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FLIGHT INTERNATIONAL

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The fall of Kabul

Photo: Shekib Rahmani/AP/Shutterstock

Almost 20 years after US and coalition forces arrived in the wake of the 9/11 terror attacks, the Taliban's crushing return to power has plunged Afghanistan into fresh instability

The timing of Afghanistan's second fall to the Taliban was notable not only for its spectacular pace, but also because it occurred less than one month before the 20th anniversary of the 9/11 attacks on the USA.

The collapse of the US- and NATO coalition-backed Afghan government, whose leaders fled the country on 14-15 August, prompted many to question the value of what had been a 20-year intervention spurred by the terrorist strikes on the World Trade Center's Twin Towers in New York, and the Pentagon near Washington DC.

Amid chaotic scenes in Kabul, comparisons were also made with the fall of Saigon in 1975, after US helicopters – including Vietnam War-era Vertol CH-46s now operated by the Department of State – ferried diplomats and embassy staff to Hamid Karzai International airport.

But this was no repeat of the Vietnam War, where Washington's ambition to win hearts and minds and repel communism's advance was doomed to fail. Instead, its combat involvement in Afghanistan was primarily a means of neutralising the threat of the Al-Qaeda terrorist group and its leader, Osama bin Laden, who was killed in a special forces raid in Pakistan a decade ago.

Beyond that point, the international mission was focused on the containment of militant groups and creating and equipping an Afghan military which was believed capable of countering the Taliban. This had included providing its air force with assets including Sierra Nevada/Embraer A-29 light-attack aircraft and Sikorsky UH-60A Black Hawk utility helicopters.

However, once faced with the resurgent Taliban only weeks after NATO had concluded its Resolute Support mission, Kabul's armed forces simply dissolved. In an exodus headed by Afghan President Ashraf Ghani, who fled to the United Arab Emirates, almost 600 personnel also escaped to Uzbekistan, reportedly taking 46 air force and Special Mission Wing aircraft with them.

The collapse of air traffic control provision prompted ICAO to declare the nation's airspace as "uncontrolled", and a situation which had already been made difficult by the departure of skilled NATO personnel has slipped to one where the future of commercial air travel is in major doubt in the country.

While welcome, conciliatory early statements by Kabul's new warlords – and their granting permission for Western powers to mount a frantic airlift to repatriate stranded nationals and evacuate refugees – are unlikely to be matched by acts of forgiveness and tolerance.

In a tribal nation with a centuries-old tradition of almost continual conflict, this is unlikely to be the last attempt by outside powers to encourage stability. But for the current US administration, continuing to focus on suppressing a militarily inferior foe in a "forever war" while near-peer rivals China and Russia make major advances was too big a risk to take.

There were many loose ends still to be addressed ahead of a 31 August deadline for the USA and its allies to withdraw the last of their personnel from Afghanistan. These included determining how many more of the combat aircraft provided to the nation's air force over recent years could also be extracted. An inability to do so could yet mean Washington's involvement ending with a bang, to ensure that the equipment does not stray into the hands of other hostile powers.

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In focus

Lockheed Martin

In depth

Escape route Afghans waiting for evacuation at Kabul airport

Fatal crash halts Ilyushin testing

Russian airframer suspends flights of Il-114-300 civil turboprop prototype following loss of military airlifter with related engines

David Kaminski-Morrow London

United Aircraft (UAC) has suspended flight testing of the Ilyushin Il-114-300 following the fatal accident involving a prototype of the military Il-112V.

Russian investigators have established a committee to look into the Il-112V crash, outside Moscow on 17 August, although it has yet to reach any preliminary findings.

But the Il-114-300 is powered by the Klimov TV7-117ST-01 engine, which is closely related to the TV7-117ST fitted to the twin-engined military transport.

Video images of the accident appear to indicate a fire in the Il-112V's starboard engine before the aircraft banked to the right and rolled into a steep dive.

"It is necessary to conduct a thorough investigation of the Il-112V accident, especially an analysis of hard evidence from the flight-data recorder," says UAC.

"It is because of this that the flight-test programme for the Il-114, which has a similar powerplant, is temporarily suspended.

"The accident investigation committee has just commenced its work. It is too early to draw any conclusions at this point."

Chief test pilot Nikolai Kuimov and senior test pilot Dmitry Komarov were among the three crew lost on the Il-112V. Both had performed the maiden flight of the Il-114-300 in mid-December last year, Kuimov stating afterwards that the aircraft had proved reliable despite the poor weather.

He participated in a joint panel at the MAKS air show near Moscow in July, which discussed publicly the testing of the Il-114-300 and Il-112V.

Bench testing

General designer of United Engine's Klimov division Vsevolod Eliseev, speaking during the event, had expected the TV7-117ST-01 and its propeller to complete flight and certification tests in the first quarter of 2022. UAC had been aiming to deliver Il-114-300s from 2023.

Klimov TV7-117 engine programme director Stanislav Konashkov said the powerplant has undergone a "huge quantity" of bench tests. "But this is not the same as testing it as part of an aircraft, along with aircraft components, when the effect of all these systems on the engine is taken into account," he told the panel audience.

United Aircraft

Il-112V had resumed test flights in March after a two-year hiatus

The Il-112V was first flown in March 2019, but then underwent a substantial period of modification before resuming test flights in March this year.

UAC has not indicated the extent to which either the Il-114-300 or Il-112V programmes might be disrupted, either by the technical investigation or the loss of its senior test crews.

The inquiry will attempt to understand why such experienced pilots – used to flying aircraft in abnormal and extreme conditions – lost control of the Il-112V and were unable to recover. Video images show the aircraft flying level at low altitude, perhaps 500ft, before losing height as it entered a right bank, rolling sharply into an inverted dive.

The aircraft had been in Moscow to participate in the Army-2021 military exhibition and was performing a test flight between the Kubinka and Zhukovsky airfields.

Investigators have yet to explain the source of the fire or disclose any link between the engine situation and the crash, including whether the aircraft sustained damage to flight controls, or whether the engine was being shut down and its propeller feathered.

The inquiry will also explore whether the bank was intentional, especially towards the side of the affected engine, and the reasons for the sudden loss of roll control.

UAC's Voronezh-based airframer, VASO, which produced the Il-112V, says Kuimov had worked at the Ilyushin complex since 1994 and had served as a senior test pilot with the defence ministry.

VASO says he was involved in flying more than 35 aircraft types – among them the Il-96, Il-76 and Il-114 – and carried out a large number of flight tests, often involving complex and potentially hazardous situations.

Kuimov was also a regular demonstrator of the company's aircraft during international air shows.

Alongside Kuimov and Komarov, VASO named Nikolai Khludeev as the engineer on board the Il-112V.

IAI is developing 'Big Twin' freighter modification with lessor GECAS

GECAS

Converts to peace

Etihad Engineering to build 777-300ER conversion line for IAI as relations between Israel and several Arab states improve

David Kaminski-Morrow London

Israel Aerospace Industries (IAI) is to set up a landmark freighter conversion line for Boeing 777-300ERs in the United Arab Emirates (UAE), tightening the new diplomatic ties established between the two countries last year.

The new conversion line will be established in Abu Dhabi under a co-operation agreement with Etihad Engineering.

IAI says the centre will help supply the "global rise in demand" for the new conversion programme. The company has recently commenced modification of the first example of the 777-300ERSF at its Tel Aviv operation.

Chief executive Boaz Levy says the diplomatic recognition agreements signed last year between Israel and several Arab states have given IAI the chance to expand to the Gulf.

He says the new conversion line in Abu Dhabi is a "testament to IAI's strong ties with the UAE", adding that it "strengthens its foothold" in the region.

Etihad Engineering says that cargo operations have been helping to offset airlines' losses during the air transport crisis triggered by the Covid-19 pandemic. "Industry forecasts show an increase in demand for widebody freighter aircraft with long-haul capacity," it adds.

Etihad Aviation Group chief executive Tony Douglas says the 777-300ERSF is "extremely attractive" to customers.

"Not only do we see the demand, but we view it as a greener, more profitable, highly innovative solution," he adds.

Etihad Engineering chief executive Abdul Khaliq Saeed says that the partnership with IAI will "maximise the potential" of the Abu Dhabi company's workforce.

IAI is developing the 777-300ERSF conversion under a co-operation agreement with US lessor GECAS, and it believes there is initial demand for at least 50 aircraft. The Israeli firm has already agreed to set up a conversion line for the type in the South Korean capital, Seoul.

Growing capabilities

Separately, IAI is further broadening its modification capabilities with a new freighter conversion line in Ethiopia for 767-300ERs.

The line will be established at Addis Ababa, at Ethiopian Airlines' maintenance facility, under an agreement with the African carrier.

Ethiopian Airlines chief executive Tewolde Gebremariam says the carrier will be the first customer, with three of its 767s undergoing conversion.

IAI Aviation Group general manager Yossi Melamed tells FlightGlobal that the expansion demonstrates the appeal of the twinjet to the cargo sector.

The rise in e-commerce, he says, has supported the demand for 767s and all the company's available slots for converting the type are "fully booked" through 2022.

Melamed says the company "needs more lines".

IAI developed the 767-300BDSF freighter as a follow-up to the -200BDSF. It features a large cargo door, a 9*g* rigid barrier, reinforced floor, and changes to several systems – such as lighting, oxygen and environmental control – within the aircraft. It has 24 main-deck and 30 lower-deck cargo positions.

Its new 767 conversion facility will complement its other cargo modification operations for the type at Tel Aviv and Mexico City.

The Mexican line was unveiled as a co-operative arrangement with Mexicana's maintenance division, and the new centre in Ethiopia will involve a similarly close relationship with the local airline.

"We were looking for an excellent MRO operation," says Melamed. But he adds that IAI sought a partner with "willingness and desire to move forward from simple MRO to something more sophisticated".

He says the company had to "pick a site carefully", because it has overall responsibility for the conversions. It explored locations in Europe and South America before settling on Addis Ababa.

Airbus sets course for new loadstar

Airframer details plans for A350 freighter, which will be substantially based on -1000 passenger variant

David Kaminski-Morrow
Dominic Perry
London

Airbus looks set to shake up the market for heavy cargo aircraft – or at least finally provide some competition for Boeing – after gaining board approval to launch a freighter variant of its A350 widebody twin.

But its arch-rival in Seattle is unlikely not to respond and appears to already be considering its next freighter development, likely to be based on the 777X.

Airbus in late July announced that development of the A350F would go ahead after its board cleared the move. Entry into service is targeted for 2025.

The airframer indicates that the A350F will be a light hybrid of its current variants but primarily a derivative of the -1000.

"It's based on the existing [A350] building blocks to a large extent," says Airbus chief executive Guillaume Faury.

But he says the freighter design is "predominantly coming from the -1000" and the larger A350 variant will be the "main driver".

While performance details have yet to emerge fully, Faury says the freighter will have a 90t-plus payload capability.

Production will be "embedded" in current A350 assembly lines, he adds, and Airbus expects to benefit from the "weight of learning" from its BelugaXL programme, the outsize freighter for its logistics arm developed from the A330.

Although cargo traffic has risen sharply as a direct result of the pandemic, Faury is not concerned about the market for an A350 freighter drying up as the recovery progresses and passenger belly-hold cargo returns.

"The wave is ahead of us," he claims. "There's a strong utilisation of cargo capacity [during the pandemic] but still a lot of old [aircraft] and we see a wave of replacements for the second half of the decade."

He believes the timing of the freighter development decision is "very good", with the aircraft set to compete only with "old variants" while the A350 will be the "only new-generation freighter".

Jonathan McDonald, head analyst with consultancy IBA Group, believes the A350F will be "slap dab in MD-11F territory" as Airbus builds a competitive response in a part of the market which is "Boeing dominated".

Market prospects

More than 100 examples of the ageing McDonnell Douglas trijet remain in service, the majority operated by logistics firms FedEx and UPS. Payload is around 90t, depending on the exact variant.

Both those operators have a history of buying new-build freighters rather than relying solely on conversions, says McDonald, and this will be key to the A350F's hopes of success.

Airbus

Larger variant of widebody twin will be 'main driver' of A350F, offering 90t-plus payload

Underpinning the variant's launch is Airbus's acknowledgement that "it is a little bit under-represented in the heavy freighter market," says McDonald.

He thinks that the proposed freighter version of Boeing's 777X – probably based on the smaller -8 – is unlikely to arrive much before 2028, presenting Airbus with an opportunity in the interim.

"Airbus has seen a little bit of a gap there and it believes it can leapfrog Boeing with a new-technology aircraft," he says.

Faury says the A350F is a "very strong" platform and has the potential to be "very competitive"

AirTeamImages

More than 100 examples of MD-11F remain in service

on the market in terms of capacity and fuel-burn, particularly given the changes in ICAO environmental regulations due from 2028.

"[We've] been quite absent from the widebody freighter market so far," he says, with Boeing having almost exclusive access. "It's time for airlines to see some competition."

Of course, Boeing is unlikely to willingly relinquish its market stranglehold, with the airframer's line-up boasting three dedicated freighter models, albeit that production of the 747-8F will end next year.

David Calhoun, the airframer's chief executive, says the company views a freighter variant of the 777X as its logical next programme.

The need for such an aircraft is partly driven by new ICAO emission standards, but competition from the A350F is also likely to play a part in the decision-making process.

"We need to develop a new ICAO-compliant freighter," says Calhoun. "I circle the 777X as the logical place for that, and the smart place to do that."

Calhoun stresses that he is not suggesting Boeing has already launched the variant or that "we have one planned".

But the company has long made known its intention to develop a freighter variant of the next-generation widebody twin.

ICAO adopted emission limits for civil aircraft in 2016, and in January the US Environmental Protection Agency (EPA) finalised its own rule that aligned with ICAO's standards.

The EPA's efficiency standards apply to new types submitted to the US Federal Aviation Administration for certification after 10 January 2021, and to in-production aircraft starting in 2028.

Boeing's other two purpose-built freighters include the 767F and 777F. Both have proved commercial successes, with the manufacturer continuing to land new sales even for the decades-old 767.

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Total deliveries of A330-200F – variant's three outstanding orders were cancelled earlier this year

Boeing holds outstanding orders for 51 767Fs and 52 777Fs, according to the airframer's data; total deliveries for each model stand at 200 and 209, respectively. It will also continue to build the current 777F even as it transitions to the 777X.

In contrast, Airbus earlier this year cancelled the three outstanding orders for its only factory-built freighter programme, the A330-200F, having delivered just 38 jets.

Beating that modest total will be Airbus's first goal, but McDonald thinks for the programme to be considered a success, sales of the A350F will need to be around 150-200 aircraft. That means it must target more than the market for MD-11F replacement. For example, some operators of 747-400 cargo aircraft might also consider the A350F.

No customers have yet emerged for either the A350F or 777X-F, although Qatar Airways chief executive Akbar Al Baker has expressed interest in both aircraft. Russian cargo carrier Volga-Dnepr was also briefed about the A350F at July's MAKS air show, where the A350-1000 was in the static display.

Third option

A third heavy freighter option is the 777-300ERSF being offered by GECAS and Israel Aerospace Industries (IAI). Structural modification work on the initial example has begun, leading to delivery in 2023.

But this may not become a direct competitor to either new-build freighter. IBA puts a value of $55-60 million on the 777-300ERSF, including the cost of the feedstock aircraft. Airbus has released no details on the A350F's likely cost, but with a passenger model valued at around $150 million, McDonald thinks the freighter variant will be "well north of that".

On that basis, he thinks customers for the A350F will remain distinct from those considering a converted 777, with criteria like emissions or fuel-burn key considerations.

While McDonald considers the IAI/GECAS conversion will deliver a "hell of an aircraft" he notes that "when those aircraft [re-enter service] some of those earliest aircraft will be 19-20 years old".

And although the 777's GE Aviation GE90-115BL is a "great engine" it is now "superseded by the [Rolls-Royce] Trent XWB" on the A350, so "Airbus is counting on the better fuel efficiency" of its new-build freighter as a key differentiator.

IAI Aviation Group general manager Yossi Melamed also shrugs off the prospect of competition from the A350F or 777X-F.

"In our eyes, conversion eyes, we don't see a [new-build] freighter as a competitor," he says, adding that such aircraft tend to be acquired by companies "which have a philosophy" of using new-build aircraft. "I'm not in this game."

Additional reporting by Jon Hemmerdinger in Tampa

Ryan Fletcher/Shutterstock

Predators hunting down rich pickings in aerospace

Covid-19 paused consolidation moves, but bids for two of the UK's key players show acquisitions are back on the agenda

Murdo Morrison London

After 18 months of pandemic-induced inactivity, merger mania appears to be back in aerospace and defence. But not all are happy with what it might mean for key national security assets and jobs.

Recent weeks have seen two big UK names subject to takeover swoops. Defence contractor Ultra Electronics on 16 August accepted a £2.6 billion ($3.6 billion) bid from fellow UK company Cobham, itself controversially acquired by private equity firm Advent International in early 2020 for £4 billion.

Meanwhile, Parker Hannifin – 32nd in FlightGlobal's latest Top 100 ranking – revealed on 2 August plans to snap up fellow top 50 player UK-headquartered Meggitt (44th) for £6.3 billion. Meggitt's board accepted the bid, only for highly-acquisitive TransDigm (20th) to trump its US rival with an unsolicited cash approach worth £7 billion.

Meggitt directors are recommending the Parker Hannifin bid as "an attractive proposition for shareholders and... broader stakeholders", including the UK government.

The UK's takeover panel gave TransDigm until 14 September to persuade shareholders otherwise with a formal offer.

The moves by Cobham and TransDigm worry some concerned about the country's sovereign defence capabilities, and commitments to domestic employment and research and development (R&D) investment.

In the 19 months since Advent took one of the UK's oldest aerospace and defence companies private it has divested around half of it – despite a pledge at the time by partner Shonnel Malani that "We have strong conviction in Cobham's businesses and look forward to delivering on each one's full potential".

The family of late founder Sir Alan Cobham had warned that the private equity owners would break up the diversified company, which was formed in 1934, reckoning that the sum of the parts would be worth more than the business as a whole.

Notable products

The latest divestment, in June this year, was Cobham Mission Systems to US industrial group Eaton. The division is responsible for what was the UK outfit's most notable products – its air-to-air refuelling systems, made famous during the long-range Falklands conflict of 1982.

A year ago, Bournemouth-based Cobham Aviation Services – provider of pilot training and maintenance services to the UK Ministry of Defence – was sold to US military training specialist Draken International, which rebranded it Draken Europe.

Cobham has said it will "offer legally binding commitments" to the UK government over its acquisition of Ultra, including on security issues, jobs, and R&D. Ultra's portfolio includes cockpit equipment for commercial and military aircraft.

UK Secretary of State for Business Kwasi Kwarteng on 19 August became involved in the takeover, issuing a public interest intervention notice. He will make the final decision on the deal, and could rule it out on national security grounds.

TransDigm, meanwhile, has expanded from a $300 million-revenue company to over $5 billion in 20 years as a result of an acquisition spree of some 50 businesses. It regularly tops the operating margin table in our Top 100 – this year delivering a figure of 34.3% – fulfilling its pledge to stockholders to deliver private equity-like returns, but raising questions about its commitment to long-term investment.

Richard Aboulafia, an aerospace analyst with Teal Group, says the merger activity shows that some aerospace concerns remain flush with cash. "The industry continues to favour the logic of critical mass," he says. "Even in one of the worst industry downturns, there's a lot of cash out there ready to help the industrial base get through."

Meggitt, which has around 9,000 employees, produces aircraft components for commercial, military and business aircraft, with around 70% of its output sole-source. Its latest revenues were $1.7 billion.

Parker is a nearly $14 billion company – its aerospace systems unit turned over $2.5 billion in the latest financial year.

See Top 100 p44

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Civil aviation grounded by Kabul's failings

US report details 'challenges' in handing over responsibility to Afghanistan for managing the nation's airports and airspace

Dominic Perry London

Even before the Taliban takeover, the USA was warning that the process of transferring management of Afghanistan's airspace and airports to local control was proving to be a significant challenge.

In its 52nd quarterly report – released in July – the Special Inspector General for Afghanistan Reconstruction (SIGAR) details the struggle to hand over management for four airports – Herat, Kabul, Kandahar, and Mazar-i-Sharif – plus air traffic control, to the Afghanistan Civil Aviation Authority (ACAA).

NATO in 2020 started a plan to turn over the running of the four airports to Kabul: they would be taken over initially by the defence ministry, before civilian operations were handed to the ACAA.

Kandahar airport was passed to the ACAA in January 2021; Herat and Mazar-i-Sharif followed in June. However, at the time the report was issued the transfer of Hamid Karzai International in Kabul was "still under review".

The SIGAR report says the transfer of airport management "faced challenges" at Kandahar which "hindered airport operations", for example, restricting civil aviation movements at the site to daylight hours.

"Airlines have complained that this inhibits their ability to satisfy passenger preferences for arrival and departure times," the SIGAR report points out.

Budget constraints

In the run up to the collapse of the Afghan government, the ACAA was still seeking contractors to operate air traffic control and ground services at Kandahar, but was being hampered by budget constraints, a situation not helped by a 28% fall in revenues due to Covid-19-related flight reductions.

"The ACAA maintains that it has ongoing challenges with retaining sufficient qualified personnel that can manage, maintain, and operate Afghanistan's airports," the report adds.

SIGAR highlighted its belief that while a "properly functioning civil aviation infrastructure" would be a "key driver for sustainable economic growth", its absence would have the opposite effect.

In the period from 2002 to 2015, the USA provided some $562 million to support Afghanistan's civil aviation sector, the report says. That included significant levels of funding and technical assistance, not least training and support from the US Federal Aviation Administration (FAA), which ran until 2014.

However, the report notes: "Despite sustained FAA involvement, including limited air traffic control training, the ACAA did not attain satisfactory proficiency to maintain its responsibilities under [ICAO]."

Although the FAA's direct involvement ceased in 2014, it concluded a memorandum of agreement for technical assistance two years later. But the Afghan government made no requests for such assistance until 2020, SIGAR says.

Responsibility for airspace management was to have transferred to the ACAA in 2014, but this was delayed by a year "in part due to the lack of certified Afghan air traffic controllers", a SIGAR audit found.

In addition, the same audit discovered that the Afghan government

Shekib Rahmani/AP/Shutterstock

"failed to use all of its overflight revenue for airspace management, despite pledging to do so, which contributed to the ACAA's inability to independently manage civil aviation operations."

Although it took over airspace management from 2015, the ACAA continued to rely on NATO's Afghan mission for key functions at airports, including air traffic control; fire, crash and rescue services; safety management; meteorological services; communication, navigation and surveillance.

Donor support

While additional support and training ensured that ACAA operations had improved by 2019, SIGAR concluded that the agency "remained reliant on donor support" and, at that point was not "capable of conducting civil aviation operations without donor support, including technical, training, and financial assistance" – shortfalls which were highlighted four years earlier.

At that point, the ACAA director general thought that the body remained "roughly two to three years away from achieving the necessary personnel, financial, and regulatory capacity to independently manage all civil aviation responsibilities within Afghanistan."

Taliban takeover severs Afghan air links

Lewis Harper & **David Kaminski-Morrow** London

An obvious and immediate consequence of the Taliban's seizure of power in Afghanistan has been the suspension of commercial air links to the country.

The chaos at Kabul's Hamid Karzai International airport was the clearest illustration of the breakdown of government and international control, and it was here the impact on international carriers was most keenly felt.

By 20 August, passenger airlines including Air Arabia, Emirates, Flydubai and Turkish Airlines had confirmed the suspension of their scheduled operations to Kabul, following NOTAMs indicating that the region's airspace would be "uncontrolled" and the civilian side of the airport closed.

Before the Taliban's advance into Afghanistan's capital, Cirium schedules data for July 2021 shows a total of eight airlines serving Kabul: Air Arabia, Air India, Ariana, Emirates, Flydubai, Kam Air, Pakistan International Airlines (PIA) and Turkish Airlines.

Of the 1,272 flights touching down at the airport during July, around half were operated by local private carrier Kam Air – whose Airbus A340s featured heavily in images of panic at Kabul's airport – with nearly 250 flown by Afghan government-owned Ariana.

Aside from a number of domestic flights, Kam Air's network featured Ankara, Delhi, Dushanbe, Islamabad, Kuwait City, Medina and Tashkent, according to Cirium data. Its A340s were most often used on services to Delhi and Medina.

Ariana's international destinations were Ankara, Delhi, Dubai, Istanbul, Jeddah and Urumqi.

Of the international carriers, Flydubai was operating into Kabul twice daily (although its services dropped to daily towards the end of July), while Turkish Airlines had been flying a mixture of daily and twice-daily services.

Emirates was operating daily into the airport, as was Air Arabia (although, like Flydubai, it cut services towards the end of July), with Air India and PIA each operating several flights per week.

The slate of carriers serving Kabul had been largely unchanged in recent years, Cirium data shows, with the only significant developments being Indian low-cost carrier SpiceJet stopping regular services to the airport at the end of 2020, and Iranian carrier Mahan Air stopping services in early 2019.

International services were also operated from Mazar-i-Sharif and Jalalabad, the data shows.

While direct flights to the country are suspended, the Taliban takeover has also seen restrictions or outright bans imposed regarding operations within Afghanistan's airspace.

On 20 August, the US Federal Aviation Administration (FAA) issued a security NOTAM stating that all US carriers and commercial operators are "prohibited" from flying within the Kabul flight information region (FIR).

Only a short sector within eastern Afghan airspace – a 12nm (22km) segment connecting airways P500 and G500, between Pakistan and Tajikistan – is permitted for transit.

That builds on earlier limitations imposed by the FAA and several other civil aviation authorities, including those in France, Germany and the UK.

These restrictions required aircraft to maintain a certain minimum altitude while overflying Afghanistan, although French civil aviation regulators have recently issued an advisory in which French carriers and crews are "requested to avoid" the Kabul FIR – the airspace which covers the entire territory of Afghanistan.

The FAA cites the "risk posed by extremist [or] militant activity", disruption to air traffic services, and "limited" risk-mitigation capabilities for tightening its constraints.

Why Afghan intervention failed

US Air Force

After a 20-year re-equipment effort, Kabul's military dissolved within hours, leaving an array of US-supplied combat aircraft under the control of Taliban militants

Craig Hoyle London

The Afghan military's near-immediate capitulation when faced with a resurgent Taliban in mid-August marked the end of a two decade-long coalition reconstruction effort, and resulted in a significant part of its air force inventory falling into the militant group's hands.

According to a 30 July report from the US Special Inspector General for Afghanistan Reconstruction (SIGAR), the Afghan air force had a fleet of 211 largely US-supplied military aircraft prior to the collapse, with 167 recorded as being in the country and usable.

Cirium fleets data shows that the service also had eight Mil Mi-35 assault helicopters, while the Afghan Special Mission Wing owned 56 Mi-8/17-series rotorcraft and 18 Pilatus PC-12NG transports.

Washington's efforts to equip the Afghan air force had resulted in an active inventory boasting 23 Sierra Nevada/Embraer A-29 light-attack aircraft, 33 Cessna 208B Caravan turboprops – including 10 armed AC-208s, three Lockheed Martin C-130H tactical transports, 33 Sikorsky UH-60A Black Hawks and 43 MD Helicopters MD530s, along with 32 Mi-17s, the SIGAR report shows.

Providing a snapshot of the investment scale involved, it notes: "The United States had obligated nearly $2.13 billion and disbursed about $1.78 billion of ASFF [Afghanistan Security Forces Fund] appropriated from FY2019 through FY2021 to build, train, equip, and sustain" the Afghan air force.

As Taliban militants massed around Kabul before retaking full control on 15 August, multiple Afghan air force crews fled the country with their aircraft. Amid the government's collapse, President Ashraf Ghani also departed for the United Arab Emirates.

Afghan air force personnel had already represented high-profile targets for the Taliban, according to the SIGAR report. "According to Reuters, at least seven

> "According to Reuters, at least seven Afghan pilots have been assassinated off-base in recent months"
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Afghan pilots have been assassinated off-base in recent months," it notes, describing this as a "worrisome development".

Such fears, combined with Covid-19 restrictions around pilot training, meant that at mid-year the Afghan air force had only 115 aircrews, against an authorised strength of 193. Of the aircraft types covered by the US report, only the C-130 force had over 50% of its positions filled.

Uzbek exodus

According to an unconfirmed report from the government of Uzbekistan, 585 Afghan military personnel arrived at its Termez air base aboard 11 PC-12NGs, six A-29s, five Cessna 208s, 19 Mi-8/17s and seven UH-60s.

On 15 August, an Afghan A-29 was involved in a mid-air collision with an Uzbekistan air force RAC MiG-29 near Sherabad, 32nm (60km) north-northwest of Termez. "Both aircraft subsequently crashed but the crews ejected safely," a Cirium accident report says.

While the Uzbek report indicates that numerous Afghan aircraft escaped before Kabul fell, social media images show Taliban militants standing alongside a variety of seized hardware, including A-29, MD530 and UH-60A airframes.

What will happen to those aircraft which remained on the ground at air bases such as Bagram, Herat, Kabul, Kandahar and Mazar-i-Sharif is far from clear.

While there is little likelihood of them being flown operationally, due to the departure of pilots and support personnel, the prospect of the Taliban having de facto ownership of such modern military equipment is a major headache for the USA and its allies. The potential risk of access being given to non-approved parties, such as China and Russia, means the US government must act fast to reduce the risk of technological know-how being leaked to such near-peer adversaries.

115

Number of aircrews available to the Afghan air force in June, against an authorised strength of 193

Data from *Flight International*'s annual World Air Forces directories highlights how Kabul's air capabilities evolved over time.

In 2008, the then-Afghan National Army Air Corps had just 62 aircraft in use: seven Antonov An-32 and two An-26 transports, 29 Mi-8/17s, 12 Mi-24/35s, nine Bell UH-1s and three Aero Vodochody L-39 jet trainers. The following year, the first of 18 second-hand Alenia Aeronautica G222/C-27JA airlifters began providing a brief uplift in tactical transport capabilities. The fleet grew to a dozen examples by 2011, but major support problems saw the type rapidly withdrawn.

In all, the disastrous acquisition cost $549 million, and in 2014 the aircraft were sold as scrap for just over $40,000, according to a separate SIGAR report.

How air forces supported escape from Kabul

Greg Waldron Singapore

Having being caught on the hop when the government in Kabul dissolved within days after 20 years of coalition military support came to an end, air forces from around the globe sprang into action to repatriate stranded nationals and evacuate Afghans at immediate risk from the Taliban.

Speaking on 24 August, US President Joe Biden said that Washington had helped to evacuate 70,700 people over the previous 10 days.

Within one 12h period, 19 flights operated by 18 US Air Force (USAF) Boeing C-17 strategic transports and one Lockheed Martin C-130 rescued 6,400 people. Early in the evacuation effort, a single C-17 departed Kabul with approximately 820 Afghan civilians aboard, the USAF says.

Efforts intensified ahead of a 31 August deadline that had been set by Biden and the Taliban for coalition forces to withdraw from Kabul's Hamid Karzai International airport.

"I've asked the Pentagon and the State Department for contingency plans to adjust the timetable should that become necessary," Biden said. "I'm determined to ensure that we complete our mission. I'm also mindful of the increasing risks that I've been briefed on," he adds, referring to concerns of the potential for an Islamic State attack on the airport.

France, Germany and the UK also performed multiple evacuation flights using Airbus Defence & Space A400Ms, A330 multi-role tanker transports (MRTTs) and Boeing C-17s, while an MRTT-equipped multinational unit based in the Netherlands also employed its aircraft in support of the task.

Crown Copyright

Military transports from multiple nations flew evacuation missions

Military transports from the air forces of Italy, Poland, Qatar, Turkey and the United Emirates also were among the many flights departing Kabul.

Asia-Pacific allies also stepped up in support of the effort. The Royal Australian Air Force flew sorties with two C-17s and a KC-30A MRTT, and Japan dispatched a Kawasaki C-2 tactical transport, a pair of C-130Hs and a government-owned Boeing 777-300ER ordinarily tasked with VIP transport duties.

GE seeks Catalyst converts

Engine maker presses ahead with certification campaign as it eyes further applications for delayed turboprop programme

Jon Hemmerdinger Tampa

GE Aviation is awaiting the European approvals required to begin flight testing its Catalyst turboprop engine, and aims to achieve a maiden sortie in the coming months.

That milestone was anticipated last year, as the manufacturer works towards certification for the Czech Republic-built powerplant in support of its launch application on the single-engined Beechcraft Denali.

Validation for the Catalyst, the first new turboprop for the business and general aviation markets to be developed in decades, is targeted for end-2022.

GE Aviation turboprops general manager Paul Corkery is hopeful first flight will occur this quarter.

Launched in 2015, the Catalyst is equipped with modern technology – notably a full authority digital engine control (FADEC) system – which has been integrated from the outset into the 1,240shp (925kW) turboprop. This reduces pilot workload by automating settings such as engine power, fuel supply and propeller pitch based on flight conditions, Corkery says.

FADECs have long been used on large turbofans but are relatively new to the turboprop world, although rival Pratt & Whitney Canada has on the PT6E – the latest iteration of its workhorse powerplant – introduced a similar electronic engine control system.

Corkery lists the technologies he says make the Catalyst unique: variable-geometry compressor stator vanes, single-crystal cooled high-pressure turbine blades, and a three-stage turbine. The engine runs hotter than competing types, and has a higher compression ratio at 16:1, he says.

GE launched the Catalyst after acquiring Czech manufacturer Walter Aircraft Engines in 2008, believing that a segment dominated by long-running programmes – notably the PT6 and Honeywell TPE331 – was ripe for change.

Textron Aviation

Single-engined Beechcraft Denali is launch platform for new powerplant

Tests have shown the Catalyst to be up to 16-17% more efficient than competing engines, one to two percentage points more than GE had anticipated, and with more power at high altitudes than predicted; performance gains that Corkery says are "not trivial".

But GE is working to make up for delays to the programme – and to the Denali. Aircraft certification has been pushed to 2023 – four years later than planned at launch. The initial engine has now been installed on the first flight-test vehicle, with a maiden sortie planned before year-end.

Schedule slip

Flight testing of the Catalyst was belatedly due to have kicked off last year, but slipped due partly to new US Federal Aviation Administration (FAA) tests related to icing.

Corkery says the company is now "buttoning up" the Czech and German regulatory approvals needed to flight test the engine in Berlin on the wing of a twin-engined Beechcraft King Air 350 testbed in place of the stock PT6 powerplant.

GE has completed about 30% of the Catalyst's certification tests, including some icing trials, and submitted 35% of the required certification documents to the FAA, says Corkery. The company has produced 16 Catalysts and completed some 2,500h of engine operation.

Now the engine is moving through certification tests related to initial maintenance intervals, which will help determine how many hours the powerplant can be operated prior to inspection.

Next will come what Corkery calls the "most-challenging" tests – "ice crystal icing" tests. A relatively new FAA requirement, the tests relate to formation of small ice crystals on aircraft surfaces at altitudes higher than ice typically forms.

GE is pursing a dual-jurisdiction certification for the Catalyst, working on design certification through the FAA and production certification through the European Union Aviation Safety Agency.

So far, the Catalyst has been selected to power two programmes: the Denali, and the XTI Aircraft TriFan 600, where it will form the core of a hybrid-electric system.

Other applications could include unmanned air vehicles: the powerplant has been proposed for the four-nation EuroDrone project, where it faces competition from a new turboprop developed by Safran Helicopter Engines.

Corkery also sees potential for the Catalyst in trainer aircraft.


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Twinjet will be powered by Rolls-Royce Pearl 10X engines

Dassault Aviation

Falcon 10X pitched for French maritime patrol mission

Dassault tells Paris its latest business jet could replace ageing Atlantique 2 fleet as joint initiative with Berlin appears to sink

Dominic Perry London

Dassault Aviation may only have launched its ultra-long-range Falcon 10X business jet in May, but the airframer is already considering its future conversion into a maritime patrol aircraft (MPA) for the French navy.

That proposal had seemed unlikely when the twinjet was unveiled, as France's future MPA requirement was due to be met by a joint development with Germany.

Paris and Berlin in 2018 had agreed to conduct feasibility studies under a project called the Maritime Airborne Warfare System (MAWS) for the eventual replacement of their respective Dassault Atlantique 2 and Lockheed P-3C Orion fleets.

But Germany on 30 June unveiled a $1.7 billion order for five Boeing P-8A Poseidon MPA. Although the country's defence ministry said the twinjets will only be operated until 2035 before the navy switches to the MAWS platform, details of the Foreign Military Sales approval from the USA indicate a 30-year lifespan. France is now considering pulling out of the planned joint project, *La Tribune* reports.

Presenting the airframer's half-year results on 22 July, Dassault chief executive Eric Trappier said

Dassault finds 'welcoming' market as it nets first sales of ultra-long-range flagship

Orders for the Dassault Aviation Falcon 10X are already racking up following the new ultra-long-range twinjet's unveiling in May.

Eric Trappier, the French airframer's chief executive, said during a late July half-year results briefing that the 7,500nm (13,900km)-range business jet has "received a lot of client interest" and "the first orders have already arrived".

Dassault does not break out its order intake by model, but during the first half it booked commitments for 25 Falcon business jets, a significant rise on the five deals recorded in the same period last year.

"The market is really welcoming this new aircraft," he says, which will be delivered from 2025.

However, Trappier defends Dassault's decision not to match the range offered by the rival Bombardier Global 7500, to which it cedes 200nm.

He says the 7,500nm range covers the vast majority of city pairs likely to be flown by the jet. In addition "we banked on the size of the cabin, we banked on the comfort of the passengers, and these compromises led to this performance".

Trappier sees the market for business jets as showing signs of improvement, particularly in the USA, although there is pressure on pricing. "It is difficult in terms of prices because after a year of dieting we have to fight to sell our planes one by one," he says.

Meanwhile, development of the ultra-wide-cabin Falcon 6X continues. Three prototypes are now in flight test and have amassed 130h across 40 sorties. First flight was on 10 March this year and the third example, which features a complete cabin, joined the certification campaign in late June.

Trappier says the company is still on schedule to deliver the first customer jet in late 2022, despite the disruption of the pandemic.

It shipped six Falcon jets in the first half, down from 16 in the same period a year earlier, driven by low order intake in 2020. The airframer has 53 units in its backlog, an increase of 19 against the first half of 2020.

that the company was "ready to propose the Falcon 10X" as an alternative MPA for France.

Dassault is already modifying its Falcon 8X and 2000LXS business jets for French military use under the respective Archange and Albatros programmes, and Trappier says that process can be repeated with the Falcon 10X.

"You know that the performance of the 10X with its endurance, capacity and size are perfectly adapted to what a future maritime patrol aircraft could [be required to] do," he says.

Due to enter service in 2025, the 7,500nm (13,900km)-range Falcon 10X is powered by twin Rolls-Royce Pearl 10X engines and will cruise at Mach 0.85, with a top speed of M0.925. The aircraft will be 33.4m (110m) long and have a 33.6m wingspan.

During the first half of 2021, Dassault's military business took in orders for 18 Rafale multirole fighters – six for Greece and 12 for France – taking its total backlog for the type to 67. However, that figure excludes a 30-unit top-up order from Egypt which has yet to be finalised, says Trappier.

> "The performance of the 10X with its endurance, capacity and size are perfectly adapted to what a future maritime patrol aircraft could do"
>
> **Eric Trappier** Chief executive, Dassault Aviation

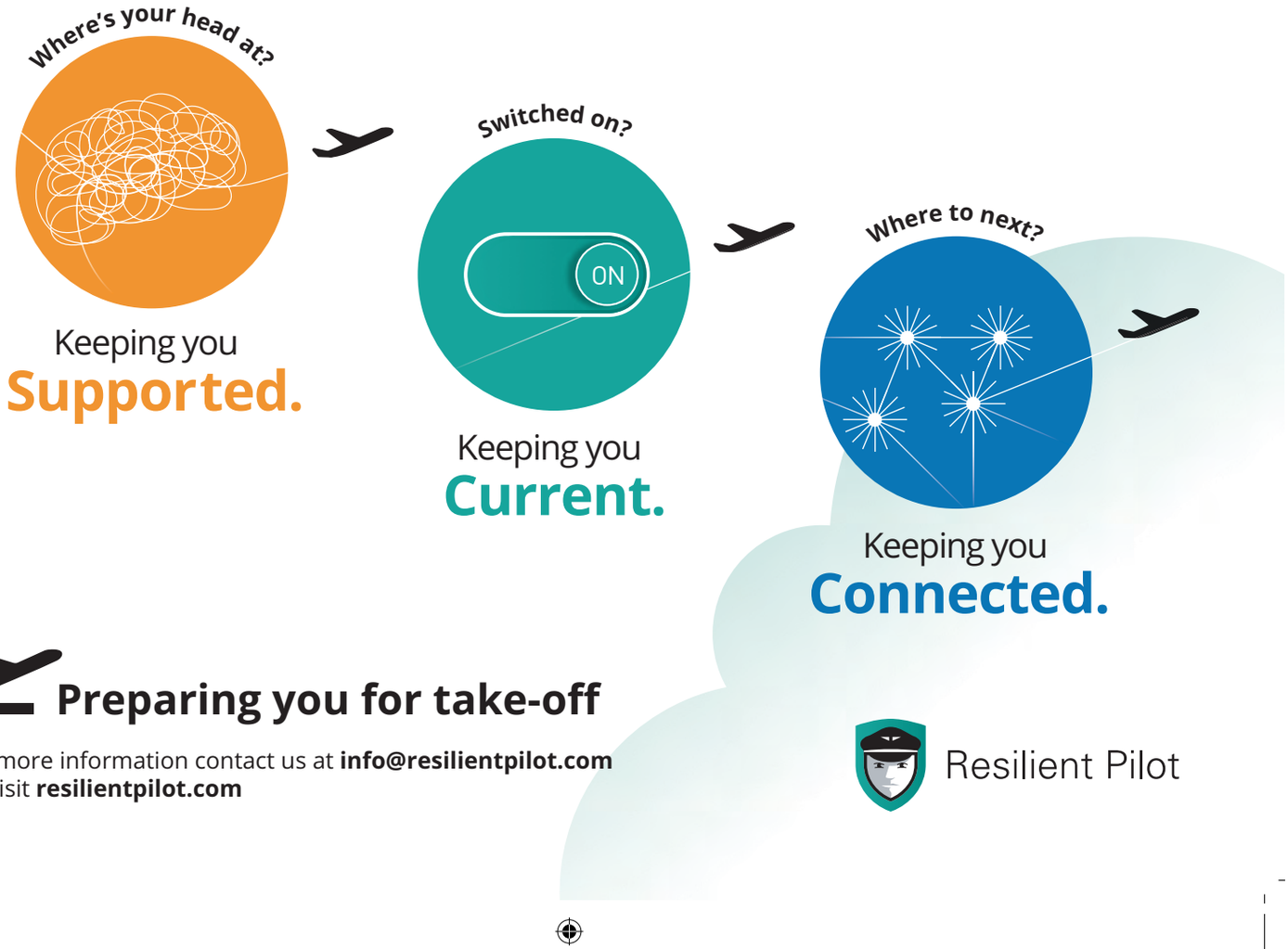
Greece is also taking 12 second-hand Rafales, sourced from the French air force. The first of these was handed over on 21 July at a ceremony at Istres air base in the south of France.

Sales success

Despite the recent sales successes, and the decision of Croatia to acquire used Rafales from France, Dassault missed out on a substantial order with Switzerland, which instead selected the Lockheed Martin F-35A for the Swfr6 billion ($6.5 billion) requirement.

Trappier says that the company was "disappointed and surprised" by the contest loss, particularly over claims that the US-built jets would cost less to operate over a 30-year period.

Meanwhile, Dassault is hopeful that two future development contracts for multinational European programmes will be signed off in the coming months, allowing work to proceed on the next phases of the EuroDrone and Future Combat Air System projects.



Embraer pledges low-carbon future

Brazilian airframer commits to broad emissions-reduction initiative as electric-powered Ipanema performs first flight

Jon Hemmerdinger Tampa

Embraer has pledged to work on "solutions" to achieve net-zero aviation emissions by 2050, including the expansion of biofuel use and continuing the development of hybrid- and full-electric aircraft.

As part of this objective – which Embraer set out on 13 August – the company intends to advocate for public policies aimed at encouraging sustainable aviation fuel (SAF) production, as well as working to advance electric and hydrogen-fuel technologies.

Wrapped into the effort is Embraer's continued development of a hybrid-electric military transport concept called STOUT, and that of a full-electric urban air taxi being worked on by its Eve Urban Air Mobility Solutions spin-off.

Embraer's target of net-zero emissions by 2050 mirrors the objectives set by airlines and numerous governments.

Embraer will "develop new solutions to [support] net-zero carbon solutions in aviation by 2050," says Luis Carlos Affonso, the company's senior vice-president of engineering, technology and corporate strategy. "We believe this is possible."

The effort will see Embraer focus on "two fronts". Those include developing "sustainable aircraft" and "collaborating to develop and advocate [for] innovation and public policies toward a sustainable ecosystem," Affonso says.

He cites electrification, SAFs and hydrogen fuel as examples of technologies that could benefit from targeted public policy.

Embraer affiliate Eve is working to get its in-development electric vertical take-off and landing aircraft in commercial service by 2026. In early August, Embraer also made the first flight of an electric-powered variant of its EMB-203 Ipanema.

Test campaign

Based at Embraer's site in Gaviao Peixoto, the test campaign is designed to develop and mature electric propulsion technologies for use in future programmes.

"Power, performance, control, thermal management and operational safety were the primary features evaluated in these manned first flights," Embraer says.

"The goal is to demonstrate real flight conditions through results obtained from computational simulations, lab tests and ground integration of technology, which have taken place since the second half of 2019."

The Brazilian airframer markets the EMB-203 – which is powered by a single Lycoming engine – as an agricultural aircraft suited for missions such as crop dusting.

> "Embraer will develop solutions to support net-zero carbon solutions in aviation by 2050"
>
> **Luis Carlos Affonso**
> **Senior vice-president of engineering, technology and corporate strategy, Embraer**

The electric Ipanema has "an electric powertrain system" supplied by Brazilian electronics company WEG, and "a set of batteries funded by" EDP, a Brazilian energy company, says Embraer.

Executives confirm Embraer is still working on a hybrid-electric military concept it calls STOUT, an acronym for "short take-off utility transport". The company is targeting the aircraft at the Brazilian air force, but has disclosed few other details.

Affonso says Embraer's proposed 70-90-seat turboprop could replace 50-seat regional jets and would burn 20% less fuel.

Executives also stress the critical role they believe SAFs will play in helping the sector cut carbon.

Embraer is working to ensure its aircraft can burn "100% SAF" by 2030, and "actively working with the supply chain to expand the global SAF production scale".

But whether the industry can meet SAF goals is far from certain.

A March report from the International Council on Clean Transportation says that only 5.5% of Europe's projected aviation fuel requirement in 2030 can come from SAF. That is due to limited availability of "sustainably available feedstock".

The source of that feedstock is important. Scientists have warned that biofuel benefits can be negated if land – forests or agricultural fields, for instance – is used to grow plants for biofuel. For that reason, the feedstock needed to make biofuel sustainable is limited.

The net-zero by 2050 commitments align with the conclusions of a UN panel in 2018, which said emissions must be net-zero by 2050 to meet temperature goals laid out in the Paris Climate Accords.

Embraer

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Company achieved the first flight of electric-powered EMB-203 in August

Turboprop design moves forward as engines shifted aft

A new configuration for Embraer's conceptual turboprop has been released, now pitching a 70-90-seat aircraft with aft-mounted engines – a design the company says can replace 50-seat regional jets.

Previous designs for the turboprop released by the Brazilian airframer – a programme it has yet to officially launch – had more conventional wing-mounted engines.

"Our proposal here is to offer a high-tech, 70- to 90-seat turboprop with the same cross-section as the E-Jets. Very comfortable, no middle seats and spacious overhead bins," Embraer senior vice-president of engineering, technology and corporate strategy Luis Carlos Affonso says.

"The rear-mounted engines will provide a quiet cabin" and capabilities similar to a jet aircraft, Affonso said of the design on 13 August.

The proposed twin-turboprop could replace ageing 50-seat jets, which include Embraer ERJs and Bombardier CRJ200s. Those types have long been out of production – but with no replacements available, they continue to see service in the fleets of many airlines.

"This turboprop will... replace the current 50-seat regional jets in very important markets," Affonso says, adding that turboprops are about 20% more efficient than jets.

The three popular passenger turboprops still in production – De Havilland Canada's Dash 8-400 and the ATR 42-600 and 72-600 – are updated versions of decades-old designs.

"Turboprops have lost their appeal," Affonso says. "Passengers see them as cramped, not possessing enough overhead space, and noisy."

Embraer's turboprop project is "moving very well, especially with the recent interest of US airlines," adds Embraer chief executive Francisco Gomes Neto. "We see that product as a good alternative for the market."

The company has for years hinted at developing a new turboprop, but has still not committed to moving forward.

In June, Embraer Commercial Aviation chief executive Arjan Meijer said the airframer could launch the turboprop in 2022, with service entry in 2027 or 2028.

Meijer has said Embraer alone has expertise needed to develop such an aircraft, but the company has been seeking partners.

In October 2020, the company released digital renderings of a turboprop design with wing-mounted engines.

Land of opportunities

World Defense Show in Riyadh next March will let exhibitors and visitors become part of the remarkable transformation vision for Saudi Arabia's defence sector and wider economy

Every defence professional and industry executive has a busy schedule, and the reopening of international travel and the trade show circuit – while welcome after many months of lockdowns, restrictions and abandoned events – will only increase those demands.

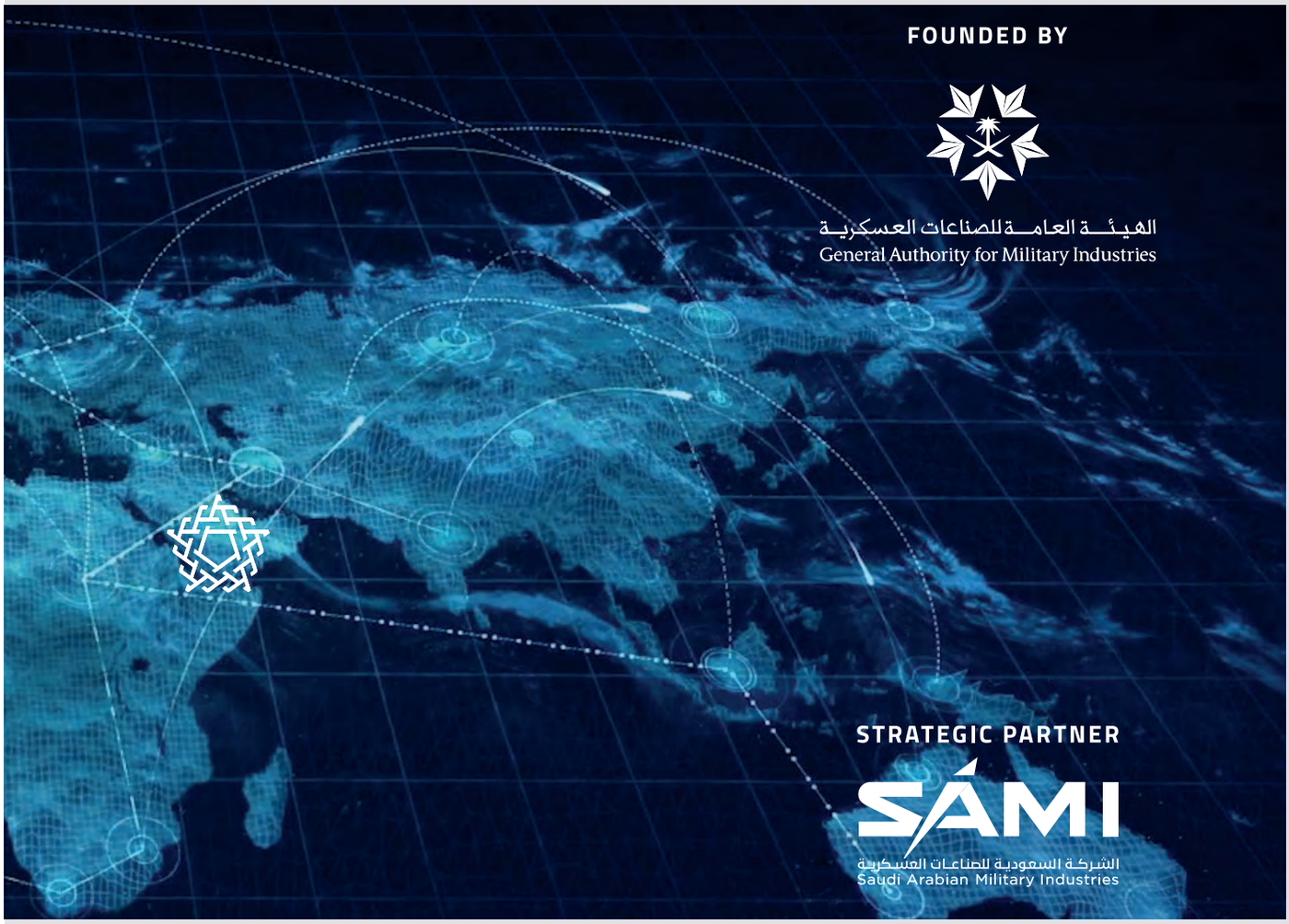
However, although in its inaugural year, Saudi Arabia's World Defense Show from 6-9 March 2022 is already set to be an essential addition to the calendar.

This will be a biennial exhibition with a difference: the first of its kind to focus on all five domains of defence – land, air, sea, security and space – and with an emphasis on integration, interoperability and innovation. The inaugural event takes place in a purpose-built venue, with 800,000 sq m of dedicated outdoor space, just one hour from the Saudi Arabian capital Riyadh.

However, the show itself is just part of the appeal. Saudi Arabia represents one of the most exciting investment opportunities for global defence and technology companies, thanks to the Kingdom's aspirations for its home-grown industry. In fact, under its Vision 2030 initiative, Saudi Arabia plans to be spending half its military budget with local businesses by the end of the decade.

Those attending will be able to engage with the organisation behind the show, Saudi Arabia's General Authority of Military Industries. GAMI regulates, licenses and enables the country's defence ecosystem, and leads the drive to attract foreign investment that will help the Kingdom achieve its Vision 2030 objectives for defence, through schemes such as the Industrial Participation Programme.

Saudi Arabia is one of the world's foremost military markets, but the show is also a gateway to opportunities in the wider region, with Gulf Cooperation Council firms booking more than 40% of the exhibition space. Almost every GCC nation is set to shift from being a consumer of overseas-built equipment to developing indigenous industrial capabilities under global partnerships.



World Defense Show will debut under the patronage of the Custodian of the Two Holy Mosques, King Salman bin Abdulaziz Al Saud. His Excellency Ahmad Al-Ohali, Governor of GAMI, described the royal patronage as "an extension of the leadership's unwavering support to localising 50% of military expenditure in line with the Kingdom's Vision 2030".

Those unfamiliar with Saudi Arabia might be surprised by aspects of a state that sits at a crossroads of three continents, at the heart of trade routes ancient and modern. A member of the G20, the nation boasts a young, highly-educated population of more than 30 million, and, as a forward-looking society, is keen to play a wider role in the global community.

While the Kingdom wants to create economic and employment opportunities for Saudis in high-tech sectors such as defence, those ambitions can only be achieved with inward investment, and that is why Saudi Arabia has introduced a series of measures to make it easier for international companies to do business there, including by liberalising the private sector.

Saudi Arabia offers investors a favourable tax regime with free trade deals covering several sectors. Incentives and support schemes encourage economic diversity and competitiveness. Its efforts have been recognised by international institutions – the Kingdom was the biggest improver in the World Bank's "Doing Business 2020" report, and is now ranked 62nd most business-friendly country.

One feature of Saudi Arabia is how welcoming it is to overseas visitors, with a culture of hospitality in its customs and traditions. The Islamic religion and local heritage informs public etiquette, but this is underpinned by values that are universal: respect for others, decorum in public, and protection of privacy.

Recent social and legal reforms have made significant changes to Saudi society, and the country – already the destination for millions of Muslims performing the annual Hajj or pilgrimage to the holy city of Mecca – has opened its doors to the wider tourism market, emphasising its stunning landscapes, centuries of history, and high-end hospitality.

Saudi Arabia is changing, and next March will offer a chance to international participants to be part of its economic and strategic transformation. World Defense Show may be the newest addition to the convention programme, but those behind the event are convinced it will become a must-attend for those planning to do business in the region .

With 85% of the exhibition space already allocated, those wishing to take part are urged to get in touch with the team to discuss their requirements as soon as possible.

World Defense Show will be held from 6-9 March 2022 in the presence of Saudi Arabia's key leadership, international delegations and prominent industry decision-makers from around the world. To learn more, visit www.worlddefenseshow.com. World Defense Show will also be participating at DSEI London from 14-17 September 2021. Meet the Team at the KSA Pavilion on Stand H3-110 to find out more about the show.

737 hydroplaned off end of runway

Miami Air twinjet overran at NAS Jacksonville after landing too fast on flooded runway, NTSB investigation determines

Jon Hemmerdinger Tampa

Loss of braking force due to hydroplaning, shortcomings by carrier Miami Air International and pilot error combined to cause a Boeing 737-800 to overrun at Jacksonville, Florida, US investigators have determined.

In its final report on the 3 May 2019 incident, the National Transportation Safety Board (NTSB), attributes the overrun to "extreme loss of braking friction due to heavy rain and the water depth on the ungrooved runway".

Contributory factors included "inadequate" guidance provided by Miami Air to its pilots on evaluating runway landing conditions, the NTSB says, noting that the crew did not request braking action or runway condition reports prior to briefing for arrival.

But the NTSB also cites pilot shortcomings, noting that the captain failed to break off an unstabilised approach.

With the pilots nearing their maximum legal duty time, and the flight already delayed, the captain may have felt pressure to land, the report says.

The captain was also acting as a check pilot to the first officer during the flight, which may have diverted his attention, the NTSB suggests. The two pilots had similar overall experience – both had logged 7,500 total flight hours – but the captain had 2,204h on the 737, while the first officer had just 18h.

"The flightcrew did not follow procedures, including continuing an unstabilised approach, landing the airplane at an excessive approach speed and delaying deployment of the speed brakes," says the report.

"However, investigators determined that even if none of those errors occurred, the airplane still would not have stopped on the ungrooved runway because the rainfall rate and runway characteristics contributed to water depths that caused the aircraft to hydroplane."

The aircraft (N732MA) was operating as Miami Air flight 293 from Leeward Point Field at US Naval Station Guantanamo Bay in Cuba to NAS Jacksonville.

After touchdown, the aircraft failed to slow sufficiently, departed the end of Jacksonville's runway 10 and came to rest in the shallows of the St Johns River.

While only one passenger suffered minor injuries, several animals died when the jet's cargo compartment flooded, the NSTB says. The jet was carrying 143 people, including 136 passengers.

The crew had initially planned to land on Jacksonville's runway 28, but switched to the opposite direction runway 10 after air traffic control warned of "moderate-to-heavy precipitation".

A few minutes before landing, while the aircraft was at 1,390ft, a controller notified the pilots they were above the glidepath. During descent, the aircraft's airspeed increased to about 170kt (315km/h), around 17kt above the target speed. The 737 also drifted 67m (220ft) to the right of the runway centreline.

'Sink rate' alerts sounded in the cockpit and the jet crossed the runway threshold at a descent rate of 1,450ft/min. That should not have exceeded 1,000ft/min, the NTSB says.

Target point

The jet touched down at 21:41 local time, 480m past the runway's displaced threshold and 176m beyond the target point, travelling at 164kt – 11kt above the nominal approach speed.

It was also hampered by a 12-13kt tailwind, which rose from a 5kt tailwind component seconds before landing as the wind veered to the west.

Reverse thrust only deployed on the starboard-side CFM International CFM56 engine, the NTSB says. And although the pilots attempted to apply the brakes, the captain told investigators that "the airplane did not decelerate".

As the 737 overran the runway it struck a seawall, before eventually coming to a halt 355m beyond the end of runway 10, and 27m right of the centreline.

Passengers evacuated via overwing exits. The jet, a 2001-built airframe, remained intact but sustained severe damage and was subsequently written off.

The NTSB says that another pilot, watching from the ground, said the jet landed in "blinding rain".

Due to "standing water" on the runway, the 737 likely experienced "viscous hydroplaning", which occurs when a tyre rolls atop a film of water, a particular hazard on smooth runways.

Miami Air ceased operations in May 2020.

National Transportation Safety Board

737-800 came to rest in the shallows of St Johns River

Simlinger/Shutterstock

Antonov plots unlikely return for An-74

Unusual engine configuration aids short-runway performance

Ukrainian airframer seeking joint development with Canada of updated Soviet-era airlifter aimed at international market

David Kaminski-Morrow London

Antonov is hoping to reach agreement with Canadian authorities on development of an extensively modernised version of the An-74TK-200 airlifter for North American and international markets.

The Ukrainian airframer says it has held a series of discussions with Canadian representatives on creating the new aircraft.

It envisions the development as a joint project with a Canadian industrial contribution and is supporting a detailed study to establish technical requirements.

The basic An-74TK-200 is able to transport 52 passengers, or serve as a freighter capable of carrying 1.8t over a range of 2,300nm (4,260km) or up to 10t over 510nm. It has been designed for harsh conditions, including those in the Arctic, and to operate in remote areas with limited runway availability and weak infrastructure.

Antonov says it has submitted proposals to aerospace and defence association Ukroboronprom as well as the strategic industries ministry, ahead of the signing of a memorandum of understanding on aerospace, security, and defence co-operation with the Canadian Commercial Corporation in June.

The Canadian Commercial Corporation assists Canadian suppliers exporting to foreign governments.

Ukroboronprom points out that the aircraft has been unable to meet market demand because a significant number of components are manufactured in Russia, and claims this has hampered certification in Europe and North America.

It states that the proposed modernised aircraft would feature a glass cockpit instrument panel and introduction of other advanced technologies. The ability to serially produce the twinjet type, it says, has previously been demonstrated by Ukrainian manufacturers.

Final assembly would be undertaken by production facilities in Ukraine and Canada, the association says. Certification and production of the aircraft, it adds, would assist the Ukrainian aerospace industry in emerging from a "long crisis".

Antonov says a formal implementation of the An-74TK-200 project would require an intergovernmental agreement between Ukraine and the Canadian province of Quebec.

Canadian independent government relations firm Capital Hill Group has been lobbying to gain political support for the project.

The revival of the An-74 would mark an unlikely comeback for a Soviet-era aircraft that made its debut in the early 1980s and of which, appropriately, only 74 were built.

A development of the An-72, the An-74 entered service in 1983. Its unusual engine configuration enables short runway performance through the Coanda effect, where exhaust gases blown over the wing's upper surface help to generate lift.

Cirium fleets data shows that of the 74 examples produced, 35 aircraft remain in service.

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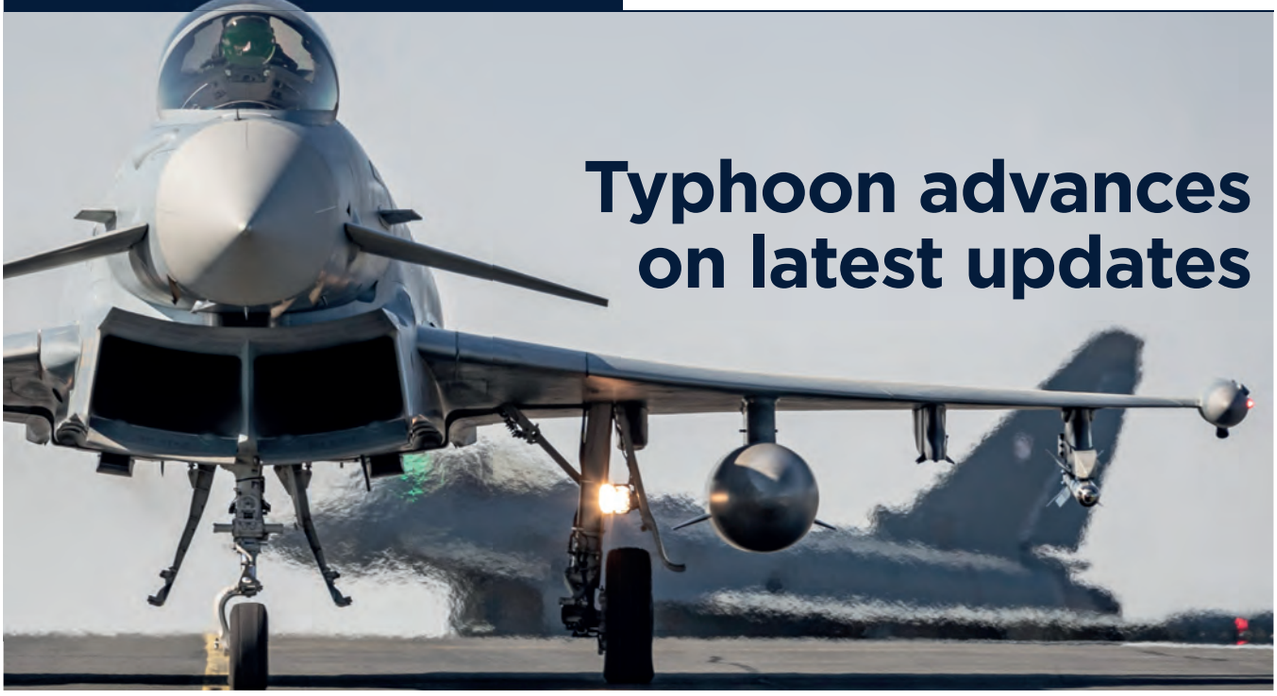

Bundeswehr

Typhoon advances on latest updates

Four-nation contract set to enhance Eurofighter's weapons functionality, boost self-protection and modernise cockpit

Craig Hoyle London

Europe's Eurofighter partner nations have finalised a deal worth almost €300 million ($354 million) to deliver a package of weapon, avionics, communication system and self-protection enhancements for the multi-role type.

The Eurofighter consortium, which signed the contract with the NATO Eurofighter and Tornado Management Agency (NETMA) on behalf of Germany, Italy, Spain and the UK on 6 August, says the move "provides the next steps in the capability evolution" for the Typhoon.

Formally named Consolidation Package Step Two and Three, Phase 1, this includes extending the use of MBDA's Meteor beyond-visual-range air-to-air missile from the Eurofighter's current mechanically-scanned radar to a new active electronically-scanned array (AESA), or E-Scan, European Common Radar System. All four nations have programmes in place to incorporate the AESA technology with all or part of their fleets.

"The package also includes improvements to [MBDA] Brimstone precision air-to-surface [missile] operations; adaptations to cockpit display formats; interoperability enhancements through development of the MIDS Link 16 radio; and further improvements towards its Defensive Aids Sub-System (DASS)," Eurofighter says.

"The contract strengthens both the air-to-air and air-to-surface capabilities of the weapon system, and rolls these updates out across the whole fleet," it adds.

In addition to the requirements of the European partner nations, the consortium says the enhancements "will equally benefit export customers, creating a consistent harmonised package as the baseline for ongoing capability development".

Versatile performance

"This package makes the weapon system performance more effective and versatile for our end users, with improvements to individual capabilities being rolled out across the whole fleet of M-Scan and E-Scan aircraft," says Eurofighter chief executive Herman Claesen.

It also "provides an important building block for further developments", says NETMA deputy general manager Ruediger Knoepfel.

Eurofighter says the initial €300 million commitment will be followed by a second-phase award to be made in mid-2022.

The work will be performed by industry partners Airbus Germany, Airbus Spain, BAE Systems and Leonardo, along with the Euro-DASS and EuroRadar groupings.

Eurofighter says that changes to the Typhoon's cockpit displays are the result of operator feedback, and will "improve the pilot and machine interaction". BAE – which had funded work on the new large-format touchscreen displays – says these will enable pilots "to respond to increasing volumes of data from the aircraft's sensors and datalinks".

BAE values its part of the deal – named Phased Enhancement Package 3c – at approximately £135 million ($188 million), and says work will conclude by the end of 2024.

Richard Hamilton, Typhoon programme director, Europe for BAE Systems Air, says the contract "will help to keep the UK skill base at the forefront of the combat air sector".

Along with Rolls-Royce and the UK units of Leonardo and MBDA, BAE forms Team Tempest, which is tasked with developing the UK's next-generation combat air capability. Italy and Sweden are also supporting the programme, which recently moved into its concept and assessment phase.

Cirium fleets data shows there are 515 Eurofighters in active service with the air forces of Austria, Germany, Italy, Oman, Saudi Arabia, Spain and the UK.

Typhoons are also in production for future operators Kuwait and Qatar, while Germany is to introduce 38 new examples via its Project Quadriga acquisition.

See p70

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Orkney flights SATE Ampaire's curiosity

Powertrain developer takes hybrid-electric Cessna on tour of UK, including Scotland and southwest England

Dominic Perry London

While not quite a flight from John o'Groats to Land's End – the far northeast of Scotland to the most westerly tip of England – Ampaire's Electric EEL has conducted its own long distance tour of the UK.

Fresh from a short series of flights from Kirkwall airport in the Orkney Isles, which lie off the north coast of Scotland, the heavily modified Cessna 337 Skymaster on 16 August departed for Exeter airport in southwest England for a second round of evaluations in Devon and Cornwall.

In both cases, the test campaigns have been funded by the UK government through its Future Flight Challenge initiative: in Orkney, Ampaire is part of the SATE (Sustainable Aircraft Test Environment) project, which is headed by Highlands & Islands Airports (HIAL); while the Exeter flights were conducted under 2ZERO (Towards Zero Emissions in Regional Aircraft Operations), a programme led by Ampaire and involving a consortium which includes Rolls-Royce Electrical, and Scottish regional carrier Loganair, among others.

Speaking shortly after the completion of its part in SATE, including a return flight from Kirkwall to the Scottish mainland on 12 August, Kevin Noertker, Ampaire co-founder and chief executive, described the project as "wonderfully successful".

Assembly required

Ampaire employees were in Kirkwall for a month beforehand, setting up the required infrastructure and re-assembling the Electric EEL (N337EE), which had been transported from the company's Los Angeles headquarters in a shipping container.

But the flights themselves were not particularly significant – the longest by the Electric EEL took place last October in California, and route-proving operations have previously been performed in Hawaii.

Noertker acknowledges that the plane "flies pretty much the same" whether in California, Orkney or Exeter, but points to the "fragmented" nature of the sub-regional airline market where operational requirements and constraints, and community perception, change at each location.

On that basis the flights under SATE and 2ZERO are important, he argues. "Each interaction on deployment means we learn something about [operational] integration." That might be about the need for charging infrastructure at an airport, or what an airline requires in terms of turnaround times or aircraft utility.

While Ampaire gains "knowledge about the maintainability and reliability" of its powertrain in the field, crucially it is also "building the relationships that are needed to deploy [a hybrid-electric aircraft] commercially one day," says Noertker.

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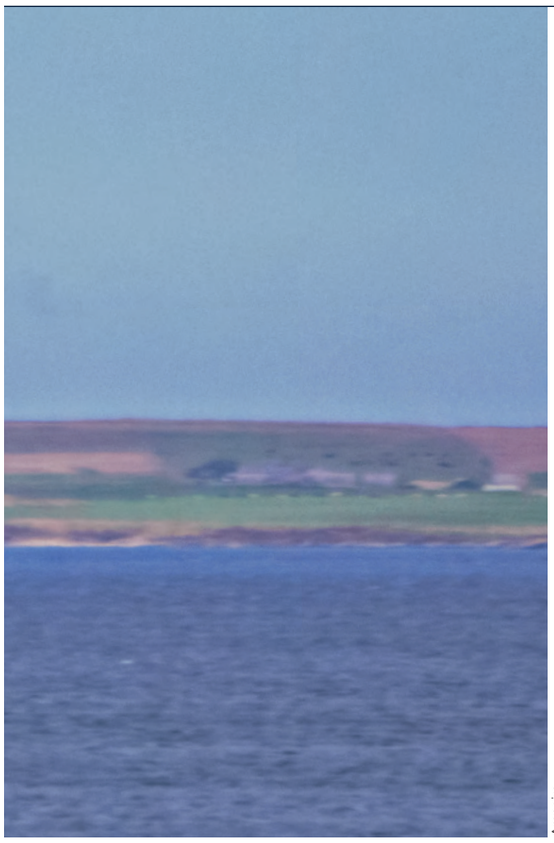

Ampaire

"We are gaining knowledge about maintainability and reliability and are building the relationships needed to deploy a hybrid-electric aircraft commercially one day"

Kevin Noertker Co-founder and chief executive, Ampaire

Prior to its departure for Scotland, the Electric EEL was also upgraded with the latest iteration of Ampaire's battery system, aiding overall resilience and allowing for "the more challenging weather in Orkney".

To create the Electric EEL, Ampaire replaced the Skymaster's rear combustion engine, which is in a pusher configuration, with an electric motor and battery system while retaining the forward-facing piston powerplant. Noertker says the fuel-burn savings are in the region of 30%.

But it is worth remembering that the at-best five-passenger Electric EEL is chiefly intended as a technology testbed, and is unlikely to make it into production.

Instead, Ampaire's focus is now on bringing to market a hybrid-electric conversion of the Cessna Grand Caravan. In that embodiment, the stock Pratt & Whitney Canada PT6 engine is replaced with a generator from an undisclosed supplier which will deliver power to an electric motor and batteries.

Ampaire is also in the process of being acquired by US technology company Surf Air Mobility, which recently announced a deal for up to 150 Grand Caravan EXs and an exclusive relationship with Cessna owner Textron Aviation.

Noertker says that Ampaire has been quietly working on the powertrain for the Grand Caravan "for quite some time, and that's the primary focus for our company". Service entry is anticipated in 2024, and the modification promises a fuel-burn saving for the nine-seater of around 25%.

But further out – and possibly more attractive for Highlands and Islands-type flights – is a twin-engined hybrid aircraft. So far, Ampaire has committed to a conversion of the 19-seat Viking Air DHC-6 Twin Otter – an aircraft it calls the Eco Otter SX – but would also consider the smaller Britten-Norman BN-2 Islander. In either case, an aircraft could be available by mid-decade, says Noertker.

Payload performance

He is confident that Ampaire can achieve a payload of nine passengers in the Grand Caravan and 19 in the Eco Otter SX. But if not all that accommodation is required, then customers may seek to trade passenger capacity for better performance through additional batteries.

Ampaire continues to finalise its supply chain, but is keen to dual-source key components. "It is a new industry where the supply chain is still relatively immature; it is a little bit more of a risk-managed approach," says Noertker.

The "best in class" lithium-ion cells currently being worked on at Ampaire's California headquarters deliver 200 watt-hours per kg, but the company sees that figure as only rising as technology improves.

For its participation in SATE, Ampaire UK – its local subsidiary – was allocated just over £532,000 ($737,000) and almost £644,000 for 2ZERO from the UK government, according to details of the grant awards. In both cases, the company contributed equal sums.

Although Ampaire is overwhelmingly a US company, its UK presence allows it to receive funding from the Future Flight Challenge: to qualify, a participant must simply be a UK-registered company, carry out its project work in the country, and intend to exploit the results of that effort from or in the UK.

Ampaire UK was registered in 2018, although the company was dormant for the first year of its existence, UK Companies House documents show. It currently has five full-time employees.

Although acknowledging the UK's aerospace engineering expertise and the government's commitment to sustainable aviation, Noertker offers no commitment to expanding its in-country presence. Its local workforce will "quite probably" expand, he says, noting that "We see some follow-on opportunities for work."

However, rather than establish a dedicated UK site, it is likely to utilise the facilities of its local partners. That said, should Ampaire begin delivering aircraft to a UK customer, then there may be a need for a local manufacturing or assembly facility, says Noertker. "But we will let that play out over time," he says.

Test flights under the 2ZERO programme are designed to assess the performance of a hybrid-electric aircraft and evaluate its operational requirements.

While the flights in southwest England were of broadly similar scope to those under SATE, Noertker points out that other consortium members are conducting work behind the scenes on technology development: for instance, Rolls-Royce is receiving £1.1 million under the project.

A later follow-on phase is also anticipated which foresees flights of the planned twin-engined hybrid. That, says Noertker, is designed to answer the question: "How do we get it up and ready for operations out here?"

Weather avoidance led to 777 scare

Air France crew flew dangerously close to Mount Cameroon after storm activity prompted deviation from route

Pilots failed to monitor position correctly during 2015 event

Air France

David Kaminski-Morrow London

French investigators believe the crew of an Air France Boeing 777-200ER misinterpreted weather radar information while trying to avoid thunderstorms, losing awareness of the jet's position before it strayed into close proximity with an African volcanic peak.

The flight was operating in darkness from Malabo, Equatorial Guinea, to Douala in Cameroon on 2 May 2015. The 40min flight was operated mainly over water at an altitude of 9,000ft, and the eastbound flightplan involved flying south of the 13,200ft peak of Mount Cameroon.

But French investigation authority BEA says the crew, after turning right after take-off from Malabo's runway 22, deviated "significantly" to the north of the planned route in order to avoid storms.

Both the captain's and the first officer's navigation displays were showing weather radar data. The first officer, who was flying, saw a large red echo in front of the aircraft and a second red echo to the right, which appeared to be tracking alongside the aircraft.

The BEA says that, although the radar filters echoes reflected from the ground, they can appear similar to storm echoes on the display.

The first officer did not understand the nature of the second echo and briefly switched his display to 'terrain' mode to check, before reverting to 'weather' mode about 6s later. However, the BEA says that the 'terrain' mode requires about 8s to fully construct a picture.

2,100ft

Minimum ground clearance of twinjet at altitude of 11,500ft

At the end of this check, the first officer believed the echo in front of the aircraft corresponded to a ground reflection of Mount Cameroon, and that the red echo to the right was a false image.

The captain, who was handling busy air traffic control communications, suggested that the first officer turn to the right in preparation for the Douala arrival, believing the aircraft was positioned southwest of the mountain. It was in fact to the northwest, putting the peak to the right of the 777's course.

The first officer selected a southeast heading of 120°, which turned the twinjet towards the northeastern flanks of the mountain.

About 30s after entering the turn the aircraft's radio height reduced to 5,000ft and triggered a ground-proximity warning. Both pilots' navigation displays automatically switched to 'terrain' mode.

The first officer increased the selected heading to 134° and the 777 was banked to 25°, with its radio height declining further to 4,150ft, activating a 'pull up' order from the warning system.

Three pilots were in the cockpit. The BEA says the first officer and a cabin crew member – who was also in the cockpit, using a jump-seat – were able to "distinguish trees" on the right side of the aircraft.

Maximum thrust

The first officer disengaged the autopilot, advanced the thrust levers to maximum and pitched the aircraft nose-up, although the jet remained in the turn and the third pilot, a relief first officer, remarked that the wings should be levelled.

After the ground-proximity alarm stopped, the climb was briefly halted before the turn was resumed with a selected heading of 150° and a selected altitude of 12,000ft.

Concerned over the possibility of traffic conflict, the captain instructed the first officer to stop the climb as the 777 approached 11,000ft but the aircraft continued to climb – its radio height reached a minimum of 2,100ft as the jet passed 11,500ft. It continued to climb to 13,000ft, although this was still below the summit elevation of Mount Cameroon.

"Avoidance of thunderstorm masses led the crew to depart significantly from the route planned," says the BEA. "Although the proximity of Mount Cameroon was mentioned during the crew briefing, the risk of a dangerous encounter with this terrain had not been identified."

The aircraft (F-GSPG) subsequently landed safely at Douala, and none of the 23 passengers or 14 crew members on the lightly-loaded flight was injured.

The BEA inquiry was conducted without cockpit-voice recorder data, which was not preserved following the incident, and instead relied on the flight-data recorder and crew testimonies.

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NH90 users discuss upgrade path

France showcases enhancements during gathering for nine operator nations, with rotorcraft due to serve beyond 2050

Dominic Perry London

While the immediate upgrade path for the NH Industries (NHI) NH90 is clear, thanks to a contract decision reached last year, officials from a majority of the rotorcraft's customer nations recently met to discuss a possible roadmap to keep the type relevant into the 2040s and beyond.

Organised by France's DGA defence procurement agency, the 21-22 July event took place at its flight-test site at Istres air base.

Attendees were able to see the enhancements being developed as part of the Standard 2 upgrade ordered by Paris in September 2020 for its final 10 examples of the TTH troop transport variant. In addition, several key equipment suppliers were on hand to demonstrate systems and technologies that could provide suitable capabilities for a future modernisation effort.

Standard 2 will be used by the French army's special forces from 2025. An initial step will see the addition of Safran's EuroFLIR 410 electro-optical/infrared sensor, with displays and controls available for all on board. The updated model will also gain a fast roping and rappelling capability through the doors, and weapons mounts installed at its rear cabin windows.

A more significant improvement in capability will be delivered via a second phase, likely to be contracted in 2022. Under this, the helicopter will gain a new distributed aperture system (DAS), with six infrared cameras arrayed around its nose. The 3D image generated will be presented on the digital screen of a next-generation Thales TopOwl helmet, aiding operations in degraded visual environments, such as brown- or white-out conditions. The second step should also provide for the upgrade of the datalink on the French navy's NFH variant to the Link 22 standard.

France is so far the only nation to sign for the Standard 2 modifications, but the DGA's NH90 programme manager – requested to be identified only as Colonel Damien – points out: "What is clear is that the triptych of TopOwl, EuroFLIR and DAS are part of the next standard, and anyone can join."

Cost analysis

Those attending the Istres user forum – which included representatives from Australia, Belgium, Finland, Italy, Germany, New Zealand, Norway and Spain – were given demonstrations of the capability offered by the Standard 2 upgrades. These included replays of flight tests of the DAS and TopOwl combination conducted by the DGA flight-test centre using its Aerospatiale SA330 Puma testbed. "It is really brand new, this is really a breakthrough to me," says Damien.

"Almost all nations were interested [in the upgrades], but the question was 'how much does it cost?'," says Damien. However, he points out that if more nations come on board, then the development burden can be shared more widely.

With deliveries of new-build NH90s to stretch well into the second half of this decade, it is likely that many will still be in service in 2050 or beyond. So, while the forum gave operators the chance to consider the potential offered by the near-term upgrades, Damien says

Safran's EuroFLIR 410 sensor will be used with six-camera distributed aperture system

DGA

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French army's special forces will field Standard 2 updates on TTH from 2025

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the focus was also on what might be required for the future – whether as a notional Standard 3 enhancement, or a full mid-life upgrade.

"All the nations agreed that some other upgrades are necessary after Standard 2, if you want to use the helicopter until 2060," says Damien.

Current areas of interest include the introduction of a modular avionics suite, Thales FlytX tactile flight displays – which for France would create commonality with its military's future Airbus Helicopters H160Ms – plus a power increase for the NH90's engines: either twin GE Aviation T700s or Safran RTM322s. In the latter case, Damien says, the French manufacturer has already devised an upgrade path, using technologies and components developed for the newer but related Aneto engine.

That wish list is not yet set in stone, but Damien points out it will need to be solidified over the next two to three years. "Clearly the goal of this forum was to try to be able [to come up with] some requirements that we can forward to industry to let them think about what they can provide us with," he says.

But the elephant in the room in any discussion about the NH90's future is its overall level of reliability. Australia, Belgium and Norway have all recently expressed dissatisfaction with the type's uptime, but they are by no means exceptions. The forum left NHI in no doubt that it still has issues to address: "The feedback was also that the NH90 is a great helicopter and delivers a really good performance, but industry needs to pay attention to availability and affordability," says Damien.

Efficiency drive

Even France has been a victim of industry's foot-dragging, despite its position as one of the biggest customers for the NH90 and with its domestic manufacturer Airbus Helicopters as the NHI consortium's largest shareholder.

Damien says the pace of retrofit activity – bringing early-build examples to the latest software standard – has been lagging, and required the customer to push NHI "to be more efficient in the way they conduct the retrofit".

"The timeline has been a little bit disappointing. They have expended a lot of time to supply us with retrofitted helicopters," he says. But Damien thinks "industry is aware of this need to improve its performance" and sees a plan in place to achieve that – even if it may not happen overnight.

Should the user forum succeed in pressuring industry to address its failings, then it could be considered a success on that criterion alone. But while that deals with the here and now, the event was clearly convened with an eye on the future.

"I was particularly pleased with the output," says Damien, both for the engagement between operators and industry, and the more strategic considerations about the programme's future direction.

The group intends to meet again in July 2022, this time in Italy.

"It was really successful – I'm happy with how it went," Damien says. "We have done the easy part – now we have to get into the details."

UK waves E-3Ds into retirement

Final mission flown by Royal Air Force Sentry fleet opens two-year capability gap before Wedgetails arrive for duty

Craig Hoyle London

The UK Royal Air Force (RAF) has ended 30 years of operational use with its Boeing E-3D Sentry airborne warning and control system (AWACS) aircraft, with a replacement capability due to enter service from 2023.

Conducted from RAF Akrotiri in Cyprus on 30 July, the final frontline sortie was flown in support of Operation Shader, the UK's contribution to coalition activities to counter Daesh militants in Iraq and Syria.

Two E-3Ds had been flown to Cyprus to support the UK Royal Navy's Carrier Strike Group 21 deployment, led by the aircraft carrier HMS *Queen Elizabeth*. This commitment involved the surveillance aircraft completing 30 missions over a nine-week period, the RAF says.

"The Sentry was able to provide the recognised air and surface picture to the Carrier Strike Group to facilitate its safe transit from the Straits of Gibraltar to the Suez [Canal]," says Wing Commander Victoria Williams, officer commanding the RAF's Sentry-equipped 8 Sqn.

The E-3Ds returned to RAF Waddington in Lincolnshire on 2 and 4 August. The type will be formally retired from use "later this year", the service says. It originally operated a seven-strong fleet of the CFM International CFM56-engined, heavily adapted 707s, with Cirium data showing three as active when operations concluded.

Following its introduction to service in 1991, the Sentry was deployed in support of the RAF's involvement in the first Gulf War. The type was subsequently committed to campaigns in Afghanistan, Iraq, Libya and the Balkans, during air defence of the UK, and in countering drug-smuggling in the Caribbean.

"Whether operating from their home base at Waddington or airfields from across Europe and the broader Middle East, Sentry has enabled others to operate with significant freedom of action against the most hostile of threats," says Air Commodore Nicholas Hay, commander of the RAF's intelligence, surveillance, targeting and reconnaissance force.

Replacement wait

A trio of 737-based E-7A Wedgetail airborne early warning and command and control aircraft are due to assume the Sentry's duties from 2023. They will be based at RAF Lossiemouth in Scotland, alongside its Boeing P-8A Poseidon MRA1 maritime patrol aircraft.

During this period of capability gap, "intelligence, surveillance, targeting and reconnaissance requirements will be covered by a combination of other aircraft and E-3s from our NATO partners", the RAF says.

The pending departure of the UK's AWACS fleet follows the February 2021 retirement of the RAF's Raytheon Systems Sentinel R1 ground surveillance aircraft. Heavily adapted examples of the Bombardier Global Express business jet, these had been in operational use for just 14 years.

Meanwhile, the US Navy (USN) has acquired one of the RAF's surplus E-3Ds for $15 million, with the asset to be employed as a dedicated trainer supporting its E-6B Mercury airborne communications and command post fleet.

Personnel from the navy's PMA-271 Airborne Strategic Command, Control and Communications Program Office had in late February inspected the UK aircraft in Lake Charles, Louisiana, the US Naval Air Systems Command (NAVAIR) says.

"The [PMA-271] programme office had been looking to acquire a dedicated training aircraft for the fleet to take the strain off using the current mission-capable E-6 aircraft," NAVAIR says. Around 600 flight hours and 2,400 landings per year are currently being logged undertaking such tasks, it adds.

"The training flights expose mission aircraft to wear and tear and impact their readiness and availability," notes PMA-271 programme manager Captain Adam Scott.

Following its receipt by NAVAIR, the ex-RAF aircraft will undergo a modification activity, "with a goal to get it out to the fleet by October 2023", the command says.

The USN has an active fleet of 16 E-6Bs, with Cirium showing these as aged between 30 and 36 years.

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Last frontline sorties were launched from Akrotiri, Cyprus

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Heart swells as market for electric aircraft begins to spark into life

Swedish start-up grabbed headlines with triple-digit orders from United Airlines and Mesa Airlines for developmental all-electric 19-seater, but chief executive Anders Forslund believes improving battery power will drive sales higher

Dominic Perry London

Swedes are renowned for their modesty; the concepts of *Jantelagen* – an unwritten rule forbidding boasting – and *lagom* – loosely translated as 'just the right amount' or 'appropriateness' – are woven into the national psyche.

So when Anders Forslund, chief executive of Gothenburg-headquartered Heart Aerospace, sums up his company's recent announcements simply as "exciting times", you cannot help but think that the tendency for understatement is at work.

In case you missed them, the start-up on 13 July revealed two key developments: first, that US carriers United Airlines and Mesa Airlines had placed conditional orders for a total of 200 of the company's in-development ES-19 all-electric aircraft, and had taken options on a further 100; second, those operators and other investors, including the Bill Gates and Jeff Bezos-backed Breakthrough Energy Ventures, had put $35 million into the company as part of its Series A fundraising.

For a company whose aircraft has yet to fly to attract the interest of one of the USA's big three and its regional partner is a remarkable feat, but arguably these are remarkable times.

To Forslund, though, it is a validation of his vision: that the economics – and zero-emission operation – promised by battery-powered 19-seaters can reinvigorate a part of the market that has been in large part abandoned owing to the expense of flying turbine-equipped aircraft.

"That's the thing: people didn't stop flying 19-seaters because they didn't fly far enough but because of the terrible unit economics of putting a [turbine] engine in an aircraft that flies 19 passengers," he says.

"This is what we are focused on – we believe that there is a market here that is larger than a lot of people understand."

Mesa, he points out, in the 1990s operated one of the world's largest fleets of 19-seat aircraft – those falling into the CS-23/Part 23 commuter category – flying an average route length of just 172 miles (276km).

445

Total commitments for ES-19, including 100 each from United and Mesa

Heart says its electric motors are 20 times less expensive to run than equivalent turboprop engines, with maintenance costs which should also be significantly lower; compelling claims for those considering their approach to the sub-regional or commuter segment.

But those figures are, for now at least, largely theoretical, no matter how earnestly they may have been calculated.

Heart has ambitions of achieving certification and service entry by 2026, on the back of a maiden sortie in 2024; flight testing will be completed with three aircraft, plus additional examples for ground test.

So far, the start-up has assembled and run a 400kW propulsion system, one of four such motors on the ES-19 for a total take-off power requirement of at least 1.2MW. It is "the first step" in building its aircraft, says Forslund, although the most crucial one: "The biggest technical challenge is to show we can build an electrical propulsion system."

On top of being able to propel the aircraft, the batteries must also power all the other vital on-board systems – the avionics, de-icing, cabin systems – and, crucially, it has to be certifiable too.

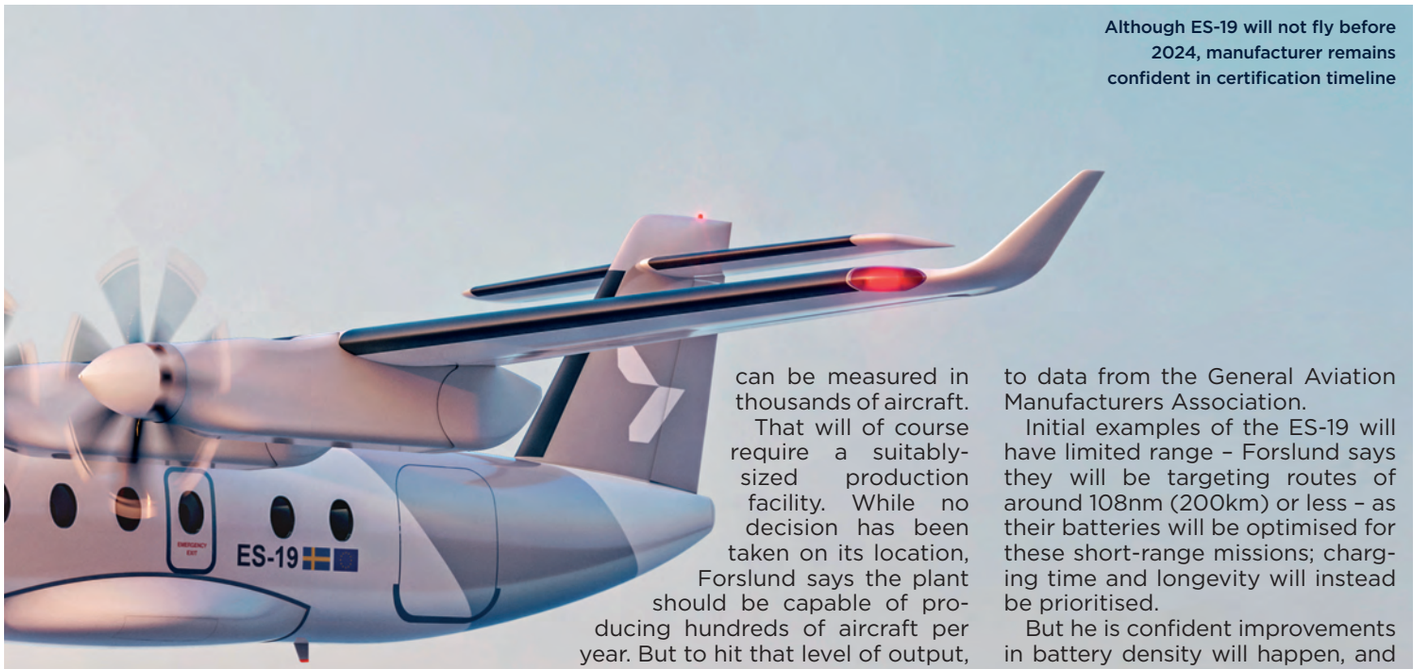
In the meantime, Heart continues to build up its supply chain for the ES-19. So far, the only disclosed partner is UK battery specialist Electroflight, but Forslund says discussions are ongoing with a number of other potential suppliers.

He sees the aircraft as essentially a "Lego kit built by a lot of different suppliers". In other words, as a start-up, Heart is anxious to "limit the number of things we take on in house".

In fact, aside from the engines, there is a tendency towards simplicity in the overall design; as Forslund puts it, "the innovation and novelty is inside the nacelles".

For example, the wings and fuselage are aluminium rather than composite, helping both manufacturability and in-service repairability. That also means the route to market is simpler and faster

Heart Aerospace



Although ES-19 will not fly before 2024, manufacturer remains confident in certification timeline

– crucial for proving out the technology in the real world.

There is one area which will require some additional consideration, however. Unlike those with conventional engines, battery-powered aircraft do not become lighter during the flight as fuel is burned off. Therefore, the ES-19's maximum take-off and maximum landing weights are one and the same, sitting at the upper end of the CS-23 regulations at about 8,600kg (19,000lb). Comparatively, the same figures for a 19-seat Viking Air DHC-6 Series 400 Twin Otter are 5,670kg and 5,580kg, respectively.

Stress factor

While storing the batteries in the wings may be "structurally efficient" in flight, it will put additional stress through the structure on landing; the landing-gear too will have to be able to take more punishment than is typical for a 19-seater.

Although its service-entry target of 2026 is only five years away – a tight timeline for an aircraft that will not fly until 2024 – Forslund points out that Heart has been working on the ES-19 since 2019. "I don't want to sound like this is some lofty goal that has not been aligned with our suppliers: this is what we tell our suppliers and EASA, this is what we are working towards. Ultimately I am confident in our roadmap."

On top of those from United and Mesa, Heart has so far attracted around 245 commitments, he says, including a tentative 20-unit order from Finnair. But Forslund believes that the total market for the ES-19 can be measured in thousands of aircraft.

That will of course require a suitably-sized production facility. While no decision has been taken on its location, Forslund says the plant should be capable of producing hundreds of aircraft per year. But to hit that level of output, Heart is counting on the operational savings from electric power to spark life into a part of the market that has been a bit of a backwater for many years.

It is hard to come up with a perfect aircraft to compare the ES-19 against, given the range of missions they perform, but the Twin Otter does at least count several airlines among its customer base. Demand seems consistent, if modest: over the past two years, Viking handed over a total of 19 examples of the twin-engined turboprop, Cirium data suggests. To get close to the 100-shipment mark, you have to drop down in size to the nine-seat Pilatus PC-12, of which there were 82 deliveries in 2020, according to data from the General Aviation Manufacturers Association.

Heart Aerospace

A 400kW engine has been tested on the ground – four of them will power ES-19

Initial examples of the ES-19 will have limited range – Forslund says they will be targeting routes of around 108nm (200km) or less – as their batteries will be optimised for these short-range missions; charging time and longevity will instead be prioritised.

But he is confident improvements in battery density will happen, and quickly. For example, cell manufacturer Cuberg is already working on next-generation battery technology that promises better energy density at lower cost. Cuberg has several links with Heart: it is a supplier to Electroflight, and in March was acquired by Northvolt, a Swedish battery specialist whose chief executive, Peter Carlsson, is also an adviser to the aircraft manufacturer.

Annual increase

Forslund points out that the requirement to change battery packs after they have been through a certain number of cycles means that operators will, in effect, "get a better aircraft on a yearly basis".

That energy density improvement will also enable Heart to develop a larger aircraft of "approaching 50 seats", although Forslund is keeping mum on the timeline.

While Heart's Series A funding round raised $35 million, Forslund estimates that some $500 million will be needed to bring the ES-19 into service.

Meanwhile, Heart continues to work through the aircraft's development milestones from its home at Save airport, a former air base to the northwest of Gothenburg. Sweden's second city is, he says, the country's "electric mobility capital" and is ideally located close to Norway and Denmark.

But with Forslund a Gothenburg native, there is perhaps an added advantage of being based close to home: "When we got started, sometimes I would call my dad to ask him to bring over a tool that we were missing," he says with a smile.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A train in vain

The vast sums required to deliver a high-speed rail service in the USA could be used to better effect backing electric aviation, argues **Garrett Reim**

Rich Pedroncelli/AP/Shutterstock

California's ambitious project is late and over-budget

When approved by voters in 2008, California's proposed high-speed rail line was supposed to run the roughly 400-mile (650km) distance between Los Angeles and San Francisco by 2020 at a cost of $33 billion.

Already one year late, officials now say the bullet train will not be finished until the mid-2030s. Meanwhile, the cost has ballooned to around $100 billion.

Which raises a question: could that money – and time – have been better spent?

In earlier decades, there wasn't a workable and environmentally friendly alternative to high-speed rail. But that may no longer hold true: rapid improvements in battery technology could make electric aircraft a true challenger.

Establishing a high-speed rail line requires governments to move mountains of earth and treasure – as well as private homes that stand in the path of their grand plans. But a small regional airline in Vancouver, Canada is working to prove how quickly electric aircraft can be introduced on short-haul routes.

Harbour Air aims to become the first airline to carry paying passengers on an electric aircraft, transporting up to four people on routes of up to 30min on a modified De Havilland Canada DHC-2 Beaver.

Four passengers is a humble start. But Harbour Air sees potential to electrify its whole fleet, including its 19-seat DHC-6 Twin Otters.

Harbour Air is a little unique in its location and primary route – linking Vancouver with Vancouver Island – but more conventional carriers such as United Airlines and Mesa Airlines also see the potential from electric-powered aircraft.

Along with aircraft developers, they are banking on improvements in battery energy density and continued falls in battery prices to make their designs successful.

Density matters

It is a bet that is not hard to understand. The cost of lithium-ion battery packs declined 89% from 2010 to 2020, according to research service BloombergNEF. What is more, average battery energy density – the amount of energy stored per kilogram of battery – is increasing by an average of 7% each year.

In theory, that should enable aircraft that are significantly cheaper to operate than turbine-powered alternatives.

That would allow them to succeed financially where other aircraft have not; they could fill in the US regional routes abandoned in recent decades by small airlines that could not make the maths work.

Such routes would put electric aircraft in direct competition with high-speed rail – often billed as best for trips "too short to fly, and too far to drive".

But rail infrastructure barely exists in the USA, requiring governments to expend significant capital – both political and monetary – to create them from scratch.

Take, for example, California's failure to build the first "easy" section of its high-speed rail line, a 171-mile link between farm towns Bakersfield and Merced. The unfinished section is billions of dollars over budget, has been reduced to a single, one-directional track and is projected to be finished a decade late. Assuming, that is, that all the parcels of land needed can be acquired.

In contrast, electric aircraft do not require land grabs. Electric air travel also has fewer "sunk costs" – upfront, unrecoverable expenses, such as for laying new track. If an airline route fails owing to lack of customer interest, aircraft and ground equipment can be moved to cities with more demand; rails cannot.

Cheerleaders for high-speed rail point out that bullet trains can drop off hundreds of passengers directly into downtown areas. That convenience is great for tourists and some business travellers. But most US travellers are not tourists. And many Americans do not live downtown these days, instead preferring the comfort of the suburbs. That shift, plus a move to smaller cities, has been accelerated by Covid-19.

These locations may not be served by rail lines, but are generally not far from one of the USA's 5,000 airports. In fact, 90% of Americans live within a 30min drive of a regional airport.

Electric aircraft are not yet proven commercially, of course. And it may be that the viable services can be launched only with hybrid aircraft, before a zero-carbon technology – be that batteries or hydrogen fuel cells – matures sufficiently.

Given that a substantial chunk of the infrastructure required for their operation already exists, US federal, state and local governments should throw their support behind electric regional aircraft. With the private sector already funding much of the research and technology activity, governments would not need to spend tens of billions of dollars to accelerate the sector.

After all, 21st century problems require 21st century solutions.

Garrett Reim is an aviation reporter for FlightGlobal and lives in Los Angeles, California

German leisure carrier Condor will renew its long-haul fleet with 16 Airbus A330-900s, for delivery from next year

Airbus

Best of the rest

We showcase some of the other notable events covered by the FlightGlobal team between issues

SkyWest Airlines is purchasing 16 new Embraer 175s. They will replace aged CRJ900 regional jets operated for Delta Air Lines

Embraer

Northrop Grumman's MQ-4C Triton has been flown in a Multi-Intelligence configuration selected for use by the US Navy and Australia

US Navy

Erickson is seeking investment support to further develop its S-64 Air Crane heavy-lift helicopter

Erickson

Latvian lawmakers have granted government-owned Air Baltic another $105 million in equity, to cover pandemic-related losses

Markus Mainka/Shutterstock

Dassault has handed over the first of an eventual 18 Greek air force Rafales, with the fighter supporting training activities in France

C Cosmao/Dassault

Embraer has performed unpaved runway trials of the KC-390 airlifter, using a dirt strip at its Gaviao Peixoto facilities

Embraer

October's issue

Next month

We mark a decade of Dreamliner operations since ANA debut

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Gulfstream

Show time
Business aviation's high fliers ready for star role in Las Vegas

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-14.2%

Revenue decrease for Top 100 aerospace companies

-84.1%

Decline in profits, according to our analysis of industry

-5.5%

World GDP reduction across 2019-2020 review period

Lockheed Martin

Lockheed Martin – manufacturer of the F-35 – takes first place with revenues of $65.4 billion

This year's Top 100 reflects an aviation industry hit by nine months or more of crisis – but also one where fortunes differ hugely depending on whether a business's focus is defence or commercial

Eye of the storm

Murdo Morrison London

The latest Top 100 aerospace listing is unlike any before. With the worst crisis in commercial aviation coinciding with the 2020/2021 financial year on which this survey is based, red ink and minus symbols permeate the results – though not as ubiquitously as some might have feared. Of the 61 businesses we have been able to calculate operating profits for, just 18 made a loss. However, only 19 of the biggest 100 aerospace players saw revenues rise year-on-year.

One of the reasons the industry has perhaps avoided worse carnage is the resilience of the defence and, to a lesser extent, business aviation sectors. That is why, for almost the first time in many years, Airbus and Boeing have been displaced at the top of the leader board. Defence giant Lockheed Martin takes over as number one, followed by Raytheon Technologies, the newly-merged parent of Collins Aerospace and Pratt & Whitney that also has a sizeable legacy military business.

Last year's survey saw Boeing lose the top spot to Airbus as the effects of the 737 Max grounding in March 2019 knocked a quarter off its revenues and pushed the company into an operating loss.

-29%

Year-on-year revenue decrease at Boeing

This time, its sales have fallen further, to $58.2 billion – meaning the company is now less than three-fifths the size it was two years ago in revenue terms. The Chicago-based manufacturer's operating losses have increased more than fivefold, to an eye-watering $12.8 billion.

But Airbus has also been dragged down the ranking by its dominant but stricken commercial aircraft operation. The Toulouse-based airframer fell even further than Boeing, to fourth place, with a 29% decline in revenues. However, it appears to have been much better than its competitor at managing costs, keeping operating losses to just $570 million.

Cushioning effect

The cushioning effect of a healthy domestic and export defence market can be clearly seen in Lockheed's results. The industry's biggest company – for now – notched up revenues of $65.4 billion, up 9% on the previous year, and, although its profits were only up slightly to $8.6 billion, margins were strong at over 13%.

Similarly, defence specialist Northrop Grumman, which remains in fifth place in the table, saw its revenues rise by just under 9%, with a more modest increase in profits.

Three other defence-focused companies in the upper reaches of the ranking enjoyed qualified success, with like-for-like revenues at L3Harris constant with 2019/2020 and profits down by around a third. Italy's Leonardo saw revenues fall slightly – partly a result of a commercial business badly hit by the pandemic – with profitability down by a half. BAE Systems reported an almost 10% boost in revenues, although profits for its aerospace interests were not possible to calculate.

In normal times, the April 2020 merger of United Technologies (divested of its non-aerospace interests) and Raytheon – fourth and seventh place, respectively, in 2020 – would have vaulted the new Raytheon Technologies into third. However, the impact of the pandemic on the commercial aviation revenues of its Collins Aerospace and Pratt & Whitney units has kept Raytheon revenues to $64.6 billion, about $11 billion less than its predecessors' combined pre-Covid sales.

The crisis has deeply affected all the engine manufacturers, which previously were deriving the majority of their revenues from the airliner market. The UK's Rolls-Royce, in 12th position, suffered a more than quarter fall in revenues to $11.8 billion, and posted a $2.6 billion loss. German propulsion systems supplier MTU – a key partner of P&W – fared better, with revenues down under 7% and remaining in profit. It has also jumped five places in the rankings, to 22nd.

Falling revenues

Revenues at seventh-placed GE Aviation, a partner in the CFM International Leap engine and reliant also on the Boeing widebody market, fell by a third to $22 billion, with profits dropping by more than four-fifths, although the US business stayed operationally in the black. Its CFM partner Safran also managed to make money in 2020/2021, aided by its non-commercial aviation assets – although revenues and profits were down substantially.

Confirming anecdotal evidence of high-end business aviation users continuing to fly during the downturn, the four biggest manufacturers in that sector also survived the financial year battered but profitable, with Bombardier – which completed its transition to a pure-play business jet company with the divestment of train maker Alstom in January this year – actually seeing its profits grow by more than a fifth, on revenues just over an eighth down on the previous year.

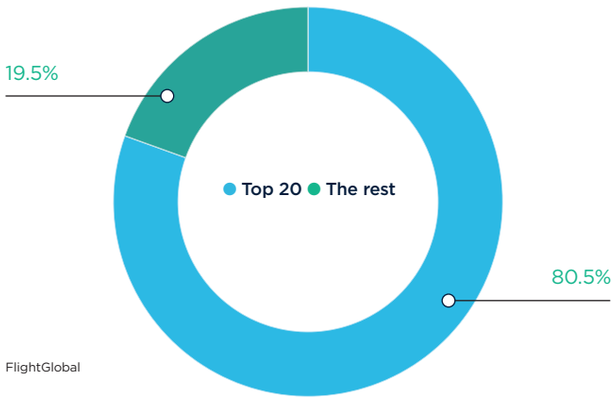
-$2.6bn

Scale of losses at Rolls-Royce

Gulfstream parent General Dynamics Aerospace also kept its decline in revenues and profits to – in the strange context of the pandemic – manageable levels. So too did Textron, which owns the Cessna and Beechcraft brands as well as helicopter manufacturer Bell, and has substantial activities in the defence and parapublic segments. France's Dassault Aviation – behind the Rafale fighter as well as the Falcon business jet range – saw profits slip two-thirds on a one-quarter revenue decline.

Save for the creation of Raytheon Technologies and the continuing slimming down of Bombardier (it announced the closure of its Learjet operation this year) the Covid-19 era has seen little in the way of merger and acquisition activity, as many companies have hunkered down in survival mode.

Top 20 share of Top 100 sales



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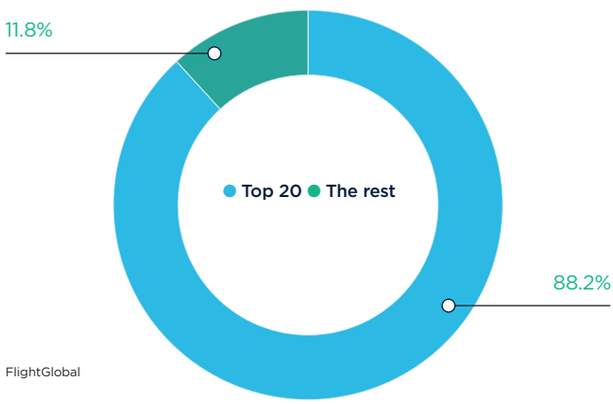
Top 20 share of Top 100 profits



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The question might be, however, how much consolidation can we now expect in a sector that has been devastated by the pandemic?

A clue to what might be to come came from the recent announcement that Parker Hannifin, ranked 32nd, is to acquire 44th-placed Meggitt – which, depending on the timing of its completion, should impact the rankings next year. Diversified and acquisitive TransDigm, meanwhile, has made it into the Top 20 for the first time. The latest addition to its empire – although it will have had little effect on the table – was the connectivity arm of Cobham, a deal announced in November 2020.

Commercial exposure

Aerostructures specialist Spirit AeroSystems has been having a torrid time because of its exposure to Boeing's commercial activities, and has fallen 13 places to 30th on a 56% decline in revenues, recording an $813 million loss. The US company did buy Bombardier's Belfast-based aerostructures division in October 2020 for $275 million. However, around the same time, it also terminated its planned but long-delayed $420 million acquisition of Belgian components maker Asco.

Consolidation within Russia's largely state-run aerospace industry has also led to a shift in the rankings,

Addition of Pratt & Whitney engine business, as well as Collins, saw Raytheon more than double in size

Pratt & Whitney

Sales growth

Mercury's rapid rise

Normally, as part of our Top 100 analysis, we rank the 20 companies which have enjoyed the best sales growth. This time, only 19 businesses grew their revenues from the previous year, and several of these by low single-digit percentages. Almost all of the 19 are defence-focused entities.

This year's leader is a bit of an anomaly. Raytheon's sales growth of over 121% is a result of the merger with the Collins Aerospace and Pratt & Whitney units of United Technologies, when compared with the legacy Raytheon business. As we noted elsewhere, the total sales in 2020 of Raytheon Technologies are considerably lower than the combined revenues of its two predecessor businesses. Still, the amalgamation of the two giants is likely to prove a long-term strategic success, giving Raytheon arguably a wider reach across aerospace than any other company, with a range spanning missiles and aero engines to avionics, aerostructures, cybersecurity and satellites.

In second place is a company we have included in the Top 100 for the first time. Mercury Systems is a US firm supplying mission-critical systems such as radio communications and jamming technologies to the aerospace and defence markets. It has been growing largely through acquisition, buying 11 businesses in the past five years. Between 2019 and 2020 it grew its revenues by more than a fifth.

Ball Aerospace and Kongsberg are the only other two companies in the ranking that saw double-digit sales growth in 2020. Ball is a relatively low-profile name, but prolific manufacturer that supplies antennas, sensors and electronic warfare equipment. Kongsberg Defence & Aerospace is the national champion of Norway, involved in many of that country's defence programmes, including contributing to the Lockheed Martin F-35. Its portfolio takes in composite aerostructures, missiles and remote air traffic control systems.

The rest of the list has some household names such as BAE Systems, Lockheed Martin and Northrop Grumman, all of which were bolstered largely by strong spending by the US and other militaries that continued during the Covid-19 crisis.

Top 20 sales growth

Rank by growth	Rank by sales	Company name	Sales growth
1	2	Raytheon Technologies*	121.4%
2	64	Mercury Systems	20.9%
3	43	Ball Aerospace	17.7%
4	60	Kongsberg	17.4%
5	11	BAE Systems	9.7%
6	1	Lockheed Martin	9.3%
7	5	Northrop Grumman	8.7%
8	31	Hindustan Aeronautics	6.3%
9	6	Rostec State Corporation	6%
10	45	Cobham	5.8%
11	98	Martin-Baker	4.7%
12	37	Aerojet Rocketdyne	4.6%
13	52	Amphenol	4.5%
14	100	Qinetiq	2.3%
15	46	Elbit Systems	2%
16	24	Israel Aerospace Industries	1.9%
17	19	AVIC	1.5%
18	23	Hanwha Aerospace	1.1%
19	9	L3Harris	0.5%

*The merger with UTC was a significant driver of this increase
Note: only 19 companies in our Top 100 increased sales in 2020

Aeroflot has 22 A350-900s on order, and took delivery of its first example in 2020

Airbus

with Rostec now the holding company for all the major aircraft manufacturers and design houses, including those that were formerly part of United Aircraft. The two groups were respectively ranked 20th and 21st in last year's survey. United Aircraft disappears from this year's listing, while Rostec jumps 14 places to number six, on revenues of $26 billion.

As has been noted many times, the crisis of the past 18 months has claimed surprisingly few corporate victims, with just one company failure among last year's Top 100 coming as a result of the pandemic. Kansas-based TECT Aerospace – placed 96th in the previous survey – filed for bankruptcy protection in April, with Boeing agreeing to purchase the remnants of the business in an auction in July.

Whether more vulnerable businesses will follow remains to be seen.

New entrants

There are four companies that are new to our survey this year. Ametek (61), a listed US corporation, is a manufacturer of electronic instruments and electro-mechanical devices. Hensoldt (93) is a German military sensor manufacturer that grew out of the electronics unit of Airbus Defence & Space. Howmet Aerospace (27) was formed in April 2020 when Arconic spun the business off. Mercury Systems (64) is a provider of secure technologies for the aerospace and defence markets.

Of these, Ametek, Hensoldt, and Mercury Systems made it into the Top 100 as part of our ongoing review of which companies should be included. Two businesses that featured last year now fall outside the Top 100: Asco and Figeac Aero, both part of the hard-pressed aerostructures sector. Military pilot survival system manufacturer Martin-Baker, ejected from the rankings last year, has returned in 98th place.

$26bn

Revenues at sixth-placed Rostec

One of the illustrations of how far revenues have declined across the industry during the Covid-19 crisis is seen in the relationship between revenue and rank. Last year, to make it into the Top 20, a business needed to be turning over at least $7 billion. This time, 20th-placed TransDigm had revenues of $5.1 billion. To be listed in the previous Top 100 required sales of $372 million. In the latest survey, the threshold for 100th-placed Qinetiq is $289 million.

Last time, 67 companies in the Top 100 posted revenues of more than $1 billion, but the latest survey has just 58 businesses in the billion-dollar-plus club. Lockheed tops the rankings, with sales of $65.4 billion. In the 2020 listing, Airbus led the way with $78.9 billion, and the year before that a rampant Boeing smashed the $100 billion barrier for the first time in Top 100 history. Lockheed's revenues this time are more than a third lower.

What effect might the cautious industry recovery have on next year's Top 100? Judging by 2021 so far, the path back to 2019 revenues and profitability could be very uneven, as government support packages run out, potential inflationary pressures loom, creditors become impatient, and OEMs demand that their suppliers once again invest in a ramp-up of commercial aircraft production if they want to secure and retain contracts. Company directors can expect plenty more sleepless nights.

Operating margin

TransDigm still profiting from growth

We may have been through the worst crisis in aviation history, but this year's table of best performers in operating margin has a familiar ring to it. The companies that are the best at squeezing profits from their revenues pretty much stay consistent year after year.

TransDigm may have become even bigger in 2020, breaking into the Top 20 by sales for the first time, but its operating margins are only slightly down on the previous year, at 34.3% compared with 36.9% in the previous ranking, despite exposure to the commercial aviation sector.

The company has grown largely by acquisition – Esterline, a specialist in cockpit avionics and simulator displays, became its biggest prize in 2019, and it added a Cobham business in January this year. Its success seems to stem from the fact that it is able to squeeze savings from its operations, despite running a diversified portfolio of largely autonomous subsidiaries.

Diversified acquisitions

However, these diversified acquisitions have something in common, and TransDigm's 2020 financial results statement gives a clue to how they are chosen. The company claims that 80% of its sales come from products for which it is sole-source provider, and just under half from the aftermarket. Historically, it says, aftermarket revenues have produced higher gross margins and been more stable than sales to OEMs.

It is worth noting, however, that TransDigm's results might be slightly flattered by the fact that the company's financial year ended on 30 September 2020 – most companies in the Top 100 report for the calendar year, or the 12 months to end-March. This means TransDigm will only have had half a year of the pandemic reflected in its results.

-10.4%

Year-on-year revenue decrease for biggest 20 businesses

Top 20 operating margin

Rank by margin	Rank by sales	Company name	Operating margin
1	20	TransDigm	34.3%
2	13	Honeywell	25.2%
3	74	Garmin	22%
4	47	Woodward	19.5%
5	98	Martin-Baker	19.3%
6	36	Eaton	18.6%
7	31	Hindustan Aeronautics	18.5%
8	32	Parker Hannifin	16.3%
9	95	Barnes Aerospace	16%
10	71	Crane Aerospace and Electronics	15.5%
11	17	Bombardier	14.4%
12	54	Pilatus	13.9%
13	60	Kongsberg	13.6%
14	15	General Dynamics (Aerospace)	13.4%
15	1	Lockheed Martin	13.2%
16	56	Teledyne Technologies	13%
17	37	Aerojet Rocketdyne	11.6%
18	64	Mercury Systems	11.5%
19	5	Northrop Grumman	11%
20	44	Meggitt	11%

CMC

Canada's CMC became TransDigm's latest subsidiary when the US holding group bought its parent Esterline

Honeywell Aerospace, which has some involvement in the commercial airliner segment through its power systems, avionics and mechanical systems businesses, but is also heavily involved in defence and business aviation, has managed to keep its operating margins almost the same as 2019, at just over 25%. This pushes the Phoenix-based entity into second place, ahead of Garmin, which has seen its operating margin fall from 34.4% last time to a still-impressive 22%. The avionics company continues to innovate, with its Collier Trophy-winning Autoland emergency landing tool likely to win more factory-fit applications in the business and general aviation market.

Fourth-placed Woodward, a manufacturer of controls and other small aerospace components, which cancelled its planned merger with composites specialist Hexcel at the start of the Covid-19 crisis, continued to deliver strong margins in 2020.

Meanwhile, Martin-Baker, a leader in ejection seats, found that it was still able to make impressive returns from a technology it pioneered at the end of the Second World War. It is ranked fifth in our operating margin table.

Boeing was still dealing with the 737 Max grounding when the Covid-19 pandemic hit

Boeing

Commercial

Boeing's nadir

It was another awful year for Boeing's commercial sales fortunes, with an almost 50% drop in revenues to just $16.2 billion. This followed a 44% decline the previous year, largely due to the 737 Max grounding. To put it in context, Boeing made just twice as much revenue from its range of single- and twin-aisle airliners as Gulfstream did in 2020 with a family of specialist business jets.

At just over $39 billion, Airbus's commercial aircraft sales were two-and-a-half times that of its US rival, but still more than 37% lower than in 2019, as a result of depressed deliveries during the first nine months of the Covid-19 crisis.

Sales suffering

The other commercial airliner makers also suffered, albeit from a smaller base, with Embraer's revenues from its E-Jet and E2 ranges dropping by a half. Sales at turboprop manufacturer ATR fell even more sharply, by over 72%. Bombardier's $314 million revenues were the residue of a regional jet business that was divested to Mitsubishi Heavy Industries in June 2020, its Dash 8 turboprop programme already having been sold to Longview Aviation a year earlier.

The business aircraft manufacturers fared better. Gulfstream's revenues were down 17.6% to just over $8 billion, but it was the best-performing brand in the sector in terms of sales by far. Closest rival Bombardier recorded revenues of almost $5.6 billion from its Global, Challenger and (now discontinued) Learjet families.

Textron's general aviation activities generated just under $4 billion, about $1.5 billion more than Dassault's Falcon Jet operation, although the French manufacturer closed the gap in 2020.

Embraer's corporate aviation types continue to be the top-sellers in their categories, but its light and medium-size business jets sell for less than the longer-range offerings of Bombardier, Dassault and Gulfstream, and often at tighter margins. The Brazilian manufacturer's revenues from this division were down 23%.

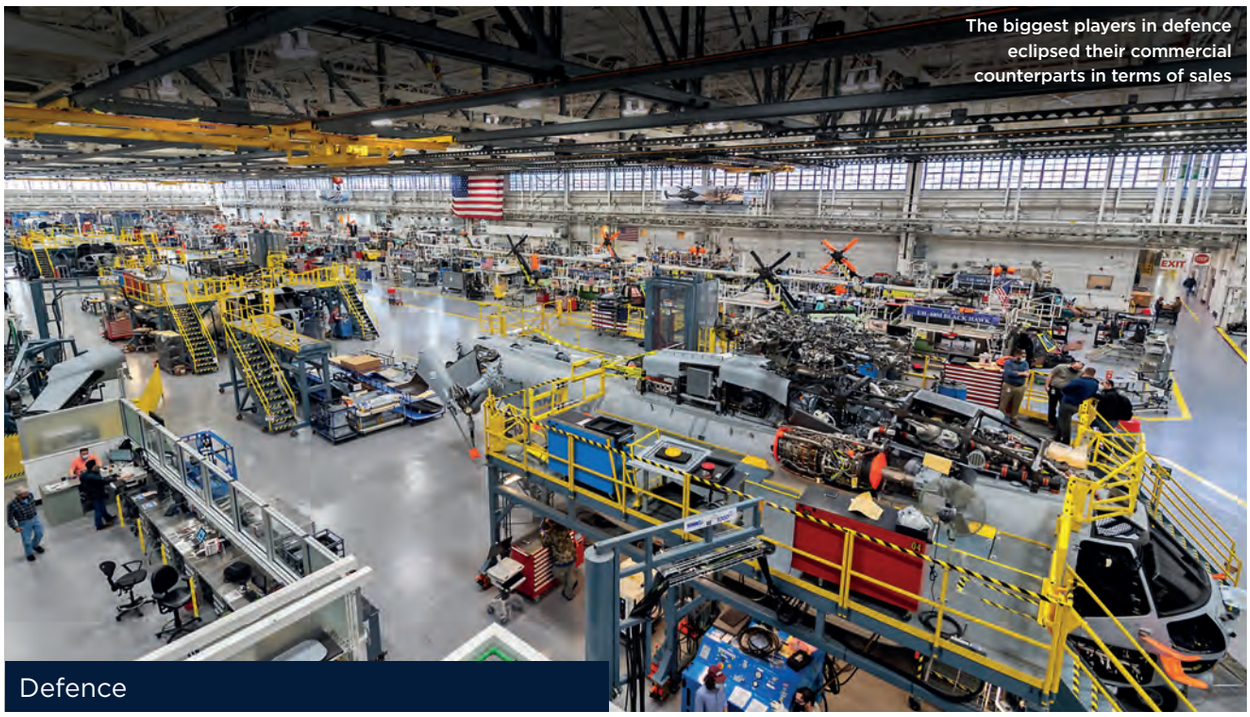
-27.9%

Year-on-year revenue decrease recorded by the smallest 20 Top 100 businesses

Top 10 Commercial aircraft sales

Rank	Company name Type	2020 sales $ millions	Sales growth
1	Airbus	39,054	-37.5%
2	Boeing	16,162	-49.9%
3	Gulfstream	8,075	-17.6%
4	Bombardier (business aviation)	5,593	3.2%
5	Textron Aviation**	3,974	-23.4%
6	Dassault Aviation	2,538	1.5%
7	Embraer (regional)	1,114	-50.1%
8	Embraer (business aviation)	1,072	-23.3%
9	ATR	454	-72.3%
10	Bombardier* (regional)	314	-74.4%

* On 1 June, 2020, Bombardier completed the sale of the CRJ regional jet programme to Mitsubishi Heavy Industries **Including military sales



The biggest players in defence eclipsed their commercial counterparts in terms of sales

Lockheed Martin

Defence

All guns blazing

Further evidence of how far behind the defence aviation market commercial aviation fell during the worst of the Covid-19 crisis comes from the sales totals of the biggest 10 players in each segment.

The largest defence businesses made almost two-and-a-half times the revenues of their commercial counterparts (for companies with activities in both defence and commercial, such as Airbus, Boeing and Leonardo, we have split their total revenues accordingly).

Five of the 10 companies in our list recorded double-digit, or close to double-digit, growth from defence sales in 2020, although Raytheon Technologies' 43.9% jump is distorted by military revenues from Collins Aerospace and Pratt & Whitney. The merger with United Technologies has added products from military engines to avionics and ejection seats to the Raytheon portfolio.

As it does the main ranking this year, Lockheed Martin tops the league of defence specialists, with sales of just under $65 billion in 2020 – ahead of Raytheon Technologies, pushing traditional number two Northrop Grumman into third. However, Northrop still recorded an impressive 8.7% sales growth for the year.

Others that enjoyed strong growth in 2020 were BAE Systems, in fifth, and 10th-placed Honeywell. The two commercial aviation giants also had disappointing years in terms of expanding their defence activities, with Airbus falling more than 9% from its 2020 total, and Boeing virtually standing still.

In fifth place, and in the Top 10 list of military manufacturers for the first time, Russia's enlarged Rostec has become an even more powerful entity in the global defence market, although its consolidated revenues fell just over 5% year-on-year.

58

Number of companies posting revenue for 2020 in excess of $1 billion (there were 66 in 2019)

Top 10 Defence sales

Rank	Company name	Defence sales $ millions	Defence sales growth
1	Lockheed Martin	64,854	10%
2	Raytheon Technologies*	41,990	43.9%
3	Northrop Grumman	36,799	8.7%
4	Boeing	26,257	0.6%
5	Rostec State Corporation	23,377	-5.2%
6	L3Harris	17,284	0.5%
7	BAE Systems	13,846	10.8%
8	Airbus	11,698	-9.1%
9	Leonardo	11,162	6.3%
10	Honeywell	5,826	9.4%

* The merger with UTC was a significant driver of this increase

Top 100 aerospace companies by revenue 2020 ($ millions)

		Movement in ranking from 2019	Sales (revenue) 2020	Sales (revenue) 2019	Operating profit 2020	Operating profit 2019	Operating margin 2020	Operating margin 2019
1	Lockheed Martin	+2	65,398	59,812	8,644	8,545	13.2%	14.3%
2	Raytheon Technologies	+5	64,600	29,176	n/a	4,538	0%	15.6%
3	Boeing	-1	58,158	76,559	-12,767	-1,975	-22%	-2.6%
4	Airbus	-3	55,892	83,111	-571.1	1,579	-1%	1.9%
5	Northrop Grumman	-	36,799	33,841	4,065	3,969	11%	11.7%
6	Rostec State Corporation	+14	25,974	27,387	n/a	n/a	n/a	n/a
7	General Electric (GE Aviation)	-1	22,042	32,875	1,229	6,812	5.6%	20.7%
8	Safran	-	18,812	27,592	1,391.1	4,292.3	7.4%	15.6%
9	L3Harris	-	18,194	18,097	1,175	1,785	6.5%	9.9%
10	Leonardo	+1	15,291	15,436	563.3	1,112	3.7%	7.2%
11	BAE Systems	+2	14,729	13,338	n/a	n/a	n/a	n/a
12	Rolls-Royce	-2	11,759	15,680	-2,641.8	727	-22.5%	4.6%
13	Honeywell	-1	11,544	14,054	2,904	3,607	25.2%	25.7%
14	Textron Aviation	+1	8,596	9,766	630	1,025	7.3%	10.5%
15	General Dynamics (Aerospace)	-1	8,075	9,801	1,083	1,532	13.4%	15.6%
16	Mitsubishi	+6	6,579	6,466	-888.3	-1,914.5	-13.5%	-29.6%
17	Bombardier	+1	6,488	7,501	937	1,194	14.4%	15.9%
18	Dassault Aviation	-2	6,259	8,221	297.6	856.7	4.8%	10.4%
19	AVIC	+11	6,111	6,018	270.6	249	4.4%	4.1%
20	TransDigm	+6	5,103	5,223	1,751	1,926	34.3%	36.9%
21	Thales	+3	4,808	6,266	-86.9	583.2	-1.8%	9.3%
22	MTU Aero Engines	+5	4,535	4,779	298.7	790.6	6.6%	16.5%
23	Hanwha Aerospace	+8	4,513	4,516	206.9	141.7	4.6%	3.1%
24	Israel Aerospace Industries	+9	4,184	4,108	195.0	121.0	4.7%	2.9%
25	Precision Castparts	-6	4,132	7,210	n/a	n/a	n/a	n/a
26	Embraer	-1	3,771	5,463	-323.4	-77.0	-8.6%	-1.4%
27	Howmet Aerospace	(New)	3,613	5,075	n/a	n/a	n/a	n/a
28	GKN Aerospace	-	3,592	4,893	-526.3	132.7	-14.7%	2.7%
29	Kawasaki	-	3,539	4,885	-296.1	391.7	-8.4%	8%
30	Spirit AeroSystems	-13	3,405	7,863	-812.8	760.8	-23.9%	9.7%
31	Hindustan Aeronautics	+3	3,119	3,089	576.1	542.5	18.5%	17.6%
32	Parker Hannifin	+7	2,527	2,696	410.8	500.5	16.3%	18.6%
33	Korea Aerospace Industries	+3	2,396	2,668	118.3	236.4	4.9%	8.9%
34	Saab	+7	2,359	2,299	77.8	240.2	3.3%	10.5%
35	IHI	-3	2,292	3,392	-379.2	191	-16.5%	5.6%
36	Eaton	+10	2,223	2,480	414	595	18.6%	24%
37	Aerojet Rocketdyne	+12	2,073	1,982	240.6	238.2	11.6%	12%
38	Sierra Nevada Corporation	+9	1,990	1,990	n/a	n/a	n/a	n/a
39	Moog	+9	1,976	1,986	137	212	6.9%	10.7%
40	ST Engineering	-2	1,969	2,533	144	230.4	7.3%	9.1%
41	CAE	-4	1,961	2,637	16.4	435.6	0.8%	16.5%
42	Triumph Group	-7	1,870	2,900	-326.2	57.9	-17.4%	2%
43	Ball Aerospace	+14	1,741	1,479	153	140	8.8%	9.5%
44	Meggitt	-4	1,732	2,370	190.1	445	11%	18.8%
45	Cobham	+8	1,698	1,595	n/a	225.5	n/a	14.1%
46	Elbit Systems	+10	1,650	1,617	n/a	n/a	n/a	n/a
47	Woodward	+3	1,591	1,881	310.1	389.1	19.5%	20.7%
48	Heico	+4	1,519	1,792	n/a	n/a	n/a	n/a
49	Turkish Aerospace Industries	-7	1,504	2,267	n/a	n/a	n/a	n/a
50	PPG Aerospace	+1	1,409	1,807	n/a	n/a	n/a	n/a

Top 100 aerospace companies by revenue 2020 ($ millions)

		Movement in ranking from 2019	Sales (revenue) 2020	Sales (revenue) 2019	Operating profit 2020	Operating profit 2019	Operating margin 2020	Operating margin 2019
51	ATI (Allegheny Technologies)	-7	1,360	2,130	n/a	n/a	n/a	n/a
52	Amphenol	+7	1,290	1,234	n/a	n/a	n/a	n/a
53	Hexcel	-8	1,277	2,049	n/a	n/a	n/a	n/a
54	Pilatus	+6	1,188	1,177	165.1	153.9	13.9%	13.1%
55	Liebherr	-1	1,168	1,669	n/a	n/a	n/a	n/a
56	Teledyne Technologies	+9	1,006	1,066	130.9	179.9	13%	16.9%
57	Daher	+6	1,003	1,075	n/a	n/a	n/a	n/a
58	Diehl Aviation	-3	1,003	1,666	n/a	n/a	n/a	n/a
59	Panasonic Avionics	-16	956	2,240	n/a	n/a	n/a	n/a
60	Kongsberg	+13	903	852	122.9	85.4	13.6%	10%
61	Ametek	(New)	854	956	n/a	n/a	n/a	n/a
62	Subaru	-4	822	1,304	-91.9	46.5	-11.2%	3.6%
63	Arconic	-40	820	1,307	n/a	n/a	n/a	n/a
64	Mercury Systems	(New)	792	655	91.1	76.6	11.5%	11.7%
65	Curtiss-Wright	+9	789	850	n/a	n/a	n/a	n/a
66	LISI	-4	756	1,116	43.1	138.4	5.7%	12.4%
67	Maxar Technologies Space Systems	-3	721	1,073	-3	6	-0.4%	0.6%
68	AIDC	-	714	923	5.8	79	0.8%	8.6%
69	RUAG	+1	703	887	-229	-61.4	-32.6%	-6.9%
70	Senior	-4	675	1,059	7.6	96.8	1.1%	9.1%
71	Crane Aerospace and Electronics	+6	651	799	100.7	189.4	15.5%	23.7%
72	Kaman	+10	650	687	n/a	n/a	n/a	n/a
73	Constellium	-6	639	966	n/a	n/a	n/a	n/a
74	Garmin	+9	623	735	137.2	252.9	22%	34.4%
75	FACC	-6	601	897	32.2	-30	5.4%	-3.3%
76	Ducommun	+9	591	671	n/a	n/a	n/a	n/a
77	Aernnova	-1	586	798	-36.5	105.8	-6.2%	13.3%
78	Sonaca	-6	579	875	n/a	n/a	n/a	n/a
79	Hutchinson	+8	563	605	n/a	n/a	n/a	n/a
80	Magellan Aerospace	-	555	766	14	67.5	2.5%	8.8%
81	Chromalloy	-10	532	886	n/a	n/a	n/a	n/a
82	Solvay Group	-21	511	1,147	n/a	n/a	n/a	n/a
83	Astronics	-2	499	763	n/a	n/a	n/a	n/a
84	Korean Air	+2	479	635	-10.9	33	-2.3%	5.2%
85	SKF	+4	475	586	n/a	n/a	n/a	n/a
86	Kaiser Aluminum	-2	473	707	n/a	n/a	n/a	n/a
87	Latecoere	-9	471	799	-197	-10.8	-41.8%	-1.3%
88	Heroux-Devtek	+6	426	462	25.4	-22.7	6%	-4.9%
89	JAMCO	-14	414	772	-113	5.6	-27.3%	0.7%
90	Nordam Group	-2	414	575	n/a	n/a	n/a	n/a
91	Aciturri	+9	405	672	n/a	n/a	n/a	n/a
92	Longview Aviation Capital	-2	393	585	n/a	n/a	n/a	n/a
93	Hensoldt	(New)	377	412	n/a	n/a	n/a	n/a
94	Aubert & Duval (Eramet)	-2	356	539	n/a	n/a	n/a	n/a
95	Barnes Aerospace	-4	354	553	56.8	122.5	16%	22.2%
96	Recaro Aircraft Seating	-17	336	773	n/a	n/a	n/a	n/a
97	Albany Engineered Composites	-2	328	453	31.5	55.5	9.6%	12.3%
98	Martin-Baker	+5	302	286	58.3	56.5	19.3%	19.7%
99	ITT	-1	291	418	n/a	n/a	n/a	n/a
100	Qinetiq	-1	289	281	n/a	n/a	n/a	n/a

Top 100 companies by name

Company	Ranking	Company	Ranking
Aciturri	91	Kaman	72
Aernnova	77	Kawasaki	29
Aerojet Rocketdyne	37	Kongsberg	60
AIDC	68	Korea Aerospace Industries	33
Airbus	4	Korean Air	84
Albany Engineered Composites	97	L3Harris	9
Ametek	61	Latecoere	87
Amphenol	52	Leonardo	10
Arconic	63	Liebherr	55
Astronics	83	LISI	66
ATI (Allegheny Technologies)	51	Lockheed Martin	1
Aubert & Duval (Eramet)	94	Longview Aviation Capital	92
AVIC	19	Magellan Aerospace	80
BAE Systems	11	Martin-Baker	98
Ball Aerospace	43	Maxar Technologies Space Systems	67
Barnes Aerospace	95	Meggitt	44
Boeing	3	Mercury Systems	64
Bombardier	17	Mitsubishi	16
CAE	41	Moog	39
Chromalloy	81	MTU Aero Engines	22
Cobham	45	Nordam Group	90
Constellium	73	Northrop Grumman	5
Crane Aerospace and Electronics	71	Panasonic Avionics	59
Curtiss-Wright	65	Parker Hannifin	32
Daher	57	Pilatus	54
Dassault Aviation	18	PPG Aerospace	50
Diehl Aviation	58	Precision Castparts	25
Ducommun	76	Qinetiq	100
Eaton	36	Raytheon Technologies	2
Elbit Systems	46	Recaro Aircraft Seating	96
Embraer	26	Rolls-Royce	12
FACC	75	Rostec State Corporation	6
Garmin	74	RUAG	69
General Dynamics (Aerospace)	15	Saab	34
General Electric (GE Aviation)	7	Safran	8
GKN Aerospace	28	Senior	70
Hanwha Aerospace	23	Sierra Nevada Corporation	38
Heico	48	SKF	85
Hensoldt	93	Solvay Group	82
Heroux-Devtek	88	Sonaca	78
Hexcel	53	Spirit AeroSystems	30
Hindustan Aeronautics	31	ST Engineering	40
Honeywell	13	Subaru	62
Howmet Aerospace	27	Teledyne Technologies	56
Hutchinson	79	Textron	14
IHI	35	Thales	21
Israel Aerospace Industries	24	TransDigm	20
ITT	99	Triumph Group	42
JAMCO	89	Turkish Aerospace Industries	49
Kaiser Aluminum	86	Woodward	47

Egypt ordered 30 Dassault Rafales in May, adding to 24 purchased in 2015

Dassault Aviation

Explanatory notes

The information used in preparing this report has been obtained solely from company annual reports, public filings, and other publicly available information.

Companies have been ranked for their financial year 2020 or 2020-2021. As far as possible we have sought to obtain representative figures for aerospace turnover. Companies involved predominantly in aviation services, finance and MRO have been excluded. Sectors involved with aero engines, aerostructures, aircraft, avionics, missiles and space are largely straightforward, but network-centric, telecommunications and C4IS (command, control, communications, computers and intelligence systems), as well as some overhaul operations have been included only when these are largely concerned with aerospace activities.

Satellite services have been excluded whenever possible, as have businesses that derive more than half their revenues from services such as leasing. Joint ventures have been included in the financials. Intersegment sales have been excluded from operating results and profits where possible. Where not possible, divisional sales have been presented inclusive of interdivision sales, which may result in aerospace revenues greater than group sales.

Generally, the profit (or loss) is before interest, tax and exceptional items and after deduction of depreciation. Discontinued or discontinuing operations have been included where they fall in fiscal year 2020 for that business.

Average dollar exchange rates for calendar years 2020 and 2019 have been used for all non-US companies, regardless of fiscal year definitions. The source for the exchange rate information was the US Inland Revenue Service. There was movement in the average dollar exchange rates between 2019 and 2020, but to eliminate exchange rate effects, we have calculated percentage increase in revenues and profit in local currencies.

Some companies have restated their 2019 results. Where this has happened, we have used the restated 2019 results in our analysis.

When looking at all companies, we have revisited our assumptions on what should be included as aerospace sales, and in some cases, we have changed our assumptions. Where we have done this, we have used the same assumptions for both 2019 and 2020.

When showing the movement in ranking, we have compared this year's ranking to the ranking in last year's survey, so ignoring the new entrants had they been in last year's survey and any restating of results.

In some companies that report the proportion of their sales which are aerospace, the aerospace sales are spread across business units, which do business across a number of sectors, of which aerospace is just one. In such cases, it is not possible to give a profit figure which corresponds to aerospace sales.

Six companies in this year's survey do not produce any estimates for their aerospace sales, which are in the public domain. We have included them because they are sizeable and important companies and we have used our industry knowledge, material available in the public domain, and best estimates to arrive at estimated sales figures:

- Chromalloy, a provider of advanced coatings and authorised repairs and parts for gas turbine engines. The operation is part of Sequa Corporation, which is owned by Carlyle.
- Hutchinson, which had total sales of €3.8 billion across all sectors in 2020, and is a subsidiary of the French oil company Total. In aerospace, it is a significant supplier of equipment across airframes, engines and cabin systems, such as insulation.
- Nordam, a private US company, which is a significant supplier of aircraft nacelles, transparencies and business jet interiors.
- PPG Aerospace, part of PPG Industries and a leading supplier of coatings, adhesives and sealants, and transparencies.
- Precision Castparts, a US company that is owned by Berkshire Hathaway.
- Sierra Nevada Corporation, a private US company, which has a range of businesses including space systems, avionics, aircraft modification and support, and cybersecurity.

The Top 100 is compiled on behalf of FlightGlobal by Counterpoint Market Intelligence. Contact richardapps@cpmil.com

Anthony Correia/Shutterstock

Legacy of horror

Everyone whose career goes back to Tuesday 11 September 2001 can remember where they were and what they were doing on that terrible day. Twenty years have passed since the attacks on the Twin Towers at the World Trade Center in New York and the Pentagon in Washington DC by terrorist group al-Qaeda. FlightGlobal reflects on the legacy of 9/11, examining the impacts on aviation security, the airline business, aircraft product strategy and the defence industry

Mark Pilling London

SECURITY

First line of defence

The way passengers are screened before boarding aircraft changed for ever following the terrorist attacks of 2001

Aviation security changed for ever following the terror attacks of 9/11. That is hardly surprising, considering that hijackers took the hitherto unimaginable step of taking control of an airliner, intent on a suicide mission.

Aviation had long been a target for hijackers, with the first dating back to 1948 when a Cathay Pacific Catalina flying boat was taken over by robbers near Zhuhai. The pilot was shot while resisting the attackers, causing the aircraft to crash. This incident, and several others in the 1950s and 1960s, led to airlines advising flight crews to comply with hijacker demands to avoid confrontations.

However, the actions of the 19 terrorists, armed simply with box cutters, who took control of the two United Airlines and two American Airlines airliners, ushered in a swift and radical overhaul of the US and international aviation security system. The rush to action saw a raft of proposals to counter hijackers in flight such as sky marshals, armoured cockpit doors, and giving guns to pilots, all of which happened.

Federal case

But as *Flight International*'s leader column commented in October 2001: "Plans for sky marshals and armoured cockpit doors on airliners miss the point – terrorists must be prevented from getting on board."

Signed into law on 19 November 2001, the US Aviation and Transportation Security Act established the body that would make this happen. A new security behemoth, the Transportation Security Administration (TSA), was created, making airport security the responsibility of the federal government.

The task was enormous, says John Vermilye, who was drafted in by the TSA in 2002 as an executive adviser on the rollout team to overhaul the airport security regime.

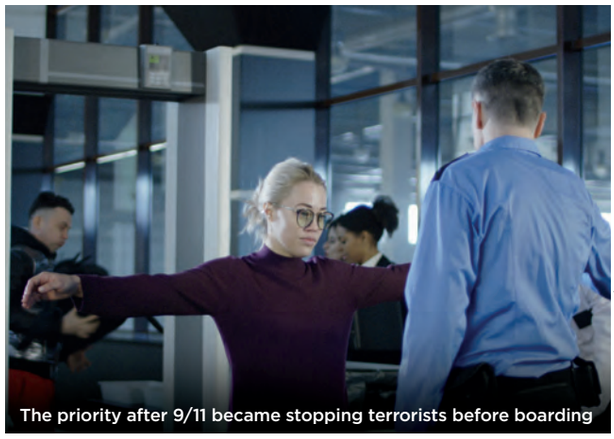
"The act required upgraded checkpoint security, federalising the security workforce, a deadline of 1 January 2003 for the screening of all checked bags and the federal air marshal programme," explains Vermilye, who was a seasoned aviation security executive as manager of corporate baggage services at Eastern Air Lines and as manager of industry baggage standards at IATA.

A "war room"-style office was created in Washington for the 35-strong team, says Vermilye. This unit worked under a $350 million contract awarded by the TSA in June 2002 to a Lockheed Martin-led group of firms. "Everybody knew checkpoints were a weak point. 9/11 taught us that it was not just unaccompanied baggage that was a problem. Checkpoints were a glaring hole and the first one to plug," he explains.

"There were 452 domestic and international airports needing hugely beefed-up screening equipment, new security processes and the redesign of screening areas," says Vermilye. "It was like working in a start-up company. There was an extremely tight, very precise timeline." More than 2,000 consultants and advisers were recruited and trained for deployment to these airports over a period of just a few months to reconfigure screening checkpoints.

Having new detection kit was just one aspect of the new regime; there were hundreds of small and not-so-small items to be worked through. "There was a moment, just weeks before rollout, when I asked about the procedure for opening a locked bag if a suspect object was detected," says Vermilye. More than half of luggage, on average, is locked. Vermilye knew that forcing a bag open was fraught with legal and practical problems, such as repacking and the paperwork needed. "It had the potential to get ugly," he says.

A team was immediately raised and had eight weeks to solve the problem. "In a way, the solution is simple because unlocking the bag is clearly the best



The priority after 9/11 became stopping terrorists before boarding

FrameStock Footages/Shutterstock

"Plans for sky marshals and armoured cockpit doors on airliners miss the point – terrorists must be prevented from getting on board"

Flight International October 2001

way, but just imagine how many keys there are for all the designs of bag. One luggage maker I talked to at the time had 72 different keys for its bags."

In collaboration with the TSA's Security Laboratory in Atlantic City the team designed a key ring with a set of master keys (these would open about half of locked bags), made guidelines on how to use crowbars and clippers to get into locked bags, doing the least damage, and set out procedures on how to reseal opened bags. Vermilye wrote the TSA's ubiquitous "Notice of Baggage Inspection" flier that is inserted into every opened bag. The solution kit was distributed to the 452 airports for use at every checkpoint ahead of the 1 January 2003 implementation deadline.

In 2003, Vermilye founded Travel Sentry after being approached by the Travel Goods Association, which represents luggage makers, to help establish a standards-based system that would permit passengers to lock their bags yet enable the TSA to open them for inspection if needed. This is essentially a super-master-key approval system that is now used in 57 countries and provided by Travel Sentry at no cost.

55,000

The TSA has grown to become one of the world's largest security operators, with a huge workforce

As the anniversary of 9/11 approaches, so too does the 20th anniversary of the organisation founded to prevent similar attacks in the future. The TSA has grown to become one of the world's largest security operators, with a workforce of some 55,000 people and a budget of $8.8 billion in 2021.

Federalising aviation security via the formation of the TSA was controversial and there have been many questions over whether it was the right move. But the strongest possible response from the US government to attacks on home soil that killed nearly 3,000 people was inevitable. Before 9/11, airport security in the USA was the responsibility of airlines.

"In hindsight, airlines did a terrible job in providing airport security," says Robert Aaronson, who was director general of Airports Council International from 2002 to 2008 and is now chairman of airport operator Propeller Airports. "Everyone underestimated the threat and the airlines bought the cheapest security they could find."

However, Aaronson is not alone in believing the TSA was not necessarily the right answer. "The US government overreacted by creating the TSA. It should have created and prepared itself to aggressively enforce a detailed regulatory regime for security and turned responsibility over to the airports working with the airlines. Having said that, the response from governments and industry to 9/11 globally clearly has been successful."

Whether or not it was the right answer, the TSA is probably here to stay, playing a role not only domestically but in helping many countries around the globe with their aviation security.

AIRLINES

Decade of disruption

The 10 years following the terror attacks were challenging, but the period did usher in a new breed of low-cost airline and different ways of doing business

In the decade following the terror attacks, the airline business was a sorry story when it came to making money. Giovanni Bisignani, the plain-speaking Italian who led the International Air Transport Association for a decade from 2002, said in his annual report of 2010 that the industry had lost nearly $50 billion in that decade.

Less than two years after the 9/11 attacks, Bisignani told airline bosses at the IATA annual meeting in June 2003: "Our industry has been hit by the Four Horsemen of the Apocalypse. The successive impact of September 11, a world economic slowdown, Iraq and SARS has been devastating. Our industry was like the boxer who gets hit harder after every knockdown."

In the early 2000s, this was described as a crisis – but however shocking those losses were, the word crisis does not even come close to describing how bad the past 18 months have been. In 2020, IATA estimates, the industry lost $126.4 billion, with a further loss of $47.7 billion expected this year.

Intense restructuring

"9/11 was one of a number of catalysts that drove industry restructuring at the time, but it did not change the ultimate direction of the business. And this is exactly what Covid will do – it will speed up an evolutionary process that has already been taking place," believes Mark Dunkerley, who had taken the chief commercial officer role at Belgium's Sabena just weeks before 9/11 and joined Hawaiian Airlines as president in 2002.

The 2000s was a period of intense airline restructuring, particularly in the USA. But there is some irony in the fact that government financial support and Chapter 11 bankruptcy processes that many US carriers entered slowed change.

"The weakest did not fade away. They restructured and came back stronger," says Dunkerley. "The impact of not letting market forces play out is like taking a bandage off slowly; it prolonged the pain."

Swissair was an early casualty of the post-9/11 crisis

AirTeamImages

There were failures in this decade, of course. Famous names such as Ansett Australia, Air Afrique, Sabena, Swissair, Transbrasil, and TWA went away.

However, just as now, there were upstarts and disruptors ready to take advantage. As *Flight International*'s sister title *Airline Business* wrote in September 2002: "While others have suffered, the crisis has provided a springboard for the new breed of low-fare operators, with JetBlue as its poster child." In Europe, Ryanair, Go and EasyJet were making waves, with WestJet in Canada and Virgin Blue in Australia growing fast too.

For Jeff Katz, a digital air travel services pioneer, who was chief executive of Swissair from 1997 to 2000 and on the board of Northwest Airlines from 2005 to 2009, airline consolidation that was triggered by the financial shock was the single biggest impact of 9/11 in the years that followed.

The biggest saw the merger of America West and US Airways in 2005, the joining of Delta Air Lines and Northwest in 2008 and the union of Continental and United in 2010.

"Europe did different versions of consolidation, with Air France-KLM, British Airways-Iberia and the formation of the Lufthansa Group; but overall, whether in the US or Europe, they have been good for airlines," says Katz. "In the US, you now have four very powerful airlines that dominate networks. Europe is a little softer, but the by-product of carefully managing capacity has happened."

Another major development in the immediate post-9/11 period was the rise of the internet to sell air tickets and travel and the acceleration of digital technology, says Katz. In June 2002, he was the chief executive of new global online travel business Orbitz Worldwide, set up by the US majors in response to the rise of online travel agencies such as Expedia and Travelocity. "Orbitz took off as online access to life became essential rather than a nice to have. Its website was much better designed than those of the airlines," says Katz.

The European carriers founded their own online travel agency, Opodo, which was launched in November 2001 by Bisignani before he joined IATA. In this decade the online booking of travel increasingly became the norm. It was also a time when IATA brought in electronic ticketing to automate several outdated processes and save money.

Change needed

For Dunkerley, who retired as chief executive of Hawaiian in 2018, one of the lessons of 9/11, and the series of shocks that followed during that decade – including SARS, Hurricane Katrina, oil prices spiking to $140 a barrel and the global financial crisis of 2008 – was that industry change had not gone far enough. "What was revealing about that decade was how the impact of each major shock showed that restructuring wasn't yet done," he says. "The industry still was not working well. It was still not producing sensible returns in good times or demonstrating resilience in bad."

Following the big US mergers – and with capacity discipline the order of the day, rather than the chase of market share – the 2010-2020 decade did usher in a period of unprecedented profitability for the US carriers and for airlines globally.

The impact of Covid has undone virtually all that progress. However, the airline industry is a resilient business, driven by the strong underlying demand for air travel. The actors delivering that service will change, and – just as after 9/11 – there will be consolidation among the strongest, and low-cost carriers will flourish.

$47.7bn

Industry losses expected in 2021, according to IATA, following estimated losses of $126.4 billion in 2020

AIRCRAFT

Reshaping how we fly

Boeing

The Sonic Cruiser fell out of favour before it even reached the market

The industry crisis that followed 2001 spelled the beginning of the end for super-large widebodies, and ushered in hyper-efficient twins

The decade after the 9/11 attacks was a defining one for commercial aircraft strategy, ushering in today's hyper-efficient widebody twins, stalling demand for the largest widebodies, setting the stage for the new generation of narrowbodies, and spelling the end of the fast jetliners.

In the eyes of most commentators, the strategic bets made by Airbus and Boeing in the years after 9/11 would have been broadly similar had the terror attacks never happened, driven as always by the normal rise and fall of the economic cycle.

"In the couple of years running up to 9/11 it was a typical cycle," says Randy Tinseth, who retired as Boeing Commercial Airplanes vice-president commercial marketing in March 2020. At the end of the 1990s, airlines were doing relatively well. "In the 1998-2000 period in the USA, you saw some hefty airline union contracts being signed as the airlines were making a bit of money," explains Tinseth.

A hike in labour costs was a common sign the market was about to overheat and financial performance would suffer. "The market was starting to turn. The dot.com bubble had burst, and economies were starting to slow," says Tinseth.

The shock of the 9/11 attacks, and the knock-on effect on demand, was unsurprisingly felt most acutely in the USA, although it did not really affect the fundamentals of supply and demand elsewhere around the globe, says Dick Forsberg, a senior external consultant at PwC and former head of strategy at lessor Avolon. "But it did trigger a massive restructuring of the domestic US airline industry, forcing carriers into a rethink of their business models," he adds.

The financial strife of the major US carriers throughout most of the 2000s helps to explain a fundamental shift in production at Boeing and Airbus as the decade unwound. In 2000, Boeing was easily number one, well ahead of its European rival, with 489 deliveries of all types compared with 311 at Airbus (*see table below*).

By 2003, the balance of power had changed. Airbus built 305 jets; the US aircraft maker built just 281. Boeing's dominance was over. Part of the explanation is down to the type of customer that each manufacturer had on its orderbook, says Tinseth. "At that time, Boeing had much more of a backlog concentration from North American airlines, while Airbus was stronger with lessors. There was a change in dynamic in the market right there, with Boeing taking a bigger hit," he explains, as US carriers slashed orders.

Balancing act

While both manufacturers moved quickly to cut production post-9/11, Boeing cut harder. A side-effect of this period is that Boeing became less reliant on its traditional US carrier customer base. "It moved the dial. If you looked at Boeing's backlog, it certainly became better balanced," explains Tinseth.

In terms of its product line, for Boeing the biggest impact of 9/11 was undoubtedly the axing of the Sonic Cruiser concept and the launch of the 787 Dreamliner. The Sonic Cruiser was a near Mach 1, 200-250-seater designed to fly 15-20% faster than conventional airliners.

Tinseth was a member of teams talking with customers about the Sonic Cruiser before and after 9/11, but customers were sceptical. "After 9/11 our customers were only looking to cut costs and pushed Boeing towards the Dreamliner. It had also become technically harder to do. Speed was important, but to get that speed you gave up fuel efficiency," he says.

Airlines wanted Boeing to plough its efforts into building a super-efficient widebody. For its part, Boeing saw that as the industry deregulated and air travel became more competitive, airlines would require smaller aircraft for point-to-point routes. It ended the Sonic Cruiser project in December 2002

Airbus and Boeing annual deliveries

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2019
Airbus	294	311	325	303	305	320	378	434	453	483	498	510	635	863
Boeing	620	489	527	381	281	285	290	398	441	375	481	462	762	380

Source: OEMs. Compiled by Max Kingsley-Jones of Ascend by Cirium

UAVs

When unmanned came of age

One lasting effect of the 2001 attacks has been to elevate UAVs from niche defence tools into mainstream vehicles in modern military operations

The arrival of the unmanned air vehicle (UAV) as a potent battleground tool is arguably the most notable legacy of the 9/11 terror attacks for aerial warfare. "While the UAV had been around for a long time, Afghanistan especially, and Iraq to a lesser extent, provided the development impetus to take them out of a niche capacity to what is now seen as an essential element of credible military capability," according to Doug Barrie, senior fellow for military aerospace at independent defence think tank the International Institute for Strategic Studies.

From the onset of the US-led coalition invasion of Afghanistan on 7 October 2001, UAVs were deployed, initially for intelligence gathering and reconnaissance, but swiftly moved into use as platforms for attacking ground targets. The black-and-white crosshair images taken from General Atomics Aeronautical Systems MQ-1 Predator UAVs, tracking a Hellfire missile as it zeroed in on an insurgency target, became an enduring image of the war.

The success of armed UAVs during these conflicts did have consequences for their global proliferation and bolstered and facilitated Chinese ambitions in this field, explains Barrie. "The US has traditionally been restrictive on who it will sell armed UAVs to, with countries such as the UK and France on the approved list. But US export policy in the past blocked sales to various countries in the Middle East and the Gulf, so many turned to China, which has an increasingly large footprint in military UAVs."

While the development of UAVs continues at pace, the focus for air forces has in recent years turned back also to classic fighter aircraft development as the threat changes once again, says Barrie. Before 9/11, as the Cold War thawed, defence spending was on a downward trend. "Obviously 9/11 brought that to a halt, but it was a new type of threat – a non-state actor," he explains.

"With the War on Terror being waged on a counter-insurgency basis, this drove the industrial footprint of air power in a certain direction," he says. Apart from the danger of ground-launched missiles, coalition aircraft operated in permissive airspace where there was no threat from enemy action. "This diverted air forces away from their traditional high-end, peer-to-peer combat capabilities, and there were suggestions in the mid-2000s that there would not be a need for top-end fighter programmes post-Eurofighter Typhoon or post-Lockheed Martin F-35," says Barrie.

UAVs such as the Predator graduated from being niche assets after 9/11

US Air Force

However, deteriorating relations with Russia and the rise of Chinese air power means the threat and therefore the aircraft development cycle has moved from a "permissive air environment to a contested air environment", says Barrie. This has led to a new generation of fighter aircraft development programmes such as the US Next Generation Air Dominance and the UK's Tempest. These seemed a distant prospect in the years soon after 9/11.

and launched the 787 family, then called the 7E7, in January 2003.

While the Sonic Cruiser was subsonic, the economic ripple effects of 9/11 and the crash of Air France flight 4590 in July 2000 did eventually spell the end of service of the supersonic marvel that was Concorde. It was simply not economically viable.

The supersonic era was over, but the decade did see widebody twinjets come to the fore. The A350, Airbus's 787 rival, was launched in October 2005. With both types some years off entry to service, the best widebody twinjets at the time, the 767 and the A330, coupled with the 777-300ER, did really well in the marketplace, says Tinseth.

However, both manufacturers were struggling to some extent even before 9/11 with their largest products, the 747-400 and the A380. "An after-effect of 9/11 was that our customers became more risk-averse. We saw some customers we thought we would count on as 747 operators go away," says Tinseth.

"After the initial wave of launch customers, the second wave of customers for the A380 that Airbus expected did not materialise," says Max Kingsley-Jones, senior consultant at Ascend by Cirium. Airlines preferred the flexibility and higher margins offered by the smaller and more efficient twinjet widebodies.

By the end of the decade, the fuel efficiency mantra was translated to the narrowbody with the launch of the A320neo in 2010. Boeing followed with the 737 Max programme in 2011.

The product strategies of the OEMs that we see today were in train. Out are the largest widebodies. In are strong families of efficient airliners, whether 150-200-seat narrowbodies or widebody twinjets. Speed is ditched for fuel efficiency coupled with the theme of sustainability. It is difficult to see what will disrupt this new orthodoxy two decades after 9/11, as airlines seek to regain their financial feet after the crushing impact of the pandemic and put in place plans to achieve net-zero carbon emissions by 2050.

The past 18 months have been miserable for the interiors industry. But with traffic and airline orders beginning to pick up, can the sector look towards 2022 with a degree of confidence?

Equipped for recovery

Murdo Morrison London

As with much of the supply chain, Covid-19 has dealt a double blow to cabin suppliers. The collapse in new airliner deliveries from March 2020 hit assembly-line demand for equipment such as seats, galleys, lighting, overhead lockers, and in-flight entertainment equipment. At the same time, the grounding or under-use of thousands of aircraft has also meant the loss of vital maintenance, retrofit and replacement revenue.

In the years before the pandemic, the interiors sector had been flying high, as soaring narrowbody orders plans saw existing suppliers boost capacity, and start-ups swarmed into the market. Meanwhile, in long-haul, intense competition between airlines for the highest-yielding customers resulted in a booming market for self-contained "suites" and other exclusive premium cabin features that provided carriers with a point of difference over their rivals.

Despite the 737 Max crisis at Boeing, Hamburg's annual Aircraft Interiors Expo (AIX) in March 2020 was set to be one of the busiest ever. But as the pandemic exploded, AIX was cancelled, along with its sister event for the passenger experience market, WTCE. This year's convention was postponed for five months, and then replaced with a virtual event from 14-16 September. The show itself will not now take place until next June – a gap of 38 months from AIX 2019.

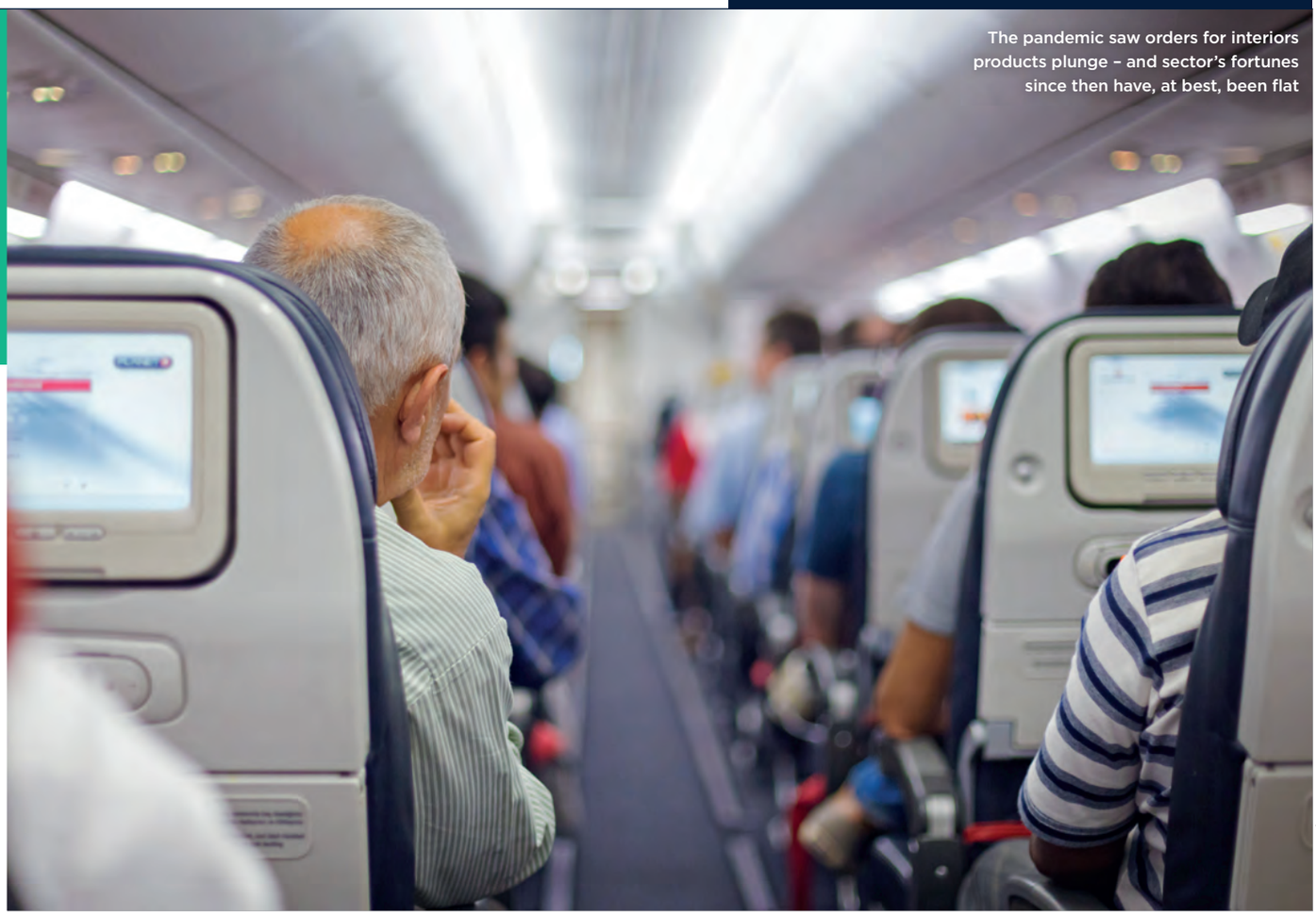
So after a bleak year and a half, do interiors specialists anticipate a pick-up between now and Hamburg 2022 – or fear more months, or years, of misery?

Traffic recovery has been patchy, with the US domestic market rebounding to 2019 numbers this year before the Delta variant put the brakes on. While Europe has seen a bounce-back in short-haul, strict border controls mean long-haul is still in the doldrums. And a resumption of normal service in the Asia-Pacific seems a distant prospect.

Despite the crisis, Recaro, the biggest pure-play seating manufacturer, has continued to bet on the future with a €50 million ($58 million) research and development centre at its Schwaebisch Hall site in southwest Germany, which opens in September. However,

BillyPix

Recaro's chief executive Mark Hiller is optimistic about future prospects



The pandemic saw orders for interiors products plunge – and sector's fortunes since then have, at best, been flat

Matej Kastelic/Shutterstock

chief executive Mark Hiller says it is "very challenging to do proper planning" because of the ever-changing nature of the virus and government responses to it.

After seeing a roughly 60% sales decline in 2020, Hiller says Recaro's revenues will remain "bottomed out" this year, although he is "very positive" about a recovery. "At the beginning [of the pandemic], there were questions about whether air travel would ever come back," he remarks. "Now most people are desperate to travel, and I think you can see this with the US domestic market, where it has already returned to 2019 levels."

Disciplined growth

He is expecting a return to "disciplined growth" for the business next year, and believes that government rules are the main reason people are not travelling. "Right now, the market is suppressed, but I am very much on the optimistic side," he says. "I support the theory that there is a lot of pent-up demand, and when restrictions are lowered or gone, we will be back to a similar growth path to years before."

Although privately-owned Recaro has been investing heavily in its premium offering for several years, its core market remains economy seats, and this has helped protect revenues as the short-haul, leisure segment has been the most resilient through the crisis. "Our share in business class is very low, but our intention is to build from there," says Hiller. "In the current circumstances, I would be concerned if it was the other way round."

Recaro this year won its first seat deal in the regional segment, supplying KLM Cityhopper Embraer E195 E2s. KLM already uses Recaro seats on its main fleet. Hiller believes it is important to be able to "support our customers with a full range", and to continue developing new products as traditional cabin classes morph into new offerings such as premium-economy-plus and single-aisle business class. "There will be more shades of grey," he says. "Seating won't be so black and white."

In nearby Laupheim, Diehl Aviation is shedding around 30% of its close to 6,000 staff globally after the German cabin and aircraft systems specialist was impacted by a drop in orders for and deliveries of Airbus twin-aisles. New chief executive Josef Koecher, who succeeded long-serving Rainer von Borstel on his retirement in April, does not see demand returning soon. "Volumes have fallen drastically, particularly in widebodies, and I think this will remain for the next few years," he says.

However, Koecher does see some upside, with Airbus and Boeing looking to increase A320neo and 737 Max production in the next two years, and some carriers planning to repurpose narrowbodies for longer-haul operations – requiring, in some instances, new-look cabins. "Our production rates are increasing on single-aisle, and we are seeing requests come in from airlines for reshaping interiors, so we could be looking at more upgrade business," he says.

Koecher also believes Diehl must become nimbler and more aggressive in its marketing, combining innovation in new technologies with bundling of its products to deliver broader "customer solutions". Links with providers of complementary services are another option. Diehl in June signed a pact with

US-based HAECO Cabin Solutions, which, as well as being a cabin equipment manufacturer in its own right, also has experience in designing, installing and certificating interior retrofits.

"We have markets, like the US and Asia, and with Boeing operators, where we can do more," says Koecher, who considers the division of the private Diehl industrial group a "global player", but smaller than the giants of the interiors sector like Collins and Safran. This means, he says, that more strategic partnerships might be on the cards as the business looks to broaden its customer base. "With Covid, the portions are smaller, so you need more portions," he remarks of the approach.

He identifies a number of trends that will come to the fore in the post-Covid world. One is touchless technology, particularly with on-board lavatories, as Covid-19 has emphasised the need for personal hygiene. Digitisation will continue to be a driver, with sophisticated cabin management systems allowing passengers more control of their immediate environment. And the quest for sustainability will remain, with cabin equipment manufacturers driven to develop advanced, lighter materials.

Challenging period

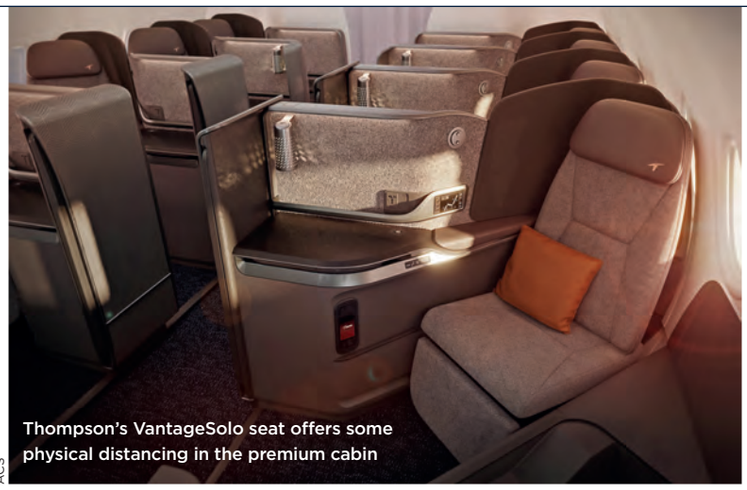
In the UK, another recently-installed chief executive at an established interiors supplier reflects on a period that has been "challenging and revealing, both in its impact and duration". Grant Bennett heads STG in Cwmbran, which makes LED cabin and emergency floorpath lighting. A government furlough scheme and ongoing demand for replacing safety-critical equipment has meant the business has been able to retain 57 of its pre-Covid 72-strong workforce, he says.

With little or no discretionary spending by airlines for upgrading cabins with atmospheric lighting, at the peak of the crisis in mid-2020 STG's revenues dropped to "20% of what we'd typically sell". But, combined with efficiencies, that core turnover allowed it to avoid "burning cash". This year has been "a bit better than we expected" as MRO activity increased ahead of an anticipated pick-up in traffic in the early summer, he says.

STG makes its serious margins from LED lighting, which it offers as a retrofit to airlines to improve the cabin environment. "An LED system on a mature aircraft makes everything look fresher, and the cost, including installation, makes it very worthwhile," says Bennett. "We have seen a lot of interest and even some deliveries. The message we are getting from the large integrators is that they are busy with RFPs [requests for proposals], but not work. There is a lot of 'getting-readyness' going on."

Diehl Aerosystems

Low-touch lavatories could become a post-Covid trend



ACS

Thompson's VantageSolo seat offers some physical distancing in the premium cabin

Like many in the sector, Andres Budo, senior vice-president commercial at AVIC Cabin Systems (ACS) – a Chinese-owned grouping that comprises Austrian interiors manufacturer FACC, UK cabin monuments designer AIM Altitude, and business class specialist Thompson Aero Seating – believes there is "a real appetite from the public to get back to normal and return to flying", but that recovery will take longer for airlines dependent on the long-haul market and premium passengers.

He also believes a market is emerging for "products that increase passenger confidence" in the Covid-19 recovery era. "We have looked at our existing portfolio for adaptations, for example anti-microbial, anti-viral surfaces and touchless features, while at the same time assessing the market to see if there are any areas where new products could help bridge the gap and provide reassurance," he says.

Crew contact

These include Thompson's VantageSolo seat that ACS says aids social distancing in the premium cabin via a "reverse herringbone" configuration that places the passenger's head away from the aisle. AIM's ARCA concept is a boxed-meal system that keeps crew contact with food to a minimum, by enclosing uneaten and used items when the meal is collected. PureCabin is a microbacterial coating that can be applied to surfaces including laminates, leather, and metal.

"What is often most important with any Covid-related products is passenger perception," admits Budo. "One of the keys to recovery lies in creating confidence." He adds: "We are, at heart, an innovative and progressive industry. We are solutions-driven and thrive in a challenging environment. We must take this attribute and use it to our advantage, in a way that benefits our customers and their passengers."

Airline inactivity has meant interiors firms have endured 18 months of misery. But a recovering commercial aviation sector, and revival in aircraft orders, particularly on single-aisles, could lead to a flurry of deals delayed since the pandemic. In addition, changing travel habits might spark new product development, as airlines rethink the post-Covid cabin.

A return to pre-pandemic peaks might be some years off, but the hope is 2022 could breathe life into the interiors market again.

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The pandemic has prompted carriers to think differently about onboard hygiene and service, with the perception air travellers have of the safety of their journey becoming paramount

Clean bill of health

Mark Pilling London

"The pandemic has changed the way airlines look at a safe and healthy travel experience," says Dr Tammy McKnight, who joined Calgary-based WestJet in April as its first-ever full-time chief medical officer (CMO).

"It has taught us that this industry is very much in the business of health."

The Canadian airline, in common with many others, has strong messaging plastered all over its website stressing its commitment – and explanations of the measures it has taken – to protect travellers from Covid-19 throughout their journey.

"From before you depart to after you arrive and at every point in between, we have your well-being at heart and will always put your Safety Above All," says WestJet reassuringly.

Whether it is WestJet's "Safety Above All", Japan Airlines' (JAL's) "FlySafe" or Scoot of Singapore's "Operation Safe Travels" series of measures, the priority for all airlines is to ensure travellers feel safe and confident to return to the air.

During the past 18 months, the pandemic has instigated a revolutionary change to the travel experience – comparable to how airport security was beefed up with intensified passenger screening in the aftermath of the 9/11 terror attacks.

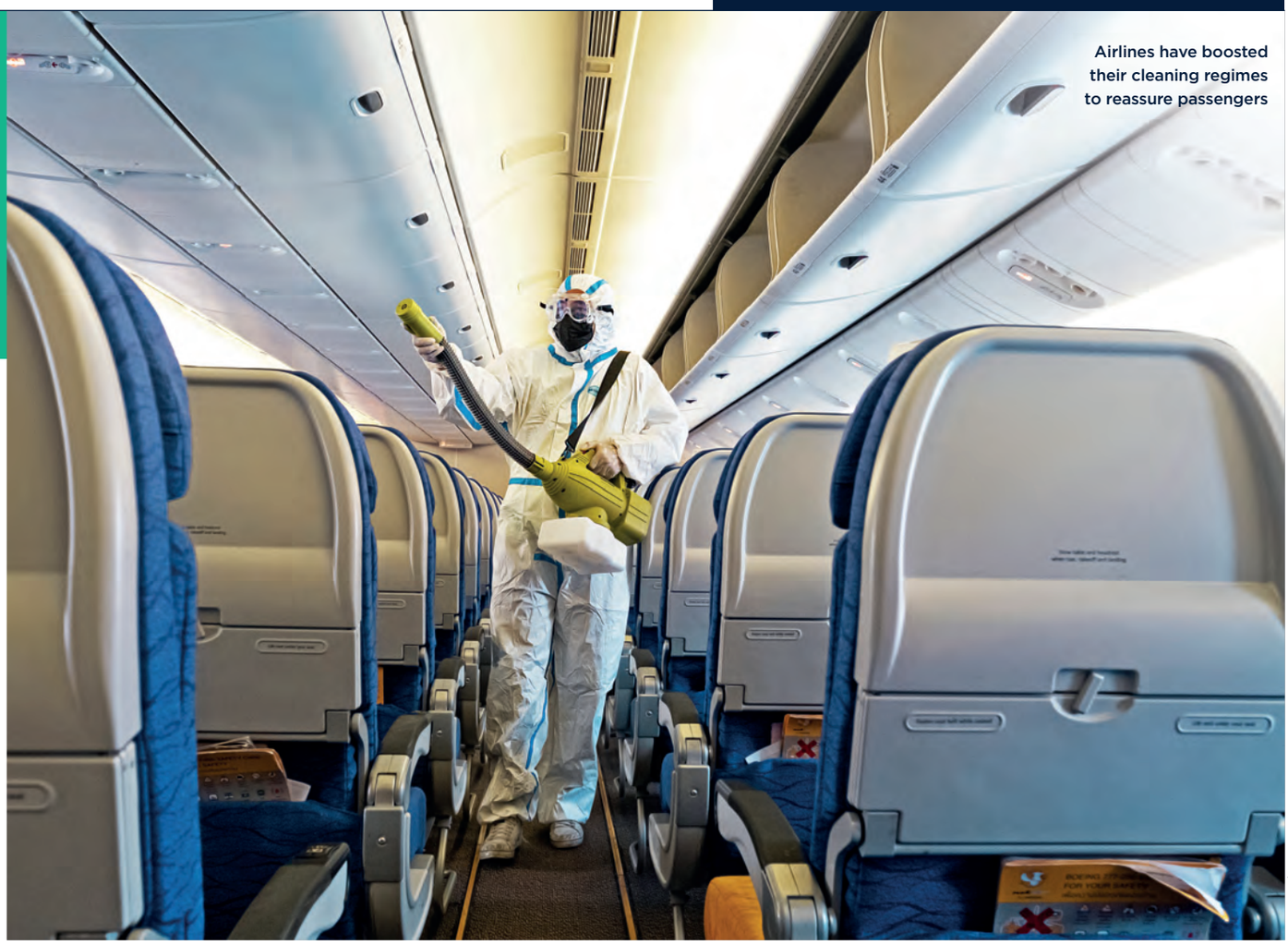
At first glance, the invisible threat of the virus has not changed much about the physical nature of the airline cabin. However, the acute financial impact of the pandemic is causing airlines to adapt their cabins to accommodate fewer business-class passengers, and more leisure and budget-conscious travellers.

But airports are more visibly affected, with greater social distancing and screens at check-in and immigration to separate travellers.

As they return to flying, passengers will discover an experience that feels familiar – but with many new features and procedures brought in to manage the

David Zalubowski/AP/Shutterstock

Queues are an inevitable side-effect of increased hygiene measures



Airlines have boosted their cleaning regimes to reassure passengers

Pradpriew/Shutterstock

new pandemic-affected world of air travel, including many inevitable queues.

Airlines have now largely become used to dealing with Covid-19 since the confusion of March and April 2020. "I think at the beginning it was hard. But eventually it has become more of a process to manage for us. We have adapted and it has become part of our daily existence," says Rossen Dimitrov, chief officer customer experience at Qatar Airways.

As the pandemic spread, travel providers scrambled to work out what virus control measures they should implement. The list grew to include masks, personal protective equipment, social distancing, barriers, handwashing, disinfection and more.

Important lessons

Although nothing had prepared the industry for a pandemic on this scale, it did not come into it cold, with important lessons learned dating back to the SARS coronavirus outbreak in 2003, says Dr David Powell, medical advisor to IATA and a former CMO of Air New Zealand. His job, originally part time, has understandably now become a "pretty much full-time" role providing medical advice to the association and its members on how to respond to Covid-19.

It is common for airlines to have permanent CMOs on their staff, but it is by no means universal. Most of the European majors and the Gulf carriers have had CMOs for years, but others buy in medical services. US carriers, for example, used to have large medical departments but increasingly outsourced this function.

But the pandemic caused something of a change in heart. In February, Delta Air Lines appointed Dr Henry Ting as its first chief health officer. Ting, a world-renowned cardiologist, came from global medical provider Mayo Clinic, which partnered Delta in the early Covid-19 days advising on employee testing, cleanliness strategies and operational tactics to reduce the transmission of the virus.

Whether from in-house or outside medical teams, via material from industry bodies like IATA or rules set out by governments, airlines have been faced with a blizzard of pandemic-related information, often conflicting, inconsistent, and complex.

"Every country has issued different regulations. There has been a great deal of regulatory diversity from the word go," says Powell. After digesting this information overload, it is up to airlines to design a safe cabin environment for customers and crew.

IATA's role in the Covid-19 response from a medical point of view is advisory, not regulatory – it provides an effective forum for information gathering and sharing, to help member carriers with the measures they are putting in place. In addition to its previous experience with outbreaks, IATA has a variety of invaluable assets already in place, says Powell.

The first resource he turned to as the pandemic swept across the world was IATA's Medical Advisory Group, a team of 10 airline medical directors with years of experience in aviation medicine. This group in turn refers to a document called the *IATA Medical Manual*, a 100-page book that "covers many of the

facets of airline administration and operations from the medical perspective". It is basically the A-Z of how an airline should run a medical operation and upon review, IATA's medical experts concluded the manual – and IATA's other online advice – was "pretty much appropriate", says Powell.

With this document as a foundational piece for airlines, one of Powell's main tasks has been co-ordinating and translating guidance and information for IATA members from CAPSCA, the key global aviation health body that most people had never heard of, until now. Established in 2006, CAPSCA – the Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation – is a voluntary, cross-sector programme managed by ICAO with support from the World Health Organisation.

"CAPSCA is designed to respond quickly to events of medical concern in aviation," says Powell. He takes part in weekly CAPSCA meetings, and it is the main global platform creating guidance for aviation and public health.

One of CAPSCA's key recommendations is encouraging states to bring in Public Health Corridors, where two countries agree to mutually recognise their public health mitigation measures to establish travel between them. ICAO has developed an online implementation package, regularly updated with the latest science, to support the roll-out of these corridors.

"It looks at the entire passenger journey, with as many as possible touchless processes at the airport, along with the use of social distancing, mask-wearing, surface cleaning, controlled boarding processes and others," says Powell.

On the ground and in flight, airlines have translated this guidance into their daily service provision, coupled with local rules on traveller vaccination and virus testing. "There is an entire patchwork of different solutions and approaches by countries and airlines," he says.

At JAL, the changes have concentrated on cleanliness and sanitation, the meal service and reducing contact points as much as possible throughout the journey, says Akira Mitsumasu, the carrier's vice-president global customer experience & marketing.

Qatar Airways

Food service is another area where carriers like Qatar Airways are emphasising their cleanliness

Food hygiene

"We have removed all procedures that involve handling any food or drink in an open environment," Mitsumasu says. "All food is either pre-packed or has a lid on it. This might not make any difference [in health safety terms] but it is a huge factor in how passengers view safety."

Lavatory cleaning is a clear focus area. "In our premium cabins they are cleaned after every use. It is a lot of extra work, and we also have to do it very quickly," says Mitsumasu.

JAL also went live in July with contactless facial recognition systems at check-in, security and boarding for international services at Tokyo's Haneda and Narita airports.

The first issue any transport provider must address is virus transmission. With Covid-19 the spread is mainly caused by breathing in air when close to an

IATA

Auditing airlines' health safety standards

To demonstrate the comprehensive nature of the Covid-19 protective measures they are taking, many carriers have turned to independent bodies to audit their processes and procedures. The Airline Passenger Experience Association – known as APEX – has teamed with global airline marketing consultancy SimpliFlying to create the APEX Health Safety powered by SimpliFlying rating.

"As more travellers return to the skies, APEX wants customers to know the verified steps being taken by airlines worldwide for their well-being," says Dr Joe Leader, chief executive of APEX. It is a free and extensive online process, with airlines awarded a tier status of Gold, Platinum or Diamond after evaluation by the SimpliFlying team, says Shashank Nigam, chief executive of SimpliFlying.

A total of 25 carriers have been audited so far, with another 15 in the pipeline. Airlines place the APEX Health Safety badge on their website to create awareness of their achievement.

The well-known airlines rating service Skytrax launched its Covid-19 Airline Safety Rating in March 2020 and finished its first assessment in July, says Edward Plaisted, chief executive, who has made about 40 flights, flying as much as he could during the pandemic. "We pursued Covid-19 ratings because we wanted to have a system based on real-time, physical inspections," he says. One of its main on-site tests is swabbing to check the cleanliness of the cabin. Seat belt buckles are common infection hotspots.

Prior to Covid, Skytrax had about 40 staff performing its rating work. That has fallen to 20 at present but will grow as travel restrictions are relaxed, says Plaisted.

"The most common question I get from airlines is 'how do I get a five-star rating?'," says Plaisted. "But it is somewhat intangible. There is no one item. It is a combination of how effective, consistent and disciplined all of the standards are at an airline and how well teams manage procedures."

The audits also enable carriers to discover new opportunities to improve, says Nigam. For example, SriLankan Airlines realised – following a question in the APEX-SimpliFlying audit – that turning the aircraft auxiliary power unit off during a turnaround meant the HEPA filters were not fully operational. It changed its operating procedures accordingly.

Dr David Powell advises IATA and its members on Covid-19 measures

infected person who is exhaling small droplets that contain the virus. By design, modern airliners have the upper hand here, as they are equipped with environmental control systems (ECS) that exchange the entire volume of cabin air for clean outside air every two to three minutes.

The ECS also contains High Efficiency Particulate Air (HEPA) filters – which the makers say provide hospital-grade 99.9% filtration efficiency, and effectively remove viruses like Covid-19. Airbus has fitted such filters to all its aircraft manufactured since 1994.

The number of reports of on board transmission is low, based on the number of published cases globally, Powell says. "The risk has proved, as we thought, to be low compared to other indoor spaces. You would expect that with controlled airflow, highly efficient filtration, mask wearing and everyone facing the same way [in their seats]," he says. "This is actually the less difficult of the two main problems to solve."

A much harder problem is the issue of importation, especially with the incubation period of the virus, which is why governments have imposed strict border control measures.

For many months after the outbreak of Covid-19 the concern for passengers was the fear that sitting around them would be someone who could infect them with the virus. "I am seeing a change," says Qatar's Dimitrov, as travellers know their fellow passengers and the cabin crew are likely to be vaccinated. "People are still cautious, but the fear is gone."

Airlines are already discussing what measures will remain as restrictions begin to be lifted. The main questions are which things are the least effective in terms of protection, and which are the most disruptive and difficult. The most important protection is ensuring all passengers do not have Covid-19 in the first place, and the critical tool is the vaccine.

"Now, we are taking the opportunity to discuss with people in technical operations and safety to look at what the best technologies are going forward, especially with sanitisation," says McKnight at WestJet. "Our decisions are always based on the data and evidence."

Mask wearing can be controversial, but Powell believes they will be slow to disappear. "They are a reasonably effective measure, and whilst annoying they are not hugely intrusive, with the exception of disruptive passengers in certain markets."

In time, business-class service will return to food being plated up and delivered by hand, says Dimitrov. However, masks and gloves will remain, as will the increased sanitation measures and the use of contactless technologies. "These items will become part of our new normal," he says.

99.9%

Efficiency of HEPA filters used by environmental control systems of airliners in removing viruses from cabin air

Whether it is onboard equipment, extra cleaning or longer turnaround times, the extra cost of Covid-19 protection measures is steep, but unquantified. The team at JAL has talked a lot about this issue, but there can be no compromises in keeping passengers safe and restoring confidence. "This is our top priority now. Customer service comes first," says Mitsumasu.

"This is not something that will end. The pandemic may end, but once you become conscious of something like hygiene safety it won't go away. You can't undo it," he says.

"At Qatar Airways, we don't meet minimum standards – we exceed them," says Dimitrov. "Some of the measures will become the cost of doing business. But you need to be smart about managing those costs."

This means thinking carefully about how amenity kits are designed, perhaps replacing a comb with a disinfectant. The carrier works closely with its ground handlers, airports, and caterers on managing costs at all points in this new reality, he explains.

What happens next depends on how well the world controls Covid-19. "We are in a transition phase between pandemic and endemic, with different countries at all different points along that journey," says Powell. Over the coming months, we will discover how long this transition will last.

The UK's military branches and industry champions will gather at the tri-service Defence and Security Equipment International (DSEI) event, keen to highlight advances made despite the pandemic

Show of strength

Craig Hoyle London

Taking place in London's Docklands from 14-17 September, the biennial DSEI event marks the first opportunity for the defence industry of the UK and 30 other nations to gather since the emergence and global spread of Covid-19.

For national aerospace champions such as BAE Systems and Rolls-Royce, this year's tri-service show will also be the first such opportunity to highlight their activities since the UK Ministry of Defence (MoD) earlier this year detailed its spending priorities until 2025.

Published in late April, the Command Paper – titled *Defence in a Competitive Age* – outlined major investment plans linked to a key future combat air system (FCAS) project, plus requirements to replace multiple aged aircraft types and increase spending on space-related activities.

Talking points

With the UK Royal Air Force (RAF) planning its largest-ever presence at a DSEI show this year, FCAS will be one of the major talking points. Team Tempest industry partners BAE, R-R and the UK arms of Leonardo and MBDA will all be present, buoyed by the project's recent advance into its concept and assessment phase.

Intended to deliver a new manned fighter, along with supporting elements such as unmanned "loyal wingman" vehicles, new-generation smart weapons and an underpinning "combat cloud" data network to co-ordinate operations, the UK's FCAS is being targeted at operational use from 2035.

The UK's four-year spending plan details more than £2 billion ($2.77 billion) in investments linked to FCAS, with additional commitments to come from partner nations Italy and Sweden. The three partners

UK's Lightning force has conducted first strikes from HMS *Queen Elizabeth*

Crown Copyright

Tempest project has entered its concept and assessment phase

BAE Systems

last year signed a memorandum of understanding to further their collaboration on the project.

On 29 July, Team Tempest was awarded an initial £250 million concept and assessment-phase contract. According to the MoD, this will enable the group to "define and begin to design the future combat air system; mature technologies; invest in the skilled workforce; [and] secure digital and physical infrastructure and tools that underpin cutting-edge digital engineering, data and software-based systems".

"The concept and assessment-phase contract will see the partners develop a range of digital concepts, embedding new tools and techniques to design, evaluate and shape the final design and capability requirements of Tempest," BAE says.

Programme choices

These activities are planned to "enable major programme choices by 2024", the MoD says. Team Tempest has previously outlined a schedule to deliver a full business case proposal before the end of 2025, following a so-called alternate systems review process.

Team Tempest's industry partners have identified smart and heavily-automated manufacturing, artificial intelligence and machine learning as among supporting technologies for the future capability.

The MoD says that such a 'digital first' construct means "simulated design and testing can significantly reduce costs, time and emissions".

£2bn

Four-year investment planned by the UK Ministry of Defence in the Tempest future combat air system

On 4 August, the Italian government approved its defence spending plan until 2023, and outlined a roughly €2 billion ($2.35 billion) investment in the Tempest programme over the next 15 years. Its commitment will value €20 million in each of the next three years, rising to €90 million for 2024-2026, and the remainder by 2035.

Rome says its participation will enable "exclusive access to a project of exceptional ambition", describing it as "the champion of innovation" across multiple high-technology sectors.

"A late membership, on the other hand, could preclude the achievement of the optimal production and offset share, certainly requiring additional charges," its defence ministry notes.

Separately, the UK and Japan in late July signed an agreement "intensifying efforts to explore working together on power and propulsion" related to their respective Tempest and F-X fighter programmes.

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After 50 years of use, the RAF's Puma helicopters are heading for retirement

Elsewhere in the combat air sector, the UK's defence planning document left open questions regarding the strength of its commitment to the Lockheed Martin F-35, stating only that it will "grow the Lightning II force, increasing the fleet beyond the 48 aircraft that we have already ordered".

The UK's programme of record requirement for the F-35 stands at 138 examples, with its orders to date being for the short take-off and vertical landing (STOVL) B-model variant. But with plans to also retain seven operational Eurofighter Typhoon squadrons and introduce Tempest from 2035, observers have long questioned the scale of its Joint Strike Fighter purchase plans.

"With aircraft currently contracted [for delivery] through to 2025 there simply was no need for an additional commitment to buy at this stage," Lockheed noted following the spending plan's release. "Contrary to recent speculation, the [UK's] F-35 programme of record has not been cut."

Lockheed has to date delivered 21 of the UK's contracted F-35Bs, with the type operational with the RAF's Marham, Norfolk-based 617 Sqn.

With the UK's Lightning force having recorded its first combat activity in the Middle East in mid-2019, 18 June saw the formal restoration of the nation's Carrier Strike capability, when F-35Bs struck targets after taking off from the Royal Navy's (RN's) HMS *Queen Elizabeth*.

"With aircraft contracted [for delivery to the UK] through to 2025 there simply was no need for an additional commitment to [buy F-35s] at this stage"

Lockheed Martin

The 65,000t vessel is currently leading the RN's Carrier Strike Group 21 deployment, with STOVL jets from 617 Sqn and the US Marine Corps' VMFA-211 unit embarked. Due to conclude late this year, the debut operational commitment for the RN's first of two new aircraft carriers has also involved participating in exercises with allied navies in the Mediterranean, Arabian Gulf and Asia-Pacific region.

Meanwhile, BAE says it is close to achieving full-rate production of aft fuselage sections in support of the global F-35 programme. Conducted at its Samlesbury plant in Lancashire, the activity involved shipping 70 structures in the first half of this year.

"We remain in lockstep with Lockheed Martin," BAE Systems Inc chief executive Tom Arseneault said during a half-year earnings call in late July. "We are expecting to hit peak [output] sometime next year," he adds, with further work also pending as part of a Block 4 retrofit activity. BAE's US unit has also to date supplied more than 800 ASQ-239 electronic warfare and countermeasures suites for the stealthy, fifth-generation fighter.

Another hot topic at this year's show will be a looming requirement to replace the RAF's veteran fleet of 23 Aerospatiale Puma HC2 support rotorcraft. The MoD in April confirmed that the type will leave use between 2023 and 2025, replaced via a New Medium Helicopter (NMH) procurement.

70

F-35 aft fuselage sections shipped from BAE Systems' Samlesbury site during the first six months of this year

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The centrepiece of Leonardo Helicopters' presence at the 2019 show was a full-scale mock-up of the AW149, which it views as a solution for the Puma replacement need. The company is currently showcasing the capabilities of the super-medium-twin using a common platform demonstrator for the AW149 and commercial AW189. If successful, it will produce the military variant at its Yeovil final assembly facility in Somerset.

But Leonardo is not alone in its pursuit of the NMH requirement, which also seeks to replace a trio of niche rotorcraft fleets operated by the British Army. Airbus Helicopters is also in the running with a 'westernised' H175M, with the manufacturer pledging to replace Chinese-supplied content used in the civilian variant with UK-built parts.

And, eyeing the rapid nature of the procurement, Lockheed Martin's UK operation also is considering making an offer based on the Sikorsky UH-60 Black Hawk. The US company had offered the type prior to a 2008 decision for Airbus to extend the life of the RAF's Puma fleet.

The UK's C-17 airlifters have logged two decades in service

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Black Hawk bid

Describing the Black Hawk as offering "a stunning, unparalleled capability," Lockheed Martin UK chief executive Paul Livingston says: "The question is, could we find a way to market it in the UK that is acceptable to meet the challenges of the [nation's] Defence Industrial Strategy?"

Published alongside its Command Paper, the MoD's Defence and Security Industrial Strategy emphasises supporting the UK's so-called prosperity agenda, with the creation and retention of skilled jobs to receive increased weighting during contests.

Highlighting its need to acquire new medium transport helicopters, the RAF earlier this year marked the 50th anniversary of Puma operations. It also passed 40 years as a CH-47 Chinook user, and will greatly extend this after ordering a new batch of 14 Block II examples from Boeing in an MH-47G-equivalent standard.

Also in 2021, the UK service completed its first 20 years of operations with the Boeing C-17 strategic transport. The RAF flies eight of the type from its Brize Norton airlift hub in Oxfordshire.

The MoD in May awarded Boeing an extension to

UK launches Space Command with skyrocketing ambitions

Among the organisational changes made by the UK Ministry of Defence (MoD) since the last DSEI show in September 2019, the establishment of a dedicated Space Command is one of the most significant recent developments.

Formed on 1 April, and with its headquarters opened at the Royal Air Force's (RAF's) High Wycombe base in Buckinghamshire in July, the Space Command is jointly staffed by personnel from the service, British Army and Royal Navy, along with civil servants and employees from commercial partner companies.

Led by RAF Air Vice-Marshal Paul Godfrey, the command's initial focus areas are threefold – described as operations to "protect and defend UK and allied interests"; personnel recruitment and training; and the development and delivery of "space equipment programmes that integrate with other defence capabilities".

It also has consolidated the RAF's Space Operations Centre and ballistic missile early warning site at Fylingdales in Yorkshire.

The space domain was earlier this year given a £1.4 billion ($1.9 billion) boost by the UK government. In its April spending review publication *Defence in a Competitive Age*, the MoD said it will "Develop a UK-built intelligence, surveillance and reconnaissance [ISR] satellite constellation and a supporting digital backbone in space."

"The space industrial revolution is gathering extraordinary pace," Air Chief Marshal Sir Mike Wigston, chief of the air staff, said during the RAF's annual Global Air Chiefs' conference on 14 July, referring to it as an "increasingly contested, congested and competed domain".

Noting the sector's importance to national security and to the functioning of society, he notes: "That critical reliance is also a vulnerability and we see countries like China and Russia seeking to exploit that vulnerability by developing and testing systems designed to interfere with or even destroy satellites and space systems".

The Space Command's establishment represents the UK's commitment to the seven-nation Combined Space Operations grouping, which also involves Australia, Canada, France, Germany, New Zealand and the USA. "The initiative seeks to improve co-operation, co-ordination, and interoperability opportunities in space, with main efforts focussed on ensuring a safe, secure and stable space domain," the RAF says.

"By 2030, the government's ambition is for the UK to have the ability to monitor, protect and defend our interests in and through space, using a

a synthetic training service for the C-17, which will support its continued use until 2040.

Worth £247 million, the agreement will expand the provision of instruction for aircrew and engineers at an International Training Centre in Farnborough, Hampshire, which hosts equipment including a full-flight simulator. Boeing has provided the service since 2014.

Along with Airbus Defence & Space A400M Atlas turboprops, the C-17s will play a critical role beyond the departure of the RAF's Lockheed C-130J tactical transports, all 14 of which are to be retired by 2023, under an accelerated schedule.

ISTAR transformation

Transformation of the RAF's intelligence, surveillance, targeting and reconnaissance (ISTAR) capabilities is also ongoing. This year has seen the departure from use of its Raytheon Sentinel R1 ground surveillance and Boeing E-3D Sentry airborne warning and control system aircraft fleets, with the latter's replacement – a trio of Boeing 737-based E-7A Wedgetails – not due to arrive until 2023. The UK's originally five-strong E-7A acquisition was earlier this year reduced by two airframes.

£247m

Value of extension to C-17 training service agreement with Boeing, covering instruction activities running to 2040

Completion of the P-8A Poseidon MRA1 maritime patrol aircraft fleet – the last four of nine adapted 737NGs are due to arrive at RAF Lossiemouth in Scotland before year-end – will be a welcome development for the service.

Its next major ISTAR fleet introduction will be of the General Atomics Aeronautical Systems Protector RG1 remotely piloted air system. To replace the service's current Reapers, the new type will be certificated to fly in non-segregated airspace, and all weather conditions.

The UK in late July ordered the remaining 13 Protectors from a 16-strong acquisition, building on an initial award placed last year. Operations with the Waddington, Lincolnshire-based Protector fleet are scheduled to begin in 2024.

DSEI organiser Clarion Defence in early August announced that this year's event will include 654 companies, from 31 countries. More than 250 of these exhibitors will be present for the first time, it adds.

"We will have 20 international pavilions" on the exhibition floor, says event director Grant Burgham. The four largest of these are for US, UK, German and French industry, with others including Belgium, Estonia, Greece and Portugal.

The exhibition space at the ExCel centre will be divided into five zones: aerospace, land, naval, security, and joint; along with Future Tech, manufacturing, medical, and space hubs.

Additional reporting by Dominic Perry

● *Flight International* is DSEI's Aerospace Zone media partner. To access all our coverage around the event, visit FlightGlobal.com/dsei

An RAF test pilot is seconded to fly Virgin Orbit's 747 satellite launcher

Virgin Orbit

mixture of sovereign capabilities and burden-sharing partnerships with our allies," the MoD says.

"As a priority, we will establish a space cloud to harvest the terabytes of space-derived data across a truly borderless domain; whilst establishing a space-based ISR programme to deliver a sovereign multi-spectral ISR constellation," says Wigston.

The military has "adopted a truly integrated approach across Space Command, industry, our science labs and academia to maximise innovation and rapid capability development", he adds.

Under current plans, a first satellite should be launched from UK soil during 2022, from a site in Scotland's Shetland Islands. Cornwall Airport Newquay is also a planned host site for aircraft-conducted launches of small satellites, with Virgin Orbit planning to use an adapted Boeing 747-400 in this role. The RAF has one of its test pilots currently seconded to the company as one of the crew for its *Cosmic Girl* launch platform.

In 2018, the RAF's Rapid Capabilities Office funded the launch from India of the Surrey Satellite Technology-built Carbonite-2 payload, with the system capable of proving real-time video from low-Earth orbit.

The MoD notes that the ability to host domestic satellite launches will "give greater strategic autonomy and flexibility in terms of what the UK puts into space, and when".

Name that airline

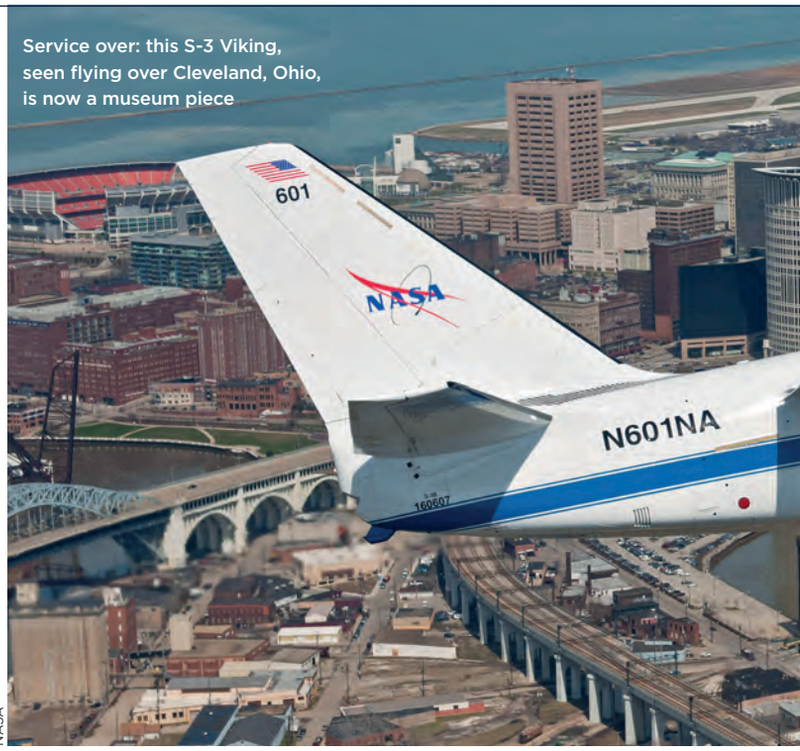
Canvassing the hive mind of the general public for ideas on corporate names and designs often doesn't end well – witness the 'Boaty McBoatface' ship-naming fiasco in the UK, or the discount-store livery forced upon the former Jat Airways.

These crimes against branding, however, have not discouraged Armenian authorities from turning to the country's citizens to think of a name for a new budget carrier being launched by Air Arabia.

Which won't be easy. In these diversity-aware times, riffing on 'Caucasian' is probably a non-starter, and there's also the issue of filtering out anything that might upset neighbouring Azerbaijan.

Air Arabia's Moroccan venture injected some local flavour as 'Air Arabia Maroc'. But 'Air Arabia Hayastan' might not catch on as easily, given that pretty much everyone else in the world calls Armenia by a name that sounds more or less like 'Armenia'.

There's always the option of looking to traditional symbols and landmarks for inspiration. Armenia's coat of arms notably depicts Mount Ararat, on which Noah's Ark was said to have come to rest. But mountains – especially those on which large transport vehicles ended up – aren't the most reassuring geological feature for aviators and, besides, Ararat isn't actually in Armenia. It's over the border in neighbouring Turkey.



Service over: this S-3 Viking, seen flying over Cleveland, Ohio, is now a museum piece

NASA

Baggins allowance

On the subject of spin-offs, it is perhaps safe to say that we won't be seeing AirAsia Australia launch any time soon.

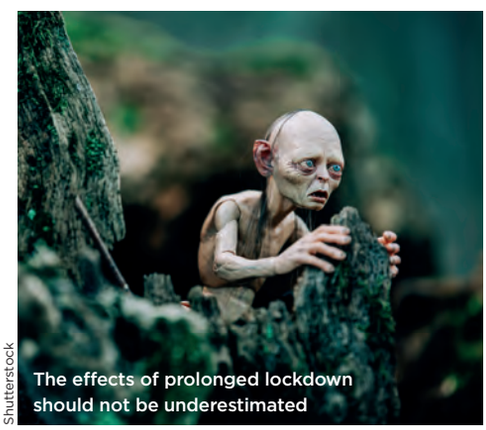
Speaking during a CAPA Live event in mid-July, AirAsia Group chief executive Tony Fernandes suggested Australia is going to struggle to reopen to international travel, even though the country "has managed itself very well" from a health perspective during the pandemic.

"Australia is going to be hermit kingdom," he says. "It's going to be the latest *Lord of the Rings* movie… *Middle-earth*."

The problem, Fernandes suggests, is that "it's going to be really hard to get into Australia" for the foreseeable future amid a slow vaccination programme and "an overreaction" to every case of Covid-19.

"It's very easy to lock down. It's very hard to un-lock down," Fernandes states.

Amid those challenges, Australian



The effects of prolonged lockdown should not be underestimated

Shutterstock

From the archive

100 75

1921 On the home font

Anti-aircraft guns during the War have had some funny things booked to their debit, both against property and the person. Therefore it is but right that praise which is theirs should be rendered unto them. Thus it transpires that in the Church of St. Margaret, Lower Halstow, near Sittingbourne, a discovery of antiquarian interest has been the result of operating these aircraft strafers. It appears that during the War the concussion caused by the powerful anti-aircraft guns posted along the reaches of the Medway cracked the plaster round the basin of the font in Halstow Church. This was removed, and underneath was found a leaden font in splendid preservation, which has been established as being work of the 12th century, originally from Germany.

1946 Dr Strangelowe

Dr J. T. Lowe, an air expert in the U.S. Department of War, evidently does not think much of the world's hope for future peace, for in an article in a new publication called *Air Affairs* he proclaims that in the "foreseeable future" entire armies will be transported by rocket-driven troop-carriers to occupy a country (he doesn't say which) momentarily stunned by attacks from atom bombs. Such "rocket ships", he explains, will streak through the substratosphere at 100,000 m.p.h. But he says that so long as the U.S. controls the air space above her territory she will not be on the receiver end of atom bombs and cannot be defeated. So apparently he has no faith in the ultimate development of the V.L.R. rocket, with an atom bomb in the business end.

Last of the Vikings heads to museum

The San Diego Air & Space Museum has received its latest exhibit, the final in-service Lockheed S-3B Viking, which has spent 16 years as a flight research aircraft at NASA's Glenn Research Center in Cleveland, Ohio.

The aircraft's final retirement comes 12 years after the US Navy stood down its fleet of the four-crew twinjet.

Although designed for anti-submarine warfare, the Viking was also highly suitable for a research role, says NASA. Its flat bottom made it possible to mount a variety of antennae, and the fact it flew low and slow was ideal for communication with ground stations. However, shortages of spare parts sealed its fate.

citizens' options for international travel are largely limited to a destination that is already famous for its resemblance to Middle-earth: New Zealand.

Disem-barking

"Getting the dogs into the aircraft is the most important thing," says test parachutist Andrei Toporkov. "They endure the flight well and even observe the clouds through the window.

"When the door opens, with the onset of wind and noise, the animals tense up. But thanks to the dog-handler, they calm down. So during the jump with the handler there were no problems."

This isn't some extreme event in whatever passes for Crufts in Russia but rather an effort by aerospace firm Technodinamika to develop a way for rescue or military personnel to carry a service dog to areas where landing aircraft is impossible.

It is conducting final tests of a harness enabling dogs up to 45kg to be dropped, with either a handler or a tandem handler and instructor, from altitudes of 13,000ft – and says it is working on doubling this height, with the use of special oxygen equipment for the mutts to breathe.

"Testers discovered that, even from a height of 3km, a dog observes the ground and tries to 'catch' it with its paws," says the company. "After landing, all the four-legged participants felt good and were ready to carry out orders."

Toporkov says that jumps without the handler were "more difficult" because it was necessary to gain the dog's trust. And he points out that test precautions included wisely not feeding or watering the dog for some time before the jump: "It was not known how their body would react."

1971 Five years of fibre

It is almost exactly five years since carbon fibres were first introduced to the engineering industry by their co-inventors, W. Watt, L. N. Phillips and W. Johnson, scientists at the Royal Aircraft Establishment, Farnborough. They began with the statement that carbon-fibre-reinforced plastics had been made which were much stiffer than any reinforced plastics hitherto available and which had a stiffness-to-weight ratio surpassing that of metals. The new fibre, they said, was two or three times as strong as steel, and had twice the stiffness but only one-quarter of the density. Rolls-Royce had been involved very early on, since the material seemed to have outstanding advantages for certain uses in aeroengines, notably in the compressor blades.

1996 Sceptical responses

Companies were asked to look at a range of possible new European institutions, including a unified aviation authority, a NASA-style research agency, a combined defence-procurement agency and a single European currency. With the exception of the single-currency issue, which 70% of companies think will be implemented, there seems to be little confidence that any of these institutions will actually happen in the foreseeable future. The issue of a unified research agency or aviation authority raises even less interest, even among the aircraft builders which have ostensibly supported calls for its creation. Just over one-half recognise the benefit of a single European currency, and this figure would have been much higher, but for scepticism from the UK.

Performance of the Tecnam/ Rolls-Royce P-Volt is unclear

Rolls-Royce

Aviation: going backwards fast

Your articles 'Powering ahead' and 'Leading the charge' (*Flight International*, August 2021) provide scant sentences, amidst several pages, relating to the commercial considerations of operating these new aircraft around electric technology.

For example: "No details are available on the performance characteristics" of the Pratt & Whitney Canada-powered De Havilland Canada Dash 8-100; and "as yet, no range or speed performance has been released" for the Tecnam/Rolls-Royce P-Volt.

For billions of dollars in investment, it seems we will soon be telling passengers they can only fly half as far, but for twice the price. This will please the effervescent green lobby no doubt, but passengers pay airlines, and airlines pay manufacturers.

Airframers and engine suppliers seem to be on the bandwagon and politicians' coattails around the world about meeting self-imposed emission targets. The aim to reduce these emissions is admirable, the timescale and practicalities are certainly not. Surely we must introduce a scintilla of common sense here?

The Wright Brothers and Louis Bleriot pioneered fantastic aeronautical achievements that gave us brilliant advances for passengers that went on and on. But now we are going backwards: higher fares, less range, heavier airframes, and an awkward perception of a tiny but vociferous lobby that flying is killing us all.

Are we all in total admiration of our green emperor, or will someone think to tell him he has no clothes?

Tim Procter
via email

Foolish words

I write with regard to the article 'Well worth freighting for' (*Flight International*, August 2021).

I was shocked, appalled and deeply offended by the cross-section headline 'Conversion therapy' on page 57 of the print edition. That phrase refers to one thing and one thing only: the highly discredited and damaging attempt by nefarious people and organisations to attempt to change someone's sexual orientation from homosexual to heterosexual.

It is a highly offensive practice, and as a gay man and long-time subscriber, I find it shocking it being referenced in a respected aviation publication.

If someone in your editorial team thought it was a clever play on words in an article about freighter conversions, he or she was sorely mistaken. It was not funny, and it never should have appeared.

Flight International owes me and other readers a formal apology – anything less will represent nothing less than a complete failure on your part to recognise the seriousness of the offence that you have caused.

John Howard
London, UK

Editor's reply: We apologise wholly for using the phrase – it was not appropriate, and should never have made it into print. Unfortunately its very negative meaning was not understood when it was introduced to the article and then missed by us in the proof-reading process. It is never our intention to offend or insult anyone on the grounds of their sexuality, religion, nationality or belief, and we will be more careful to avoid any such inadvertent slip in the future.

Taxi prank?

It seems that hardly a day goes past without us seeing the announcement of yet another battery-powered vertical take-off and landing air taxi project, usually by a start-up company (*Flight International*, July 2021).

These are more likely to start up and then close down, dissolving back into the dreamland they came from, methinks.

I can't imagine that the general public of modest pocket will want to travel in these buzzers – nor would they delight in seeing the very rich taking such shortcuts.

When the town councillors feel where their votes really come from, I expect they will ban them from urban areas.

David Stevens
via email

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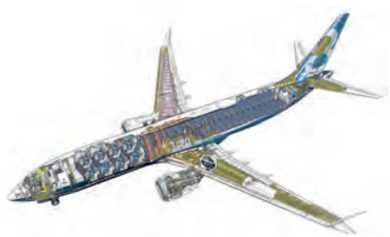

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As project manager for NASA's spectacular unmanned helicopter flights on Mars, **MiMi Aung** advanced awareness of autonomous capability – and inspired a new generation of scientists

Out of this world Ingenuity

Pilar Wolfstellar Las Vegas

NASA's Jet Propulsion Laboratory (JPL) sits at the end of Oak Grove Drive in Pasadena, California. In the summer of 1990, a young electrical engineer named MiMi Aung drove up the tree-lined boulevard for a job interview.

"I thought to myself, 'Oh my god, I'm on Oak Grove Drive. I am driving up to JPL.' I couldn't believe it," she says.

Thirty years later, Aung led the team that proved an aircraft could be flown on Mars.

When the helicopter "Ingenuity" lifted off the red planet's surface in April, the media spotlight landed on Aung. She was the programme's project manager and the driving force who had kept the endeavour on track through years of research and development.

Her family hails from Myanmar, but Aung was born in Illinois while her parents pursued their PhDs in the USA. Her mother is a mathematician, and her father a chemist. And from an early age MiMi was surrounded by science and a love of learning.

Clear career

When she was two, the family returned to Myanmar, and then later moved to Malaysia. Educated at international schools, Aung chose to return to the USA for her own higher education.

When the time came to choose a career path, it was clear she would follow her parents into the sciences.

"My master's degree was focused on signal processing and communications, and a professor said the NASA Deep Space Network would be an exciting place, because they are tracking tiny, tiny, tiny signals from spacecraft millions and millions of miles away," Aung says. "I thought, they probably have good signal processing communications challenges for me."

She had been drawn to space exploration as a child, but never believed she would have an opportunity to work in the field. "Then all of a sudden, you think, 'Hey, I may actually have a chance at this,'" she says.

Aung got the job at JPL and spent the ensuing decades working her way through the organisation, choosing ever-more-complex projects and taking on increasing responsibilities.

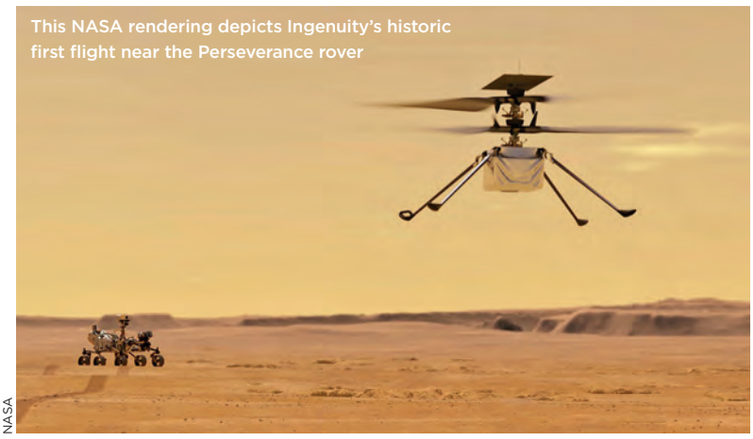
"After about 15 years, I became passionate about autonomous space-based systems," she says. "There's so much room to be more autonomous and more capable. Our systems are state-of-the-art, but I think it's still early days."

The Mars helicopter was a nearly nine-year labour of love. The idea was born in 2012, when JPL revisited research that had been done decades earlier but abandoned. Back then, the necessary technology did not exist. Today, it does.

Ingenuity arrived on Mars in the belly of the rover Perseverance on 18 February. Both had been launched from Earth seven months earlier, on 30 July 2020.

Perseverance deployed Ingenuity in April, and over the following weeks the sophisticated robotic helicopter – a 1.8kg (4lb) craft with dual 1.2m (4ft) rotors – began its flight test campaign.

On 19 April, Ingenuity lifted off the surface of Mars for the first time, climbed to an altitude of 10ft,



This NASA rendering depicts Ingenuity's historic first flight near the Perseverance rover

NASA

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New goals: after 30 years at NASA, Aung joined Amazon's Project Kuiper in July

turned 96° and landed gently after a 39s flight. It marked humankind's first powered, controlled flight of an aircraft on a planet other than Earth.

"It was an unbelievable feeling. We could finally breathe. Over the years the team had bonded in an unusual way. We were under so much pressure, and something could have gone wrong at every milestone," she says.

"We are a technology demonstration, so Perseverance didn't really need us. They could have gone to Mars without us. There were so many moments through the years I felt like I wanted to cheer but got this glare from the rest of the team."

Celebration of those early successes was premature, her colleagues told her. "But that was the moment when we could all say, 'It's okay. We've done it.'"

By the end of July, Ingenuity had completed 10 flights – five more than planned. The longest lasted 2min 46s and covered a distance of 625m (2,051ft), with the drone reaching an altitude of about 33ft. By then, Ingenuity had survived more than 100 sols (Martian days, which last about 24h 40min) – four times longer than its expected lifespan. Just how long it will keep flying remains unknown, but the team will continue operating the craft as long as possible.

> "I will continue to pursue more capable, more autonomous space systems. It's where my heart is"

Aung will go down in history as the engineer who led the 150-person team that proved humans could fly an aircraft on Mars – a remarkable feat.

But she is not done yet. "I will continue to pursue more capable, more autonomous space systems. It's where my heart is," she says.

Toward that end, Aung left NASA in July, taking a job with Amazon's Project Kuiper, an initiative to build a low-Earth-orbit satellite constellation. Through the project, Amazon aims to provide reliable, affordable broadband services to underserved communities worldwide.

Strong signal

Aung's career led her to the opposite side of the planet from Myanmar, where she had sat on her bed as a child, dreaming of space.

What would her advice be to her 11-year-old self – and to kids everywhere?

"If you are really good at something, and you like something, be very attentive to that, because it's a really important signal," she says. "When I was 11, I didn't know which country I'd go to next. I just really loved math. I didn't know where I would be going. But I didn't let go of what I really liked learning."

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