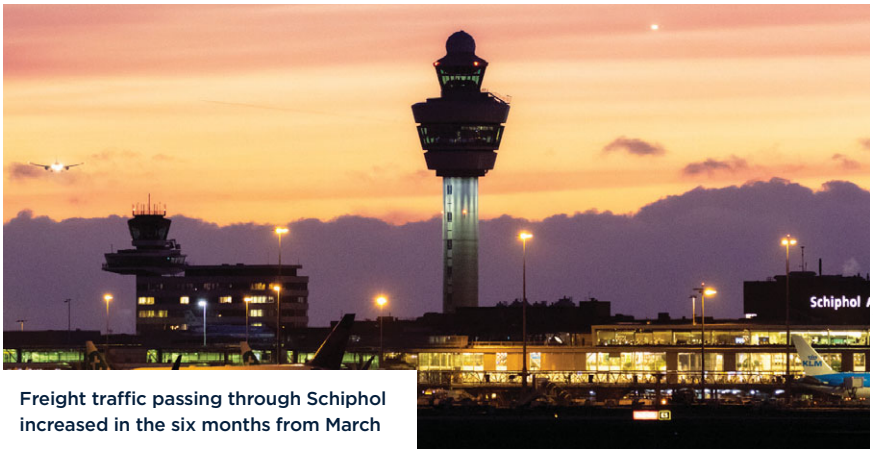
The NLR thinks that the increase in overall freighter flights from Schiphol, which are up by 8% year on year, is partly responsible for the discrepancy.

With cargo operations typically serving longer routes – burning more fuel – CO_2 emissions were pushed up by 11% year on year.

But if Dutch carrier KLM's use of its Boeing 747-400 Combi aircraft solely for cargo operations from April onwards is factored in, the number of cargo flights effectively increased by 14% compared with 2019, contributing to a 24%, rather than 11%, rise in CO2 emissions.

"On top of that, there is actually also a contribution from extra flights where cargo was transported in the cabins of passenger aircraft," says Bram Peerlings, who was involved in the study.

The NLR also says that short-haul travel was hit more severely than long-haul. Overall passenger flights dropped by 69%, but corresponding CO_2 emissions fell by only 63%.



VanderWolf Images/Shutterstock

Freight traffic passing through Schiphol increased in the six months from March

While travel between Amsterdam and destinations such as Egypt, Israel, Morocco and Turkey reduced significantly, flight levels to and from intercontinental destinations further away, such as South Korea and Taiwan, remained constant or even slightly increased, says the research council.

"Again, this increases the average distance per flight, causing a corresponding increase in fuel consumption and CO_2 emissions."

Usage data

However, the NLR admits that because of a lack of precise usage data, it has counted freight-in-cabin flights as passenger operations.

While this does not have an affect on the overall figures, the relative impact of cargo or long-haul passenger flights changes depending on how those freight-in-cabin services are categorised.

And although total CO_2 emissions fell, lower passenger loads ensured that emissions per person were pushed up.

Statistics show that occupancy on flights to and from the Netherlands' five largest airports approximately halved over the March-May period, meaning that emissions per passenger kilometre "have almost doubled".

IATA figures suggest a slightly lower reduction in passenger occupancy across the whole of Europe – down 40% from March to May and down 30% from March to August.

"It is plausible that this trend also applies to the Netherlands," says Peerlings. "That means emissions per passenger have fallen somewhat again compared with earlier this year. Nevertheless, the fuel consumption per person is significantly higher than before the crisis."

However, the NLR believes that the accelerated introduction of new-generation aircraft – which burn less fuel – owing to the coronavirus crisis, will have a positive impact on CO_2 levels.

"If we simulate all flights again in the period March to September 2019, but in a situation where the oldest aircraft have been replaced by a newer generation, this will save more than 4% in CO_2 emissions," it says.

In its analysis, older aircraft include the Airbus A300, A310, A340 and Boeing 737 Classic, 747, 757, and 767, with newer models comprising the A330, 737NG, 777 and 787. CO2 would fall further if the latest generation of aircraft were introduced, it adds.

Aircraft Interiors EXPO®

31 AUG – 2 SEPT 2021
HAMBURG, GERMANY

THE DESTINATION FOR THE AIRCRAFT INTERIORS INDUSTRY

Aircraft Interiors Expo is the leading marketplace where the cabin interiors and inflight entertainment industry supply chain meet buyers from commercial airlines, lessors and business jets. They come together to collaborate, find solutions to today's challenges and design the cabin of the future.

Join the global industry at:
www.aircraftinteriorsexpo.com

NEW
BUSINESS JET INTERIORS ZONE

Co-located:
World Travel Catering & Onboard Services EXPO | 31 AUG – 2 SEPT 2021 | HAMBURG, GERMANY
Passenger Experience CONFERENCE

Organised by:
Reed Exhibitions®

In co-operation:
Hamburg Messe + Congress

Connect with us:

FBB

Lufthansa and EasyJet flights arrived as part of new facility's opening ceremony

Opening ends Brandenburg wait

German capital's overdue airport finally began operating in late October, but Covid crisis means it has excess capacity

David Kaminski-Morrow London

One of the ironies of Berlin Brandenburg airport's much-delayed opening is that the onset of the air transport crisis has brought an excess of capacity to a hub that was once thought to have a shortage.

Combined passenger numbers for Tegel and Schonefeld airport for the first eight months of 2020 reached just 7.3 million, a figure more than 40% below the level in 2007 – the original projected opening date for a new Berlin hub.

Brandenburg finally opened on 31 October, 13 years behind schedule and eight years after the extraordinary decision to abandon a firm June 2012 opening just a couple of weeks beforehand.

The airport was originally intended to be a landmark privatisation initiative, but the competing consortia became mired in a legal dispute after the selection process, eventually opting to team up and propose a jointly managed project.

This proposal was rejected by the German government, which said the price was too high and proposal too risky; it scrapped the privatisation in 2003 in favour of a decision to fund the project from public and commercial sources.

Brandenburg then faced delays arising from legal consideration of noise, the insolvency of a technical planning partner, and new European security requirements.

But as the airport neared a final opening date of 3 June 2012, a bombshell revelation emerged: the terminal building's complex fire safety and smoke-extraction system did not meet requirements.

This was a crucial determination, because the German government had been rocked by the Dusseldorf airport terminal fire in 1996 which resulted in 17 fatalities – many of them from smoke inhalation.

The abandonment of Brandenburg's opening at such a late stage triggered a backlash from airlines – notably local carrier Air Berlin, which had carried out extensive preparations to transfer to the new hub and expand its operations.

Adapting the fire-protection system required extensive redesign and modification to a building which had already effectively been completed, with substantial changes to the basic architecture of the system, along with relocation of dozens of kilometres of cabling, and updating of the IT equipment.

Knockdown price?

Such was the extent of the work required that there were even calls for the entire terminal to be demolished and rebuilt.

The delay forced investment to upgrade the old airports, which were supposed to have closed once Brandenburg was operational, and prompted concerns that the new hub's initial design capacity would ultimately be insufficient.

The main building, Terminal 1, can handle about 25 million passengers annually, says operator FBB.

After Air Berlin filed for insolvency in August 2017, total passenger numbers at Tegel and Schonefeld fell during the following 10 months. By the end of 2018, however, the decline had been reversed, and the airports showed a 4.2% increase in passenger numbers, to 34.7 million, for the full year.

While capacity from Air Berlin's collapse was snapped up, the air transport crisis has inflicted far more damage on airline operations at the new capital airport – and provided a much greater than expected margin in terms of capacity.

Brandenburg has an adjacent building, Terminal 2, which FBB says "will not be needed for the commissioning" owing to the crisis.

FBB says the former Schonefeld airport has been redesignated as Terminal 5, offering capacity of 8-10 million passengers.

The operator says that "sufficient capacity" is available at the overall airport system, which will have the ability to handle more than 40 million passengers and becomes the third-largest airport in the country behind Frankfurt and Munich.

Commercial services at the hub began on 1 November, following the arrival of symbolic Lufthansa and EasyJet flights during the opening ceremony the day before. Flights initially used the northern runway, with the southern runway employed from 4 November.

"The people here in the German capital region waited a long time for this day," said FBB chief Engelbert Lutke Daldrup at the opening.

"With the opening of the airport, the time has come to regain lost confidence," said Brandenburg state minister president Dietmar Woidke. "It is time to look ahead. [The airport] will be a strong driver for economic growth and employment in the region and for the whole of eastern Germany."

The nuts and bolts of safety

It is the details that matter where aviation accidents are concerned, argues **Don Porter**

Peter Gudella/Shutterstock

Tragedies can result when small mistakes trigger a chain of events

The Federal Aviation Administration (FAA) states that flying on US-based airlines is safe. But the agency equates "safety" with the occurrence of actual accidents – not "incidents" where mechanical issues could result in an accident. An aircraft with undetected maintenance problems is, in reality, unsafe.

It is a truism that a small event can lead to a massive incident. A single match can spark a forest fire that devastates a huge area. In aviation, a tiny nut, bolt or pin – or the absence thereof – can trigger an accident that kills hundreds of people.

That can be seen in the crashes that led to the grounding of the Boeing 737 Max. While the post-accident focus was rightly on the jet's automated systems, many factors figured in the demise of the Indonesian and Ethiopian aircraft. But one fact is clear in each case: the deadly chain of events that killed, respectively, 189 and 157 people, began with the failure of a small angle of attack (AoA) sensor.

Max aircraft flew in excess of 10 million passengers between their first days in service in May 2017 and their grounding in March 2019. But they flew with hidden flaws. It took the failures of those AoA sensors – through poor overhaul or damage – to trigger an automatic, computer-driven chain of events that brought the jets down. Although millions of passengers had flown in Maxes without a single accident, the possibility for a crash existed during any one of those flights.

But this is not a new phenomenon. The National Transportation Safety Board's archives are full of incidents which very nearly became fatal accidents. For example, on 6 November 2019, as a Republic Airways Embraer 175 climbed to 2,200ft, the plane's nose rose abruptly. The captain clicked the autopilot/pitch trim disengage switch. There was no response. The co-pilot's trim switch being functional, the crew was able to land after 15 harrowing minutes aloft. The cause: chafed wiring connecting the horizontal stabilizer trim actuator to the captain's switch. Compounding the error, the switch had been installed upside down.

Aborted take-off

On 17 August 2015, the pilots of Allegiant Air flight 436, a Boeing MD-83, aborted take-off from Las Vegas due to a missing cotter pin in the elevator linkage. No-one was killed or injured, so the event was classified as a serious incident and not an accident. The jet had completed 216 uneventful flights after a mechanic forgot to install the pin. A bolt usually retained by the pin fell out, jamming the elevator. If the crew had continued the take-off, there's little doubt the aircraft would have crashed, probably killing many of the 162 people aboard.

Here's what the FAA safety inspector who investigated the incident wrote to his superiors: "I recommend that a sanction be added for each of the 216 flights that were flown... in an unairworthy condition." But his bosses disagreed, and no punitive action was taken against the air carrier or its maintenance contractor.

One does not have to look too far back to see what might have been.

On 1 September 1961, TWA flight 529, a Lockheed L-049 Constellation, crashed four minutes after departing Chicago, killing all 78 people aboard. The cause: someone forgot to install a cotter pin on a nut. It caused the elevator controls to jam, making the aircraft uncontrollable.

Three weeks later, also in Chicago, a Northwest Airlines Lockheed L-188 Electra crash killed 37. The cause: a missing 2in (5cm) piece of safety wire in the aileron linkage that someone forgot to install.

To reiterate: 115 people died because a cotter pin and 2in of safety wire were missing.

Of course, all machines are susceptible to mechanical failure, and that applies to aviation whether the aircraft was built in 1950 or rolled off an assembly line this afternoon. No-one disputes that things can go wrong; that is why aviation's rules and regulations are so prescriptive.

But until the industry establishes greater emphasis on a workplace culture committed to safety above all else, and applies that consistently across the globe, the existing safety margin that should protect flightcrews and billions of air travellers will continue to be eroded.

Don Porter is a former FAA-licensed mechanic, technical representative, and product support manager for a major aircraft manufacturer. He has investigated hundreds of mishaps, some ending in tragedies. His latest book, Flight Failure: Investigating the Nuts and Bolts of Air Disasters and Aviation Safety, is out now

54th INTERNATIONAL PARIS AIR SHOW

Paris • Le Bourget • **21 > 27 June 2021**

LET'S BOOST AEROSPACE BUSINESS **TOGETHER**

an event by GIFAS

siae.fr

Next month

FLIGHT INTERNATIONAL

On sale
31 December

In our country special: why Italian industry strengthens Tempest

BAE Systems

Plus...

BlueBarronPhoto/Shutterstock

Back on course
Will 737 return mean end to Boeing's crisis in 2021?

Drop of Light/Shutterstock

Biden time
How new US president could redirect aerospace

Airbus

Watch the skies
What chance for air show gatherings amid pandemic?

Militaries around the world made good use of their fleets in response to the coronavirus pandemic, while also meeting more regular commitments. Our annual snapshot looks at the in-service picture

Crown Copyright

A Turkish A400M flew emergency supplies to the UK

To the rescue

Craig Hoyle London / **Data by Cirium**

Military personnel are trained to always expect the unexpected, but even the sharpest-minded defence planners could not have foreseen the swift pace and staggering impact of the coronavirus pandemic during 2020.

Rather than having normal day-to-day activities or combat commitments at the front of their minds, the world's air forces, armies and navies had to rapidly react and adapt to the health crisis as it swiftly swept the globe after emerging in China's Wuhan province.

Ordinarily tasked with transporting personnel and equipment in support of military operations, strategic and tactical transport aircraft were re-assigned to more critical supply flights, delivering personal protective equipment, medicines and ventilators from locations including China and Turkey.

Medical evacuations

The US Air Force (USAF) called on assets including the Lockheed C-5M, Boeing C-17 and Lockheed Martin C-130 to perform such work, while European air forces deployed Airbus Defence & Space A330 multi-role tanker transports (MRTTs) and A400M airlifters. Along with commercial airliners, these assets were also used to repatriate nationals stranded overseas by snap lockdowns, and to conduct medical evacuation tasks.

With every part of the globe affected, most militaries also made full use of their combat helicopter fleets to transfer vital equipment or help move critically ill patients to hospital.

Global military fleet

	Country	Active fleet	Share
1.	USA	13,232	25%
2.	Russia	4,143	8%
3.	China	3,260	6%
4.	India	2,119	4%
5.	South Korea	1,581	3%
6.	Japan	1,480	3%
7.	Pakistan	1,364	2%
8.	France	1,057	2%
9.	Turkey	1,056	2%
10.	Egypt	1,053	2%
	Other	23,218	43%
	Total	53,563	100%

Source: Cirium fleets data

While the commercial air travel sector all but closed down as the effects of Covid-19 spread, air force mobility assets have rarely been in greater demand.

Another example of air forces responding to crises was the reaction to a devastating explosion in the Lebanese capital Beirut on 4 August. Multiple nations conducted relief flights, among them Brazil, which delivered supplies using its air force's new Embraer KC-390 transport.

Underscoring the importance of such assets, Cirium fleets data shows that the number of in-service transport aircraft increased by 36 over the 12-month period since our last snapshot, to a new total of 4,301; some 8% of the total fleet.

4,301

Number of military transport aircraft in service around the world this year – 8% of the total fleet

Overall, the global active military inventory contracted by 327 aircraft during the same time, to 53,563 as of 30 September. This represented an overall cut of 0.6%; up from the 0.2% downsizing seen between our 2019 and 2020 reports.

Latin America experienced the sharpest decrease, with a 3% cut over the review period, to 3,231. This was almost entirely due to 83 retirements made in the combat helicopter category.

However, Brazil's first of a currently contracted 36 Saab Gripen E/Fs arrived in the country and was formally welcomed and flown during a ceremony in Brasilia on 23 October. Locally designated the F-39, the type will enter squadron service with the nation and for Sweden during 2021.

Europe's 8,485 aircraft total was down 129 from last year; a reduction just short of 1.5%. Key contributors included the retirement of 24 Belgian Dassault/Dornier Alpha Jet trainers, and the French air force almost halving its fleet of the same type, from 97 to 57 units.

The French army's combat helicopter fleet underwent major change, with its Aerospatiale SA341/342 inventory trimmed from 165 examples to 112 and 55 SA330s removed from use, leaving only 19. The nation's navy also ceased operations with the Westland Lynx; a reduction of 23. Meanwhile, Paris ordered the first Airbus Helicopters H160s: an initial four for its navy as an interim measure.

Budgetary squeeze

Germany trimmed its army's Bell UH-1D fleet from 101 to 62 aircraft, and axed a plan to replace its air force's Sikorsky CH-53s with either the Boeing CH-47F or CH-53K, due to budgetary factors. However, Berlin ordered a pair of Airbus A321LRs, for troop transport and medical evacuation duties, and on 11 November signed for a further 38 Eurofighters.

Brazilian Air Force

Brazil made relief flight to Lebanon with its KC-390 transport

Fleet size for leading countries by role

Combat aircraft

	Country	Active fleet	Share
1.	USA	2,717	19%
2.	China	1,571	11%
3.	Russia	1,531	10%
4.	India	672	5%
5.	North Korea	572	4%
6.	South Korea	476	3%
7.	Pakistan	447	3%
8.	Saudi Arabia	360	2%
9.	Egypt	338	2%
10.	Taiwan	288	2%
	Other	5,663	39%
	Total	14,635	100%

Special mission

	Country	Active fleet	Share
1.	USA	749	38%
2.	Japan	161	8%
3.	Russia	130	7%
4.	China	115	6%
5.	India	70	4%
6.	France	46	2%
7.	Brazil	40	2%
8.	Germany	40	2%
9.	Australia	31	1%
10.	South Korea	30	1%
	Other	572	29%
	Total	1,984	100%

Tanker

	Country	Active fleet	Share
1.	USA	625	76%
2.	France	23	3%
3.	Saudi Arabia	22	3%
4.	Russia	19	2%
5.	Israel	11	1%
6.	Italy	10	1%
7.	Singapore	10	1%
8.	Spain	9	1%
9.	UK	9	1%
10.	Germany	7	1%
	Other	79	10%
	Total	824	100%

Source: Cirium fleets data

There are 501 F-35s in service; and 19 B-2s

US Air Force

Elsewhere on the continent, Greece has introduced a large fleet of 57 second-hand Bell OH-58s since our last directory. And in September, Athens announced its intention to acquire 18 Dassault Rafale B/C fighters.

The Irish Air Corps introduced three Pilatus PC-12NGs to use, and ordered two Airbus Defence & Space C295 maritime patrol aircraft to replace its current CN235s. And Hungary signed for two KC-390s, to be delivered in 2023-2024.

Luxembourg received its lone A400M, to be operated within a joint unit with the Belgian air force, which will take seven of the Atlas transports.

Assets directly assigned to NATO are recorded within Europe's fleet total, as it is the operating location for the Alliance's pooled airborne early warning, tanker/transport and strategic transport fleets. Currently involving six countries, the NATO Multinational MRRT Fleet organisation received its first two refuelling boom-equipped A330s, based at Eindhoven, the Netherlands, with at least seven additional aircraft to follow.

Long-term Lockheed F-16 operator Denmark has ordered its first two Lockheed F-35As, from a planned 27-unit acquisition. This came as the in-service fleet of F-35s passed the 500 mark – by one example. However, the stealthy type does not yet appear in our Top 10 listing of combat aircraft (*see p46*), as 175 of the in-use examples are dedicated for use as training assets.

An overall fleet reduction was also recorded in the Asia-Pacific region, with the removal of 190 aircraft equating to a 1.3% reverse, to 14,807.

Transport

	Country	Active fleet	Share
1.	USA	941	22%
2.	Russia	429	10%
3.	China	264	6%
4.	India	251	6%
5.	Brazil	124	3%
6.	France	118	2%
7.	Iran	83	2%
8.	Turkey	80	2%
9.	Colombia	76	2%
10.	Germany	72	2%
	Other	1,863	43%
	Total	4,301	100%

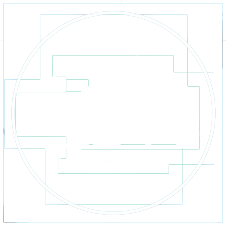
Combat helicopter

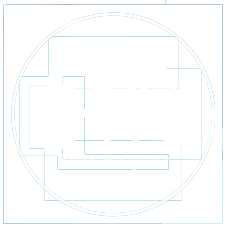
	Country	Active fleet	Share
1.	USA	5,434	27%
2.	Russia	1,540	8%
3.	China	902	4%
4.	India	775	4%
5.	South Korea	734	4%
6.	Japan	552	3%
7.	Turkey	471	2%
8.	France	432	2%
9.	Italy	410	2%
10.	Germany	338	1%
	Other	8,680	43%
	Total	20,268	100%

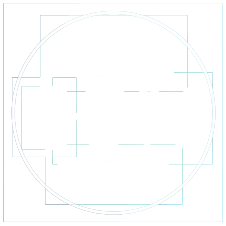
Training aircraft/helicopters

	Country	Active fleet	Share
1.	USA	2,766	24%
2.	Pakistan	510	4%
3.	Russia	494	4%
4.	Japan	427	4%
5.	China	405	4%
6.	India	345	3%
7.	Egypt	341	3%
8.	South Korea	296	3%
9.	Turkey	273	2%
10.	UK	244	2%
	Other	5,450	47%
	Total	11,551	100%

Worldwide active fleet by region

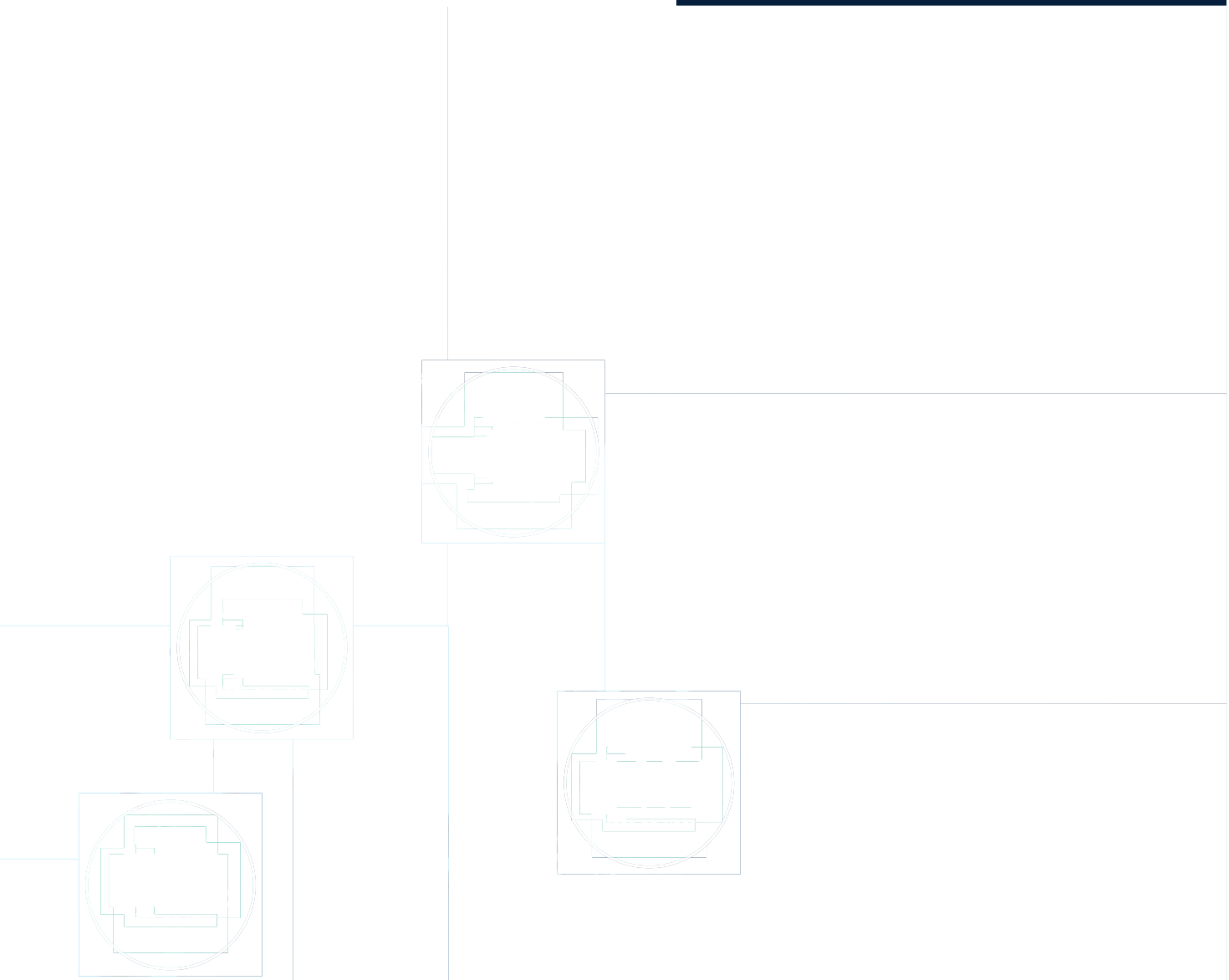






Combat aircraft	2,779	Combat aircraft	466	Combat aircraft	2,076	Combat aircraft	959
Tanker	631	Tanker	11	Tanker	69	Tanker	5
Combat helicopter	5,547	Combat helicopter	1,145	Combat helicopter	3,446	Combat helicopter	1,602
Total	**13,609**	**Total**	**3,231**	**Total**	**8,485**	**Total**	**4,061**
Year-on-year fleet change	0%	Year-on-year fleet change	-3%	Year-on-year fleet change	-1%	Year-on-year fleet change	1%

Shutterstock



Combat aircraft	1,473	Combat aircraft	1,880	Combat aircraft	5,002
Tanker	45	Tanker	19	Tanker	44
Combat helicopter	1,488	Combat helicopter	1,920	Combat helicopter	5,120
Total	**4,341**	**Total**	**5,029**	**Total**	**14,807**
Year-on-year fleet change	1%	Year-on-year fleet change	0%	Year-on-year fleet change	-1%

New additions were outweighed by the retirement of 92 MD Helicopters MD500s by the Japan Ground Self-Defence Force, 75 army UH-1s and 10 navy Aerospatiale SA319s by South Korea, 23 Sikorsky S-61 Nuri rotorcraft by The Royal Malaysian Air Force, and Vietnam's removal of a combined 39 Mil Mi-24 and UH-1H helicopters.

The Indian air force retired the last of its Mikoyan MiG-27s; 42 were listed in our last directory. This leaves only 12 of the type in use, with the air force of Kazakhstan. New Delhi also disposed of its last 12 MiG-23 trainers.

Pakistan's navy retired its seven Fokker F27 special mission aircraft, while boosting its fleet of ATR 42 maritime patrol assets by one unit, to three. The Royal Australian Air Force also waved off its last Pilatus PC-9 trainers, having replaced them with 49 of the more capable PC-21 turboprop.

13,609

Total North American fleet – down by 0.3% with retirements of T-34 trainers and AH-1W rotorcraft

Meanwhile, the gap between the Asia-Pacific and North America fleet totals came down by 150, to just shy of 1,200 units.

North America's 42-unit in-year decrease – to 13,609 – represented a 0.3% reduction. This came as the US Navy trimmed its veteran Beechcraft T-34 trainer fleet from 75 aircraft to just 13, and the US Marine Corps in October ended operations with its Bell AH-1W attack helicopters. Our previous directory included 59 of these, now succeeded by the service's AH-1Zs. The Marines' last five UH-1Ns also were stood down.

In a move that will influence its future fleet mix, the USAF ordered its first Boeing F-15s for more than two decades, as part of a plan to eventually acquire up to 144 in the new F-15EX standard.

Russia and its Commonwealth of Independent States allies added a combined 13 aircraft, with their collective total rising to 5,029. The Russian air force received its first two Mi-38 transport helicopters, but reduced its fighter fleet by more than 80 Sukhoi Su-27/30s, leaving 342 of the type, plus trainers.

Middle East-region nations added 57 aircraft, representing a 1% growth, to 4,341. This included the Egyptian air force introducing its first five Su-35 fighters, and the United Arab Emirates (UAE) the lead two of a potential five Saab GlobalEye surveillance aircraft; heavily adapted Bombardier Global 6000s. Kuwait also introduced a pair of Airbus Helicopters H225Ms, part of a 30-unit acquisition.

Cairo removed all but one of its Aero Vodochody L-39 trainers from use, cutting 48 examples. The Royal

SpaceKris/Shutterstock

Su-57 represents Russia's most advanced fighter

Worldwide Top 10 active aircraft types

Combat aircraft

	Type	Active fleet	Share
1.	F-16	2,267	15%
2.	Su-27/30	1,057	7%
3.	F-15	956	7%
4.	F-18	884	6%
5.	MiG-29	817	6%
6.	Eurofighter	514	3%
7.	Su-25	470	3%
8.	J-7	418	3%
9.	F-5	403	3%
10.	Su-24	389	3%
	Other	6,460	44%
	Total	14,635	100%

Special mission

	Type	Active fleet	Share
1.	P-3	213	11%
2.	King Air	199	10%
3.	EA-18G	164	8%
4.	737	146	7%
5.	E-2	124	6%
6.	707	118	6%
7.	C295/CN235	63	3%
8.	C-130	59	3%
9.	Y-8	59	3%
10.	Il-18	49	3%
	Other	790	40%
	Total	1,984	100%

Tanker

	Type	Active fleet	Share
1.	KC-135	419	51%
2.	C-130	190	23%
3.	DC-10	59	7%
4.	767	45	5%
5.	A330	38	5%
6.	Il-78	35	4%
7.	707	18	2%
8.	A400M	12	1%
9.	A310	5	1%
10.	747	3	1%
	Other		0%
	Total	824	100%

Source: Cirium fleets data

Jordanian Air Force retired its Casa C-101 jet trainers; last year it operated 13 of the type, which now remains in use with only the air forces of Chile and Spain.

A 1% fleet increase was recorded among African nations, partly due to Morocco boosting the size of its operational Dassault Mirage F1 fleet, from single figures to some 46 examples. The continent now has an active inventory of 4,061 military aircraft.

The equipment changes recorded around the globe have had minimal effect on our Top 10 rankings, bar nudging China into second place – ahead of Russia – in terms of combat aircraft fleet size (*see p42*). This is despite a slight adjustment by Cirium regarding the Su-27 family, with improved data recording 39 Chinese air force examples as UBK-model trainers.

However, Beijing's 11% combat aircraft share, with 1,571 units, still sits a great distance behind the USA's 2,717 (19%), in both volume and capability terms.

Numerical advantage

Indeed, the US military heads all six of our Top 10 equipment categories by nation, with its comparative advantage including owning 36% of all special mission aircraft and 76% of the world's in-service tankers.

The placement of two national listings have been adjusted for our 2021 report, which overall includes information about 160 countries. Eswatini is the new name for the former Swaziland, while Macedonia replaces the prior use of the title North Macedonia.

Available to download, our annual fleet review excludes those aircraft recorded by Cirium as not being in day-to-day use, such as the more than 4,900 examples known to be in storage, or involved in or awaiting upgrade. We also do not list the 685 assets permanently assigned to performing VIP duties, or employed by military-operated airlines in some nations.

Other omissions include almost 350 aircraft detailed as permanently tasked with supporting research and development or experimental tasks, including for France's DGA defence procurement agency, Germany's WTD 61 test unit and the UK's Qinetiq.

A further 270 aircraft recorded as for calibration or mapping, firefighting, police support, satellite tracking, skydiving, surveying, target towing, or weather reconnaissance duties are also excluded.

This year, we also have reduced the number of potential future orders included in our listing, narrowing our focus to show those deals which are the subject of a letter of intent to order only. Less definite commitments have been excluded in the majority of cases, with exceptions including showing the full programme of record commitments made by F-35 partner and customer nations, plus the UAE.

Transport

	Type	Active fleet	Share
1.	C-130/L-100	863	20%
2.	King Air	279	7%
3.	C295/CN235	277	6%
4.	C-17	275	6%
5.	An-24/26	260	6%
6.	Il-76	203	5%
	7. An-30/32	140	3%
8.	Cessna 208	138	3%
9.	Y-8	117	3%
10.	C212	89	2%
	Other	1,660	39%
	Total	4,301	100%

Combat helicopter

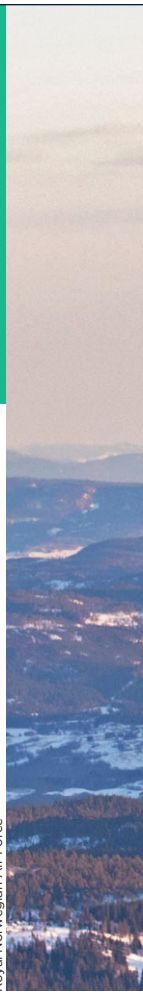
	Type	Active fleet	Share
1.	S-70/SH/UH-60	3,929	19%
2.	Mi-8/17	2,906	14%
3.	AH-64	1,222	6%
4.	UH-1	1,141	6%
5.	Mi-24/35	962	5%
6.	CH-47	935	5%
7.	MD500/530	634	3%
8.	AH-1	499	2%
9.	SA341/342	426	2%
10.	H145	416	2%
	Other	7,198	36%
	Total	20,268	100%

Training aircraft/helicopters

	Type	Active fleet	Share
1.	T-6	970	8%
2.	F-16	650	6%
3.	Hawk	610	5%
4.	L-39	598	5%
5.	T-38	581	5%
6.	MFI-15/17/395	479	4%
7.	Bell 206	415	4%
8.	PC-7	364	3%
9.	F-18	336	3%
10.	SF260	301	3%
	Other	6,247	54%
	Total	11,551	100%

More European nations fielding the fifth-generation F-35 will be a key element in NATO's drive to deter Russian military ambitions, but older assets also have a big part to play

Advancing by stealth



Royal Norwegian Air Force

Garrett Reim Los Angeles

The growing number of Lockheed Martin F-35 stealth fighters being acquired by European air forces would give NATO an edge over Russia in a high-intensity conflict, according to the RAND think tank.

Published in late October, its report – *At the Vanguard: European contributions to NATO's future combat airpower* – notes that Moscow's political and military leaders are already concerned about the Alliance's advantage in the air domain. Such worries are likely to deepen as the number of fifth-generation fighters in use increases, it adds.

Seven European NATO nations already operate or plan to field the F-35: Belgium, Denmark, Italy, the Netherlands, Norway, Poland and the UK.

By 2025, their militaries should collectively own more than 200 examples of the Lightning II. "This will exceed the number of US fifth-generation aircraft stationed in the European theatre by a wide margin," says the report. Within a further five years, the number of F-35s with European allies is likely to approach 400 aircraft.

"Russian announcements and efforts to build advanced systems to defend against Western weapons indicate that Moscow harbours real concerns over NATO's ability to conduct rapid deep strikes," the report states. "Between 2008 and 2015, the Russian military received more than 350 new combat aircraft and about 1,000 helicopters, as well as hundreds of air-defence systems," it adds.

Moscow also plans to field 78 Sukhoi Su-57 fifth-generation fighters by 2028, with its first operational examples of the stealthy type planned to be delivered by year-end.

Cirium fleets data shows NATO's European nations have almost 1,800 combat aircraft in active use (see *p50*), with this total dominated by fourth-generation types including the Lockheed F-16, Eurofighter Typhoon and Dassault Rafale. Italy, the Netherlands, Norway and the UK now have 76 F-35s in service, including 19 employed as training assets.

Ground threat

RAND says fourth-generation types would be vulnerable during a high-intensity conflict, because of Moscow's robust surface-to-air missile defences.

"During the opening phases of a conflict with Russia, vulnerability to advanced ground-based threats would constrain the roles of most fourth-generation and so-called fourth-generation-plus platforms," says the report. "As long as an extensive [integrated air-defence] threat persisted, more advanced platforms such as the Rafale or Eurofighter could theoretically perform strike missions inside the threat zone in conjunction with fifth-generation platforms, although this approach could yield unacceptable attrition."

With fourth-generation types expected to still make up 70% of NATO's European combat aircraft inventory by 2030, the think tank says Alliance members need to find ways to make better use of their legacy aircraft.

This could include employing them to launch long-range missile strikes from beyond the reach of Russia's surface-to-air missile defences. Additionally, equipping the aircraft with active electronically scanned array (AESA) radars would boost their defensive capabilities, the report says.

Norway has 18 F-35s in operation

"The resultant situational awareness and ability to defeat multiple threats at the same time makes an AESA capability essential for aspects of high-intensity operations – for example, to intercept cruise missiles," it notes. "The French decision to procure AESA [sensors for the Rafale] is informed by the opportunity to provide a 50% increase in detection range, including of low-observable targets, and maximise the value of new weapon systems such as the [MBDA] Meteor beyond-visual-range missile."

The Meteor is a radar-guided air-to-air weapon with an effective range of more than 54nm (100km), already integrated with the Eurofighter, Rafale and Saab's Gripen.

"Uncertainties remain as to which nations will invest in AESA radar technology, advanced and long-range munitions, and secure communication links, among other important capabilities," says RAND. "The degree to which European air forces acquire these technologies will directly impact their ability to contribute to the range of combat air missions expected in a high-intensity conflict."

The UK in September announced plans to add the European Common Radar System Mk2 AESA array to potentially 40 Royal Air Force Tranche 3 production-standard Typhoons, with initial operational capability targeted for 2025. Developer Leonardo UK claims that the technology will deliver "the world's most capable fighter radar", also providing electronic attack and jamming functionality.

Germany and Spain also in 2020 advanced plans to integrate AESA radars with some of their Eurofighters, with the work to be respectively led by Hensoldt and Indra.

Ultimately, to make the most of a mixed fleet of fourth- and fifth-generation fighters, NATO will need to invest in communications technologies to link the jets, as well as training exercises to practise co-ordinating their operation.

F-35s are capable of communicating among themselves using their multifunction advanced data link (MADL), and RAND points to a future combat intelligence, surveillance and reconnaissance (ISR) operating concept.

"In the 'combat ISR' mode, a four-ship flight of F-35s connected by MADL generates situational awareness and shares targeting data with legacy platforms that can then fire their payloads from outside the range of the most capable of the enemy's air defences," the report explains. The formation

European NATO F-35 inventory

Nation	Active	Ordered
Belgium		34*
Denmark		2+25*
Italy	17	74*
Netherlands	12	6+19*
Norway	18	3+24*
Poland		32*
UK	29	3+117*
Total	76	14+325*

Notes: Includes dedicated training assets. *Pending order confirmation
Source: Cirium fleets data

Crown Copyright

Eurofighter Typhoon with Su-30

would communicate and pass such targeting information via the Link 16 system.

However, this strategy might represent a vulnerability. "It is reasonable to assume that the Russian military would seek to disrupt this synergy during a conflict, particularly in light of recent Russian investments in EW [electronic warfare] capabilities," RAND says.

Still, European militaries are getting more practice with the F-35. "Already, allies have undertaken initial steps to establish common tactics, techniques and procedures for incorporating fifth-generation assets into combined operations through targeted exercises as well as preliminary synthetic training systems that link fourth- and fifth-generation aircraft," it notes.

One of the highest hurdles to NATO collaboration might be investment in aircraft readiness. "To be operationally relevant during a theatre conflict, NATO's air forces must maintain a sufficient number of available aircraft, munitions, and aircrew," says RAND. "Currently, most European air forces maintain around half of their existing fleets or less at mission-capable status, with some allies falling below that mark."

Many fourth-generation aircraft are also suffering from "rising maintenance costs from age, wear and tear resulting from a high operational tempo, and challenges with spare parts pipelines are significant constraints to aircraft availability".

RAND recommends a number of solutions to NATO aircraft readiness problems, including making public data on mission-capable rates, and establishing standard availability objectives.

The report concludes that the growing number of stealth fighters in Europe means the "trend lines lead in the right direction. With additional budgetary and policy attention to increasing readiness, European allies have the opportunity to significantly enhance combat airpower over the coming decade," it says.

Additional reporting by Craig Hoyle in London

Europe

Stronger together

We detail the combined combat power of European NATO nations

Craig Hoyle London

NATO's combined total of 30 full member states includes 28 European nations, in addition to Canada and the USA.

Some 1,781 combat aircraft were in active use with 19 European NATO nations as of 31 September, Cirium fleets data shows. The other nine states – Albania, Estonia, Iceland, Latvia, Lithuania, Luxembourg, Macedonia, Montenegro and Slovenia – all lack such a capability.

Cirium information shows that there are 16 different combat aircraft types in service with the militaries of Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Spain, Turkey and the UK.

VanderWolf Images/Shutterstock

Belgium is among F-16 users

Lockheed Martin's F-16 is the most numerous and broadly employed type, with 512 units – a 29% share – flown by nine of the nations. The latest V-model example is also on order for Bulgaria and Slovakia.

Germany, Italy, Spain and the UK fly a combined 415 Eurofighter Typhoons, 23% of the regional total, with follow-on purchases planned by Berlin and Madrid. The other 14 types each account for less than a 10% fleet share, ranging from 166 Dassault Mirage 2000-family jets flown by France and Greece to just four Sukhoi Su-25s, used by Bulgaria.

The use of Soviet-era combat assets among European NATO nations continues to dwindle rapidly, now standing at just 111 aircraft: 6% of the active fleet. This total also includes 46 RAC MiG-29s, 32 Su-22s and 29 Mikoyan MiG-21s, in the inventories of Bulgaria, Croatia, Poland, Romania and Slovakia.

European NATO combat aircraft fleet

Type	Active	Share
F-16	512	29%
Eurofighter	415	23%
Mirage 2000	166	9%
Rafale	143	8%
Tornado	126	7%
F-4	81	4%
F-18	72	4%
F-35	57*	3%
MiG-29	46	3%
AMX	32	2%
Su-22	32	2%
MiG-21	29	2%
AV-8	26	1%
Gripen	24	1%
L-159	16	1%
Su-25	4	1%
Total	1,781	100%

Note: *Excludes dedicated training assets
Source: Cirium fleets data

FlightGlobal
PREMIUM

Access all areas

Subscribe to FlightGlobal Premium

A FlightGlobal Premium subscription gives you all of the following, plus more:

- 24/7 unrestricted access to all FlightGlobal content, including the latest from Flight International and Airline Business
- Premium Daily alert – get commentary on the key stories of the day
- 20 + years of stories in the FlightGlobal news archive
- Flight International magazine in print or digital format

Subscribe now at
FlightGlobal.com/subscribe

The crisis has hit engine manufacturers twice over, with orders plummeting but aftermarket business also down. Is it the end for their per-hour support business models, or is the rationale behind service contracts strong enough to see them survive?

Power vacuum

Michael Gubisch Cirium

On 1 October, Rolls-Royce disclosed a plan to raise £3 billion ($3.9 billion) of fresh capital through new shares and a bond offering to help weather the aviation crisis. It was a stark reminder of the predicament all engine manufacturers have faced since the pandemic began.

If the dearth in new aircraft orders wasn't trouble enough for the entire aerospace sector, engine makers have additionally been hit hard by the decline in passenger flights, as maintenance of the existing fleet is a key revenue source for manufacturers.

Maintenance providers – both manufacturers and third-party MROs – have seen a sharp fall in demand as airlines reduce their activity amid the pandemic.

Lufthansa Technik does not see any fundamental change to current models

Gregor Schlaeger/Lufthansa Technik

Engine overhauls rank among the most profitable services in the MRO sector and are vital for some service providers. But one insider says that work volume at a major European engine overhaul facility has shrunk 75%. Another says a third-party overhaul shop lost virtually its entire orderbook within weeks.

For engine manufacturers, the decline in airline passenger flights has exposed the Achilles heel of their business model. As engines are typically sold with substantial discounts, as part of aircraft deals, aftermarket services are crucial for manufacturers to recover development and production costs.

Under the long-term, hour-based service agreements frequently arranged as part of aircraft sales, airlines pay flat-rate fees to manufacturers for engine support, irrespective of whether action is required or not.

In return, the manufacturers carry all financial risk associated with the engines' operation. If a failure occurs, it is up to the OEM to provide a spare, get the aircraft back in the air, and repair the engine.

So when operators parked aircraft because of the pandemic, the engine makers' aftermarket business dried up.

Cirium flight-tracking data shows that at 30 September, the seven-day average in daily flight-hours for air-transport-category aircraft was 56% below the level a year before.

Daily flight-hours were down 51% for narrowbodies and 71% for widebodies.

The seven-day average number of aircraft in operation had declined 38% overall – or 34% for narrowbodies and 59% for widebodies.

For those flights that are being operated, airlines tend to deploy their latest, most-fuel efficient aircraft in order to preserve cash.

Airbus

Rolls-Royce was a pioneer of power-by-the-hour service agreements

The engines of many new aircraft, especially new-generation types, are covered by long-term service agreements with OEMs, so shop visits – if necessary – might not be an immediate concern for operators.

Pratt & Whitney says: "In many cases, our flight hour-based agreements make our engines the most practical option to fly, since the cost is consistent, predictable, and aligned with the aircraft utilisation."

For mature and long-established engines, airlines tend to find more bespoke MRO arrangements, as third-party overhaul capacity is widely available and lively spare-parts competition exists for many engine types.

For aircraft powered by such engines, airlines have made efforts to avoid shop visits as overhauls are among the mostly costly MRO items.

Engine exchange

Shop-visit costs vary depending on workscope and spare-part choices. A typical narrowbody engine overhaul can cost anywhere from $3 million to $8 million, while shop visits for widebody engines can surpass $10 million.

In order to preserve cash, airlines tend to deploy aircraft with engines for which scheduled overhauls are not due for some time. If issues arise that require ad-hoc shop visits, airlines tend to exchange rather than repair engines as a lot of spare equipment is on the ground.

This dynamic has affected all MRO providers. But what has made the situation challenging for OEMs is their reliance on aftermarket activities to recoup heavy upfront investments in new engine programmes.

In addition to the costs of development and production, engine manufacturers bear the weight of the discounts they offer, the reliability and efficiency targets they guarantee, the spare engines they provide, and the MRO capacity they have built up. With new-generation equipment, they are often required to develop product updates and cover airline costs incurred while technical issues are being ironed out.

In July, GE Aviation posted a second-quarter loss of $680 million – after a $1.39 billion profit in the same period in 2019. Revenue was down 44% at $4.38 billion. Revenue from commercial engine services fell 67%.

The US engine maker attributes the overall loss primarily to Covid-19-related charges in the commercial services business, fewer spare-part and spare-engine shipments, and a decreased volume of shop visits.

GE Aviation's partner in the CFM International joint venture, Safran Aircraft Engines, reported a two-thirds decline in aftermarket business for the second quarter.

P&W's commercial aftermarket revenue was down 51%, while overall adjusted sales declined 30% to $3.6 billion and the US engine maker slid to a $151 million adjusted operating loss, from a $452 million profit last year. The result was "primarily driven by lower commercial aftermarket sales volume and unfavourable mix", the company said in July.

R-R reported in August that flight hours for its large engines had nearly halved during the first six months this year, and that it expected the number would be down 45% for the full year.

Like its competitors, R-R saw the decline in flying hours as a main reason – alongside reduced deliveries and exceptional charges – for an underlying gross loss of more than £1.5 billion for the half-year.

The UK engine maker is especially affected by the sharp decline in long-haul flights as its commercial engine business is entirely concentrated on Airbus and Boeing widebodies.

In August, R-R forecast that flight hours could recover to about 70% of 2019 levels next year and 90% in 2022. But a recovery in airline activity seen in July and August petered out, and operators have since reined in previous capacity growth plans.

Roland Gerhards, chief executive of German aviation research centre ZAL, believes the competitive MRO environment will "definitely change", partly because low aircraft utilisation has put manufacturers and their hour-based service agreements in a "weak" position.

Engine OEMs may be keen on renegotiating service agreements that were signed in a previous age and currently work mainly in the airlines' favour, since they pay only for hours actually flown. However, airlines are themselves in a survival struggle, too, and in no position to accept potentially higher prices from OEMs.

"The engine manufacturers really stand with their back against the wall and are in a bad negotiating position," Gerhards says.

CFM says it is in constant contact with operators. Asked whether contractual changes to its hour-based services are being considered because of the crisis, the engine manufacturer responds that it is "working with each customer individually to ensure their support is optimised" as airlines seek "solutions to preserve cash and maximise flexibility".

Customer-support teams liaise with clients on a daily basis to assess maintenance needs and assist with aircraft preservation or reactivation efforts, CFM notes. Three call centres have been maintained throughout the pandemic to provide 24h customer support as "one of CFM's key areas of focus is responsiveness".

No change

However, the manufacturer does not foresee a fundamental review of its hour-based aftermarket services: "Based on today's environment, there are no plans to make significant changes to CFM Services' business model."

Similarly, R-R says: "We continue to believe in the benefits our TotalCare agreements offer our customers and we have no plans to change the shape of our service contracts.

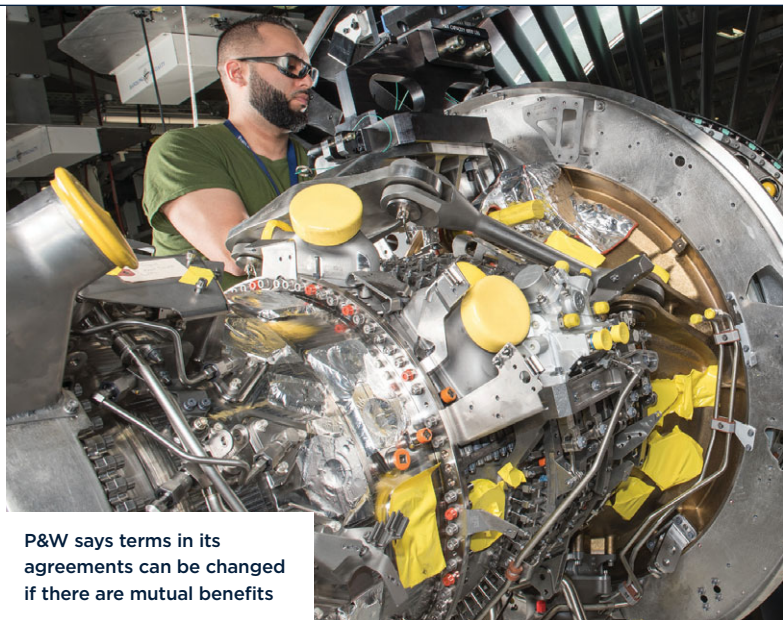
"R-R has pioneered long-term service agreements under the power-by-the-hour model in civil aerospace since the 1990s and it remains very popular today – 90% of our customers have chosen TotalCare coverage on new to mid-life engine programmes."

The vast majority of Trent-series operators have subscribed to the UK manufacturer's support packages because there are no overhaul shops that are not at least part-owned by R-R, and there is virtually no third-party competition for Trent spare parts and component repairs.

Still, R-R pledges that it is "always listening to our customers on what they need and we will continue to offer them a range of flexible services".

P&W suggests that terms in its hour-based aftermarket agreements can be changed if there are mutual benefits: "Where it makes sense for our customers and Pratt & Whitney, we will modify contract terms, or change the structure to help each other during this difficult period."

The US manufacturer adds that customers may want to convert agreements nearing expiry to new contract structures while utilisation is low. However, it believes that the crisis will not fundamentally change the engine MRO market and that aftersales activities will remain central to its business model.



P&W says terms in its agreements can be changed if there are mutual benefits

"Overall, we like our products and we like the relationships that have created MRO capacity and flexibility. We intend to leverage our customer relationships, engine knowledge and expertise, and our extensive part-repair capabilities to create value for our customers and for Pratt & Whitney."

Whether OEMs are in a position to sell their engines at higher prices and rebalance their revenue from aftersales toward equipment sales – especially in the current environment – is a key question.

Lufthansa Technik (LHT) senior director of product sales and engine lease Marc Wilken does not foresee a fundamental shift away from hour-based service agreements, especially for new engines. As manufacturers provide product warranty and performance guarantees for new engines' initial "honeymoon" period anyway, as part of regular equipment sales, Wilken argues that the step to providing full-service support is a small one.

Furthermore, airlines have embraced hour-based service agreements for new equipment because they transfer operational risk to manufacturers and offer predictable MRO costs. But as equipment matures and a greater choice of spare parts and component repair options becomes available, there is a shift towards more customised MRO solutions based on time-and-materials contracts – or variants of that model, such as fixed-price or maximum-ceiling-price overhauls.

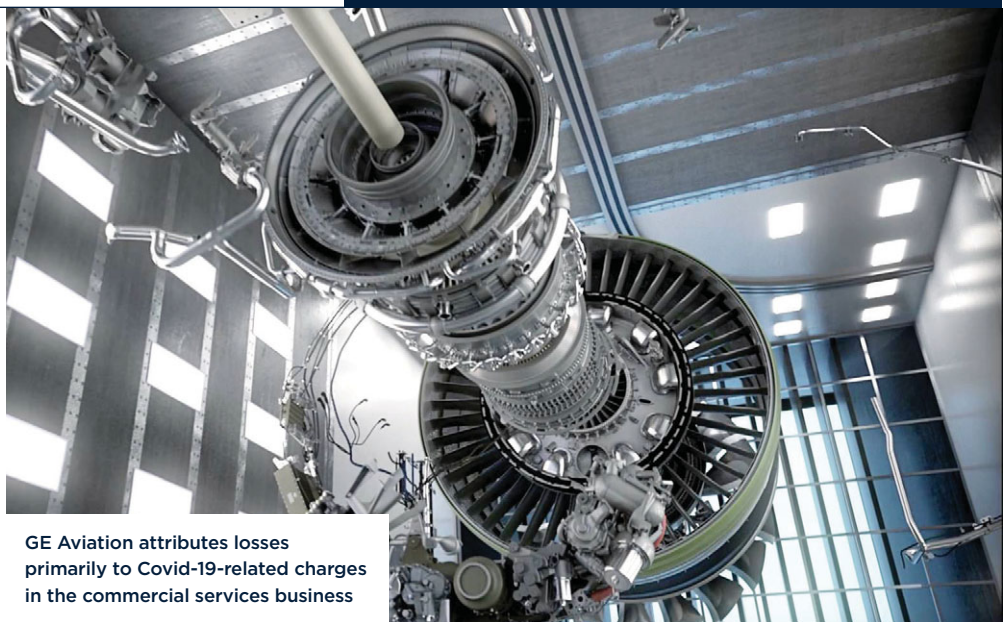
Wilken notes that the risk-transfer principle of hour-based support contracts becomes too costly and inflexible when ageing equipment requires more maintenance. Support for most middle-aged and older engines is therefore based on time-and-materials contracts, says LHT and other MRO providers.

Wilken can imagine, however, that greater availability of spare engines – given the spike in aircraft storage – has the potential to change the MRO market.

He says the retirement of Airbus A340-500/600s by several airlines before the crisis had a clear effect on R-R's support for Trent 500 engines, the sole powerplant for these aircraft. The manufacturer adapted its support programme as a large number of still relatively young engines became available for redeployment on in-service aircraft or as spare-part sources, he says.

LHT has seen increased demand for hospital shop

Raytheon Technologies



GE Aviation

GE Aviation attributes losses primarily to Covid-19-related charges in the commercial services business

visits to conduct limited, specific quick-turn engine repairs – for example, to replace individual modules.

As there is no shortage of idle equipment on the ground, Wilken says airlines are using modules from multiple engines to keep others in service in an effort to delay overhaul costs. LHT disclosed in September the opening of a new hospital shop in Dublin – close to the leasing community – in addition to similar facilities in Frankfurt, Montreal, Shenzhen and Tulsa.

Swiss maintenance provider SR Technics, meanwhile, announced in September that it had established a dedicated quick-turn line in its Zurich overhaul shop.

Still, growth in quick-turn shop visits by no means compensates for the decline in regular overhaul work amid the crisis, Wilken warns.

And, he notes, the practice of avoiding overhauls by stripping modules from some engines to keep others in service cannot be pursued forever. At some point – whether traffic demand recovers or not – airlines will have to overhaul engines, he points out.

Fierce competition

In the meantime, the crisis is likely to lead to further consolidation in the MRO sector. LHT chief executive Johannes Bussmann said in August that he foresaw "fairly fierce competition" and that some maintenance providers would exit the market.

This could play out during the northern winter season, a period in which maintenance providers' activity typically peaks as airlines' fleet utilisation drops and there is time for longer checks.

For the engine manufacturers, the decline in aftermarket activity comes at a crucial point in time – just as investments are required to develop new technology for future aircraft generations.

Already, before the crisis, manufacturers were under pressure to recover development costs for their latest aircraft and engines, as product cycles had become shortened versus previous equipment generations, leaving fewer years to make money back.

But now, manufacturers are on the brink of a technological step change to entirely new propulsion systems that require huge investment – be it full- or hybrid-electric or hydrogen-fuelled power systems.

Noting that new engine technology is central to new aircraft developments – and accounted for most of the fuel savings delivered by latest-generation jets – Gerhards thinks the manufacturers' situation is a "very exciting challenge [about] who will eventually have deep pockets to develop the new technologies".

R-R said on 1 October that it was "re-phasing" investment in its UltraFan future engine programme – which involves a geared-fan architecture and new materials – to cope with a probable shift in the timeframe. Previously, the manufacturer had been aiming the programme at applications beyond 2025.

"We are looking at new ways of working in order to deliver more compelling returns for shareholders," said R-R, adding that it was "actively exploring new forms of industrial partnership" on the UltraFan, with the intention of optimising investment return.

Ultimately, Gerhard predicts, "a lot of state aid" will be required to prop up engine manufacturers and facilitate development of new technology.

Citing the huge support packages provided by several European governments for their nations' aerospace and airline sectors, he says he expects that aid will be conditional on companies having to meet increased environmental targets. "Politicians want to have more environmentally friendly air transport, and this will be demanded by [passengers]."

However, Gerhards foresees another reason engine manufacturers need to review their business models and be less reliant on aftermarket revenues.

Electric propulsion systems will have "radically reduced" maintenance costs because they will have fewer moving parts and won't operate at temperatures as high as in gas turbine engines. Lower maintenance costs will enable the aircraft to be used for applications – such as air taxis or short-haul regional flights – where widespread deployment of gas turbine-powered equipment was previously not viable, Gerhards says.

He acknowledges that large gas turbine engines are not likely to be replaced by electric powerplants in the foreseeable future. But, given the possibility of using electric power to boost performance of gas turbine engines for selected flight phases, and thus reduce the size of fuel-burning engines, he is certain that electric power will revolutionise commercial air transport.

"This will turn the entire industry on its head in 20-30 years," says Gerhards. "Maintenance costs will be a fraction [of current MRO costs] as soon as you fly electrically... because it's so much simpler."

This analysis was written by Michael Gubisch, part of Cirium's London-based reporting team

Max Kingsley-Jones

CFM International Leap engines power every 737 Max

Jon Hemmerdinger Tampa

The big engine manufacturers have released figures that show how badly they have been impacted by the crisis on two fronts: tumbling revenues from a slump in new aircraft orders and deliveries and, perhaps more critically, huge holes in their aftermarket business, as airlines reduce flying hours and payments for on-wing support contracts.

CFM International, GE Aviation, Pratt & Whitney, Rolls-Royce and Safran have been playing defence, taking steps to stem cash outflows, and trying to hold on until the industry recovers. But amid such conditions, the ability of engine makers to pursue ambitious clean-energy technologies with the same gusto they showed pre-pandemic seems unlikely.

Some projects, though certainly not all, seem to have been pushed back. That is no surprise considering the numbers staring executives in the face. Safran, which jointly owns CFM with GE Aviation, on 30 October disclosed that its aerospace propulsion revenue slipped 48% year on year in the third quarter. For the first nine months of 2020, that revenue was down 37%.

The figures partly reflect the slow pace of CFM's Leap deliveries after the Boeing 737 Max grounding and the pandemic-driven airline industry collapse. In the first nine months, CFM shipped 622 Leaps, which are an option on Airbus A320neo family aircraft and power every 737 Max, down 53% year on year.

Responding to that, Safran has cut its workforce – which stood at 95,000 staff in 2019 – by some 15,000 full-time workers. The company slashed research and development spending by one-third in the January to September period, it says.

In the USA, GE Aviation's third-quarter operating profit sank 79% year on year to $356 million, with revenue slipping 39%, to $4.9 billion. The Ohio-based engine maker still turned a $681 million profit in the first nine months of 2020, but that was down 86% year on year, and GE in the third quarter alone cut 3,500 staff.

Declining sales

Connecticut competitor P&W lost $615 million in the third quarter, with sales off one-third year-on-year. Year to date, P&W has lost $597 million, parent Raytheon Technologies reported on 27 October. P&W shipped 417 large commercial engines, including PW1000Gs, in the first nine months of the year, down 21% from 2019 levels.

Executives have made clear that engine deliveries are down precisely because, amid the pandemic, airlines have little need for new aircraft. And aftermarket sales have slumped because airlines have grounded so many aircraft amid the downturn. In recent decades, engine makers adopted business models based on selling new engines at discounts – even losses – then making up the difference with profitable engine-service contracts.

"This downturn is different," Kevin Michaels, managing director at consultancy AeroDynamic Advisory, said on 28 October during the virtual MRO TransAtlantic conference. "It's the fact that we have a major MRO and production downturn at the same time. If you add the Max shutdown into this, it really muddies the picture." Airlines have further reduced their need for engine maintenance by swapping engines from grounded jets onto in-service ones, adds Michaels.

The coronavirus pandemic has hammered aircraft engine makers and their future product strategies, with negative financial results raising questions around investments in key disruptive projects

Reverse thrust

R-R has only announced half-year results. But the pandemic, in choking demand for long-haul international air travel, has crippled the UK company. R-R specialises in manufacturing engines for large widebody jets. "The net effect is a significant reduction in the demand for new engines," R-R civil aerospace director of product development and technology Simon Burr tells FlightGlobal. He notes that R-R engines power roughly half of the global fleet of types like 787s and A380s, while the Trent XWB is the sole choice for the A350.

R-R's civil aerospace business generated £2.5 billion ($3.3 billion) in revenue during the first half of 2020, down 37% year-on-year. The business lost £1.8 billion in the six-month period. "So much money has been sucked out of the transportation sector. It will take years to recover," perhaps until 2024, Burr says.

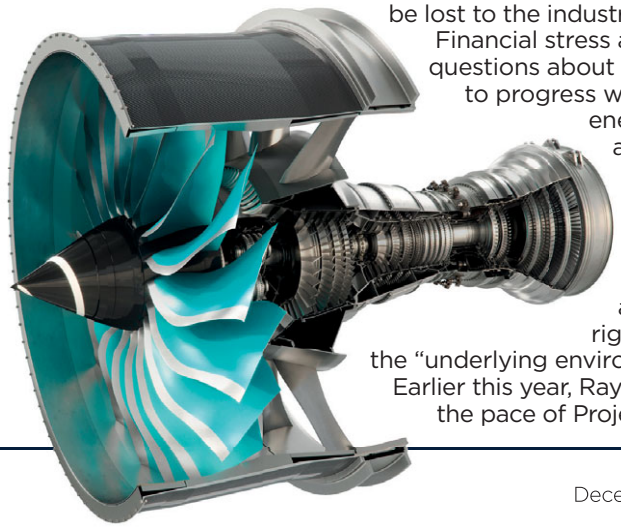
He adds that furloughing staff and other temporary cost-cutting measures "are not sufficient". R-R responded earlier this year by announcing plans to reduce its payroll by 9,000 workers, including 8,000 staff from its civil aerospace businesses – and to consolidate its manufacturing footprint.

The company is ending widebody-aircraft engine assembly at sites in Germany and Singapore, consolidating that work at its Derby, UK site. It is also consolidating Trent fan blade production from two sites to a single facility in Singapore, concentrating disk and turbine blade machining in the UK and consolidating blisk production at two sites, down from three. "What we are doing is consolidating where we have duplication of capability," says Burr.

Skills shortage

Such sweeping staff cuts could leave engine makers and other aerospace companies at risk of facing a shortage of skilled workers when a recovery does eventually take hold. Burr believes that workers shown the door in 2020 could take jobs in other sectors, such as auto racing and automotive manufacturing, which need related skills. "There is a real risk that people will be lost to the industry," he notes.

Financial stress and loss of staff raises questions about the engine sector's ability to progress with development of clean-energy technologies. These are critical if the airline industry has a chance of meeting industry-wide carbon-reduction goals. Burr says new-technology development "may not be at the top of the agenda... right now", but he insists that the "underlying environmental pressures" remain. Earlier this year, Raytheon Technologies slowed the pace of Project 804, an effort to



Rolls-Royce

Rolls-Royce's UltraFan effort could be delayed as a result of the crisis

develop a hybrid-electric propulsion system for a regional airliner, starting with a De Havilland Canada Dash 8-100. Raytheon corporate predecessor United Technologies, in partnership with corporate siblings P&W and Collins Aerospace, launched the effort in 2019.

Then, in April, Airbus announced it was ending a joint R-R hybrid-electric project called E-Fan X. The companies were working to equip a BAE Systems Avro RJ100 with a 2MW electric motor, to replace one of the jet's four Honeywell turbofans, but the companies closed the project ahead of test flights.

Aerospace expects have long insisted that battery technology must advance significantly before being practical to power commercial airliners. Executives from aircraft and engine manufacturers echoed that message on 4 November during the Royal Aeronautical Society's Climate Change Conference.

They described the benefits of electric systems as incremental, not revolutionary – at least not yet. "Today's batteries clearly have a long way to go," P&W senior vice-president of engineering Geoff Hunt told the conference. However, Hunt notes battery technology advances rapidly, meaning that "in coming years we are likely to see improvements to open up the space".

€15bn

France's post-pandemic investment plan for its aerospace sector, including clean-energy targets

Meanwhile, Hunt sees promise in reducing carbon output by shifting toward "more-electric" designs – supplementing turbines with electric systems. Adding a 1MW electric system to a single-aisle jet, for instance, would allow that jet to have smaller-core turbofans, he says: "We continue to study... how we can use that to improve efficiency, and help us down the path."

Airbus's A380 UK chief engineer Jacqueline Castle likewise views the "more-electric" path as promising. Replacing conventional hydraulic systems with electric systems, for example, would reduce weight and improve efficiency, she says.

But the industry is under pressure to curb carbon output by more than by a few percentage points. ICAO has set the goal for the industry to cut emissions to half of 2005 levels by 2050.

Getting there is the tough part. But in June France set the pace when it unveiled a €15 billion ($17.8 billion) aerospace investment plan. This funds clean-energy technologies and sets impressive carbon goals.

It calls for the industry to develop an A320 replacement that would be 30% more efficient and that might be powered by zero-emission hydrogen technology. The French scheme also urges development of a new hybrid-electric or hydrogen-powered regional aircraft. The plan aims for service entry of the new regional aircraft in 2030 and of the new narrowbody between 2033 and 2035.

Seemingly taking the cue, Airbus in September unveiled three hydrogen-powered concept aircraft it says could be flying commercially in the 2033-2035 timeframe. The concepts, which Airbus calls "ZEROe", include a conventional-looking airliner, a blended-wing design and a 100-seat regional aircraft.

Airbus

Hybrid-electric E-Fan X project has been closed

Hydrogen propulsion, long viewed as the holy grail of clean energy, also generated attention in August when former Airbus and United Technologies executive Paul Eremenko announced he had formed Universal Hydrogen, a company seeking to develop a hydrogen production and distribution network for aviation.

Future projects aside, engine makers note that current in-service and in-development engines are far more efficient than those of the last generation, and will be powering jets for decades to come.

R-R is working to improve conventional turbofan efficiency through development of its UltraFan, a next-generation widebody engine. That turbofan will achieve improved efficiency through a geared-fan architecture and greater bypass and pressure ratios, Burr says.

R-R had aimed for UltraFan to be powering aircraft beyond 2025. But little is certain amid the pandemic; R-R recently said the project could be delayed. The UK company is also working to promote greater use of sustainable aviation fuels, and studying electric and hybrid-electric technologies, Burr says.

GE says hybrid-electric technologies are also in its sights. So too are open-rotor engines and "boundary-layer ingestion" designs, according to a GE report about technology and sustainability. GE has studied open-rotor design for decades, successfully flight-testing its open-rotor GE36 in the 1980s. Such engines lack heavy fan cases and hold promise of delivering 30% fuel-burn savings, GE says.

Reducing drag

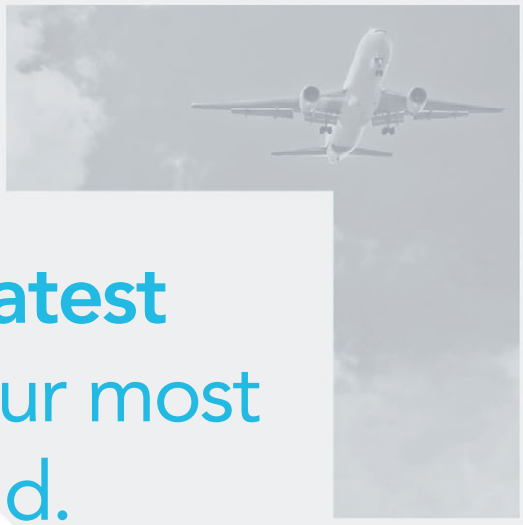
Boundary-layer ingestion designs involve mounting engines at the extreme rear of aircraft. There, engines can reduce drag by ingesting slower-moving "boundary" air, which forms along the outside of aircraft and creates drag, according to GE.

But the company's report notes new technologies will take "years of additional development". So GE views sustainable aviation fuel and more-efficient air-traffic management as key to attainable carbon cuts.

GE also highlights fuel-efficiency improvements already achieved. The company's narrowbody and widebody engines burn 40% less fuel than engines did in the 1980s, it says. Efficiencies have come from higher bypass and overall pressure ratios, use of carbon fibre and ceramic-composite materials, hotter engine temperatures and reduced weight.

The Leap-1A's bypass pressure ratio is double that of the CFM56-5B, while the GE9X has an overall pressure ratio of 60:1, up from the GE90's 40:1 ratio, GE says.

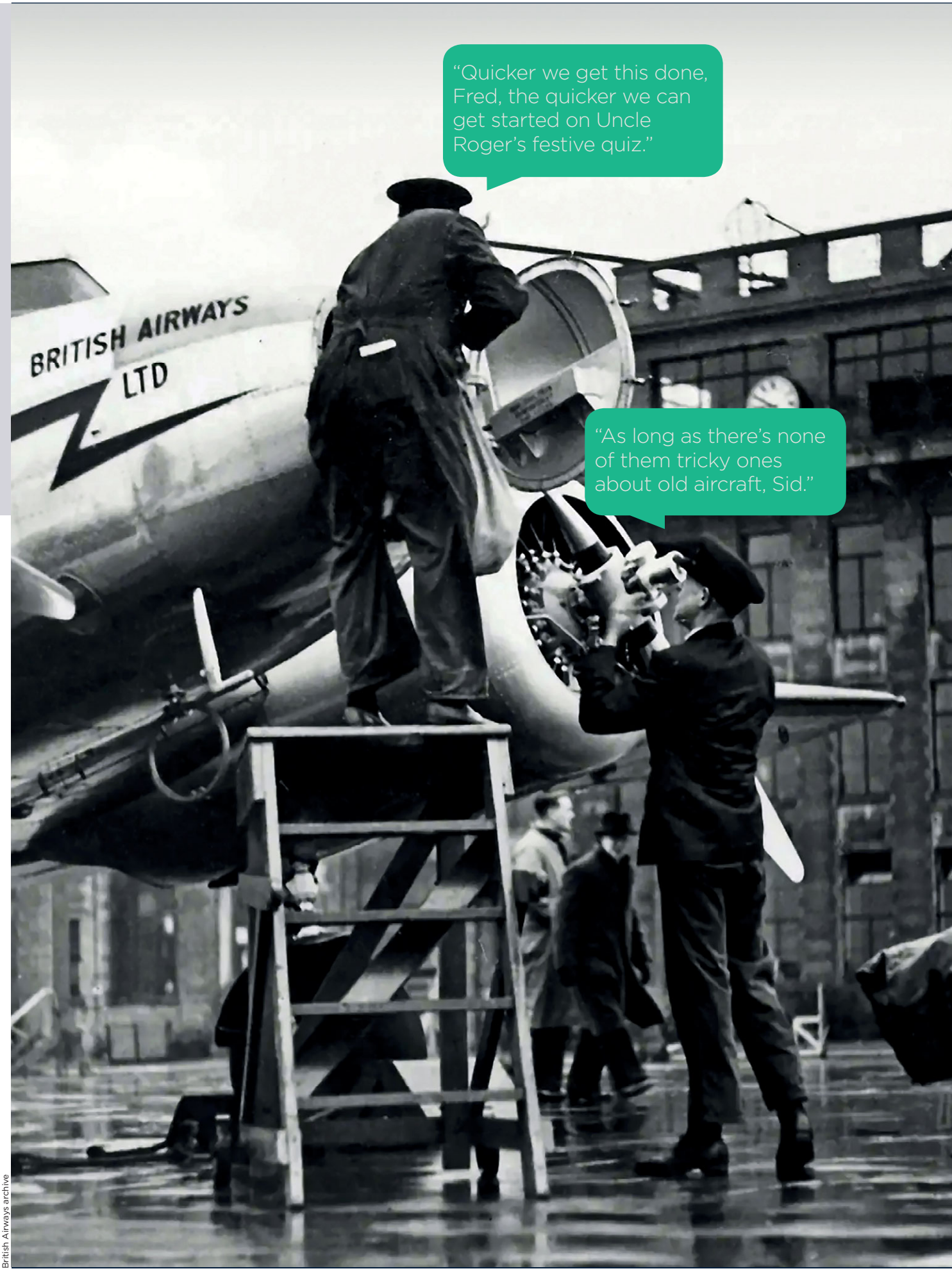
FlightGlobal



Did you miss out on our latest webinar? You can watch our most recent webinars on demand.

Future webinars will cover topics including: crisis management for aerospace leaders, network planning, how pilots can survive the crisis, the finance market, air cargo, business aviation, sustainability, and much more.

Visit flightglobal.com/webinars



British Airways archive

A year to remember

The landing lights are on for Flight 2020 after the bumpiest journey any of us on board have experienced. Before we take off again into the hopefully sunnier skies of 2021, it is time, as always, to reflect on the 12 months that was in the company of Uncle Roger and his always popular festive quiz. How much attention have you paid to the news, grim though it has mostly been? Has lockdown stunted or sharpened your aircraft spotting skills? This is your chance to end 2020 on a high. There are 50 multiple choice questions, along with 10 identify the type. Score more than 50 out of 60 and celebrate your status as a Total Aviation Person. If your tally is between 30 and 49, you are well on your way to your captain's stripes. Get 15 to 29 right and a few more lessons in the simulator are required. Fewer than 15 and you are well and truly grounded – until December 2021 at least. See p76 for answers – but no peeping!

1 Louisville Muhammad Ali airport staff found a stray kitten on the ramp in October. What did they name him?
A Boeing
B Ali Cat
C Louie
D Cassius

2 Russia started designing its first widebody, the Il-86, 50 years ago. What was its NATO code name?
A Cossack
B Claptrap
C Camber
D Condor

3 Airbus's A330 became the third widebody to reach 1,500 deliveries, but which operator received the milestone aircraft?
A TAP Portugal
B Azul
C Air Mauritius
D Delta Air Lines

4 Which aircraft is associated with the 'double sunrise' flights after which Qantas's globe-spanning Project Sunrise A350-1000 plan is named?
A Short Sunderland
B Consolidated PBY Catalina
C Avro Lancastrian
D Consolidated B-24 Liberator

5 Which airline, in August 2020, became the first to place itself under the new single European Union Aviation Safety Agency air operator's certificate?
A EasyJet
B Ryanair
C Eurowings
D Wizz Air

6 Which new version of Boeing's "Eagle" fighter has the US Air Force ordered?
A F-15ER
B F-15ES
C F-15EX
D F-15EZ

7 Name the strike aircraft Greece plans to acquire?
A Dassault Rafale
B Eurofighter Typhoon
C Lockheed Martin F-35
D Saab Gripen E/F

8 Who is the lone export customer so far for Boeing's KC-46A tanker?
A Israel
B Japan
C NATO
D United Arab Emirates

9 Which European nation's military has ordered a pair of Airbus A321LRs, for transport duties?
A France
B Germany
C Italy
D Spain

2

Tony Best

3

Airbus

6

Boeing

8

US Air Force

Fund an Angel Virtual Auction

The Fund an Angel Virtual Auction raised significant funds in support of Corporate Angel Network (CAN). Proceeds from the event will ensure CAN is able to continue helping cancer patients, like Scarlett, in critical need during the pandemic and long after. Thank you to all who generously contributed.

Scarlett, an immune compromised pediatric cancer patient, was in need of transportation to a specialized treatment center. CAN was able to transport the family just before Scarlett's 5th birthday.

A SPECIAL THANK YOU TO OUR CURRENT SPONSORS

PRESENTING SPONSOR NBAA

PLATINUM Gulfstream A General Dynamics Company · SAFE FLIGHT Instrument Corporation · SEL Schweitzer Engineering Laboratories · Williams International

GOLD AIN · Dassault Falcon Jet · Directional · EJM Executive Jet Management · NETJETS · Beechcraft · Cessna · Hawker · Textron Aviation

SILVER AOPA · CAE · Extant Aerospace · JetAviation A General Dynamics Company

BRONZE BASF We create chemistry · ConocoPhillips Global Aviation · GAMA · Maria and Michael Herman · Pratt & Whitney Go Beyond · Rolls-Royce · Signature Flight Support · Stoneworth Investment Banking

Sponsors as of October 1, 2020

To learn more about Corporate Angel Network and future events, visit corpangelnetwork.org.

14

US Navy

10 A US Marine Corps Lockheed Martin F-35B crashed after colliding with another type – name it
A Bell Boeing MV-22
B Boeing F/A-18
C Lockheed Martin KC-130J
D Lockheed Martin F-35B

11 What is the acronym for NATO's pooled tanker force?
A ATF
B FUEL
C MMF
D NTF

12 Which of these is not associated with US Army rotorcraft programmes?
A FARA
B FASTA
C FLRAA
D FVL

13 Which company could trial rocket cargo delivery for the US military in 2021?
A Blue Origin
B NASA
C SpaceX
D Virgin Orbit

14 The Blue Angels gained a new support aircraft – who originally flew it?
A Italian air force
B UK Royal Air Force
C US Air Force
D US Marine Corps

15 Which European country axed its heavy-lift helicopter purchase plans?
A France
B Germany
C Poland
D UK

16 Spirit AeroSystems delivered 606 737 fuselages to Boeing in 2019. In 2020, how many does it expect to ship?
A 72
B 23
C 240
D 155

17 Through much of the type's grounding, Boeing continued building the 737 Max even though it wasn't delivering them. As of October 2020, roughly how many undelivered Max had Boeing stockpiled?
A 375
B 560
C 700
D 450

18 Airbus began manufacturing A220s in Mobile in 2019. Which airline received the first Mobile-built example, in October 2020?
A Delta Air Lines
B Spirit Airlines
C JetBlue Airways
D Breeze Airways

19 In September Spirit AeroSystems announced it had terminated a plan to acquire what?

A Gulfstream's wing-manufacturing work
B Asco, a Belgian components company
C Bombardier's aerospace businesses in Morocco and Northern Ireland
D Triumph Group aerostructures assets

20 This supersonic-aircraft company announced plans in 2020 to establish a new corporate headquarters on Florida's Space Coast, and to begin building jets there in 2023.
A Boom Supersonic
B Spike Aerospace
C Aerion Supersonic
D Wing

21 Swiss start-up Kopter was acquired by which rival this year?
A Airbus Helicopters
B Bell
C Leonardo
D Russian Helicopters

22 Which two helicopter operators merged in 2020 to form an oil and gas industry giant?
A Babcock and CHC
B CHC and Bristow
C NHV and PHI
D Bristow and Era

23 Where will the TH-73A, the US Navy's new training helicopter, be built?
A Columbus, Mississippi
B Lafayette, Louisiana
C Ozark, Alabama
D Philadelphia, Pennsylvania

24 Ecuador calls its air force's new helicopter the 'Cobra' – but which type has it acquired?
A H125
B H135
C H145
D H160

25 What does the MBB-BK-117 D-3 gain over the D-2?
A A new tail rotor
B An extra rotor blade
C New engines
D Updated avionics

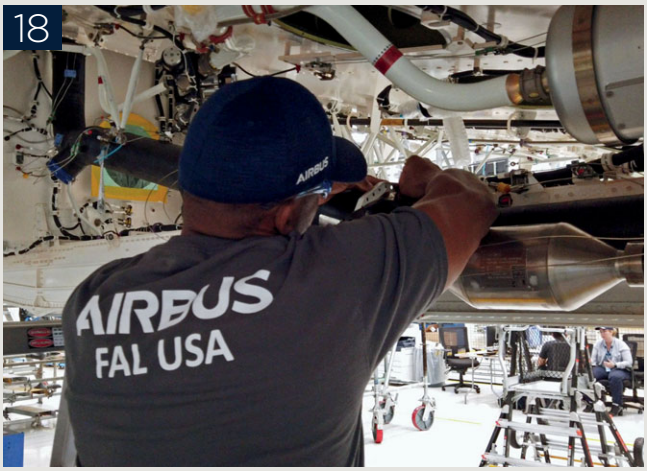
26 In March, which film did IATA evoke when describing the bleak outlook for the world's airlines?
A *Armageddon*
B *The Day the Earth Stood Still*
C *Apocalypse Now*
D *28 Days Later*

17


Boeing

21


A Osborne/Kopter

18


Airbus

26

Shutterstock

27 Which retail giant did Greg Foran leave to become Air New Zealand's new chief in March?
A Walmart
B Costco
C Walgreens
D Tesco

28 Which airline left the Oneworld alliance on 1 May?
A Qatar Airways
B LATAM Airlines
C Cathay Pacific
D S7 Airlines

29 What is the name of the new long-haul leisure unit announced by Lufthansa Group in July?
A Beach
B Clear Waters
C Sunseeker
D Ocean

30 When Emirates brought A380s back into service in mid-July after a four-month absence, to which destination did the first departure head?
A Amsterdam
B London
C Paris
D Frankfurt

31 Which airline chief said of the crisis: "We have been waiting for this moment for 10 years"?
A Maurice Gallagher, Allegiant Air
B Jozsef Varadi, Wizz Air
C Adel Abdullah Ali, Air Arabia
D Enrique Beltranena, Volaris

32 British Airways retired its remaining 747s this year. But how many of the jumbos did it have in 1998 when its fleet of the type peaked?
A 75
B 78
C 81
D 83

33 Which AirAsia Group carrier ceased operations in early October?
A AirAsia X
B Thai AirAsia
C AirAsia India
D AirAsia Japan

34 Which chief executive said in October: "If there were ever a scenario for us to consider making a change in aircraft, it would be now, because we're not desperate to grow the airline."
A Gary Kelly, Southwest
B Eddie Wilson, Ryanair
C Ted Christie, Spirit Airlines
D Paulo Kakinoff, Gol

35 IATA claimed in October that a person is more likely to be what, than catch coronavirus on a commercial airline flight?
A Eaten by a crocodile
B Struck by lightning
C Attacked by a hippopotamus
D Hit by a falling anvil

36 Identify the world's longest subsonic narrowbody jet?
A Airbus A321XLR
B McDonnell Douglas DC-8-61/63
C Boeing 707-320
D Boeing 757-300

37 Name the world's oldest airline (still operating under its original name)
A KLM
B British Airways
C Qantas
D Avianca

38 Which aircraft and airline combination set a subsonic Atlantic crossing record in 2020?
A Virgin Atlantic Airbus A350-1000
B American Airlines Boeing 787-8
C British Airways Boeing 747-400
D UPS Boeing MD-11F

39 Complete the sequence: CSeries to A220, DC-9 to MD-80, Diamond to Beechjet, BAe 146 to...
A BAe 800
B Jetstream 61
C Vickers V1000
D Avro RJ

Identify the type

There's only one correct answer for each of these 10 pictures...

1

2

3

4

5

40 What is the world's oldest western commercial jet in active airline passenger service (according to Cirium fleets data)?
A Boeing 737-200 (Venezolana)
B Airbus A300B2 (Iran Air)
C McDonnell Douglas DC-9-10 (USA Jet Airlines)
D BAe 146-200 (Aerovias DAP)

41 Which manufacturer/aircraft designation combination is fictional:
A Boeing Stratoliner
B Lockheed ShapeShifter
C Vickers Vulcan
D Douglas Seven Seas

42 Which US carrier inaugurated DC-10 services?
A American Airlines
B Delta Air Lines
C United Airlines
D Eastern Airlines

43 Name the first two-crew widebody to enter service?
A Boeing 767-200
B Airbus A300B4
C Lockheed TriStar 500
D Airbus A310-200

44 Which engine powered the Sud Aviation Caravelle 10B/10R series?
A Rolls-Royce Avon
B GE CJ-805
C Pratt & Whitney JT8D
D Bristol Siddeley Orpheus

45 Boeing will end 747 production in 2022, but which airline took the final passenger version, and when?
A Lufthansa/2015
B Korean Air/2017
C Air China/2018
D Japan Airlines/2016

46 Dassault's latest Falcon business jet is the Pratt & Whitney Canada PW812D-powered 6X. But which engine was on the ill-fated 5X?
A P&WC PW307
B Safran Silvercrest

6

7

8

9

10

C Honeywell TFE731
D Rolls-Royce BR725

47 Who is the launch customer for the Airbus ACJ TwoTwenty?
A Comlux
B NetJets
C Flexjet
D Luxaviation

48 What did Bombardier name its latest version of the Learjet?
A Leopard
B Legacy
C Liberty
D Leeway

49 Which country announced it was selling a British Aerospace BAe 125 presidential jet acquired in 2017 by a previous administration?
A Portugal
B Turkey
C Uruguay
D Indonesia

50 Which jet that made its first flight this year features a Symmetry flightdeck and electronically-linked active control sidesticks?
A Bombardier Global 7500
B Embraer Praetor 500
C Textron Aviation Citation Longitude
D Gulfstream G700

50

Is there a commercial future for the personal propulsion device, despite the collapse of one of the technology's foremost developers? Two start-ups, in the UK and USA, firmly believe there is

Pack leaders

Murdo Morrison London

It is 55 years since the concept first captured the world's imagination when the late Sean Connery strapped on a Bell Aerosystems Rocket Belt and took off from a chateau roof to evade enemy agents in the opening sequence of the James Bond movie *Thunderball*. Now could the so-called personal propulsion device finally be on the brink of a commercial, or military, breakthrough?

There have been any number of attempts to develop a practical jet suit or jet pack since Bell demonstrated the futuristic Rocket Belt to the US Army in 1961 as a potential asset for special forces; commanders were unimpressed with the hydrogen peroxide-fuelled contraption's inability to provide more than 21sec of flight time and the project was abandoned.

Successful endeavours include those of "Jetman" Yves Rossy, a Swiss aviator and inventor who has performed with his personal flight pack around the world, including accompanied by an Emirates Airbus A380 at the 2015 Dubai air show. Despite this, Rossy has never intended his one-off machine to be anything other than for entertainment, at least in the short term.

Grounded

The closest a company has come to bringing a personal propulsion device to market has been the rather cumbersome ducted-fan Jetpack devised by Martin Aircraft of New Zealand (no relation to Lockheed Martin). However, 10 years after unveiling its $100,000 product at the AirVenture show in Oshkosh in 2008 – and attracting a flurry of interest – the business ran out of money and ceased trading.

The latest developer confident of surmounting the financial, technical and regulatory challenges of delivering personal propulsion – if not to the everyday consumer then to a specialist customer base such as the military and mountain rescue teams – is UK start-up Gravity Industries. It has demonstrated its single-engine Jet Suit in more than 100 sorties in 31 countries since launching the device three years ago.

Its most recent high-profile trial was in England's Lake District in September, when Gravity's founder and chief executive, Richard Browning, illustrated how the Jet Suit might be used by a paramedic to deliver critical care in a mountain rescue emergency. Working with the Great North Air Ambulance Service (GNAAS), he flew for 90sec from a valley bottom in Langdale Pikes to a simulated casualty site on a hillside.

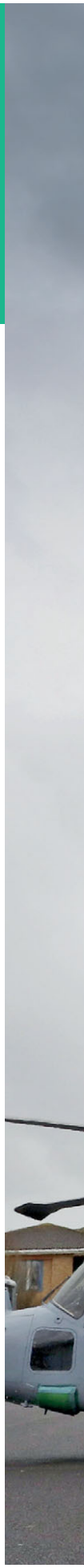
43kt

Forward speed achievable by Gravity Industries' five-engine Jet Suit

According to GNAAS, which had been working with Gravity on the project for a year, to reach the victim by foot in a similar situation would have taken an exhausting 25 minutes. "We didn't know for sure how this would work in practice," said GNAAS director of operations Andy Mawson at the time. "We have seen it now and it is, quite honestly, awesome."

GNAAS says it is "exploring the next steps" with Gravity. However, Browning, a former BP oil trader and UK Royal Marines reservist, cautions that putting the Jet Suit into operation in the search and rescue field will require a Mark 3 version. The company is working on that and he says that during "late spring" he hopes to have "carefully managed operational trials under way".

Browning launched Gravity in March 2017, after securing $650,000 from two investors. The first suit used a single gas turbine engine. Later iterations came with two, four and six turbines. Eventually a five-engine configuration was chosen that weighs about 25kg (55lb) and is normally flown with an additional 10kg of Jet A1 or diesel. It generates 1,050hp (783kW) or 144kg of thrust for vertical lift. The pilot changes direction by vectoring an engine attached to each arm.



Crown Copyright

Richard Browning demonstrating his device at UK Royal Navy base HMS Sultan in the UK in 2019

Martin Aviation

The Martin Aircraft Jetpack attracted much interest but the company ceased trading in 2018

Gravity has produced five suits so far and says the device is capable of forward speeds in excess of 43kt (80km/h) and technically reaching an altitude of 12,000ft, although for safety reasons it is flown much lower. Typical flight durations are between 1min and 3min, although, depending on conditions, 10min is possible, giving a potential range of around 6nm (11km), claims Gravity. However, the longest distance flown to date is 0.75nm.

Browning says aviation authorities, including the UK CAA, have allowed demonstrations even though the product does not fall into any existing aircraft categories. "Because of our record and self-regulating and the experience of former military pilots in our team, they are happy as long as we don't fly too high or over people or property," he says.

Lighter regulation

"But if the regulator stepped in, it wouldn't be a problem. This is not a mass market thing, so I think we can avoid [excessive regulation]." Unlike emerging sectors such as electric vertical take-off and landing vehicles, "we are not out to disrupt mainstream transportation", he says. Gravity has sold two examples to US customers "who insisted" on paying $440,000 per suit. However, Gravity has kept the equipment and "we make it available to them when they want".

He maintains that one of the characteristics that differentiates the Jet Suit from other personal propulsion devices, such as the ill-fated Martin Jetpack, is that "we fall below a line above which is a machine that you are strapped to rather than being part of the machine. We have kept the human at the core of it all."

While mountain rescue is an obvious application, a perhaps more potentially lucrative target for Gravity might be the military market Bell tried to tap six decades ago. Browning says he has demonstrated the product to defence organisations, including the UK Ministry of Defence. "If you want to move a special ops operative quickly or insert them – and others from different directions – into a location in a way that's hard to detect, it's hard to see anything that can get close," he says.

JetPack Aviation

JetPack Aviation demonstrating its device at the Statue of Liberty in 2015

Los Angeles-based JetPack Aviation has been offering what it calls the "world's first portable JetPack" since 2016, after spending around five years designing it. Founder and chief executive David Mayman flew the JB9 prototype JetPack around New York's Statue of Liberty in November 2015 in what the company claims was the first US Federal Aviation Administration (FAA)-approved flight of such a machine. Since then, it has demonstrated the device in six countries.

The JetPack's designers included Nelson Tyler, who worked on the original Bell Rocket Belt that was also flown at the opening ceremony of the 1984 Olympics in Los Angeles. The company went on to develop two more products between 2016 and 2018: the 38kg JB10, which produces 90kg of thrust, 15% more than the original JB9, and the 52kg JB11, which uses six 400N-thrust engines rather than the two 900N plants in the JB10, each delivering around 40kg of thrust.

The company claims 8min endurance and top speed of 104kt for the JB10. The JB11 has an endurance of 10min, and a computer that balances the thrust between the engines. The pilot controls the JetPack by "vectoring the entire engine, rather than just vectoring thrust", says the firm. "This is how we achieve such great manoeuvrability and speed control." Both types can be flown under FAA rules, under certain conditions, without a pilot's licence as an ultralight vehicle.

Display team

Perhaps the person who has done most to bring personal propulsion to a wider audience is Rossy. After developing his jet-powered, 2.4m (7ft 8in)-wide mounted wing in the early 2000s, the former Swiss International Air Lines and Dassault Mirage pilot flew over the Alps in 2008, and later that year crossed the English Channel after jumping from a Pilatus PC-6 at 8,200ft over Calais. In 2015, he and Vince Reffet flew their choreographed demonstration with the A380.

One of the drawbacks of Rossy's original design has been that, although it allowed powered flight at altitude, it entailed jumping from an aircraft and landing with a parachute – something he claims to have addressed with his latest machine. In December last year he announced that by deploying four, more powerful, vectoring German-made JetCat P550 micro-jet engines, he could now take-off vertically at up to 97kt and land without a parachute.

Videos on his website show Rossy testing the vertical take-off and landing kit inside a hangar, tethered by a safety rope, and then, at a height of a few metres, over a lake. While Rossy believes he can use his body to control the flight direction, two challenges remain: transitioning to horizontal flight once there is sufficient vertical acceleration to provide lift in aeroplane mode, and landing safely if something goes wrong at too low an altitude to deploy a parachute.

At the 2015 Dubai air show, Martin Aircraft was confident of delivering the first customer Jetpack the following year, with the United Arab Emirates touted as a possible buyer. However, despite investment from Chinese firm KCS, and taking on around 100 staff, the Christchurch-based firm failed to secure any revenue and ran out of money in 2018. It ended a 30-year dream for founder Glenn Martin, who began work on the concept in his garage in the 1980s.

The Jetpack, which had a microlight certification from the New Zealand aviation authorities, was powered by a V4, two-stroke gasoline engine, generating 200hp (150kW), driving two ducted fans to provide lift. A pair of joysticks allowed the pilot to control throttle and pitch. The 125kg device, which had a flight ceiling of 2,500ft and an endurance of up to 45min or range of 10.8nm, was able to carry a 120kg human.

Flying bikers

Others to have developed personal propulsion devices include Denver-based Apollo Flight Labs, a spin-off from the firm behind the Apollo chewing gum brand. Two years ago it auctioned prototypes of its turbine-powered JetPack and its JetBike, which it claims is the "world's first jet engine-powered flying motorcycle".

Apollo, which claimed to have performed more than 1,000 demonstration flights with the JetPack, which was listed at a retail price of $179,000, said buyers would be provided with "familiarisation flights on our training systems", adding that it was "aware of the risks involved with piloting these machines". The company is no longer producing the devices.

Powered personal flight – as opposed to gliding – continues to fascinate despite the laws of physics, and economics, that conspire against a breakthrough of the technology into the enthusiast market. On 30 August, two pilots reported seeing a mystery man in a jetpack, flying at around 3,000ft, dangerously close to the approach path to Los Angeles International airport. The strangest aspect of the story: no jetpacks on the market are capable of flying at that high an altitude.

This article was completed prior to the tragic death of Vince Reffet on 17 November, while training in Dubai. We send our condolences to his family, friends and Jetman Dubai colleagues.

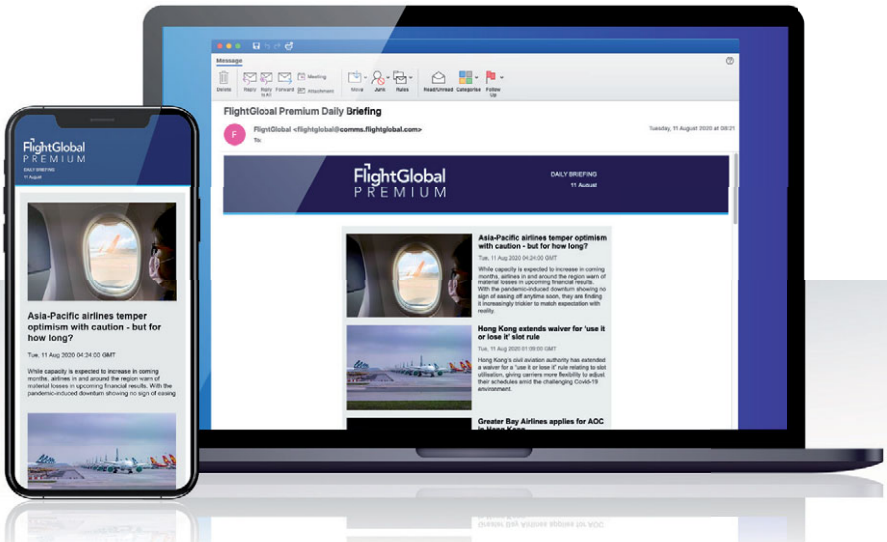
Shutterstock

With his original concept, 'Jetman' Yves Rossy uses a parachute to land

FlightGlobal
PREMIUM

The Daily Briefing eAlert is just one of the benefits of a FlightGlobal Premium subscription. Subscribe today and the latest aerospace and aviation stories to be making the headlines will be emailed to you every Tuesday to Saturday.

Take a look for yourself...



"Featuring the latest on major developing stories and key insight into the issues impacting the aviation industry, the Daily Briefing provides must-read insight from our team of global journalists into the most important stories every day."

Graham Dunn, Content Director

SAVE UP TO 15%

SUBSCRIBE TODAY

Alongside the Daily Briefing, you'll also secure these subscriber-only benefits:

- Unlimited access to all FlightGlobal content
- Flight International magazine in print or digital format
- Exclusive interviews with industry thought leaders
- Unrestricted access to the FlightGlobal news archive

FlightGlobal
PREMIUM

FlightGlobal.com/subscribe

*Images included are for illustrative purposes only.

Coming to the Ness-cue

Europe's only surviving Consolidated PBY Catalina has been stranded on Loch Ness – and, as we went to press, the team behind the Second World War flying boat was trying to raise money from public donations to bring her home.

Miss Pick Up damaged her starboard engine while being filmed for a TV production over the stretch of water, and it needs to be replaced before she can return to the Imperial War Museum at Duxford.

Plane Sailing, the Cambridge-based group of pilots and other volunteers who keep the iconic amphibian in the air to honour her legacy, say replacing her Pratt & Whitney Twin Wasp and getting her back in the air before the Scottish winter sets in will be a challenge.

"The logistics involved are massive," says pilot Paul Warren Wilson. "The damage this could do to the aircraft – an important piece of aviation history – could be irreparable."

Although he says the team has been "staggered and humbled" by the thousands of pounds raised so far, there is still a long way to go. However, bringing the Catalina on to dry land means there is "a light glimmering at the end of the tunnel", he says.

In a normal year, Miss Pick Up appears at up to 20 shows, although this year Covid-19 has limited this to two.

● Information at catalina.org.uk

Plane Sailing

Loch-down: Miss Pick Up before being lifted on to dry land

In for the gull

Some inquiries by the UK's Air Accidents Investigation Branch are mercifully short, such as that into an incident involving an unmanned air vehicle in southwestern Scotland.

The vehicle – a DJI Matrice 200 quadcopter weighing a hefty 6.1kg (13.4lb) – had been conducting a roof survey of a large building in the vicinity of Stranraer Academy on 6 July, the latest bulletin from the investigation authority states.

After carrying out pre-flight checks and launching the aircraft on a pre-programmed path, the pilot flew it manually before engaging autonomous operation.

But shortly into the return flight a black-headed gull swooped over the pilot from behind

Shutterstock

Aerial threat: black-headed gull

From the archive

1920 Summons in the sky

During the unveiling by Sir William Robertson on Armistice Day of the Potteries' Cenotaph at Stoke-on-Trent, it is alleged that Capt. O. P. Jones flew over the monument and dropped a wreath. This opened up a question of a breach of the provisions of the Aviation Act, 1919, which took the form of a summons in the hands of Police Inspector Adlem of Stafford for said alleged breach. The latter, evidently a sportsman of the right calibre, upon being invited to have a flip when he arrived at the aerodrome to serve the summons, promptly accepted, and paid his footing by endorsing the summons "Served personally in mid-air, November 24, 1920." Whether the Inspector quite expected such full value as a few "loops" thrown in is a question.

1945 Underground effort

Amidst the changes of policy, reckless dispersal of effort, and general misdirection that dogged German efforts in air warfare, the production of jet-propulsion turbine units stands out as one of their solid achievements. By a decision of extreme boldness, they set up a great chain of bomb-proof underground factories for series production of jet units on a vast scale, although they were short of vital raw materials. No other country so desperately short of the vital heat-resisting alloys so essential for turbine efficiency would have dared to gamble to such an extent. Germany was undoubtedly well ahead of the Allies in production, and hoped, by having large numbers of jet fighters and bombers in action during the autumn of this year, to regain the initiative in the air war.

and attacked the quadcopter, damaging a forward propeller and causing it to crash on to a roof.

"[The pilot] had not experienced this level of aggression before," says the bulletin, without specifying whether the aggression was coming from the gull, whose space had been invaded, or being directed towards it, for busting up a £5,000 drone.

Yesterday's Cruz

Days after Alex Cruz was ousted as chief executive of British Airways with immediate effect, keeping only his non-executive chairman role, we suspect LinkedIn did not quite read the room when it posted to his contacts: "Congratulate Alex Cruz on his new position."

Air safety's slippery slope

Switching from a highly personal account of his father's escape from a Nazi camp, the subject of his previous book, to the pitfalls of cutting-edge aircraft technology is quite a leap, but Jack Hersch makes a decent fist of explaining some of the crucial issues in *The Dangers of Automation in Airliners*.

Hersch adopts a historical perspective, tracing automation development over the decades of flight evolution before concentrating on its influence in high-profile accidents – Colgan 3407, Air France 447 and those involving the Boeing 737 Max – without delving too deeply into the complexities of behavioural human factors analysis.

The narrative leans towards light storytelling, rather than heavy academic analysis, and inevitably might not suit those who – if already familiar with the accidents described – would prefer a narrower-but-deeper focus.

But Hersch, an aviation enthusiast, has done his homework and injects readability into this controversial and multi-faceted topic. Anyone keen to explore the slippery slope from Sperry's gyrostabiliser to the notorious MCAS will probably learn something.

The 248-page book is published by Air World, part of Pen & Sword, and is priced at $32.95.

50

1970 Dawn of the mini-jets

Financial restrictions in America over the last year have considerably affected sales of business aircraft. The ripples of this have been felt in Europe, but on a considerably reduced scale because sales this side of the Atlantic were much lower than in America in the first place. Some business aircraft projects, such as the Gates Twinjet helicopter, have suffered in the form of slowed-down development programmes but in general manufacturers have pressed on, looking forward to the upward swing which we feel must be at hand. Most significant is the development of the new mini-jets — Falcon 10, Corvette and Citation. While these aircraft will not be available in the next year, they introduce a new variation to corporate aviation planners.

25

1995 Handling competition

In a landmark decision, European transport ministers have agreed to a full liberalisation of the region's airport ground-handling from 1 January, 2003. Germany and Austria have refused to sign the agreement, but will still be bound by the decision, which is expected to be ratified by the European Parliament within six months. Other countries, including the UK, wanted faster implementation, but accepted a European Commission (EC) compromise under which competition will be introduced gradually. From 1 January, 1998, self-handling on the landside (within the airport terminal) will be fully liberalised, while airlines will be allowed to carry out their own handling on the airside at airports with more than one million passengers a year.

Buzz off

Having never achieved proficiency as either a pilot or a gardener, I read your recent article regarding the pitot tube insect larvae blockage on a lockdown-stored Wizz Air Airbus A321 in the UK during June (FlightGlobal.com, 12 November) and a thought occurred to me.

Since it appears to be inappropriate to seal pitot tubes tightly when a jet is in storage, leaving the risk of penetration and blockage by insects, might it instead be feasible to simply impregnate the existing looser covers with an insecticide?

Perhaps that would deter those pesky critters?

Richard Glen
via email

Road to ruin?

The railways, buses and most dramatically the airlines have suffered a massive reduction in passenger numbers as a consequence of the coronavirus crisis, while the volume of private car traffic on the UK's motorways has apparently increased significantly.

Every other form of transport faces coronavirus safety requirements, but this is not the case for travellers on our roads.

Nobody is telling motorists to ask themselves, 'Is your journey really necessary?', or 'Can your needs be satisfied by communication on social media?'

Airlines and railways are having their businesses damaged simply because they are an easy target – not because they are the majority spreaders of the virus or highly dangerous environments.

Paul Brown
Sheffield, South Yorkshire, UK

More to say

As a long-term subscriber I have adjusted to a monthly format for my favourite magazine.

However, I was disappointed to see just a single-page format for the letters page in the first issue (*Flight International*, September 2020). I believe that four pages per month is required to maintain this section as it was.

The quality analysis and practical insights that are presented on these pages were in my view very much a part of the *Flight* experience for the readership.

I'm sure there is no shortage of letters of the standard in the first issue – four pages please!

John Blundell
Auckland, New Zealand

Editor's reply: Hopefully you will have enjoyed the two-page letters sections in our October and November issues. While our new design makes use of bigger pictures, the word count has remained equivalent to that for a spread in our old weekly edition format. We always love to hear readers' very informed views about our reporting, other aerospace topics and even "tales of yore", but correspondence levels can vary. Our letters section is nothing without your contributions, so please send your thoughts to flight.international@flightglobal.com

Expert knowledge

Regarding your article about a retired British Airways Boeing 747-400 being preserved as a film set (FlightGlobal.com, 22 October), you might also have pointed out that Dunsfold airfield used to belong to Hawker Siddeley and was the site where the Harrier was manufactured.

Paul Burch
Farnham, Surrey, UK

Congratulations to Paul Burch, whose name was first out of the hat in our draw to win a copy of legendary former *Flight* editor Mike Ramsden's updated biography *Sir Geoffrey de Havilland: A Life of Innovation*.

Festive Quiz answers

1. A. Boeing
2. C. Camber
3. D. Delta
4. B. Catalina
5. D. Wizz Air
6. C. F-15EX
7. A. Rafale
8. B. Japan
9. B. Germany
10. C. KC-130J
11. C. MMF
12. B. FASTA
13. C. SpaceX
14. B. RAF
15. B. Germany
16. A. 72
17. D. 450
18. A. Delta
19. B. Asco
20. C. Aerion
21. C. Leonardo
22. D. Bristow and Era
23. D. Philadelphia
24. C. H145
25. B. Rotor blade
26. C. *Apocalypse Now*
27. A. Walmart
28. B. LATAM
29. D. Ocean
30. B. London
31. B. Varadi
32. A. 75
33. D. Japan
34. A. Kelly
35. B. Lightning
36. B. DC-8
37. A. KLM
38. C. 747
39. D. Avro RJ
40. C. DC-9
41. B. ShapeShifter
42. A. American
43. B. A300B4
44. C. JT8D
45. B. Korean Air
46. B. Silvercrest
47. A. Comlux
48. C. Liberty
49. C. Uruguay
50. D G700

IDENTIFY THE TYPE

1. Aerospatiale BAC Concorde
credit Max Kingsley-Jones
2. Avro Canada CF-105 Arrow
credit BAE Systems archive
3. Avro Tudor 4
credit BAE Systems archive
4. Boeing 377 Stratocruiser
credit Boeing
5. Boeing 707-100 credit Boeing
6. Vickers VC10
credit BAE Systems archive
7. Airbus A330-800
credit Max Kingsley-Jones
8. Sukhoi Su-30MKM
credit Max Kingsley-Jones
9. de Havilland DH112 Venom NF3
credit BAE Systems Archive
10. Sikorsky (Westland) S-51 Dragonfly
credit British Airways archive

SIPA/Shutterstock

Unreliable airspeed led to AF447 disaster in 2009

Safety critical

I find it absolutely astounding that the constant display of angle of attack in modern glass cockpits is still not mandatory.

For most cockpits this is a customer-selectable option – it seems to me, however, that not too many airlines are willing to pay for this.

As incidents with unreliable airspeed information sadly keep happening, the information of current angle of attack would be an independent and vital information for the flightcrew to verify their aircraft's energy state.

Anti-skid brakes, ground proximity warning and terrain collision avoidance systems are standard equipment for airliners today – angle of attack should be too.

Michael Scheiba
Weinheim, Germany

A brief word

May I concur with Barry Wheeler's letter 'Yesterday's news' (*Flight International*, November 2020).

In-depth articles should be mixed with shorter items and pictures. That way your readers can dip in or settle down for a longer read.

Nigel Champness
via email

News round-up

Having received my October issue of *Flight International*, I would just like to make a quick comment on the new format.

There were some interesting articles across a good range of topics and overall it was an enjoyable read.

But I feel that many readers would appreciate two or three pages giving the headline news for the month. I know that we can go online every day to get the latest news, but it is too easy not to do so regularly.

And, as always, it's a pity that *Flight* feels that aerospace stops at 40,000ft, when there are so many interesting developments in the space sector.

Hugh Tansley
Toulouse, France

We welcome your letters about our coverage, or any other aerospace-related topic. Please email flight.international@flightglobal.com, or write to: The Editor, Flight International, 1st Floor, Chancery House, St Nicholas Way, Sutton, Surrey, SM1 1JB. Letters should be no longer than 350 words in length, and supplied with the correspondent's name and location. Letters may also be published on FlightGlobal.com, and do not necessarily represent the views of the editor.

Reader services

EDITORIAL

1st Floor, Chancery House, St Nicholas Way, Sutton, Surrey, SM1 1JB, UK

flight.international@flightglobal.com

Editor Craig Hoyle
+44 7795 486691 craig.hoyle@flightglobal.com

Deputy Editor Dominic Perry
+44 20 8912 2164 dominic.perry@flightglobal.com

Head of Strategic Content Murdo Morrison FRAeS
+44 20 8722 8389 murdo.morrison@flightglobal.com

Consulting Editor David Learmount
+44 7785 901787 david.learmount@ntlworld.com

Magazine Enquiries
flight.international@flightglobal.com

AIR TRANSPORT TEAM

Executive Editor Graham Dunn
graham.dunn@flightglobal.com

Managing Editor – Airline Business Lewis Harper
lewis.harper@flightglobal.com

Air Transport Editor David Kaminski-Morrow
david.kaminski-morrow@flightglobal.com

AMERICAS

Americas Managing Editor Jon Hemmerdinger
+1 617 397 2809 jon.hemmerdinger@flightglobal.com

Americas Air Transport Editor Pilar Wolfsteller
+1 510 634 3496 pilar.wolfsteller@flightglobal.com

Aviation Reporter Garrett Reim
+1 571 216 5327 garrett.reim@flightglobal.com

ASIA/PACIFIC

Asia Editor Greg Waldron
+65 9489 4153 greg.waldron@flightglobal.com

Reporter Alfred Chua
+65 9643 4228 alfred.chua@flightglobal.com

CIRIUM DASHBOARD EDITORIAL

Michael Allen, Steve Goldstein, Michael Gubisch, SiMin Ngai, Niall O'Keeffe, Thomas Risen, Jonathan Robins

FLIGHTGLOBAL.COM

Online Content Manager Amber Elias
+44 7816 991648 amber.elias@flightglobal.com

EDITORIAL PRODUCTION

Group Production Manager Isabel Burton
Art Editor Tim Noonan
Layout Copy Editor Tim Norman
Consulting Technical Artist Tim Hall

DISPLAY ADVERTISEMENT SALES

1st Floor, Chancery House, St Nicholas Way, Sutton, Surrey, SM1 1JB, UK

EUROPE

Key Account Manager Grace Murphy
+44 20 8092 4080 grace.murphy@flightglobal.com

Sales Support Gillian Cumming +44 20 8092 4082

NORTH & SOUTH AMERICA

Vice-President, North & South America Rob Hancock
+1 703 795 5155 robert.hancock@flightglobal.com

Sales Director, USA & Canada Brett Ryden
+1 630 450 1164 brett.ryden@flightglobal.com

ITALY

Sales Manager Riccardo Laureri
+39 (02) 236 2500 media@laureriassociates.it
Laureri Associates SRL, Via Vallazze 43,
20131 Milano, Italy

ISRAEL

Sales Executive Asa Talbar +972 77 562 1900
Fax: +972 77 562 1903 talbar@talbar.co.il

Talbar Media, 41 HaGiva'a St, PO Box 3184, Givat Ada 37808, Israel

ASIA/AUSTRALASIA

Key Account Manager Jay Ee
+65 9173 3502 jay.ee@flightglobal.com
DVV Media International (Asia) Pte. Ltd.
15 Beach Road, 2nd Floor, Singapore 189677

RUSSIA & CIS

Director Arkady Komarov Tel/Fax: +7 (495) 987 3800
komarov@worldbusinessmedia.ru

World Business Media, Leningradsky Prospekt, 80, Korpus G, Office 807, Moscow 125190, Russia

RECRUITMENT

Sales Manager Katie Mann
+44 7792 152097 katie.mann@flightglobal.com

Business Development Manager Lauren Cooper
+44 20 8092 4085 lauren.cooper@flightglobal.com

CLASSIFIED

Key Account Manager Jay Ee
+65 9173 3502 jay.ee@flightglobal.com

ADVERTISEMENT PRODUCTION

Production Manager Sean Behan +44 20 8092 4078

DATA

Data cited in Flight International is sourced from Cirium, a data and analytics company in the wider travel industry. For Cirium's data team, contact:

Trevor Mountford
trevor.mountford@cirium.com

PUBLISHING MANAGEMENT

Managing Director Andy Salter

VP, Publishing and Conferences Mark Pilling
mark.pilling@flightglobal.com

Commercial Director Publishing Sophie Wild
+44 7715 364765 sophie.wild@flightglobal.com

SUBSCRIPTIONS

Flight International Subscriptions,
DVV Media International,
PO Box 302, Haywards Heath,
West Sussex, RH16 3DH, UK

Subscription Enquiries If you have any subscription queries, please contact customer service:
+44 330 333 9533

To purchase a FlightGlobal Premium subscription, visit FlightGlobal.com/subscribe

Print & Digital Subscription Rates
(best rates are quoted)

1 year: £212.50/€229/$293.25 Save up to 15%
2 years: £450/€484.50/$621 Save up to 10%
3 years: £600/€645.85/$828 Save up to 20%

Digital Subscription Rates
(best rates are quoted)

1 year: £187/€205.78/$263.50 Save up to 15%
2 years: £396/€435.80/$558 Save up to 10%
3 years: £528/€581/$744 Save up to 20%

Only paid subscriptions available.
Cheques payable to Flight International

Flight International is one of FlightGlobal's (publishing, events and FlightJobs) products and services.

CIRIUM

FlightGlobal uses data and analytics sourced from Cirium.

www.cirium.com

Flight International welcomes unsolicited contributions from readers but cannot guarantee to return photographs safely.

Registered at the Post Office as a newspaper
Published by DVV Media International Ltd,
1st Floor, Chancery House, St Nicholas Way,
Sutton, Surrey, SM1 1JB, UK.

Newstrade distributed by Marketforce (UK),
2nd Floor, 5 Churchill Place, Canary Wharf, London,
E14 5HU, UK. Tel: +44 20 3787 9001

Classified advertising prepress by CCM.
Printed in Great Britain by William Gibbons and Sons

Flight International published monthly 12 issues a year.

ISSN 0015-3710 (Print) ISSN 2059-3864 (Online)

DVV Media International

New and used aircraft

amapola.nu

Fokker F50 Freighter & Passenger aircrafts for SALE

The Fokker 50 aircraft is perfect for operation on gravel and shorter runways, the aircraft model is known as the true working horse, there other aircrafts can't operate! Perfect cargo for bulk loading pallets and loose equipment. Passenger cabin in excellent condition.

- ✓ *Availability September 2020*
- ✓ *Currently in operation*
- ✓ *Fully EASA Ops 1 compliance*
- ✓ *Fokker E-Class configuration. Max payload 7.200 kg, 56 mq*
- ✓ *Fokker passenger configuration 50 seat*
- ✓ *Fresh from C-Check*
- ✓ *Good engine, propellers and landing-gear status*
- ✓ *Excellent component status*
- ✓ *For outright sale, lease purchase TBD*
- ✓ Export CofA in progress

For details please contact: Mr. Thomas Carlborg
E-mail: thomas.carlborg@amapola.nu
Mobile: +46 733 85 85 55
Website: www.amapola.nu

Request For Proposal

Equipment, maintenance and service

mt-propeller

Pilatus PC-12 with worlds first 7-blade MT-Propeller - The Silent 7

Airport Straubing-Wallmuehle, EDMS
94348 Atting / Germany
Phone: +49(0)9429-9409-0
Fax: +49(0)9429-8432
sales@mt-propeller.com
www.mt-propeller.com

Development & Production of high performance composite constant speed propellers.

FLY GREEN - FLY MT

Sales & Service for products made by McCauley, Hartzell, Sensenich, Woodward, Goodrich.

REQUEST FOR PROPOSAL (RFP)

Willis Lease Finance Corporation is requesting sales proposals for the supply of up to 30 unencumbered / off-lease DHC-8 Q400, ATR42-500 and ATR72-500 aircraft.

For full details, or to submit your RFP, visit www.willislease.com/rfp.aspx.

RFPs must be submitted by December 18, 2020, 5:00 PM (PST).

TEL +65 9173 3502 EMAIL Jay.Ee@flightglobal.com

New and used aircraft

Courses and tuition

EXCITING OPPORTUNITIES

A South East Asia based VVIP operator is seeking new recruits to fill a variety of positions in its Engineering and Logistics Departments. We are looking for experienced qualified personnel for the positions described. The successful applicants will be offered an initial 3 year contract with an attractive package. The contracts are renewable with 2 or 3 year options.

Interviews for successful applicants will be held in London in early December 2020.

Package

- Initial 3 year contract
- Renewable with 2 or 3 year contract
- End of contract and midterm travel (business class)
- Yearly performance bonus
- End of contract gratuity at 20% of earned salary for completed contract.
- Salary increment at contract renewal
- 48 days annual leave
- Duty travel expenses
- No income tax
- Full medical cover including family
- School fees assistance
- Spacious furnished accommodation

Available roles

Senior Quality Assurance Engineer x 1

- Minimum of 15 years in the industry with a certifying staff background
- Minimum of 3 years working experience in a quality system e.g.Q-Pulse
- EASA Part 66 B1 / B2
- Formal training on audit techniques and experience in auditing
- Good working knowledge of current regulations such as Part 145, Part M, Part 21J

Licensed Aircraft Engineer Avionics x 1

- Minimum of 10 years in the industry
- Minimum of 3 years as a certifying engineer, preferably with Sikorsky and Boeing aircraft.
- EASA Part 66 B2
- Working knowledge of EASA and/or EASA based regulations

Licensed Aircraft Engineer Rotary Wing x 3

- Minimum of 10 years in the industry
- Minimum of 3 years as a certifying engineer, preferably with Sikorsky aircraft.
- EASA Part 66 B1-3
- Working knowledge of EASA and/or EASA based regulations

Logistics Manager x 1

- Minimum of 15 years in the industry
- Minimum of 5 years in a logistics managerial position
- Relevant training for goods inwards / dangerous goods and Human Factors
- Working knowledge of EASA and/or EASA based regulations

Logistics Controller x 1

- Minimum five years in the industry or equivalent experience
- Holding a goods inwards authorisation
- Preferably holding dangerous goods authorisation
- Working knowledge of EASA and/or EASA based regulations

Technical Records / Library Supervisor x 1

- Minimum of 10 years in the industry
- Relevant experience in the registering of technical /airworthiness publications and data
- Familiarity with Rusada Envision or similar maintenance data base would be advantageous
- Working knowledge of EASA and/or EASA based regulations

For those individuals who are interested, please apply by submitting a CV (with personal details) via email at **recruitment@hmsf.gov.bn** quoting the relevant position

Lee Hui Fung is ST Engineering's vice-president for Smart MRO, and has been in the industry for nearly 30 years. She explains how gender diversity in the aerospace sector in Singapore has changed

'Are you here to take minutes?'

Alfred Chua Singapore

In her first meeting shortly after joining what was then known as ST Aerospace Services Company (SASCO) more than 15 years ago, Lee Hui Fung recalls entering a meeting, notebook in hand, and taking a seat among the many men in the room.

Shortly after, a male attendee turned to her and asked: "Are you the minutes-taker for the meeting?"

It was a cringe-making question, and one that has stayed in Lee's mind.

In a similar incident, Lee was walking the hangar floor days after she joined SASCO as a marketing and programme manager, when she greeted an elderly male cleaner. He returned the greeting, before politely asking her: "Are you the [lady] who is replacing the administrative assistant because she has gone on maternity leave?"

Recounting these incidents, Lee, now vice-president of Smart MRO at ST Engineering's aerospace division, says she felt more "amused" than offended or "humilated" by the questions.

Still, it showed the perception that "women's role in MRO and aerospace is always about playing the supporting role", says Lee.

"You're [seen to be] either a secretary, in the finance department, or in human resources," she adds.

Lee entered SASCO, now known as ST Engineering Aerospace Services Company, in 2003, after moving over from the parent's Engineering and Development Centre (EDC), which she joined after graduating with a master's degree in engineering.

Coming from the research-centric work environment in EDC, it could not have been a more "stark contrast" for Lee on entering the operational part of the business at SASCO.

At EDC, Lee says about 80% to 90% of her colleagues were engineers by training, of whom about 30% to 40% were female.

By contrast, when she started at SASCO, Lee noticed that there was nary a female engineer working in the hangars.

So she took it upon herself to push for change on the shop floor, after realising that this was not the norm in European countries such as Germany, where female engineers in the hangar were a common sight.

"I questioned management, and soon enough, we had female licensed engineers... we started taking them in, under apprenticeships, and trained them," Lee recalls.

Hearing the excitement in Lee's voice as she takes us on an impromptu hangar tour at the end of the meeting, it is hard to imagine that her foray into the aerospace industry was purely "by chance".

"I liked maths [and] science, and my two elder brothers also studied engineering, so I was influenced," she says. "I wanted to be a teacher, actually."

Composite studies

She finished her undergraduate studies at the National University of Singapore, studying mechanical and production engineering, before pursuing her master's degree at Singapore's Nanyang Technological University, specialising in composites.

In 1993, as she neared completion of her master's degree, her professor told her of a job opportunity at ST Engineering, and felt that she fitted the bill, given her background in composites engineering.

"Coming into [ST Engineering], I asked myself, would I be here for two years, or maybe five years? But here I am, close to 30 years already," Lee says.

Her first project in ST Engineering's EDC was the development of the then-Eurocopter EC120 helicopter, a joint venture between Eurocopter, ST Engineering, and the China National Aero-Technology Import and Export Corporation (CATIC).

She was also part of the Boeing 757 freighter conversion programme at the EDC, focusing on stress analysis of the modification's design.

ST Engineering

Lee believes it must be made easier for young women to climb the career ladder

"How do you move women in aerospace to become the leaders? This is not easy... there are so many obstacles to discourage them"

Then she moved to SASCO, where she spent a good 15 years, rising to the position of deputy general manager of the unit.

At SASCO, Lee oversaw a number of key programmes, including MD-11 passenger-to-freighter conversions, as well as 767 Boeing Converted Freighters. In 2018, she was appointed to her current role to oversee the unit's smart MRO initiatives.

Reflecting on her journey in aerospace, Lee acknowledges she has come a long way since the days of being mistaken on the hangar floor for an administrative assistant.

"I can tell you that now, when I go down to the hangar, I feel very good because everyone will say hello. When I chair a meeting, [people] don't treat me any differently," she says.

She credits having supportive mentors and bosses at work — something she hopes will be more commonplace in the future.

Encouraging signs

Lee is also encouraged by the increasing gender diversity in the MRO and aerospace engineering sector in Singapore, including at ST Engineering.

"It is an encouraging sign that there are more and more [women in aerospace], but I always wish there are even more," says Lee, noting that Asian countries tend to have a lower level of women in the aerospace industry.

Another area she sees as equally important is retaining the female talents that enter the industry.

"How do you move them to the next level [to] become the leaders? This is not easy... because there are so many obstacles to discourage them. And our job is... to help them to clear the path and [let] them feel that this is a possibility," she adds.

For women wanting to pursue a career in aerospace engineering, she has this advice: "Whatever the guys can do, the girls can do as well."

She adds: "Your start [will be] a bit rocky: people will tend to doubt you [and question your abilities]. If you have an interest, just go for it, follow your heart, work on it, and let your results speak for itself."

"I mean, look at me and the stories I have shared!" she adds, breaking into laughter.

We Innovate For Those Who Move The World™.

Always reaching higher

Every day, aircrews and passengers depend on our flight critical systems. We bring four decades of experience in designing highly reliable and efficient systems that operate in the harshest environments.

baesystems-ps.com

BAE SYSTEMS