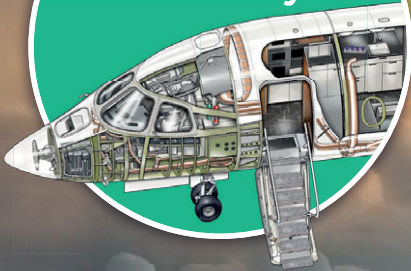


FLIGHT INTERNATIONAL

Dassault Falcon 10X cutaway



New fighter programmes get ready to soar **p12**

Airbus details hydrogen powertrain progress **p20**

Raider revealed

US Air Force lifts veil on transformational bomber **p6**



Going Boeing
United signs massive fleet renewal deal **p8**



Victory Bell
Valor tiltrotor will succeed Black Hawk **p19**



£5.99




GO BEYOND

POWERING SUSTAINABLE AVIATION™

SMARTER. CLEANER. GREENER.

Pratt & Whitney is committed to supporting the commercial aviation industry achieve net zero carbon emissions by 2050. Getting there will take big ideas, expertise, experience and hard work, qualities at the core of who we are. To reach net zero we go beyond — working smarter, cleaner, greener today for a more sustainable tomorrow.

LEARN MORE AT [PRATTWHITNEY.COM/SUSTAINABILITY](https://prattwhitney.com/sustainability)


 Serious deterrent: the B-21 Raider bomber

Sixth sense

A tantalising batch of next-generation combat aircraft programmes are powering up for the USA and multiple key allies – now it is critical that such efforts can deliver success

In an action-packed final month, 2022 reached its conclusion with no fewer than three “sixth-generation” combat aircraft programmes making key advances, as multiple Western and allied nations moved to outpace their so-called near-peer rivals.

The highest profile development was the unveiling of the US Air Force’s (USAF’s) next strategic bomber: the Northrop Grumman B-21. Revealed in Palmdale, California, the stealthy Raider is the spiritual successor to the service’s small fleet of B-2 Spirits.

Crucially, with a projected 100 examples to be purchased, the new, nuclear-capable model is more affordably priced – albeit at an estimate of \$631 million each – and will be easier to maintain and upgrade.

To enter frontline use later this decade, the Raider fleet will represent a more capable and potent deterrent to potential foes such as China and Russia, the Pentagon says. Delivered by US defense secretary Lloyd Austin at the unveiling event, Washington’s message to such global players is unequivocal: “The risks and costs of aggression [against the USA and its allies] far outweigh any gains.”

In Europe, meanwhile, two competing fighter development projects cleared their latest hurdles on the way to achieving service entry from 2040 and 2035, respectively.

After a one-year delay caused by workshare wrangles between Airbus Defence & Space and Dassault Aviation, the French-German-Spanish Future Combat Air System (FCAS) activity at last took off, with a Phase 1B contract signature.

The agreement sees Dassault take the role of prime contractor and “architect” for the FCAS capability’s New Generation Fighter, but the expected first flight of a demonstrator has slipped until 2029 due to the protracted impasse.

Now the three-nation programme must make up for lost time, and – critically – ensure that its newfound harmony is maintained until a Phase 2 decision is taken in 2025 to continue further.

Also entering its next stage is a UK-led effort centred on delivering a future manned Tempest fighter. On 9 December, this was formally rebadged as the Global Combat Air Programme (GCAP); now as a joint endeavour between the UK, Italy and Japan.

Under the trilateral effort, the nations will merge their previous Tempest and F-X fighter needs to deliver a shared solution from the middle of next decade. The inclusion of Japanese industry is, says UK Prime Minister Rishi Sunak, clear evidence that “the security of the Euro-Atlantic and Indo-Pacific regions are indivisible”.

Both the FCAS and GCAP initiatives also include the development of supporting air-launched weapons, unmanned remote carrier vehicles and advanced data networks. Such technologies are needed to deliver a key advantage in speed of action against potential adversaries like Beijing and Moscow, who are advancing their own next-generation aircraft systems, along with fielding hard to counter hypersonic weapons.

The USAF, meanwhile, is secretly progressing its own Next Generation Air Dominance programme to – along with the B-21 – help counter such sophisticated foes.

Whether these pursuits of seemingly exquisite capabilities can survive versus the reality of pressured budgets and fractious national industrial needs remains to be seen. But for advocates, the appeal and need is clear: namely, the greater quality of Western equipment and decision-making will continue to trump quantity, both on and above the battlefield.

And, they note, while the war in Ukraine has seen low-cost tactical unmanned air vehicles and even adapted hobbyist drones play a significant role, this is only because neither Moscow or Kyiv have been able to secure the most critical advantage during the conflict: total air dominance. ▶

See p6, 12

In focus

Secretive Raider breaks cover **6**
United plans growth together
with Boeing **8**
Energia management **10**
'Sixth-generation' fighter
programmes take off **12**

P&W powers up F-35A engine
enhancement **18**
Bell to build Black Hawk
successor **19**
H2-go for Airbus **20**
Max reprieve in sight **23**

Wrongly refitted switch left E175
pilots fighting for control **26**
Aura Aero ushers in new ERA **31**
Airbus Helicopters chided for
H145 icing risk assumptions **33**
A rotary revolutionary **36**

42



Brighter future? Aerospace sets
course for a more prosperous 2023



72



Regulars Comment **3** Best of the rest **38** Straight & Level **76** Letters **79** Jobs **81** Women in aviation **82**

In depth

Horizon of hope 42

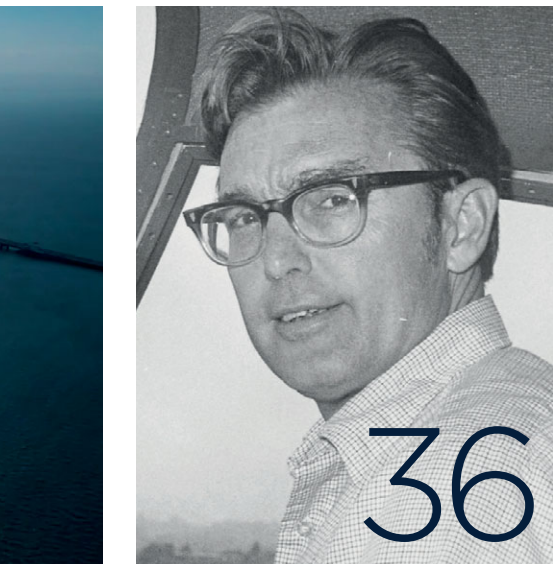
Pandemic precautions and travel restrictions are now in the past for most parts of the world. Could 2023 be the first 'normal' year for aerospace and aviation since 2019?

Electric avenues 66

The solution to the industry's carbon emission problem lies in electric, hybrid-electric and hydrogen-powered aircraft, but how much progress is being made bringing them to market?

Luxury aloft 72

Dassault Aviation's flagship Falcon 10X will combine home comforts with ultra-long-range performance and flight-control technology derived from the Rafale fighter



Configuration retains the stealthy flying-wing design of its predecessor



Secretive Raider breaks cover

First example of 'sixth-generation' B-21 bomber unveiled as USAF hails deterrent effect of nuclear-capable platform

US Department of Defense

Ryan Finnerty Palmdale

A veil of secrecy has finally been lifted from Northrop Grumman's B-21 Raider – the next-generation stealth bomber under development for the US Air Force (USAF).

Joined by senior members of the US Department of Defense, Northrop revealed what it describes as the world's first "sixth-generation" military aircraft on 2 December in Palmdale, California.

"The B-21 looks imposing," said US secretary of defense Lloyd Austin, with the streamlined aircraft behind him. "But what is underneath the frame and space-age coating is even more imposing."

The unveiling came some 34 years after the B-21's predecessor and current USAF strategic stealth bomber, Northrop's B-2 Spirit, had made its first public appearance

– also at the company's Palmdale prototyping and testing facility, which sits on the USAF's Plant 42 site northeast of Los Angeles.

Chief executive Kathy Warden says Northrop drew heavily on its decades of experience in producing and maintaining the B-2 to create "the most-capable stealth bomber ever built".

Design options

The Raider retains the flying-wing design of its predecessor. Warden notes that Northrop settled on the final configuration after exploring thousands of options to meet the USAF's requirements for cost and low-observability.

The B-21 test aircraft, which remained in its hangar during the event, has its engine intakes greatly recessed above the wing, reducing exposure to ground-based radars.

The USAF has set a price target of \$500 million per airframe,

valued in 2010 dollars; equating to \$631 million each currently, and Warden says Northrop is on track to meet that goal.

USAF chief of staff General Charles Brown says the price ceiling is critical to ensuring his service can build-out a sufficiently deep B-21 fleet.

"One hundred is the number we're shooting for," says Brown, adding: "it will be the backbone of our bomber fleet."

"We had a very firm cost target," adds USAF acquisition chief Andrew Hunter. "That will allow us to meet our number needs." He insists that the focus on price does not come at the expense of low-observability requirements, which were "central to the design process".

Northrop aims to perform the B-21's first flight in 2023, using a "production-representative" test aircraft, named T1. The company currently has six airframes in

Joint crew prepares for milestone flight in 'production-representative' aircraft

The next milestone for the B-21 programme will be the first flight of its T1 test aircraft, scheduled for some time in 2023. Flying that first mission will be US Air Force (USAF) and Northrop Grumman test pilots Lieutenant Colonel Clifton Bell and Chris Moss.

"There's a few things in your career that you never expect to happen," says Bell, who flew both the Boeing B-52 and Northrop B-2 bombers for the USAF. "Having the opportunity to bring forward

the next generation of bomber is very exciting."

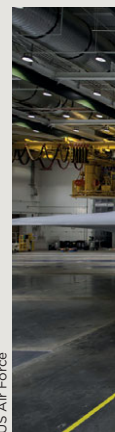
Ahead of T1's debut flight, Bell says the test crew are spending plenty of time in high-fidelity simulators, to both evaluate and "get comfortable" with the prototype's flight-control systems.

"Being able to execute those systems and know the difference between something going wrong and the way the system operates", is how Bell describes one of the pair's current main points of

focus. "We spend a lot of time in simulators working on that."

"We've had the chance to help develop the flying qualities of the aircraft," says Moss of simulator evaluations conducted over the past six months. Both he and Bell provide feedback to engineers to help improve the "handling qualities of the airplane", he adds.

Although the Raider's first flight will be made using a test aircraft, Northrop stresses that it aims for the "production-representative"



US Air Force

various stages of production and testing, with a first delivery projected for the mid-2020s.

The USAF has selected Ellsworth AFB in South Dakota as its B-21 main operating base, and aims to reach initial operating capability before the end of this decade. Its 28th Bomb Wing currently operates 27 Boeing B-1Bs from the site.

"It's going to be a huge transition from B-1: conventional-only to low-observable, nuclear-capable," says 28th Bomb Wing commander Colonel Joseph Sheffield.

The base will be adding around 1,700 personnel and undertaking construction projects worth \$1 billion over the coming decade. That work will include adding an operation and maintenance campus, flight training unit, simulator facility and mission planning centre, along with a new weapons generation facility and command post with communications and control equipment for the nuclear deterrent mission.

"It's over 30 big projects", Sheffield says, with six "well under way", including building a new hangar to house B-21s.

Critical tool

The Raider is the USAF's first new combat aircraft since 2016, and only its fourth new crewed strike platform since 1990. Service leaders say it will be a critical tool of deterrence – and, if necessary, combat power – for decades.

"Even the most-significant air defence systems will struggle to detect the B-21 in the sky," says Austin. The type's advanced sensor systems will also allow it to play an important role in other realms of

"We are making it plain to any foe. The risks and costs of aggression far outweigh any gains"

Lloyd Austin US secretary of defense

warfare, including intelligence and battlefield management.

Hunter says the Raider "will allow us to carry out our missions in the Indo-Pacific, and anywhere in the world".

Retired Major General Doug Raaberg, a former B-2 pilot and current executive vice-president of the Air and Space Forces Association, predicts the new bomber will become "the essential backbone of US national security strategy".

"Its ability to get in, stay in and kill targets – to hold targets at risk – is how we deter potential adversaries from taking the chance of war with the United States and our allies," he says.

While the Raider shares some general features with the B-2, its manufacturer says the new aircraft has substantial upgrades.

Last September, Northrop vice-president Thomas Jones said the new model's flight computer represents a "leap forward" that will allow for faster and easier upgrades. Engineers also designed the aircraft for ease of maintenance, making it a "daily flyer".

The B-2 – priced at \$2.2 billion per airframe – requires a costly and labour-intensive regimen of regular maintenance to retain its stealthy surface and low-observable profile,

including a major overhaul every nine years.

The USAF only acquired 21 B-2s, despite initial plans for many more, in part due to spiralling costs during the type's development.

Some observers see the need for an even larger B-21 fleet. "We need a force of at least 200 aircraft," says retired Boeing B-52 pilot Mark Gunzinger, now with the Mitchell Institute for Aerospace Studies.

Global reach

Northrop says 90% of the USAF's current bomber fleet is incapable of "penetrating enemy air defences and reaching targets anywhere in the world", referring to its 72 B-52s and 43 B-1Bs.

Randall Walden, director of the USAF Rapid Capabilities Office, in May 2022 described the B-21 test aircraft as the "most production-representative aircraft, both structurally and in its mission systems, at this point in a programme, that I have seen in my career".

While the programme has several years to run before becoming operational, the message from Washington policy makers is clear.

"We are again making it plain to any foe," says Austin. "The risks and costs of aggression far outweigh any gains." ▀



Type will make debut sortie from Palmdale in 2023

aircraft to be as close to a final model as possible.

Part of that effort has involved extensive testing of flight systems using a Gulfstream GV business jet testbed.

Northrop and the USAF say that by doing as much of that testing as possible "off the [B-21] aircraft" will reduce risk and save costs.

However, Moss notes: "We can't validate the model until we actually go and fly. So all we can do is be prepared for everything that we think may be a problem, or could be a problem."

Supporting the flight team are thousands of engineers, who are developing the data objectives and test points that the crew will achieve in the course of the Raider's flight debut.

The USAF says ground-based testing has proceeded smoothly, with the digital models used ahead of loads calibration having proved to be "very accurate" to real world performance.

"We're really happy with the results," says Lieutenant Colonel Joshua Schneider, deputy B-21 programme manager.

Chicago-based carrier added 737 Max orders alongside Dreamliner deal

United plans growth together with Boeing

Boeing

US carrier could take up to 200 787s on the back of latest pact, as it emphasises 'immense amount of trust' in airframer

Jon Hemmerdinger North Charleston

United Airlines sees a massive order for 100 Boeing 787s – plus 100 options – as a means to leapfrog US competitors through aggressive international expansion as the industry recovers from the Covid-19 downturn over the coming decade.

Executives at the Chicago-based airline say the order, plus a separate commitment for 100 737 Max – both disclosed on 13 December – also reflect confidence in Boeing, a business working to overcome troubles that have impacted most of its major aircraft programmes.

“Boeing is one of the most important companies in our country,” United chief executive Scott Kirby said during a 13 December event at Boeing’s 787 manufacturing site in North Charleston, South Carolina.

“Trust is rare in corporate America these days,” he adds. “I have an immense amount of trust in Boeing.”

Boeing chief executive David Calhoun says United’s 100-aircraft deal is “the largest 787 order in history”.

It boosts Boeing’s 787 backlog by around a quarter, swelling it from 412 to 512 aircraft.

United expects to receive the 100 737 Max by 2028, and the 100 787s between 2024 and 2032.

The deal gives momentum to Boeing, which has been beset by problems in recent years – with internal

and external issues combining to batter the company, eroding both its credibility and balance sheet.

Those troubles extended to the 787, deliveries of which were largely paused between October 2020 and August 2022 as Boeing addressed fuselage quality issues. During that period, it slashed 787 production rates and stopped making the widebodies in Everett, Washington, leaving North Charleston as its sole Dreamliner assembly facility.

Kirby declines to say how much United will pay for its 737 Max or 787s, but hints United landed a favourable deal. “I’m smiling,” he says.

Optimistic response

Kirby and other United executives frame the airline’s latest aircraft order as reflecting an aggressive and optimistic response to the recent air travel downturn.

Amid the Covid-19 pandemic, other airlines grounded older jets like 767s and 757s, Kirby says. But United kept those types and began planning for recovery, including by ordering 270 Airbus and Boeing narrowbodies in June 2021, forming a partnership with Emirates Airline earlier in 2022 and, now, ordering 200 more Boeing jets.

“That really sets United up,” Kirby says.

United chief commercial officer Andrew Nocella says the incoming 787s will help United expand its international flight network.

Cirium fleets data shows the airline’s in-service widebody fleet now includes 254 aircraft: 767s, 777s and 787s. By comparison, competitor American Airlines has 154 widebodies, while Delta Air Lines has 172.

United says the 100 787s will replace its 767s – it has 45, which it expects to retire by 2030 – and some of its 95-strong 777 fleet.

United retains orders for 45 A350s but the airline has agreed with Airbus to push back deliveries of those jets until 2030 at the earliest.

The carrier already operates 65 787s: 11 -8s, 38 -9s and 16 -10s.

Although United has not specified the variant split of the latest batch, Nocella says each has a place in United’s network.

He notes United operates 787-8s on transatlantic flights such as those to Accra, Ghana and Amman, Jordan. It deploys 787-9s on ultra-long-distance routes, such as from San Francisco to Singapore and from Houston to Sydney.

But the 787-10 is “the star of the show... its economics are unbeatable”, Nocella says.

However, on the narrowbody side, he says United faces an imperfect fleet trade-off later this decade due to the lack of a new-production aircraft with capabilities comparable to the airline’s ageing 757-300s.

Instead, the carrier will replace its 757s with 737 Max 10s and A321neos. “That’s not a trade we are excited to make,” Nocella says. ▶



Airframer sees potential for 19- and 30-seat hybrid-electric types with range of 500nm

Embraer

Energia management

Brazilian manufacturer Embraer has refined its low-emission concept aircraft as it eyes a possible route to market

Dominic Perry London

Embraer insists that it is serious about developing a new low-emission regional aircraft under its Energia initiative and could even launch a fully-fledged development programme within the next two years.

But first it will fly a series of hydrogen-based demonstrator aircraft, with the next – a fuel cell-powered Ipanema – to arrive in 2025.

Nonetheless, the airframer says that whatever design it ultimately pursues will be supported by a strong business case – for itself and for operators.

“I believe we have set bold but realistic goals for these concepts to come to market,” says Embraer Commercial Aviation chief executive Arjan Meijer. “We can apply those systems more easily on a small scale before we put them gradually on bigger and bigger aircraft.”

Unveiling the evolution of its Energia concepts on 6 December, Embraer showed four aircraft designs reflecting the airframer’s work since the project was announced in 2021.

The revised Energia aircraft lineup has been shaped by feedback

from airlines on its Energia Advisory Board, and a better understanding of the technological roadmap.

Embraer now sees potential for 500nm (926km)-range 19- and 30-seat hybrid-electric aircraft to enter service from 2030 – it has ditched the previous plan for a nine-seat hybrid – and 200nm-range 19- and 30-seat hydrogen fuel cell-powered models from 2035, rather than just a 19-seater. Both designs feature rear-mounted engines or electric motors, allowing efficiency gains from lightweight, slender wings.

Timetable shifts

Meanwhile, the possible service entry for a nine-seat all-electric type has moved to as late as 2040, from 2035 previously. A hydrogen-burning turbine-engined design with 35-50 seats is still pegged for 2040, however.

Explaining the shift in capacity, Embraer Commercial Aircraft vice-president of marketing Rodrigo Silva e Souza says “the higher you go in seat capacity, the less uncertainty we have about demand”.

The company sees potential to sell anywhere between 4,000 and 20,000 aircraft, Souza says.

Customer interest in a 19-seater is “more difficult to predict than

if you go to 30 or 50 seats or beyond”, he adds.

“That’s why we went up a little bit [in size], because the intention is to make a business case for this – we are not here just for the technology development or a greenwashing exercise.”

Assuming that business case can be closed relatively rapidly, a programme launch could come sooner rather than later, says Souza, as an aircraft with a novel powertrain may require a longer development cycle than the typical five-year timeframe for an aircraft using conventional technology.

“These projects might require a different business model, some different thinking,” he says, noting that Embraer’s Eve advanced air mobility vehicle “had an earlier launch”.

“So it’s actually part of the study [of] how to make this programme viable to analyse different business models. In a normal way [launch] would be around 2025.”

But despite the changes to the capacity of the Energia aircraft, which Embraer stresses are still no more than concepts, its service-entry targets still lag behind those of other manufacturers and powertrain developers, whose products are slated to arrive on the market from 2025.

But Souza is unconcerned: “Most of these projects are from start-ups, and they need to market an earlier entry into service to attract investors. In our case, it is different,” he argues.

“In some cases, you have already seen people moving entry into service to the right – moving from 2025 to 2027 or 2028. I would expect that movement to continue.”

Embraer, he says, is working to the concept of “complete entry into service” – a more holistic view of the entire ecosystem and the ability of operators to turn a profit – than simply a narrow focus on technology readiness.

Indeed, Embraer seems particularly bearish on the prospects for a battery-only aircraft, with its service-entry forecast around a decade behind those of rival developers – even those working on clean-sheet designs.

Battery limitations

That is coloured by Embraer’s analysis of the trajectory of battery improvement, says Daniel Galhardo Gomes, head of market intelligence, market and product strategy for Embraer Commercial Aviation.

“The way we see the batteries that will be available in this decade, they will give poor performance for this airplane.” To get any sort of commercially viable range, the weight of the batteries would be so significant that “payload would be very limited”, he argues.

Because Embraer’s hybrid-electric concepts are so-called “mild” hybrids – using batteries to supplement rather than supplant a thermal engine – they are less reliant on significant improvements in cell performance or cost.

“These projects might require a different business model, some different thinking”

Rodrigo Silva e Souza Vice-president of marketing, Embraer Commercial Aircraft

And while others – Airbus, for example – see strong potential for fuel cells to power an aircraft with at least 100 seats, Embraer thinks the “optimum design point” for such technology is with smaller aircraft as a result of thermal-management challenges, which grow in step with the size of the system.

Embraer views fuel cells as having a marked efficiency advantage over small turbine engines, but it is a gap that narrows significantly as power requirements increase.

At a power output of 4MW “the thermal management issues start to get really big”, requiring large heat exchangers and associated weight and drag penalties. “This is why we are focused on this sweet spot in the 19- to 30-seat category,” Souza says.

Over the next year, Embraer will “go deeper on these concepts”, including further research on fuel cells which may prompt it to scale up further. “But for now, that’s our best view in terms of technology readiness and commercial viability,” he says.

Embraer’s concept sees the heat exchangers located in the nacelles and the rear fuselage, the latter including an air intake at the base of the vertical tail. This takes advantage of the Meredith effect – using the expansion of the air used for cooling to generate thrust – to offset much of the drag.

Liquid hydrogen would be stored in a tank in the aft fuselage, with the fuel cells in the rear of the tail.

With the clock ticking towards a possible launch decision, Embraer is taking input from its Energia advisory board and working to deepen its understanding of the potential technologies.

Market research

The advisory board comprises 27 individuals from 20 airlines, both mainline and regional, Souza says. So far, only Wideroe in Norway and Ruili of China have been named.

Meanwhile, Embraer in 2023 will have a “lot of interactions with the engine manufacturers and the new propulsion system manufacturers to understand their development plans,” Souza says.

On top of this, the airframer will develop its own technology demonstrators. It has already flown an electric-powered version of its Ipanema crop-duster and by 2025 will be operating a fuel cell-powered version of the same type.

Additional hydrogen demonstrators will follow to “advance its technology readiness”, including liquid hydrogen storage, cryogenic systems, dual-fuel combustion, and thermal management. ▀

*Additional reporting by
Jon Hemmerdinger in Tampa*



New! Part 145 Refresher Training – Introduction to SMS Requirements

Is your Part 145 organisation SMS ready? Our 1-day refresher courses examine the changes to Part 145 under Regulation (EU) 2021/1963, including the introduction of a Management System, SMS and occurrence reporting.

UK/EASA Part 145 Refresher

Designed for organisations that hold a UK/EASA Part 145 approval, explore the changes to Part 145 in accordance with UK and EASA requirements.

Virtual | 19 January 2023

Virtual | 25 May 2023

Virtual | 23 November 2023

CAA Malaysia Part 145 Refresher

Designed for organisations that hold a CAA Malaysia Part 145 approval, explore the changes to Part 145 in accordance with UK, EASA and CAA Malaysia requirements.

Virtual | 7 February 2023

To book now or for more information, please visit:

www.caainternational.com/training or contact us at training@caainternational.com.





'Sixth-generation' fighter programmes take off

Competing efforts to develop a new class of combat aircraft for Europe's leading militaries have cleared major hurdles, with Japan also formally getting on board the UK-led candidate

Craig Hoyle Madrid
Dominic Perry London

Europe's rival programmes to develop a new class of "sixth-generation" combat aircraft each entered their next phase as 2022 drew to a close, with one also securing the involvement of a key partner in the Asia-Pacific region.

On 1 December, Airbus Defence & Space and Dassault Aviation announced the resolution of a months-long industrial stand-off over their roles in the French-German-Spanish Future Combat Air System (FCAS) effort.

Phase 1B negotiations had been deadlocked around attempts to reach agreement on the design and construction of a New Generation Fighter (NGF) demonstrator.

Detailing the advance, Dassault chief executive Eric Trappier said the project had been "at a standstill" since mid-2021. Talks originally should have concluded in December that year, paving the way for a first flight of the demonstrator in 2027, but the schedule for that event has now slipped until 2029.

"We have been confirmed in our role as prime contractor and architect of the aircraft, and we have obtained protection for our industrial know-how and technologies,"

Trappier says. "Being the architect of a new fighter aircraft is very motivating for our company, our teams, those of Airbus, our main partner, Indra, and our long-standing partners, Safran, Thales and MBDA."

In addition to replacing part of the nations' Dassault Rafale and Eurofighter Typhoon fleets from around 2040, the FCAS programme will provide smart weapons, accompanying unmanned air vehicles - remote carriers - and an overarching Combat Cloud data network.

€3.2bn

Value of Phase 1B deal signed on behalf of FCAS programme partners

On 16 December, a €3.2 billion (\$3.4 billion) Phase 1B deal was signed on behalf of the partners by France's DGA defence procurement agency. This will cover activities until the agreement of a Phase 2 contract during 2025.

Airbus, Dassault, Indra and engine consortium EUMET hailed the advance as enabling the development of "a powerful, innovative and fully European weapon system to meet the operational needs of the countries' armed forces".

Speaking ahead of the contract award, Airbus's FCAS programme head, Bruno Fichfeux, described the effort to harmonise industrial priorities as having been a "difficult" process for the nations. However, "The interests and the motivations of each company are safeguarded, so now the stars are aligned politically, operationally and industrially," he adds.

"We are sure that launching Phase 1B together is the best approach for us," he says of all the parties involved.

"Programmes for the next generation [of combat aircraft] are moving ahead in the US and in the UK, and we need to keep the pace," he notes. "We think we are well ahead, because there is a significant financial commitment from the nations to fund this programme for the next eight years."

"There is already a framework, an ambition and a budget for Phase 2," Fichfeux said during Airbus's annual Trade Media Briefing event in Getafe near Madrid on 12 December.

Development priorities for the NGF will include meeting shared operational goals, along with specific national-only requirements, notably France's need for it to be capable of carrying nuclear weapons and operating from an aircraft carrier.

"It's a European programme. Once it goes into full development

Tokyo's pact with London and Rome will build on the work done by Team Tempest

it may be attractive to others beyond the three – probably in Europe to begin with,” notes Airbus Defence & Space chief executive Michael Schoellhorn.

Separately, the governments of Italy, Japan and the UK on 9 December announced an agreement to jointly develop a future fighter via their Global Combat Air Programme (GCAP).

London says the endeavour “will build on the substantial progress already made” by the UK’s Team Tempest grouping since 2018. This work has involved BAE Systems, Leonardo UK, MBDA UK, Rolls-Royce and the UK Ministry of Defence.

“We need to stay at the cutting edge of advancements in defence technology – outpacing and out-maneuvring those who seek to do us harm,” says UK Prime Minister Rishi Sunak. “The international partnership with Italy and Japan aims to do just that, underlining that the security of the Euro-Atlantic and Indo-Pacific regions are indivisible.”

BAE in July 2022 announced the start of work on a demonstrator for a Tempest fighter, with this to be flown for the first time in 2027. The company is now working with Japan’s Mitsubishi Heavy Industries, which has led Tokyo’s indigenous

F-X fighter development project for several years.

Bilateral industrial agreements had previously been signed by the UK and Japan covering joint engine and radar demonstrator development projects, respectively involving R-R and IHI, and Leonardo UK and Mitsubishi Electric.

Italian industrial involvement in GCAP will include Avio Aero, Elettronica and Leonardo.

US support

The trilateral project aims to produce a new manned fighter and supporting technologies for service introduction from 2035. The UK says it expects that additional “like-minded countries” will also buy into the project.

Washington has backed the GCAP initiative, with its Department of Defense noting: “The United States supports Japan’s security and defence co-operation with like-minded allies and partners, including with the [UK] and Italy.”

Notably, all three of the GCAP partners are current operators of the Lockheed Martin F-35.

The Pentagon also notes that it is pursuing its own joint development efforts with Tokyo, including “discussions on autonomous systems capabilities” which could “complement” its future fighter programme.

The next phase of GCAP will launch in 2025, with the partners to establish cost-sharing arrangements based on a joint assessment of requirements and national budgets, the UK says.

Sweden had initially also been studying potential shared future combat air requirements alongside the UK and Italy, but is no longer participating in the effort. Stockholm’s near-term needs will be met using a 60-strong fleet of Saab Gripen E fighters, due to enter frontline operational use in early 2025. ▀

Berlin confirms F-35A acquisition to meet nuclear commitment

Ryan Finnerty Tampa

Germany will complete its planned purchase of 35 Lockheed Martin F-35A stealth fighters, following the receipt of funding approval.

“It was decided to prepare the parliamentary procurement decision for the F-35A as the successor to the [Panavia] Tornado fighter-bomber for the Bundeswehr,” the German parliament’s budget committee confirmed on 14 December.

“The F-35A is to take over the role of nuclear sharing previously assigned to the Tornado until its decommissioning,” the nation’s government says. The US-built type will also perform ground-attack and close air support duties, it adds.

Berlin in March 2022 declared its intent to procure the batch of F-35As to assume its nuclear commitment to NATO, since its air force’s Eurofighter fleet lacks the ability to carry the US-provided weapons.

Lockheed will deliver the service’s first Lightning II in 2026, according to the US F-35 Joint Program Office. Berlin says its first eight examples will remain in the USA to support the training of pilots and maintenance personnel, with shipments to Buchel air base to commence during 2027.

Confirmation of the plan sees Germany become the 17th nation to sign on officially to the F-35 programme.

Dassault has secured its status as ‘architect’ for trilateral New Generation Fighter



Can Symphony hit the right note?

Supersonic start-up Boom reveals engine development plan with trio of partners – but analysts are sceptical of prospects

Jon Hemmerdinger Tampa
Pilar Wolfsteller Las Vegas

Faced with a lack of alternatives from the major engine manufacturers, Boom Supersonic has turned to a trio of companies to develop an all-new powerplant for its Overture supersonic passenger aircraft.

Called “Symphony”, the engine will be a twin-spool, medium-bypass turbofan, similar to those on conventional aircraft, with no afterburner, producing 35,000lb (156kN) of thrust at take-off.

Partnered with Boom on the programme are Florida Turbine Technologies (FTT), GE Additive and StandardAero.

A business unit of Kratos Defense & Security Solutions, FTT will be responsible for engine design, GE Additive for “additive technology design consulting” and StandardAero for maintenance.

FTT is already developing turbofan engines for cruise missiles and unmanned air vehicles, albeit in the 600-900lb-thrust range.

“Developing a supersonic engine specifically for Overture offers by far the best value proposition for our customers,” says chief executive Blake Scholl.

“Through the Symphony programme, we can provide our customers with an economically and

environmentally sustainable supersonic airplane – a combination unattainable with the current constraints of derivative engines and industry norms.”

The new engine will include a Boom-designed axisymmetric supersonic intake, variable-geometry low-noise exhaust nozzle, and passively cooled high-pressure turbine.

Boom’s decision to seek out alternative propulsion suppliers came after major aircraft engine makers declined to engage with the start-up, saying the development of a new powerplant for the supersonic market was too risky.

Rolls-Royce had been partnered with Boom, but stepped away from the project in September 2022.

Despite Scholl’s upbeat tone, aerospace analysts are unconvinced by the viability of Boom’s plan.

Michel Merluzeau of the AIR consultancy views the decision of the major engine makers to shy away from the programme as “indicative that they’ve done their analysis and there is a fundamental risk”, he says.

“Engine development is one of the most-complex engineering

efforts that any start-up would undertake,” he adds. “It’s financially draining. It’s time-consuming. It’s engineering heavy.”

Merluzeau is sceptical that Boom can ever sell enough Overtures to cover the cost of developing the Symphony engine.

Alex Krutz, managing director at aerospace and defence advisory Patriot Industrial Partners, thinks the plan might benefit from efficiencies and an “entrepreneurial” spirit.

However, Krutz says designing, testing and producing an engine will cost billions of dollars.

“A start-up commercial airline OEM that has not certified an aircraft... now intends to design, develop, test and produce its own engines. There [are] lots of challenge in its flightpath,” he says.

Addition of the Symphony engine is the latest design change for Boom, having last July revealed a new look for the Overture, featuring a longer wingspan and a more contoured fuselage, and with four engines rather than two.

Design of the Symphony engine is already under way, Scholl adds, maintaining the Overture is on track to receive type certification by 2029. The company plans to begin production of the aircraft in Greensboro, North Carolina in 2024, with a first flight currently scheduled for 2027. ▾

See p42

Company maintains Overture is on track for type certification by 2029

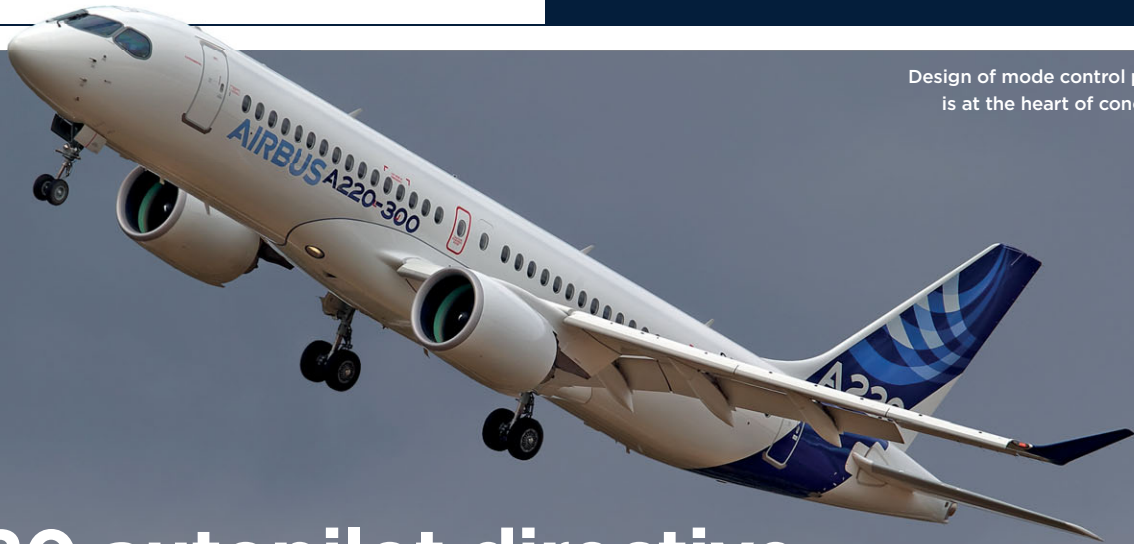
Boom Supersonic

Download the 2022 Commercial Engines Report
now with updated enhanced data and in-depth market analysis

FlightGlobal.com/commengines



Design of mode control panel
is at the heart of concerns



A220 autopilot directive followed 'nearly catastrophic' take-off incidents, says FAA

AirTeamImages

Regulators warn about risk of inadvertent activation of automated system on Airbus single-aisle during departure

David Kaminski-Morrow London

US regulators have disclosed that two “nearly catastrophic” events were among 38 take-off incidents involving inadvertent Airbus A220 autopilot engagement, and are taking additional action to prevent a recurrence.

Transport Canada has already mandated aircraft flight manual changes to emphasise the risk of unintentionally activating the autopilot during the take-off roll.

But the US Federal Aviation Administration (FAA) is imposing an additional requirement after an incident in September in which the crew attempted to re-engage a disconnected autothrottle but mistakenly activated the autopilot, causing the jet to rotate below the V1 decision speed.

“This resulted in a low-energy take-off, which is extremely hazardous as it could lead to the [aircraft] stalling [or] impacting terrain,” said the FAA in a 22 November directive.

Autopilot and autothrottle buttons for the A220 are located, one directly above the other, in the centre of the mode control panel.

“The control panel for autothrottle and autopilot engagement is structured in such a way that it

is possible for the flightcrew to mistakenly engage the autopilot when attempting to re-engage the autothrottle,” says the FAA.

Activation of the autopilot is normally prohibited below 400ft.

The FAA states that the autothrottle is “prone to disconnect” during turbulence because it sources airspeed information from a different source than the flight-control system monitor. Different sources for pressure altitude between systems can also cause a disconnection.

Manual updates

Operators have already been instructed by Transport Canada to amend flight manuals to warn that inadvertent autopilot engagement could result in premature rotation, tail-strike, inability to climb or a loss of control.

But the FAA’s directive goes further by requiring an additional limitation in the manual – the prohibition of selecting or re-selecting the autothrottle once the thrust levers have been advanced to the take-off setting.

This will apply until the aircraft has ascended to at least 400ft above ground – the threshold for autopilot engagement.

In its emergency directive, Transport Canada states that “several” events have occurred in which

A220 crews have accidentally activated the autopilot late in the take-off phase, or have done so while trying to re-engage a disconnected autothrottle.

If the autopilot – which is not inhibited – is activated too early, it could command an increase in pitch to capture a pitch target, resulting in premature rotation.

This could occur even at speeds below the V1 decision speed, possibly causing the twinjet to become airborne with low energy or suffer a tail-strike if the take-off is not aborted.

“Premature [aircraft] pitch-up will require the crew to intervene immediately,” the directive stresses.

Airbus Canada, which manufactures the A220, has issued operational procedures for autothrottle selection, and instances in which the autothrottle disconnects on take-off.

“Operators should be aware that the autothrottle cannot be re-engaged if it becomes disconnected on take-off above 60kt (111km/h) and below 400ft,” says the Transport Canada directive, which covers both the A220-100 and -300.

“Crews should not attempt to re-engage the autothrottle if it becomes disconnected on take-off as this may lead to an unsafe condition if the autopilot is inadvertently engaged.” ▸

MTU turns on Switch project

Clean Aviation-funded research programme will see steam-injection and hybrid-electric systems brought together for future engine concept

Dominic Perry London

Technologies that could equip a future generation of Pratt & Whitney geared turbofan (GTF) engines, including hybrid-electric and steam-injection systems to slash greenhouse gas emissions, are to be matured under an ambitious EU-backed research programme led by MTU Aero Engines.

In September, the EU's Clean Aviation body disclosed that it had selected MTU's Switch effort – “sustainable water-injecting turbofan comprising hybrid-electrics” – as one of 20 projects sharing €700 million (\$730 million) in phase-one funding. Also included in the MTU-headed consortium are Airbus, Collins Aerospace, GKN Aerospace and P&W, plus several research bodies and universities.

MTU has previously disclosed research and technology activities around its water-enhanced turbofan (WET) engine concept, which recycles water and heat from the exhaust stream to inject steam into the combustion chamber. This is predicted to increase overall engine efficiency through heat recovery, and cut greenhouse gas emissions and contrail formation.

Parallel lines

However, the Switch project sees the WET architecture combined with a parallel hybrid-electric system, including a pair of motor generators – a 500kW unit on the high-pressure spool and a 1MW unit on the low-pressure spool – to further optimise the performance of the gas turbine.

“We aim to demonstrate the potential of these technologies to improve fuel efficiency and hence reduce CO₂ emissions by up to 25% compared to the state-of-the-art propulsion systems for short- and medium-range aircraft,” says Dr Claus Riegler, senior vice-president

technology and engineering, advanced programmes at MTU. NO_x emissions could be reduced by 80% and contrail formation by half.

Riegler declines to reveal the overall project cost but says it is a 50-50 split between industry and public funding, including a contribution from the UK Research & Innovation agency.

Under the project's timeline, by 2025, ground runs of a hybrid-electric-equipped GTF will have been performed, alongside technology and component tests for the WET engine, plus aircraft integration studies for the combined system.

25%

CO₂ emission reduction target from Switch engine compared with current propulsion technology

But Graham Webb, chief sustainability officer at P&W, says the project partners are already looking to go further. He sees the potential to conduct flight demonstrations of the hybrid-electric GTF “as early as 2026”, providing the underlying technologies are proven and additional funding is secured.

Phase one activities should take the WET concept to technology readiness level (TRL) 4 by the end of 2025, with the hybrid-electric system at TRL5. A second stage could then follow, running from 2026 – taking the Switch engine to TRL6 and encompassing “an ground and integrated hopefully

flight test for the overall Switch engine concept”.

Webb sees Switch as an opportunity to “build technologies that will further extend the efficiency of the GTF architecture”.

“With Switch, the revolutionary WET and hybrid-electric technologies will be integrated to deliver a step-change in emissions and also improve efficiency or reduce energy across the full operating system of the aircraft,” he says.

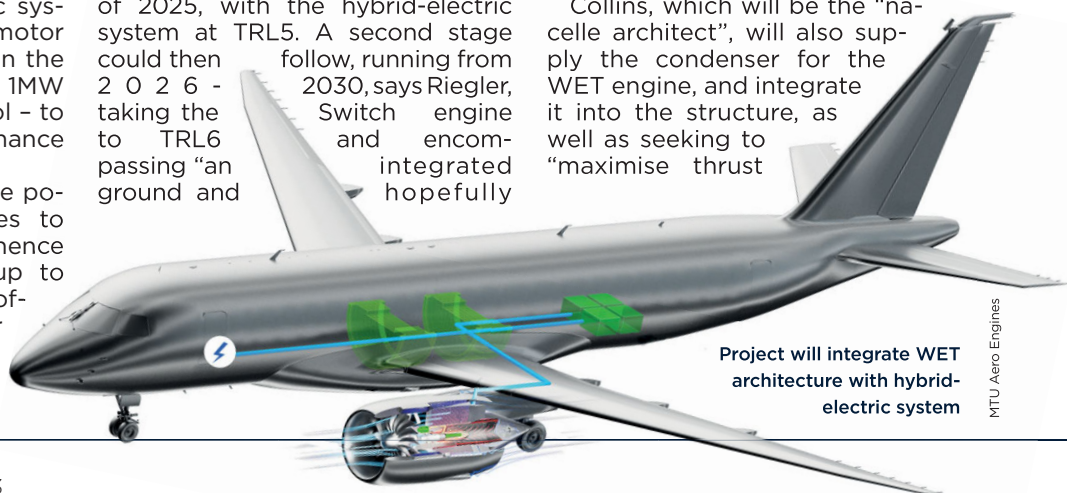
Within the consortium, P&W will be responsible for the integration of the hybrid-electric and WET systems into the GTF engine, plus the steam combustion technology.

P&W is already working on a related project, funded by the US Department of Energy, called HySIITE, which uses steam-injection technology in a hydrogen-burning engine.

Webb acknowledges some similarities between the two concepts, with “several component technologies” common to both. However, while the Switch powerplant will be evaluated for hydrogen compatibility, its “primary fuel” is designed to be sustainable aviation fuel (SAF), rather than liquid hydrogen in the HySIITE engine.

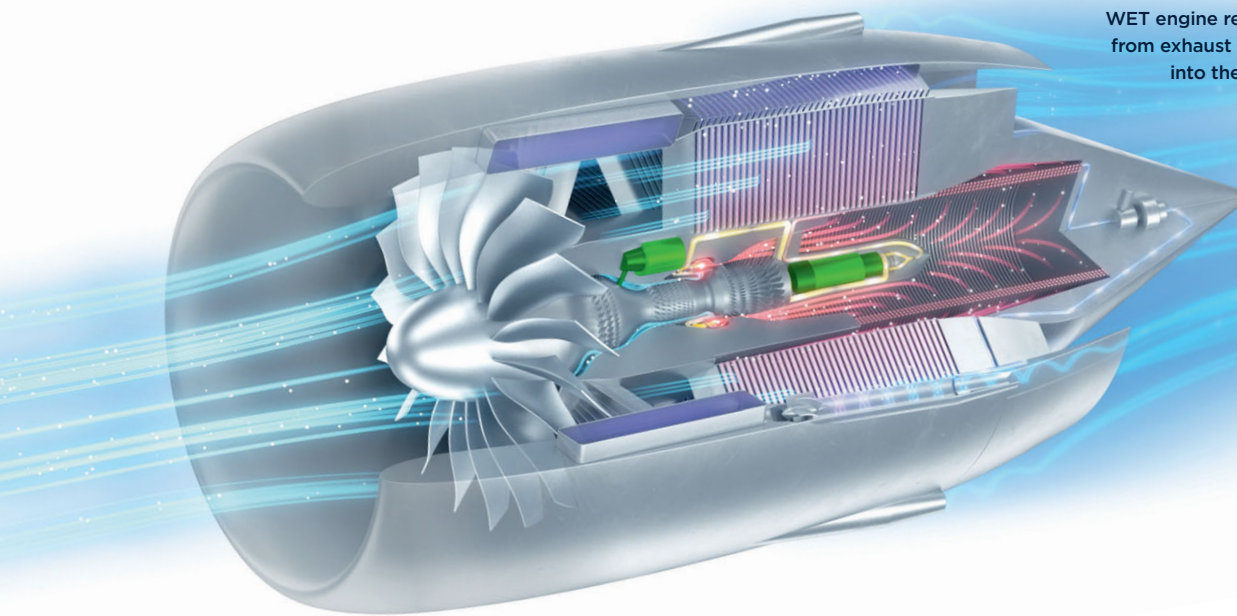
“They are related, but there are some significant differences in terms of the heat-exchanger medium, when we are talking about air versus cryogenic hydrogen from the condenser perspective, as well as the other heat exchangers.”

Collins, which will be the “nacelle architect”, will also supply the condenser for the WET engine, and integrate it into the structure, as well as seeking to “maximise thrust



Project will integrate WET architecture with hybrid-electric system

MTU Aero Engines



WET engine recycles water and heat from exhaust stream to inject steam into the combustion chamber

reverser functionality”, says Mary Lombardo, vice-president of applied research and technology at the US aerospace giant.

Additionally, Collins will supply the motor generators, safety elements of the power distribution system, and will demonstrate the “Switch integrated electric [power] train” at a new facility in Rockford, Illinois, scheduled to open next year.

Those motor generators “will enable the engine to operate more efficiently across the full flight envelope”, says Webb, providing additional power during key flight phases such as take-off or step-climb, or even relieving the gas turbine. Using energy harvesting, the aircraft’s batteries will be recharged during the cruise.

Weighty matters

Karim Mokaddem, Airbus head of electrification, says the airframer will “assess that this approach is beneficial at the aircraft level”.

“The whole system optimisation is around managing the energy at the aircraft level in such a way that the benefits [of the Switch architecture] are not killed by the added weight that we are providing with the new technologies,” he says.

Riegler says the additional equipment required for the WET system – the condenser, steam generator and water separator, for example – will see the “propulsion system grow in weight by about 50%”. The extra components will also mean a longer engine, creating more drag.

“I would like to point out though that the weight [and drag] increase is significantly compensated by the SFC [specific fuel consumption] benefit we will get,” says Riegler.

“At the point there is an opportunity for a new GTF engine, we are going to take everything we can get and leverage that”

Karim Mokaddem Head of electrification, Airbus

“So, in the end on a fuel-burn level, that engine, or that concept, contributes significantly to the overall 25% fuel-efficiency benefits.”

The hybrid-electric system will add another 1t of mass, Mokaddem says. “But this is why we need to make it beneficial with this drawback,” he says. “And into that the key technology that will pave the way to more benefits is the battery.”

He sees improvements in battery energy density arriving over the coming years, largely driven by the automotive sector.

Although both the hybrid-electric and WET systems offer potential performance improvements on their own, Riegler argues that there will be greater synergies from combining them, in particular to address the impact of the large heat exchangers on the “transient operation” of the engine: “We think that with a combination with hybrid-electric there is a significant opportunity to counteract that drawback,” he says.

P&W has for some years been considering what technologies to adopt on a second-generation GTF engine. Webb says both the hybrid-electric system and the WET technology will be considered, but much will depend on their maturity when airframer demand emerges.

“At the point there is an opportunity for a new application and a new GTF engine, we are going to take everything we can get and leverage that. Right now, it’s not possible to say whether it’s [generation] two or three. It’s dependent on how these technologies develop.”

Airframe integration

However, integration with the airframe will be key, he stresses, due to the dynamics of such a novel propulsion system. To date, neither of the big two airframers has indicated any need for a new powerplant before the middle of next decade.

While Airbus will consider the applicability of the Switch engine for its existing products, Mokaddem sees the changes to the aircraft architecture driving the need for a clean-sheet design.

Besides leading the project, MTU is also responsible for the steam turbine and water-recovery unit of the WET system. GKN Aerospace, meanwhile, will develop engine structures, including the vaporiser and heat exchangers – utilising its hot test rig in Trollhattan, Sweden – while GKN Fokker in the Netherlands will develop the high-voltage power distribution and wiring systems. ▀

Modifications are designed to increase output and cooling



P&W powers up F-35A engine enhancement

F135 provider accelerates work on core upgrade for US Air Force fighter fleet, touting cost-effectiveness of improving current design versus its replacement

Ryan Finnerty Tampa

Pratt & Whitney says it is ramping up a programme to perform an F135 engine core upgrade (ECU) on the US Air Force's (USAF's) Lockheed Martin F-35As, after receiving a preliminary support contract worth \$115 million.

"We are on contract, and we are ramping it as if it is never going to stop," says Jennifer Latka, P&W's vice-president for F135 engines.

The company now has 250 engineers working on the programme, with milestones established for the improved powerplants to enter service by 2028.

The USAF has been engaged in a multi-year effort to meet increased power generation and cooling requirements for the F-35A, which already exceed the design limits of the model's current engine.

As well as studying F135 enhancements, its separate Adaptive Engine Transition Program funded the development of more

advanced, entirely new engines by P&W and GE Aerospace.

While P&W developed and tested its XA101 demonstrator, it favours the ECU enhancement - previously referred to as the enhanced engine package - for the in-service engine, which Latka says "solves the problem in the most cost-effective way".

250

Number of engineers Pratt & Whitney now has working on its F135 engine core upgrade programme

"We believe that the core upgrade will provide \$40 billion in savings to the customer," she adds, compared with the costs associated with the development, production and sustainment of a replacement powerplant.

GE, meanwhile, maintains that its XA100 adaptive engine represents the best choice for the USAF to

"maintain a competitive edge over near-peer adversaries".

"GE Aerospace has developed an engine with 30% more range, 20% greater acceleration and double the thermal management capacity," says the company, adding it could deliver replacement engines from the end of this decade.

However, funding for either contingency was conspicuously absent from a defence spending agreement released by congressional leaders in Washington DC in early December. Instead, the 2023 National Defense Authorization Act directs an audit of all "efforts to modernise the propulsion, power and thermal management systems of the F-35", with a report to Congress due by 28 February 2023.

The bill does include funding for the continued research and development of advanced adaptive engine propulsion systems under the USAF's Next Generation Adaptive Propulsion initiative. That effort involves GE and P&W, plus Boeing, Lockheed and Northrop Grumman. ▶

US Air Force

FlightGlobal

IN ASSOCIATION WITH



Download the 2023 World Air Forces Report

FlightGlobal.com/waf

Bell to build Black Hawk successor

V-280 Valor tiltrotor chosen for long range assault element of US Army's transformational Future Vertical Lift programme

Ryan Finnerty Tampa

As 2022 drew to a close, the US Army made the first move in what it describes as an aviation "strategic pivot", selecting Bell's V-280 Valor tiltrotor for the first part of its ambitious Future Vertical Lift (FVL) programme.

By picking the Textron subsidiary to deliver its Future Long Range Assault Aircraft (FLRAA), the service also has set in motion a transfer of utility rotorcraft dominance from UH-60 Black Hawk producer Sikorsky.

Lockheed Martin company Sikorsky had sought to maintain its position via a joint development activity with Boeing, with the pair offering the coaxial Defiant X platform. But on 5 December, the army announced its selection of the V-280 to provide its next generation assault helicopter capability.

"This down-select represents a strategic pivot for Army Aviation to the transformational speed and range our army needs to dominate future battlefields," says Major General Walter Rugen, director of the FVL cross-functional team.

With both bidders having flown demonstrator aircraft in support of their offers, he adds: "The prototyping and risk-reduction efforts allowed the army to significantly reduce the time needed to get to today's announcement."

"FLRAA's inherent reach and stand-off capabilities will

ensure mission success through tactical manoeuvre at operational and strategic distances," the army says. It had launched the FLRAA competition in 2019, seeking dramatic increases in range, speed and survivability versus the Black Hawk, which has been on active service for more than four decades.

Strategic emphasis

Earlier in 2022, Rugen said initial evidence gathered from the Russo-Ukraine war validates the US Army's strategic emphasis on boosting the speed and survivability of its aircraft, noting: "low and fast matter".

"Bell has a long history supporting Army Aviation and we are ready to equip soldiers with the speed and range they need to compete and win using the most mature, reliable, and affordable high-performance long-range assault weapon system in the world," says Bell chief executive Mitch Snyder.

Textron chief executive Scott Donnelly, meanwhile, describes the V-280 as a "remarkable and transformational weapon system". During a flight-test campaign totalling 214h, Bell demonstrated its design's ability to achieve a maximum speed of 305kt (564km/h).

Under an initial FLRAA contract worth \$232 million, Bell will refine

"weapon system design, sustainment, digital enterprise, manufacturing, systems integration, flight-testing, and airworthiness qualification" through the production of a virtual prototype, rather than an actual aircraft. The entire programme will be worth tens of billions of dollars over the coming decades, however, also including export potential for the Valor.

Cirium fleets data shows that the US Army currently operates more than 2,300 UH-60-series rotorcraft.

The defeated Sikorsky-Boeing team notes: "We remain confident Defiant X is the transformational aircraft the US Army requires to accomplish its complex missions today and well into the future.

"We will evaluate our next steps after reviewing feedback from the army," the Sikorsky-Boeing team adds. Should the partner companies opt to do so, it could file a formal protest with the US Government Accountability Office seeking to stop initial contract work and have the decision overturned.

Also being staged under the FVL programme, the army's Future Attack Reconnaissance Aircraft competition pitches Bell against Sikorsky. The companies are respectively promoting their conventional 360 Invictus and coaxial-rotor RaiderX designs for the requirement to replace the service's retired Bell OH-58 Kiowa Warriors, with flight testing to begin in late 2023. ▶



Flight-test campaign demonstrated design's ability to reach a speed of 305kt

Flight tests using modified superjumbo are scheduled to begin in 2026



H2-go

Airbus has begun development of its own hydrogen fuel cell powertrain which will be flown aboard an A380 testbed

Airbus

Dominic Perry Ottobrunn & Toulouse

Inside an otherwise nondescript building on Airbus's campus in Ottobrunn near Munich – all grey steel and mirrored glass – high-tech components vital to a future generation of zero-emission airliners are beginning their journey, perhaps, to production.

There are few external clues as to what the building is for, save for the twin vent towers on the roof, and tall white cylinder outside that holds 800kg (1,760lb) of hydrogen.

In fact, this is the airframer's E-Aircraft Systems Test House (EAS). Opened in 2019, the facility and the office blocks that sprawl around it, are key to Airbus's future decarbonisation agenda. It is, at over 3,000sq m (32,300sq ft) the company boasts, "the largest test house dedicated exclusively to alternative propulsion systems and fuels in Europe".

Originally commissioned for the since-axed E-Fan X programme, the EAS has nonetheless helped Airbus to maintain its exploration of new propulsion systems, a quest that has gained extra impetus in recent years thanks to aviation's decarbonisation commitments.

That has crystallised in Airbus's ZEROe programme of technology studies and maturation, through which the airframer hopes to be in a position in 2027 or 2028 to launch a zero-emission passenger aircraft for service entry in 2035.

In the EAS, several test campaigns are due to kick-off in early 2023, but perhaps the most striking – for a whole host of industrial and strategic reasons – is an initiative under ZEROe that has seen Airbus design and begin assembling its own fuel cell propulsion system.

Airbus has always included fuel cells in its list of potential future energy sources, but most industry observers assumed it would bring in a powertrain from one of the many companies currently working on such technology. Instead, the airframer has opted to create its own.

2MW

Output envisaged by Airbus for 100-seat, 1,000nm-range future aircraft

Disclosing the effort at the Airbus Summit 2022 in late November, Hauke Ludders, head of fuel cell propulsion systems for ZEROe, said: "We have been able to design and develop the first fuel cell engine demonstrator at lab scale, already reaching two-megawatt class."

In a large Perspex-type box, around the size of a 20ft shipping container, the evidence of that effort is visible. Dubbed the "iron pod", the test rig is a carefully deconstructed – for reasons of access and measurement – version of an eventual powertrain: there is the

hydrogen feed, there are the fuel cell channels (each containing two stacks), there the cooling system, the pumps, and all the other balance of plant required for their operation; in appearance it resembles an exploded diagram of a full propulsion system.

However, currently missing from this are the motors – integration testing will be complete by next May – and a propeller, which will not be used for the iron pod tests, with the rig instead able to simulate its function.

So far, tests have largely been confined to the power-generation capabilities of the fuel cells, but, over the coming months the different systems will be gradually brought together until, at some point in the middle of 2023, a full system test will be performed. Maximum power of 1.2MW will be reached over the coming year.

And while the rig can simulate various stages of a flight – be it take-off, landing or cruise – the equipment is not in any way ready to be put onto an aircraft. However, what it will allow the ZEROe team to do is derisk the process of taking it to flight.

Laboratory tests of the underlying systems for the fuel cell powertrain will continue until the end of 2023, says Mathias Andriamisaina, head of ZEROe demonstrators and tests at Airbus.

At that point a "second step" is envisaged, he says, "which will be more integrated equipment, but also flight-qualified equipment",

Airbus

allowing the company to “take this technology into the air”.

That milestone is anticipated in 2026 using the airframer’s A380 MSN1 flying testbed.

Airbus sees a need for a 2MW-system to power the 100-seat, 1,000nm (1,850km)-range aircraft being contemplated under ZEROe.

However, a scaled version of the powertrain, sized at around 1MW, will be used for the flight tests.

In February, the airframer disclosed that it would use the same A380 for tests of a hydrogen-burning turbofan in partnership with CFM International, modifying the upper port-side fuselage to incorporate an engine pylon.

Airbus will take advantage of the addition of the “stub” pylon and related structural reinforcement from that effort, plus the hydrogen fuel system, to also test the fuel cell powertrain, says Andriamisaina.

The hydrogen-combustion trials will use four fuel tanks, each holding 125kg of liquid hydrogen, but the fuel cell system requires just one.

Flight trials

Flight tests are due to run over the 2026-2028 period, taking the fuel cell system to technology readiness level 6 or 7, says Glenn Llewellyn, vice-president zero-emission aircraft at Airbus.

Although the in-house powertrain development threatens to reverse Airbus’s traditional role as a customer rather than producer of propulsion systems, Llewellyn says no decision has been taken on the go-to-market strategy.

“We need to drive the technology forward... [it] will influence the overall aircraft design and we need to consider it as a global package”

Hauke Ludders Head of fuel cell propulsion systems, ZEROe

“I think the first point to highlight is that right now we are developing the technologies... and we are developing the methods for integrating those technologies into a fuel cell-type engine.

“It doesn’t mean Airbus will do this on its own. In a subsequent step, if we decide to commercialise that technology we might decide that’s the best approach, but we could also decide to partner,” he says.

“We need to drive the technology forward and we see this as our duty to significantly invest and to really understand that because also this technology will influence the overall aircraft design and we need to consider it as a global package,” adds Ludders.

Llewellyn points out that there are already several partnerships in place to support the demonstrator system. These include internal suppliers – Airbus Helicopters is helping to develop the gearbox and propeller, the latter around the same size as the 5.33m (17.5ft) component on the A400M-powering Europrop International TP400 – joint ventures such as the Aerostack fuel cell business Airbus has established with

Erlingklinger, and external companies such as the undisclosed supplier of the electric motors.

In its current iteration, the powertrain features a gearbox and propeller, but Andriamisaina says other configurations are under consideration, including eliminating the gearbox, depending on the speed range of the motor, or adding a ducted fan.

Size matters

Airbus is considering two different aircraft under its ZEROe initiative, one sized to transport 100 passengers on routes of 1,000nm and the other, 200 passengers on 2,000nm routes.

Llewellyn says hydrogen propulsion appears feasible for both designs but thinks it will be harder to scale a fuel cell powertrain to the size required for the larger aircraft.

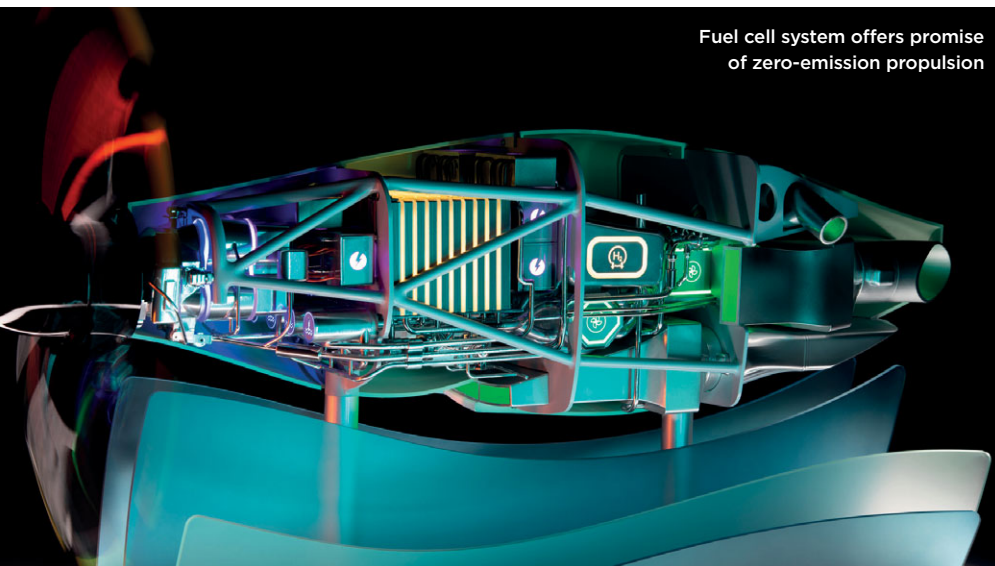
Inside the EAS, opposite the iron pod, another test rig is coming together. Rather than for fuel cells though, this will test a superconducting and cryogenic electrical distribution system for Airbus’s UpNext innovation arm.

Superconductive materials offer the promise of being able to dramatically improve the performance of electric components and to shed weight from the electrical system. However, to achieve that, the material must be cooled to at least -200°C (-328°F).

Conducted under a project dubbed ASCEND, experiments using the 1MW ground-test rig will take place in 2023, running for up to six months.

Separately, UpNext has signed an agreement with CERN, the European Laboratory for Particle Physics, to conduct additional evaluation of superconducting technology through a project called SCALE.

Although not part of ZEROe, superconducting technologies matured through ASCEND or SCALE could also potentially support that project’s aims. ▶



Fuel cell system offers promise of zero-emission propulsion

Innovations include redesigned rotor head and simplified Fenestron



Revolution over evolution

DisruptiveLab concept will mature new technologies that could halve fuel burn from future helicopters

Dominic Perry Toulouse

Airbus Helicopters has revealed a clean-sheet concept rotorcraft to validate a set of new technologies it hopes will collectively deliver a fuel-burn reduction of up to 50%.

Dubbed the DisruptiveLab, the single-engined helicopter (F-WADL) was due to make its maiden sortie as *Flight International* went to press.

Despite its resemblance to existing models in Airbus Helicopters' line-up, the manufacturer stresses that it is a completely new aircraft.

"There is not one piece from another helicopter," says Tomasz Krynski, vice-president research and innovation at Airbus Helicopters.

A clean-sheet approach was necessary to incorporate all the desired enhancements, he says. "If you don't design [them in] from the very beginning you don't get the capability," he says.

"We have reached the limits of what we can test if we had just based the demonstrator on an existing platform," says Airbus Helicopters chief executive Bruno Even.

"We have reached the limits of what we can test if we had just based the demonstrator on an existing platform"

Bruno Even Chief executive, Airbus Helicopters

While it is not a programme in its own right, the DisruptiveLab will help Airbus Helicopters "facilitate the transition from innovation R&T to development", he adds.

Technologies under evaluation include a redesigned rotor head with inter-blade lead-lag dampers integrated into the hub, enabling a more compact design. This reduces drag from the rotor head by 40%.

A new aerodynamically-improved composite and aluminium fuselage, including highly-integrated skid landing gear able to counteract ground resonance, has around 20% less drag than previous versions.

In addition, the DisruptiveLab features a slimline tail boom designed around a maintenance-free fully enclosed transmission.

Although retaining the airframer's distinctive Fenestron shrouded tail rotor, Airbus Helicopters has cut the number of parts in the system by 40% and reduced the size of the fan, the latter move enabled by the lighter, more aerodynamically efficient design of the rotorcraft.

Krynski points out that for every 5kg (11lb) of mass reduction, 1kW less power is required from the propulsion system, in turn reducing

the amount of torque the tail rotor is required to counter.

Additionally the DisruptiveLab is fitted with a parallel hybrid-electric drive system capable of recharging the batteries during flight. "This will produce a very strong reduction in CO2 emissions," he adds.

Section specialists

Even says each of the manufacturer's main production sites contributed structures for the helicopter in line with its new industrial model. This sees each specialising in a particular section, such as the rear or main fuselage.

However, he declines to reveal suppliers for crucial elements of the design, such as the engine or hybrid system.

The DisruptiveLab is around the same size as Airbus Helicopters' existing H130-based FlightLab demonstrator, but Even notes that the technologies being evaluated are scalable.

Separately, the airframer is continuing development of its emergency battery system to assist with auto-rotative landings in single-engined helicopters.

System functionality has been "validated", says Krynski, with Airbus Helicopters now working with its supplier "on the costs of this function and the mass of the global system".

"This is something we want to get to [technology readiness level six] by the middle of next year [2023]. It is not enough to demonstrate something can fly - it must be affordable." ▀

Max certification reprieve in sight

US lawmakers seem to grant Boeing exemption from need to update latest variants of twinjet ahead of validation

Jon Hemmerdinger Tampa

Boeing appears to have secured critical regulatory exemptions for its 737 Max 7 and Max 10 thanks to provisions slipped into a US government spending bill working its way through Congress.

Due to be voted on as *Flight International* went to press, the bill would exempt the Max 7 and Max 10 from requiring an updated pilot-alerting system.

However, it does mandate the retrofit of two “safety enhancements” for the twinjet – an update to the 737 Max’s angle-of-attack (AOA) system, and changes to its stick-shaker warning system. Boeing must bear the cost of those upgrades.

As written, the provisions specify that the pilot-alerting requirement does not apply to type certificates for which manufacturers submitted applications prior to 27 December 2020 – the date the law took effect. That language frees the Max 7 and Max 10 from the legislation.

Introduced under the Trump administration, that law prohibits the Federal Aviation Administration (FAA) from certifying aircraft which lack a modern “flightcrew alerting system”.

All Max variants, including those yet to enter service, do not comply with the new requirement, and Boeing was facing the possibility that the FAA would refuse to certificate

the Max 7 and Max 10 without the implementation of costly and time-consuming changes.

Boeing aims to have the Max 7 certificated by early 2023, and the Max 10 in late 2023 or early 2024.

Lawmakers included the measures in a broad fiscal year 2023 spending bill. The bill has been approved by leaders of the Senate and House of Representatives.

In an apparent compromise, the spending bill also includes safety enhancements which mirror those recently floated by US Senator Maria Cantwell, who represents Washington state.

Synthetic system

They require all Max variants to be equipped with a “synthetic enhanced angle-of-attack system” and a “means to shut off stall-warning and over-speed alerts”.

Any changes would take effect for new production aircraft, regardless of variant, one year after the FAA issues the Max 10’s type certificate. Airlines would then need to update all in-service Max jets with the safety enhancements within another two years – a timetable consistent with when aircraft will need heavy maintenance checks.

“The safety-first alternative is much stronger than the no-strings-attached approach that was first offered,” says Cantwell, referring to an earlier proposal that included an exemption but no requirement for other updates.

“Passengers need to know that the entire Max fleet will be uniform and safer.”

The synthetic AOA sensor would supplement the 737 Max’s existing system, consisting of two physical AOA vanes. Erroneous AOA readings contributed to a pair of fatal crashes, in 2018 and 2019, which led to the narrowbody’s lengthy grounding.

Boeing is already developing an “enhanced” AOA system for the Max 10, an update required by European regulators, with plans to also update the other variants.

Allowing pilots to disable stall and over-speed alerts is viewed as a means to help flightcrew address aircraft problems by minimising cockpit distractions.

Signalling his support for Cantwell’s proposal in mid-December, Boeing Commercial Airplanes chief executive Stan Deal said the modifications add “the capability to discern the false AOA signal, and also [an] inhibit switch for the stick-shaker”.

However, the airframer declines to comment on the legislative push. Several weeks ago, supporters in Congress failed to insert similar language into a military spending bill.

Such an exemption faces push-back from families of victims of the two Max crashes, as well as from the Allied Pilots Association, which represents crews at American Airlines. ▀



US FAA requires fire resistance in vicinity of A321XLR rear fuel tank

Regulator outlines modifications that must be made for long-range narrowbody to conform with safety protocols

David Kaminski-Morrow London

US regulators have laid out formal requirements for the Airbus A321XLR's lower fuselage, in the vicinity of the rear centre fuel tank, to be resistant to fire penetration.

The large tank – situated in the aft fuselage, with the top of the tank directly below the passenger cabin floor – is crucial to the A321XLR's range capability, but the unusual structure has prompted concerns over fire risk in the event of an accident.

It will be integral to the aircraft, with the exterior A321XLR fuselage skin forming part of the tank wall.

"These areas will lack the thermal [and] acoustic insulation that usually lines the exterior skin of an airplane fuselage," said the US Federal Aviation Administration (FAA) in a 6 December regulatory filing.

This design was "not envisaged" by safety criteria originally drawn up for transport aircraft, which requires any thermal and acoustic insulation in the lower half of the fuselage to comply with "stringent" flame-penetration resistance tests.

Such insulation was intended to provide an additional barrier between passengers and the source of a fire – particularly one resulting from a pool of spilled aviation fuel.

"Accidents have illustrated the threat that exists due to fuel spillage from damaged aircraft fuel tanks that result in pool fires that penetrate into the cabin," states an FAA advisory circular on insulation installation.

"Research has shown that the [aluminium] skin currently in use offers little opportunity to prevent burn-through."

Thermal and acoustic insulation, it says, can delay onset of fire into the cabin for a "sufficient" length of time to allow passenger evacuation.

But the fire-resistance rules for insulation do not actually demand that insulation be fitted to the aircraft because, at the time, lower-fuselage insulation was assumed to be a normal design feature.

The design of the A321XLR rear centre tank, however, does not allow compliant insulation to be placed beneath the cabin floor.

This means passengers seated above the tank could experience discomfort from the cooling effect of the large quantity of unheated fuel beneath them.

Insulating panels

Airbus has opted to fit insulating panels between the top of the tank and the cabin floor, to aid passenger comfort. But the limited space, and the need for ventilation and to keep nearby decompression panels free of blockage, means the airframer is not able to meet the normal regulatory compliance standards for thermal and acoustic insulation.

This has resulted in the FAA's having to revisit its rules on fire resistance, given that the A321XLR's design contradicts the assumption that the lower fuselage would be fitted with normal insulation.

"Specifically the FAA will require that the lower half of the airplane fuselage, spanning the longitudinal area of the tank, be resistant to fire penetration," it states.

This resistance will be "equivalent" to that which would have been provided if the fuselage was fitted with normal thermal and acoustic insulation, it adds, to address the burn-through "vulnerability".

Such resistance could be achieved through the construction of the fuel tank itself, or the inclusion of other surrounding features.

Boeing has submitted comments to the FAA regarding Airbus's application for special conditions to apply to the A321XLR tank.

Boeing requested that the A321XLR rear tank fire-resistance capability should be equivalent to that of the wing-box area, arguing that the FAA's proposal – based on equivalence to thermal insulation of the fuselage – "does not address" hazards associated with fuel tanks.

But the FAA has rejected this, stating that the special conditions are "not intended" to ensure that the rear centre tank is constructed to ensure fire-resistance similar to that of the wing-box area.

"This [A321XLR tank] design presents a [burn-through] vulnerability that is addressed by these special conditions," it adds. "The same vulnerability does not exist with wing-box construction due to that structure's significant mass, and large surface area that dissipates heat."

There is no need to add insulation over the wing-box, the FAA says, as this "would not contribute" to fire-penetration resistance.

Meanwhile, Airbus on 13 December conducted a test flight with a duration of 13h 15min as part of its development programme for the long-range twinjet.

The airframe (F-WXLR) departed Toulouse shortly after 08:00, returning to land at about 21:20. ▀



Service entry of developmental narrowbody is envisaged in 2024

Crew opted to return to Hong Kong shortly after taking off



UPS 747-8F engine fire traced to 'finger loose' bypass valve port

Blaze in GEnx-2B powerplant occurred as freighter departed Hong Kong – and continued after it returned to airport

Alfred Chua Singapore

Hong Kong investigators have identified an improperly installed bypass valve port as the cause of a fuel leak that led to an engine fire on a UPS Boeing 747-8 Freighter.

Releasing its final report into the 20 July 2021 incident, Hong Kong's Air Accident Investigation Authority (AAIA) says the valve port was found to be "finger loose", with a gap between the fitting and the housing of the fuel metering unit.

Operating as flight UPS3 to Dubai from Hong Kong International, as the 747-8F (N624UP) transitioned from take-off to climb, at about 300ft, the crew received a fan-speed exceedance warning for the left outboard engine. Despite commanding the engine to idle, it continued to oscillate around the take-off speed/overspeed limit "causing a loss of thrust control", says the report.

As a result, around 4min into the flight, the crew opted to shut down

the powerplant and return to Hong Kong. Some 12s later, an engine fire alarm was triggered. The crew discharged two fire extinguisher bottles but the fire warning continued, lasting approximately 9min 30s in total, ending shortly before touchdown.

After landing in Hong Kong at 12:30 local, inspections by the airport's fire department revealed no fire. However, 22min later white smoke and then flames began to emerge from the engine, a GE Aerospace GEnx-2B67/P turbofan. Additional suppressants were applied and the fire extinguished within 40s, says the AAIA.

Thermal damage was sustained to the engine exterior core. The engine pylon, thrust reversers, exhaust sleeve and cone were all removed and replaced. However, the rest of the aircraft was undamaged, the report says.

Subsequent tests performed on the engine fuel system discovered multiple leaks from the fuel metering unit (FMU), which were eventually isolated to three loose bypass

fittings. Further analysis narrowed the leak that triggered the fire down to a loose fuel supply pressure bypass valve port fitting.

During the flight, the incorrect low pressure readings in the FMU caused by the leak were sufficient to cause the engine FADEC to request more fuel to avoid a flame-out, which in turn caused the fan overspeed.

Hot components

Investigators believe the in-flight fire was caused by the auto-ignition of leaking fuel as it came into contact with hot engine components. This lasted around 10min in total, the report says.

Fuel remaining in the under-cowl area after shutdown, probably leaking as a result of "secondary damage" to fuel-carrying components, plus a significantly higher temperature due to the in-flight fire, caused the ground fire, the AAIA adds.

"The under-cowl area likely contained components above fuel auto-ignition temperature even after 22 minutes of shutdown," it says.

The AAIA has recommended a 100% torque verification procedure that "minimises the likelihood" of an improper installation. GE has also advised operators to introduce a shim check inspection, to ensure the valve port is properly installed.

The freighter was delivered to UPS in November 2020. The logistics company operates a fleet of 28 747-8Fs, Cirium fleets data shows. ▶

"The under-cowl area likely contained components above fuel auto-ignition temperature even after 22 minutes of shutdown"

Hong Kong Air Accident Investigation Authority

Wrongly refitted trim switch left pilots fighting for control of E175

Crew were forced to declare an emergency after maintenance error caused them to struggle keeping regional jet's nose down

David Kaminski-Morrow London

An Embraer 175 pitch-trim switch, which had been inadvertently fitted upside-down, resulted in the crew's experiencing a serious flight-control incident on departure from Atlanta, US investigators have determined.

The captain had already flown the American Eagle jet from Detroit to New York LaGuardia earlier the same day, but the crew noted a pitch-trim failure message during the journey, and chose to have the issue checked on arrival.

Maintenance personnel partially removed the trim switch on the captain's yoke with the intention of replacing it, but then decided instead to defer the item.

National Transportation Safety Board (NTSB) investigators believe the partial removal of the switch at LaGuardia resulted in its being accidentally re-installed upside-down. The deferral decision meant the switch was not tested.

The switch was placarded as inoperative – but not deactivated, as there was no requirement for such action – and the captain was simply advised not to use it.

During the second flight of the day, a service from LaGuardia to Atlanta, the first officer flew the aircraft without any problems.

But the captain took the role of the flying pilot for the next departure, from Atlanta back to LaGuardia, and the inquiry believes “highly-practised behaviour” meant the captain automatically reverted to using the yoke trim switch even though he had been told otherwise.

It states that his use of the yoke switch resulted in the aircraft's pitching up when he was attempting to trim down.

Trim runaway

As a result, the captain thought the aircraft was affected by a trim runaway as it climbed out of Atlanta, and the crew declared an emergency, seeking to return to the airport, less than 2min after departure.

Flight-data recorder information revealed multiple trim-up commands from the captain's trim switch and showed the aircraft's horizontal stabiliser – initially positioned at 4° nose-up – moved to 13° nose-up over the same interval.

The captain told the inquiry that both he and the first officer had to push forward on their control columns to prevent the aircraft from

pitching up. The jet underwent several pitch oscillations, and reached a maximum pitch-up attitude of 27°, the crew subsequently informing air traffic control that the aircraft was in a “stalling situation”.

With the use of banking and activation of a trim system cut-out switch, the crew managed to regain control of the aircraft. The flight-data recorder captured a number of trim-down commands from the first officer's switch, and the captain transferred control to the first officer.

The aircraft – registered N117HQ and operated by Republic Airways – successfully returned to Atlanta, touching down on runway 10 about 20min after take-off.

None of the six passengers on the lightly-loaded jet, or its three crew members, were injured during the 6 November 2019 incident.

Embraer had already previously advised operators that the trim switch could inadvertently be fitted the wrong way round, and issued a service bulletin in February 2015.

The bulletin recommended installation of a support in the yoke to prevent incorrect installation. It had a compliance period of three years, but the aircraft involved in the incident had not been modified. ▀



Embraer had advised operators of risk but affected aircraft had not been modified



— Our unrelenting
passion fuels
change

— **Because we believe the world
works better when it flies**

At GE Aerospace, we have the spirit, the ambition, and the means to help achieve the industry's commitment to net-zero by 2050.

Leveraging highly innovative technological advancements, our people are relentless in their pursuit of decarbonization to keep operators, defense forces, and global commerce moving forward.

See what we're doing today for the benefit of us all tomorrow.

— geaerospace.com



GE Aerospace

New NH90 boss targets stability

NH Industries president Axel Aloccio urges customers to keep faith in type as consortium tackles lingering deficiencies

Dominic Perry London

The new president of NH Industries (NHI) believes a trio of nations seeking to ditch their fleets of NH90 helicopters are abandoning the programme at the worst possible moment, with long-sought availability improvements just around the corner.

Axel Aloccio took over as the head of NHI in mid-September and was swiftly forced to deal with a fresh crisis, when Sweden on 1 November announced plans to replace its 18-strong NH90 fleet.

Stockholm followed Australia and Norway, which had revealed similar decisions within the previous 12 months, in seeking to exit the programme. Canberra currently operates 47 of the type, while Oslo has

already pulled its 13 delivered examples from use, and refused to take delivery of its remaining final helicopter.

While each nation has specific complaints, the

common thread linking their decisions is a long-running dissatisfaction with availability rates.

But Aloccio, speaking exclusively to FlightGlobal, says improvements are within reach. "The timing is a bit unfortunate, because we feel they have done most of the hard work," he says. A customer does not acquire a platform and make the associated investment in training and support "just for 10 or 15 years - you do it for 50 years", he adds.

He compares the situation to a mountain stage during the Tour de France, where "there's a big climb and it's hard" but once you reach the summit "you know the most difficult part is done and then it starts to be flat or even downhill. But this is where they decide to get off the bike and give up."

Improved availability

In recent months, availability rates in Australia and Sweden, at least for the latter's nine anti-submarine warfare-ruled examples, have been well above average, he notes.

Aloccio also argues that "dropping the NH90 now" would not be the most cost-effective solution for the countries or their taxpayers, given that billions of dollars will be required to bring alternative helicopters into service.

Instead, if "they invested even a very small fraction of that into further enhancing the NH90 support system", additional pilots or technicians could be trained, or more spare parts procured. "We are offering them many things for a very small fraction of what



Sweden recently announced plans to replace its 18-strong fleet

they would invest in procuring new helicopters," he says.

But whatever the three nations eventually choose, Aloccio says NHI will "respect their decision" and "support them until the end".

Under his predecessor Nathalie Tarnaud Laude, NHI and its partner companies - Airbus Helicopters, Leonardo Helicopters and GKN/Fokker - launched a transformation plan called New Horizon.

In December 2021, Tarnaud Laude promised that system-wide changes, such as better spare part availability and localisation of overhaul services, would drive average global fleet availability to 50-60% by the end of 2022.

Aloccio admits NHI has failed to reach that target, with average global fleet availability sitting at "a little bit above 40%". However, that figure disguises the extremes: at one end, some operators are hovering around 90%, while others are "achieving much less".

The shortfall is down to numerous factors. Some, including an



Airbus Helicopters

"In the long run we will have an extremely robust support system that will cater to the needs of all the nations"



ongoing supply chain crunch, and the war in Ukraine, are outside of NHI's control, but Aloccio admits there also has been a longer than hoped for period of "latency" – the time taken for any changes made to have an effect on averages taken over a six- or 12-month period.

Performance indicators

Despite this, he is confident that progress will become apparent "over the next 12 to 18 months", when "we will definitely see an improvement in the KPI [key performance indicators], that's for sure".

The length of time it is taking to retrofit early-build aircraft to the latest standard has also only improved slightly, from 24 months in late 2021 to a minimum of 18 months.

Asked whether he thinks other dissatisfied customers could follow suit and seek to exit programme, he says: "I have no reason to believe that they will. But we are working very closely with all the other nations to tell them what we are doing. We also keep them informed of the status of our discussions with Australia, Sweden and Norway."

NHI is sharing "in full transparency" all the changes it is implementing to the supply chain and support system, as well as longer-term enhancements.

"We are convinced that in the long run we will have an extremely

robust support system that will work, and will more importantly be able to cater to the needs of all the nations in terms of achieving their flight-hour targets," Aloccio says.

He cites maintenance inspections having been extended from 600 to 900 flight hours – a 50% increase – and the time before overhaul for dynamic components has been extended from 1,200h to 1,800h. Crucially, the new figures both are multiples of 900, enabling maintenance, inspection and overhaul activities to be synchronised.

Aloccio also sees a performance-based support contract launched by France and Germany in mid-2022 as a blueprint for future sustainment activities. "The same discussion is being extended to other NH90 nations which have shown some interest in such contracts."

He declines to name the interested parties, but notes that they are all members of the NAHEMA group, which also includes Belgium, Italy and the Netherlands.

Such long-term actions are key, he argues, since based on the current backlog and the likelihood of further orders taking production out to 2030 – plus a planned life-extension activity – the NH90 will probably be in operation until 2070 or 2080.

To support that goal, NHI is carrying out a study of the composite fuselage to ensure it will last for 50

years – two decades beyond the previous limit – with the results due in early 2023.

That should provide operators with a "long-term perspective", allowing them to consider other future upgrades of mission equipment or weapons. "But the foundation is to really have the core vehicle last 50 years – and this should be confirmed early next year," he says, adding: "we already know the study should be positive".

Pending deliveries

There are around 110 NH90s still to be delivered, including examples to core nations France, Germany, Italy and Spain, plus to Qatar, the latest export customer, and by the end of 2022 NHI will have delivered the 500th example. Aloccio remains confident that top-up orders can be secured from existing operators and those new to the programme.

"The NH90 story didn't start and will not end with Australia and Sweden, and we will continue to support these five, six, maybe seven hundred aircraft in the long run," he says. "We are making sure that we will have a support system that is able to respond to the needs of those aircraft."

A potential mid-life upgrade is also being discussed with operators, although Aloccio stresses there is "no rush" to decide on its content as it will not be implemented until the mid-2030s – around 30 years after the first NH90 was delivered.

He is also anxious to clear up what he feels is a mischaracterisation of the European rotorcraft: "On social media you see people saying the NH90 is a peacetime helicopter, not one for wartime, and this is something that annoys me," he says.

He points to deployments in "high-intensity conflicts" in Afghanistan, Iraq and Mali, and to anti-piracy missions off the Somali coast and in the Caribbean, where "each time the helicopter has performed extremely well in terms of mission capability and maintenance.

"When deployed the NH90 has always had between 70-80% availability – even when it's been in theatre without the support of industry," he says. "The NH90 is not just for disaster relief or training – it's a military helicopter for wartime.

"We know this is what our customers expect. We want to support them deploying the NH90 in theatres of operations everywhere." ▀

Ampaire flies Eco Caravan as it lays out route to market

California-based developer sees targeting of operational fleet as quickest way of ensuring hybrid-electric technology uptake

Dominic Perry London

Propulsion system developer Ampaire has performed the first flight of a Cessna Grand Caravan modified to run on a new hybrid-electric powertrain.

Conducted from Camarillo airport, located to the northwest of Los Angeles, the 30min sortie of the “Eco Caravan” was designed to make initial evaluations of the parallel hybrid propulsion system.

This consists of a Red Aircraft piston engine, an electric motor, and batteries supplied by Electric Power Systems, replacing the Caravan’s stock Pratt & Whitney Canada PT6 turboprop.

Flown by test pilot Elliot Seguin, the Eco Caravan (N405GV) was taken to 3,500ft at full power – combining the output from the combustion engine and electric system.

Kevin Noertker, Ampaire chief executive, hails the sortie as a vital step towards the company’s goal of being first to market with the new powertrain technology.

“Launching hybrid-electric aviation is no simple task, but we have made it easier by upgrading an already certified aircraft,” he says.

Federal Aviation Administration (FAA) approval of the modification via a supplemental type certificate is targeted for 2024. Noertker describes this path as a “more efficient” approach than whole-aircraft certification and says Ampaire is “deep in the [application] process”.

“To our knowledge we are the very first to go through the application

process for a hybrid-electric aircraft and so there is also the opportunity for [the FAA] to learn,” he says.

Noertker argues that Ampaire’s strategy of using “existing electrification technology” is the right balance of “aspirational goals and pragmatic approaches”.

Retrofitting current aircraft “is an accelerant to achieving certification and providing useful products rapidly into the market”, he says.

Installed base

To some extent that strategy of targeting the installed base is embodied by its test aircraft: a 2001-built example previously operated in Alaska under the Ravn Connect banner by now-defunct carrier Hagelund Aviation Services.

“It’s definitely the right approach in this industry to start with the existing assets and to upgrade them [and] to get it into the fresh-build variants of those planes so people can, off the factory line, choose a hybrid or a combustion variant.”

A line-fit option for the powertrain would require an agreement with Textron Aviation, which owns the Cessna brand, but Noertker declines to comment on the status of any discussions with the airframer.

“We anticipate working with OEMs like Textron Aviation, and there are other OEMs out there as well who have planes very well aligned with early adoption of hybrid systems,” he says.

Ampaire is, he says, “building the operating system for electric aviation” which is “broadly applicable and scalable” to other aircraft types.

It has previously disclosed an interest in the De Havilland Canada DHC-6 Twin Otter – which it dubs the Eco Otter – and potentially the Beechcraft King Air, another Textron Aviation product. Noertker says the scalability of its powertrain means it is already considering larger FAA Part 25 aircraft for potential conversion, and possible partnerships.

However, first it must prove the viability of the technology and business model with the nine-seat Eco Caravan.

Ampaire claims the hybrid-electric system cuts the cost of operation by 25-40% over the turbine-powered version, depending on the mission profile, and brings the cost per available seat mile to “near that of driving”.

As well as maintaining the seat count of the baseline model, maximum range is “beyond 1,000 miles”. Range with eight passengers is comparable to the stock aircraft.

To date, Ampaire has disclosed orders for 75 units, including most recently from Monte Aircraft Leasing for 25 aircraft, plus 25 options.

But Noertker says Ampaire has “a pretty solid backlog of folks who are at various stages in that [deal] pipeline, pre-public announcement, in the order of hundreds of units”.

Orders booked to date have been secured by deposits, he adds. The company has also just embarked on a Series B funding round.

Conversion and ground testing of the Eco Caravan has taken place at Ampaire’s base at Hawthorne Municipal airport in Los Angeles. ▀

See p66



Aircraft was taken to 3,500ft at full power during 30min sortie

Service entry for regional type is envisaged in 2027



Aura Aero ushers in new ERA

Development of clean-sheet hybrid-electric 19-seater gathers pace, as French start-up holds to 2024 first-flight target

Dominic Perry London

French start-up Aura Aero is close to settling on the design of its Electric Regional Aircraft (ERA), as it pushes to maintain a first flight target of late 2024.

Designed to carry 19 passengers or 2.5t of cargo on flights of up to 1,000nm (1,850km), the hybrid-electric ERA is set to enter service in 2027.

"We are a few weeks away from having the concept frozen. It is progressing very well. Industrial launch will happen quite rapidly after that," says Jeremy Caussade, co-founder, president and chief engineer of the Toulouse-based manufacturer.

Current designs for the ERA show an aircraft with six electric propulsion units distributed along the wing – Caussade says around 2MW of power is required at take-off – a streamlined fuselage, and a distinctive tail with twin vertical stabilisers.

Caussade, an Airbus veteran, says considerable effort has been expended over the latter part of 2022 to "demonstrate that the concept is workable and we have the techno-bricks and suppliers at the right level in order to proceed with the programme."

Save for Safran, which is to provide the aircraft's six electric motors and high-voltage electrical distribution and protection system – and potentially the turbogenerator – no

suppliers for the programme have so far been announced.

Caussade says the ERA's supply chain will be revealed in early 2023, with key decisions to be made around the avionics and fly-by-wire controls.

"We are in talks with big aerospace players worldwide. We are not a start-up programme with supplier start-ups involved – we will have lots of very big players involved," he says.

Aura is also evaluating which elements of the aircraft it may build itself, rather than outsource.

Maintaining progress

Although Caussade admits the first-flight target of late 2024 is "challenging", he stresses the importance of maintaining progress in order to achieve service entry in 2027. However, he says it will not be a disaster if the maiden sortie slips into the following year.

"I fully believe that we will make this aircraft a reality from a certification and industrial standpoint," he adds.

He believes the hybrid powertrain will be scalable beyond 19 seats, but at this stage is hesitant to commit to the exact size of any follow-on aircraft.

Aura is currently engaged in a Series B funding round, seeking in the region of €50 million (\$51 million). That process is "well advanced", he says, but is still open to new investors.

To date, the company has been bankrolled by private funds, Paris-based venture capital firm Innovacom, and the Occitanie region of southwest France.

This has enabled the establishment of a 5,000sq m (53,800sq ft) production facility at Toulouse Franczal airport and development of the Integral, a two-seat trainer.

A combustion-engined version of the Integral is in the final stages of European certification, while a full-electric variant is due to make its first flight in 2023.

Aura has so far gained letters of intent (LoI) for more than 330 aircraft, with lessor Amedeo committing to 200 units.

In early October, Aura revealed LoIs for 130 ERAs, of which only 95 were attributed to specific carriers – a mix of small regional or commuter airlines, along with a VIP aircraft specialist.

The undisclosed customers will be unveiled in the coming weeks, he adds, "and we will announce several tens of additional aircraft".

Caussade says it is seeing interest from cargo operators, commuter or regional airlines, and the business aviation sector.

The orderbook may be dominated by smaller firms at present, but Aura is also "discussing with bigger names who want to take advantage of the roll-out of such technology". While there are substantial airlines in the mix there are "even more big logistics operators", he adds. ▀

EASA details plans to target post-crash fuel fires in helicopter fleet

Proposals will bring Europe into alignment with USA where all new rotorcraft must adhere to latest safety standards

Dominic Perry London

European regulators have outlined proposals to close a legislative loophole that has left thousands of helicopters operating which are equipped with fuel systems that do not meet the latest crashworthiness standards.

Under European Union Aviation Safety Agency (EASA) legislation introduced in 2003, only rotorcraft certificated after 1994 are required to have a crash-resistant fuel system (CRFS) installed.

While that excludes older out-of-production types, newer variants or derivatives whose type certification relies on 'grandfathering' are also exempt from the requirements.

EASA calculates that 40% of the 5,810-strong European rotorcraft fleet in 2020 – or 2,327 helicopters – are not compliant with "occupant protection" rules, mainly relating to CRFS installation.

Uneven regulation

The uneven regulation has "resulted in a mixed fleet of rotorcraft with some rotorcraft being compliant with the CRFS requirements and some not, depending on the certification year", says the agency, which is currently consulting the industry on its plans.

"The rotorcraft that are not compliant with the CRFS requirements have had an adverse effect on the overall safety of the European rotorcraft fleet due to the higher likelihood of a post-crash fire with associated fatalities."

Since 2011, nine safety recommendations have been addressed to EASA by accident investigators urging it to improve the levels of CRFS incorporation on both new-build and in-service helicopters. Norway's SHT raised the issue in a report into a 2019 crash and post-impact fire of an Airbus Helicopters H125 which was not fitted with a CRFS; all six occupants died



Six people were killed by fire in 2019 after a H125 crashed in Norway

SHT

in the accident. The airframer has since introduced a CRFS as standard equipment on the type.

Based on EASA's calculations, 13 fatalities could have been prevented across 11 accidents that caused a total of 27 deaths in the 2009-2018 period, it says. In addition, it cites seven deaths from two further accidents – the crash in Norway, plus another in Portugal – in 2019.

Although EASA notes that the European fleet will eventually become compliant with CRFS requirements as new helicopters are introduced and older models retired, this will not occur until after 2054, when non-compliance will still be at 5%.

"In the meantime, operators will continue to operate and carry passengers in rotorcraft with older designs that do not offer the same level of protection to the occupants in the event of a crash," it adds.

EASA examined six policies to tackle the issue, from no change at one end to more comprehensive solutions at the other. Its preferred option is to require the installation of a CRFS onto all newly-produced rotorcraft from 2025 and onto all existing rotorcraft with five or more occupants from 2030.

Rotorcraft designed for four or fewer occupants should be brought within the scope of the legislation from 2038, it argues.

While conceding there will be significant financial penalties, running to hundreds of millions of euros, for both manufacturers and operators from its proposals – none of the options are "cost-effective", EASA admits – the agency stresses that doing nothing is not an option.

Punitive premiums

In addition to failing to meet objectives set out in the EU's "Rotorcraft Safety Roadmap", inaction could result in higher costs through litigation and punitive insurance premiums, EASA adds.

Failing to legislate also risks divergence with the USA, EASA notes. In 1994, the Federal Aviation Administration required helicopters certificated after that date to be fitted with a CRFS. That regulation was strengthened in 2020 when US lawmakers mandated that newly built rotorcraft operated or registered in the USA be fully or partially compliant with the CRFS requirements.

The consultation is open for comments until 13 February. ▶



Airbus Helicopters chided for icing risk assumptions on H145

Dual engine flame-out experienced by Norwegian air ambulance in snowy conditions pinned on ice ingestion

Norsk Luftambulans

Dominic Perry London

Norwegian investigators have criticised Airbus Helicopters for assumptions made during certification testing of its H145 that left examples fitted with an inlet barrier filter (IBF) vulnerable to engine failure due to ice ingestion.

Airbus Helicopters “did not do a thorough enough verification of their assumptions about the IBF system and if they were still valid during the certification process of the [H145] D2,” says Norway’s SHT air accident investigation agency.

At issue are the changes between the C2 and D2 variants of the type, notably more powerful engines, says the SHT in its final report into a dual engine flame-out on a Norsk Luftambulans-operated H145 (LN-QOS) on 20 November 2021.

As part of its certification campaign for the D2 upgrade, Airbus Helicopters performed icing tests using an aircraft equipped with the standard “mushroom” air intake grid. However, the SHT says “no such evaluation was performed” on an example fitted with an IBF system, as the “assumption was that the C2 testing was still valid”.

That judgement was based on the IBF being identical on both models.

In fact, Airbus Helicopters believed the installation of an IBF would decrease the risk of ice build-up thanks to a modified airflow path and proximity to hot engine and gearbox components.

However, flight trials performed by the airframer in the wake of the Norwegian incident showed the reverse was true: the increased airflow

from the more powerful Safran Helicopter Engines Arriel 2E turboshafts “lowers the temperature of the air stream”, says the report.

“This leads to the possible creation of a local area where the conditions for icing are present, even though the overall conditions are not conducive to icing.”

Airbus Helicopters conducted its testing in Bronnoysund, Norway from 10-26 January 2022 using a modified H145 D3 – the latest five-bladed variant – equipped with cameras and temperature sensors. However, the engine and IBF configuration were the same as those on the incident aircraft.

“The flight testing showed that ice can form in the IBF system and that this ice can enter the engine unhindered,” the report says.

Bypass system

Ice build-up was particularly noticeable on the underside of a grid that forms part of the bypass system which allows airflow to the engine to be maintained if the IBF starts to clog.

Testing showed that if the temperature varies, and rises above 0°C (32°F), “the ice can quickly melt on the contact surfaces leading to dislodging of ice or slush”.

“The results [of the tests] identified a risk of significant icing in the IBF system when the air temperature is between -5°C and 1°C with high humidity (snow, sleet, rain),” the report adds.

During the 20 November incident, the pilots of LN-QOS were performing a search and rescue mission for a party of lost hikers in the Botnfjellet mountains in the north of Norway.

Although icing conditions had not been forecast, snow showers were present.

The report says it took longer than the crew anticipated for the party in distress to reach the helicopter, during which time it had been hovering or on the ground with the engines running.

After embarking the hikers, the H145 took off to the east, turning southeast and travelling slowly along the Kongsvikdalen valley as the crew attempted to locate a powerline crossing in front of them.

As it proceeded down the valley, the left-hand engine suddenly shut down, forcing the pilots to make an emergency landing. While on the ground, the starboard engine also shut down without warning.

No technical faults with either engine or the fuel system were discovered during the SHT’s post-incident inspection.

However, visual inspection of both powerplants showed “soft [foreign object debris] damage” to their axial compressor blades, with the left-hand engine sustaining the most damage due to its higher rotation speed.

The SHT believes both engines on LN-QOS “most likely stopped due to a flame-out caused by the ingestion of ice”, probably shed from the IBF system.

In the aftermath of the event, Airbus Helicopters restricted the flight of IBF-equipped H145s in certain winter conditions, leading many operators to remove the filters.

But the manufacturer is also working on longer-term changes to the IBF, adding an extra grid to the air inlet tube and modifying the bypass door grid. ▀

Prototype is being used to test tilt-propeller system and flight controls

Maker makes way as Archer arrows in on Midnight

US eVTOL developer shows off two-seat demonstrator while preparing ground for larger follow-on aircraft

Archer Aviation

Pilar Wolfsteller Salinas

Salinas, California, a small town near the Pacific coast about 90min by car south of Silicon Valley, is best known as the inspiration for writer John Steinbeck, the place where Janis Joplin let Bobby McGee slip away, and where 30% of the world's lettuce is grown.

But in the middle of this agricultural heartland, a group of engineers has made Salinas centre-stage for cutting-edge aviation technology.

At the town's municipal airport, air taxi developer Archer Aviation is testing the aircraft which it hopes will revolutionise air travel in the 21st century.

Revealed to journalists, analysts and investors on a sunny and crisp day in mid-November, Maker, the company's two-seat prototype that first flew less than a year ago, is now ready for a live audience. As it rises from the apron, countless cell phones held overhead record video as engineers on the ground put the two-person electric vertical take-off and landing (eVTOL) aircraft through its paces.

"Maker is our demonstrator aircraft, and we used it as a certification testbed," chief executive Adam Goldstein tells FlightGlobal.

"We used Maker to validate a lot of the technology... The tilt-propeller system, the aero model, the flight controls. And now it's kind of near the end of its campaign."

Archer's engineers are flying Maker almost daily, pushing the aircraft's envelope with every test sortie. On 29 November it achieved another crucial milestone: performing a full transition from hover to forward flight. Data from the testing of Maker will ease the arrival of a new, bigger prototype called Midnight.

Seating four passengers and a pilot, Midnight will have 12 wing-mounted rotors and a V-tail, similar to Maker. The aircraft will be designed to take off vertically, with its six front rotors tilting from vertical to horizontal positions as the aircraft transitions to forward flight.

Fast charging

Archer intends for Midnight to be optimised for operating back-to-back trips over distances of about 20 miles (30km), with charging times of approximately 10min between flights, the company says.

The aircraft's maiden flight is expected to take place in the first half of 2023, leading to certification by the end of 2024. The airframer aims to be first to receive the Federal Aviation Administration's (FAA's)

blessing in this cutting-edge part of the aviation market.

"From day one, Archer's strategy has been about finding the most efficient path to commercialising eVTOL aircraft," Goldstein says. "Our strategy and our team's ability has allowed us to establish our leadership position in the market, and we are confident we will be the first company to certify an eVTOL aircraft in the US with the FAA."



Archer Aviation

Certification is a multi-step process, and Archer has an aggressive timeline to complete all those stages. It is aiming to have its means of compliance accepted by the US regulator by the end of 2022, with 18 subject-specific certification plans to be submitted to the FAA by the first half of 2023.

The FAA could approve those plans as early as the second half of 2023, paving a path to type certification by the second half of 2024, according to Archer.

Shuttle services

Archer and customer United Airlines – which has committed to purchase up to 200 examples – already have a first route lined up, announcing in early November they would launch shuttle services between Newark’s Liberty International airport in New Jersey and Downtown Manhattan Heliport, located at the southern tip of New York’s financial district.

United and Archer are banking that passengers will be eager to dodge traffic snarls, streamlining their travel between airports and downtown destinations. But Goldstein sees other uses, and is focused on opportunities for the Midnight to replace fossil fuel-burning, noisy helicopters.

“Imagine going to Hawaii, and there’s two different tour operators, and one gives you the chance to ride in a vehicle that’s fully redundant with zero single points of failure, and the other one

“From day one, Archer’s strategy has been about finding the most-efficient path to commercialising eVTOL aircraft”

Adam Goldstein Chief executive, Archer Aviation

gives you a choice with 300 single points of failure,” Goldstein says. “I think that presents a really interesting option.”

Other users could include medevac-aircraft operators – either for personnel transport or first responder missions. Military uses have also been discussed.

“The way that the [US] Air Force has looked at using these vehicles is similar to the way we would use them commercially, which is moving people around,” Goldstein adds.

But the price of this aviation revolution is high – and rewards distant. Goldstein estimates it will take between \$500 million and \$1 billion to shepherd an aircraft through the FAA’s certification process.

And while dozens of companies are striving for a piece of the future advanced air mobility (AAM) cake, many will likely run out of cash before they get anywhere near a certifiable product.

Goldstein sees three more factors that will be integral for early eVTOL successes, whittling the group down even further. First,

the design must be a fixed-wing aircraft, he believes.

“In order to compete [on] the missions that we are going to be flying, meaning 20-mile trips, but with rapid back-to-back missions, you need a wing in order to remain efficient. If you don’t, you drain the whole battery, and then you have to sit on the ground charging.”

Metropolitan lines

Second, a focus on the urban air mobility market – meaning short downtown-to-airport trips, or flights within a large metropolitan area, dozens of times a day.

Finally, the aircraft must be piloted by a human. “If you want to get to market any time soon, you’re going to have to put a pilot in these vehicles in order to get through the FAA,” he says.

Technology and certification aside, widespread public acceptance is the X-factor that will make or break the industry.

“The best thing that we can do is make sure the aircraft are really, really safe and quiet,” Goldstein says. “The good news is the FAA has very high standards and we will be certifying these vehicles at very high levels of safety.

“When you work with a partner like United, somebody pulls up to one of these vehicles, and there’s the United logo on the side, I do think that helps increase consumer acceptance of these vehicles,” he says. “It’s not just Archer’s helicopters, or something like that – it’s United Airlines.”

The company is speaking to other major commercial carriers, but also has not ruled out an “Archer-branded airline”.

Archer will build the Midnight at a new facility it has established adjacent to Covington Municipal airport in Georgia. It has recently announced the selection of Garmin and Molicel as suppliers of the aircraft’s avionics and batteries, respectively. ▶

Maiden flight of four-passenger Midnight is expected in the first half of 2023



Remembering a rotary revolutionary

Frank Robinson's fascination with helicopters inspired him to enter the aviation industry and create a family of affordable personal aircraft now widely operated all round the world

Howard Hardee Sacramento

Pioneering engineer Frank Robinson - who greatly expanded access to rotorcraft by designing a series of light helicopters starting with the two-seat R22 - died on 12 November 2022 at his Rolling Hills, Southern California home, aged 92.

He possessed an extraordinary drive to succeed that allowed Torrance, California-based Robinson Helicopter to overcome a major early setback: the crash of the first R22 about halfway through the US Federal Aviation Administration's (FAA's) certification programme, says Tim Tucker, a long-time colleague, employee and friend.

"He just absolutely refused to fail, and he wouldn't let you cause his project to fail, either," Tucker recalls. "He had this will that was especially evident during the years of trying to get the helicopter certified after the crash of the first R22. That could have easily put the helicopter company out of business, but he just refused to let anything get in the way."

"[Frank] Robinson will be remembered for the design and manufacture of the R22, R44 and R66 model helicopters," the airframer says. "Known for their simplicity and reliability, the popular helicopters have a distinct profile and can be spotted easily and frequently all over the world."

Leading the way

When the company received FAA type certification in 1979 using serial No 2, the RA-22 was the first helicopter to have been approved under its new, strict Part 27 rules.

"This little guy on a shoestring with his own design actually got an FAA type certificate under a regulation that was stricter and more difficult, and before other manufacturers had done so," Tucker says. "That's kind of incredible, to do that as a one-man show."

Robinson had a lifelong fascination with rotorcraft that began in childhood, when helicopters also were in their infancy. Born in Carbonado, Washington on 14 January 1930, he studied helicopter design at the universities of Washington and Wichita.

Starting in 1957, he initially worked for Cessna on the only helicopter the company ever developed: the CH-1 Skyhook.

He later studied inexpensive rotorcraft design with McCulloch Motors, which produced small four-cylinder, two-stroke engines often used to power small gyroplanes. Robinson then gained a reputation as a tail rotor expert as his career continued with Bell and Hughes Helicopter.

But, having been unable to pitch helicopter companies on light, low-cost designs for civil aviation, in 1973 he founded Robinson Helicopter out of his home in the Los Angeles area.

"This is something he'd always wanted to do - design a small, personal helicopter - and he tried to get other companies interested," Tucker says. "He was in his early 40s and I think he got to the point where he thought, 'If I don't do this now, I'm not going to do it.'"

Private-use helicopters hardly existed as late as the 1960s. Robinson, who had earned his private pilot's license in college, "wanted the same thing for the world of helicopters that he'd seen with airplanes", he says.

Robinson was a free thinker who did whatever the job required. Tucker says: "People say, 'This fella thinks outside the box.' You hear that all the time. Well, for Frank, there never was a box. The box didn't exist... That could be seen in a lot of his designs and the way he ran his business."

Reliable design

Most helicopters to that point had been complicated and difficult to maintain, but Robinson focused on machines designed for simplicity and reliability. Every ball bearing in a Bell UH-1 Huey, for example, had to be greased about every 25h. But not those in R22s.

Four-seat R44 was developed in the 1980s and certificated in 1992



David Acosta Alley/Shutterstock



Robinson in his RA-22 - in 1979 the first helicopter approved under FAA Part 27 rules

Robinson Helicopter

“The grease would extrude out and attract dirt; it was always an issue,” Tucker says. “Well, Frank’s helicopter didn’t have one bearing that needed to be greased. He was the first with all-greaseless bearings.”

In another innovation, while other helicopter manufacturers of the era were taking engines that ran at lower RPM in aircraft and tweaking them to provide more horsepower, Robinson did the opposite.

“He was the first one to take an engine that was used in airplanes and run it at lower RPM and ask the engine for less power,” he says. “By doing that, he made the engine so much more reliable and last so much longer.”

Under his lead, the company developed the four-seat R44

“People say, ‘This fella thinks outside the box.’ You hear that all the time. Well, for Frank, there never was a box. The box didn’t exist”

Tim Tucker Colleague and friend

starting in the mid-1980s, achieving FAA certification in 1992.

Frank Robinson retired at age 80 in 2010 following delivery of the first R66 - a turbine helicopter powered by a Rolls-Royce RR300 engine - and handed the company to his son and current president, Kurt Robinson.

Living with serious illness, Robinson had not visited the company’s factory for several years, Tucker says.

More than 13,000 of his aircraft have been delivered. ▀

Frank Robinson
14 January 1930 - 12 November 2022

Fractional ownership company
NetJets ordered four Bombardier
Global 8000 ultra-long-range
business jets, worth \$312 million



Bombardier

Best of the rest

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

Air Corsica received the first ATR 72-600 with Pratt & Whitney Canada PW127XT engines, offering a 3% fuel-burn improvement



ATR

Shutterstock

China Eastern Airlines received the first Comac C919 narrowbody (B-919A), in a 164-seat, two-class configuration



Baykar Technology launched ground testing with its Kizilelma unmanned combat air vehicle



Baykar Technology

A UK Royal Air Force Airbus Defence & Space A330 Voyager tanker flew using 100% sustainable aviation fuel



Crown Copyright

The Italian army took its 60th and final NH90 transport from Leonardo Helicopters' Venice Tessera plant



Leonardo Helicopters

Boeing rolled out the last 747 to be built, after 1,574 units were made. Atlas Air is scheduled to take delivery of the -8 Freighter in early 2023



Paul Weatherman/Boeing

Next month

Our review of airline safety in 2022

FLIGHT

INTERNATIONAL

On sale
26 January



Plus...

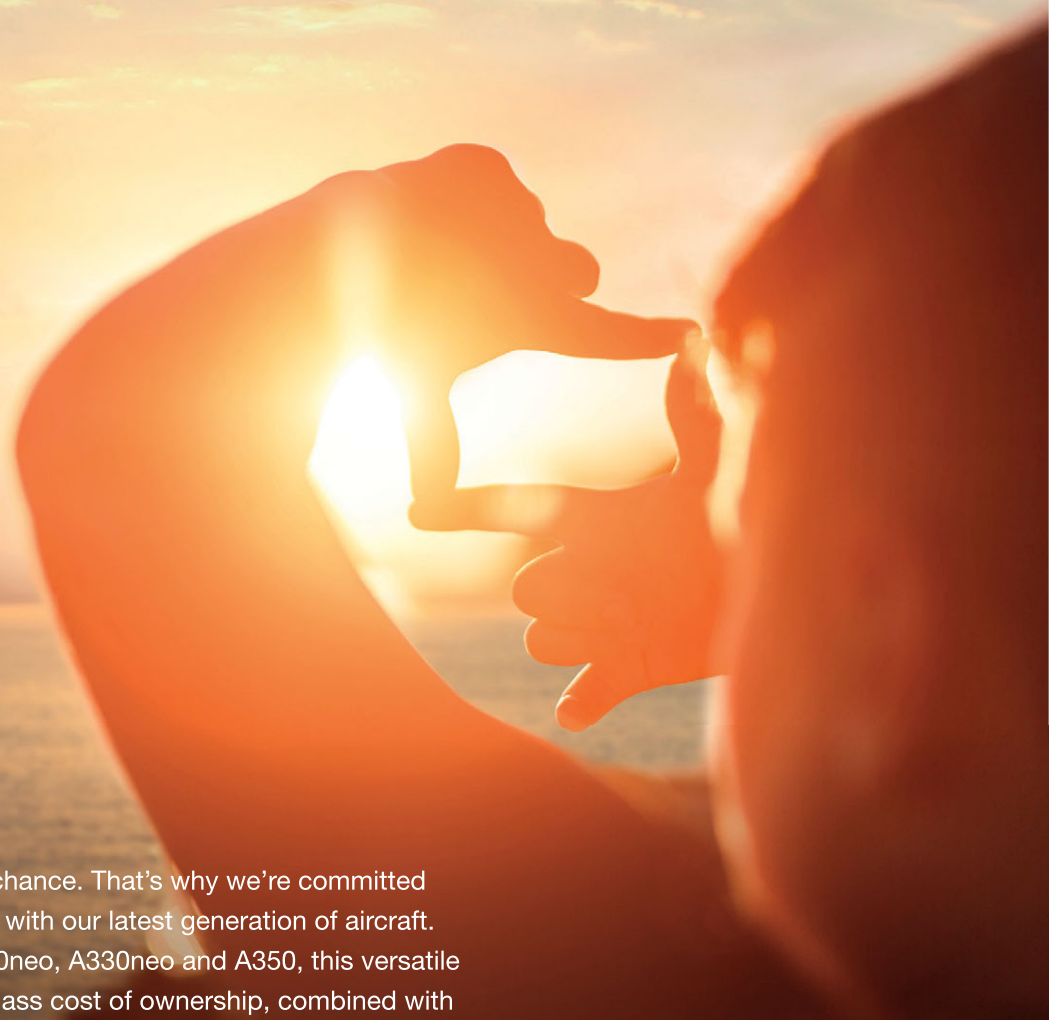


Buying power
As industry prepares for Aero India, what are the nation's top priorities?



Fighting fit
We assess Australia's procurement activities, ahead of Avalon show

GIVE THE FUTURE A POSITIVE OUTLOOK



We can't leave the future to chance. That's why we're committed to giving it a positive outlook with our latest generation of aircraft. Comprised of the A220, A320neo, A330neo and A350, this versatile collection provides best-in-class cost of ownership, combined with exceptional reliability. Designed to reduce fuel burn by 25%, these aircraft also have a lower noise footprint. So passengers can benefit from a quieter, more comfortable experience, while together, we help ensure the world remains a beautiful place.

AIRBUS



Perfect Lazybones/Shutterstock

Horizon of hope

With pandemic precautions and travel restrictions now in the past for most of the world, 2023 is set to be the first 'normal' year for the aerospace and aviation industries since 2019. But with inflation surging, conflict in Ukraine, labour shortages, snags in the supply chain, and faltering consumer confidence, how normal will it be? In our regular annual feature, our writers examine the outlook for the next 12 months – from airliner orders and production to the impact on defence budgets, the role of sustainability, prospects for new technologies, and pilot recruitment

Boeing forward... slowly

Marco Meneses/Shutterstock

Company aims to deliver between 400 and 450 737s in 2023

OEM strategy

If the airframer achieves its goals for 2023 it will make significant progress following four terrible years – but it is far from being out of the woods

Jon Hemmerdinger Tampa

Boeing's top brass stressed in November that the company's 2023 goals include nursing its 737 Max programme back to health and delivering more 787s – targets intended to help the airframer again become a cash-generating combine.

Executives also made clear Boeing does not intend to launch development of a new narrowbody aircraft in the foreseeable future, a strategy some analysts fear will leave it far behind competitor Airbus.

Future projects aside, the industry will watch to see if chief executive David Calhoun and his colleagues can steer Boeing through the stabilisation and recovery plan they outlined during a 2 November investor day.

Scepticism exists among some industry and financial analysts. After all, Boeing's leaders had predicted much for 2022 that never panned out. Analysts had expected Boeing would, by now, have recovered more than is actually the case.

"Our focus [is] on executing stable rate ramp-ups, as well as working through, and working with, our supply chain to bring them through a disrupted world," said Boeing Commercial Airplanes (BCA) chief executive Stan Deal during the investor day.

That comment largely sums up Boeing's 2023 plan, which essentially calls for it to get back on track – to hike deliveries, overcome supply, labour and quality problems, and generate much more cash.

Increased production

Specifically, Boeing intends in 2023 to deliver 400-450 737s and 70-80 787s. That would mark a significant increase on 2022. The company aimed to deliver a total of 375 737s during the year, including military P-8A maritime patrol aircraft, and had shipped 321 commercial examples by end-November. Due to a roughly 20-month 787 production halt, it had handed over just 21 of that type during the same period.

Longer term, Boeing hopes to be delivering 800 jets of all types annually by 2025 or 2026, supported by monthly production of 50 narrowbodies, 10 787s and four 777s.

Such rates would equal Boeing's output in 2018, prior to the 737 Max grounding and Covid-19 pandemic. The airframer's executives say such a production ramp will fuel a financial turnaround, enabling BCA to generate \$2.5-3.5 billion in operating cash in 2023, and \$9 billion in 2025 or 2026 – by which time the company aims to be generating \$100 billion in annual revenue, executives said.

"I want nothing more than to return money to you," Boeing chief financial officer Brian West told investors. But analysts are not fully convinced.

"It's a big 'if' in our view, given the persistent execution issues in the past," said a 3 November JP Morgan research report, noting Boeing's inability to hit previous 737 delivery targets. "We're not yet sold on Boeing's assumptions."

AeroDynamic Advisory managing director Richard Aboulafia thinks Boeing can "probably" achieve the lower end of its 400-450 737 delivery range in 2023, but he doubts it can hit 800 total annual deliveries in 2025 or 2026, partly because of competitive inroads made by Airbus.

Financial firm Jefferies estimates Boeing will deliver 424 737s in 2023, and 732 jets of all models in 2025, according to an 8 November research report.

"Our focus [is] on executing stable rate ramp-ups, as well as working through, and working with, our supply chain to bring them through a disrupted world"

Stan Deal Chief executive, Boeing Commercial Airplanes

Taking Boeing's projections with a pinch of salt is understandable considering 2022 – not 2023 – was to have brought so much improvement.

In late 2021, Boeing executives told investors that in early 2022 they would bring 737 production to 31 monthly, deliver the first 737 Max 7 and resume Max deliveries to China.

Boeing also planned in 2022 to deliver 500 737s and resume 787 deliveries.

Although Boeing did restart 787 shipments in August 2022, the other goals it set for itself for the year were not met.

Production of 737s remains below the 31-monthly target and Max deliveries to China remain on hold. Boeing also pushed back the expected certification of three aircraft: it now sees certification of the Max 7 by early 2023, the Max 10 by late 2023 or early 2024, and the 777-9 by 2025.

Still, Calhoun exuded optimism in November.

"We believe the plan that we have out here, and the guidance that we've provided, is doable," he said. "If we didn't, we wouldn't put it up. And we think it's clear-eyed with respect to what we're going to face." ▶

Russia

On its own

Will Moscow's import substitution strategy allow it to protect and even grow its aerospace and aviation sectors in the face of Western sanctions?

David Kaminski-Morrow London

Russia's aerospace industry has ambitions to manufacture more than 300 aircraft over the next two years, as it grapples with the pressure that has been piled on the sector by sanctions over the Ukrainian conflict.

But most production in 2023 will comprise helicopters, as airframers seek to catch up with sanction-related delays to the main airliner programmes.

The government had already been moving to shore up its domestic manufacturing, adopting a policy of import substitution, to introduce more Russian-built components into its aircraft and reduce dependence on foreign suppliers.

But international sanctions, by blocking access to crucial technologies, have forced a need to hasten this transition.

Revised strategy

Russia's aircraft manufacturing union SAP has newly drawn up a revised strategy for aircraft production to the end of the decade.

It states that Russian aviation companies were operating 1,160 passenger aircraft in April 2022, and 700 were leased from foreign companies – almost all of which were then absorbed into the Russian registry. Foreign aircraft accounted for some 95% of passenger traffic.

SAP lists plans to build 138 domestic aircraft in 2023, although 85 of them will be Mil helicopters – including nearly 70 Mi-8s – while 20 Aircraft Industries L-410 turboprops will account for almost all of the airliner output.

But in 2024, according to the SAP strategy, production of the Irkut SSJ-New – a revamped version of the Superjet 100 – will be ramped to 20 aircraft, while the first six Irkut MC-21-310s will be completed.]

1,160

Passenger aircraft operated by Russian aviation companies as of April 2022 – with 700 leased from foreign firms



Arnold OA Pinto/Shutterstock

Russia plans to complete the first PD-14-powered MC-21-310 in 2024

】 The -310 is the Russian-powered variant of the MC-21, fitted with Aviadvigatel PD-14 engines, while the SSJ-New will be equipped with PD-8s.

United Aircraft (UAC) will also build the initial pair of Ilyushin Il-114-300 turboprops, the strategy states.

Capacity will be supplemented by production of three Tupolev Tu-214s in 2023 and seven in 2024, increasing to 10 Tu-214s, plus two Il-96-300s, annually for the second half of the decade.

The SAP outline to 2030 also features 140 of the under-development UZGA TVRS-44 regional turboprop, as well as more than 150 of its new LMS-901 utility aircraft - contributing to a total output of over 1,000 fixed-wing airframes.

Technological resources

But the strategy sets out a substantial number of measures needed to support the industry, stating that consolidation of efforts from governmental, scientific, educational and supplier communities is necessary to create a “favourable legal, investment and business climate” and ensure adequate technological and personnel resources.

The human resources aspect is particularly pressing. UAC had expressed concern about the difficulties of recruiting sufficient personnel in late 2021 - months before the Ukrainian conflict - and the complications of offering attractive salaries while competing against other industries, especially IT, for talented staff.

State technology firm Rostec has launched a large-scale scheme, Wings of Rostec, for training aviation

industry engineers, in co-operation with UAC, United Engine and Russian Helicopters.

Rostec aimed to accept some 2,600 graduates to the scheme in Moscow alone during 2022. The airframer Aviastar stated in the same year that it was hiking salaries in a bid to employ 1,500 production personnel.

SAP’s outline strategy says actions should be implemented for “continuous education and training” of specialists, and guaranteed employment with aviation suppliers.

But it also seeks to overcome a number of persistent domestic problems for suppliers, such as a lack of sufficient competency in supply chain management, product integration, marketing, and the design and availability of aircraft components.

There are “still gaps to be filled” in quality management and other areas, and the relative absence of aftersales service systems can hamper domestic suppliers.

SAP adds that the Russian economy also suffers from “systemic problems”, such as expensive credit resources, difficult pricing schemes for defence orders and supplier-selection processes aimed at reducing product cost - with potential negative effects on quality.

It says the regulatory framework ought to be improved for managing suppliers and the quality of design, certification, production and maintenance, while “elimination of bureaucratic and financial barriers” and other support measures to small and medium enterprises should be developed. ▀

Military procurement

War footing

The conflict in Ukraine has weakened Russia and led NATO to refocus on defence. But divided government in Washington DC could affect procurement plans

Ryan Finnerty Tampa

Generals, it is said, prepare to fight the last war. After nearly a year of intense fighting in Ukraine, military generals, and the public, have a glimpse of how the next war may look.

For the first time, the world witnessed the full reality of warfare on a battlefield flooded with armed drones and man-portable, precision missiles. In addition to the newly-deployed systems, tried-and-tested models such as Raytheon's FIM-92 Stinger surface-to-air missile made a return to combat service, after a decades-long hiatus from battlefields between nation states.

Much of the results, both military developments and civilian suffering, were broadcast over social media almost in real time.

Observers saw just how difficult a task it can be to achieve air superiority, even against a numerical and technologically inferior adversary, when that opponent is determined to fight.

As the months wore on, the type of battlefield innovation that wars often produce was on display: precision NATO weaponry mounted onto Soviet-type fighters for the first time, naval engagements using unmanned air vehicles and cruise missiles to overwhelm air defences and the heavy use of commercial drones modified for combat duty.

Global response

Away from the battlefield, governments in capitals across Europe, and the world, have sought to bolster their own defences.

Finland and Sweden officially moved to join NATO, while India cancelled an order of RAC MiG-29 jets and Mil Mi-17 helicopters from Russia.

Numerous US allies, including Germany, Canada and the Czech Republic declared their intent to acquire Lockheed Martin's stealthy F-35 strike fighter, seen as an essential asset in modern, contested airspace.

In Washington, Congress and the Biden administration renewed a call not heard since Europe's last great land war more than 80 years ago, declaring the USA to once again act as the "arsenal of democracy".

The Pentagon has shipped some \$18 billion worth of military hardware to Ukrainian forces since the



War in Ukraine has led several European nations to rethink their policies on military spending

Shtatsoyav Sherchenko/Shutterstock

Cruel summer

As it continues to recover from the Covid-19 pandemic, can the industry avoid a repeat of the queues, delays and blame game of 2022's busiest holiday period?

Graham Dunn London

It seemed the cruellest of ironies for an embattled airline industry that, having waited two years for the travel-demand taps to be turned back on, the rush of customers sometimes proved too much for airport ecosystems to handle, with people once again unable to travel.

Recriminations continue as to where the blame lies for the struggles in meeting recovering demand: airlines point the finger at airports for not preparing early enough; airports flag onerous security checks and hiring processes; but the backdrop is of an industry struggling to attract staff into some of its more arduous roles, often with anti-social hours.

However, the more pressing issue for the industry is whether history might repeat itself in summer 2023.

On the one hand, the crisis point for most airports has passed – with the notable caveat that by

start of the invasion, including loitering munitions, guided anti-radiation missiles and numerous air defence systems.

US defence manufacturers all reported greater interest in their products from European governments in the months following the start of Russia's invasion.

However, arms manufacturers continue to grapple with labour and materials shortages in the wake of the global Covid-19 pandemic. Some executives have sounded the alarm, warning that it takes much longer to re-open shuttered lines or scale up the production of modern, high-tech weapons than it did during the Second World War.

Still, around the Western world, defence budgets are swelling, with some of the largest increases coming in Eastern and Central Europe.

In the early months of the war, at least seven European governments declared their intent to boost military spending, including Norway, Sweden,

its nature, an operational wrinkle at an airport can quickly cause chaos, as numerous past IT failures and weather disruptions have painfully illustrated. Indeed, while a number of airports were caught up in challenges during the initial ramp-up, most got a grip on their operations relatively quickly – albeit in some cases by capping peak-time capacity.

"It's not every airport globally or indeed in Europe. I live in Geneva and Geneva has had zero problems," noted IATA director general Willie Walsh, speaking in early November. Hardest hit have been the hubs of Amsterdam Schiphol and London Heathrow. "The rest of Europe to a large degree has functioned okay. There have been isolated incidents, but it wasn't widespread and was short-lived in most cases."

While Schiphol airport has retained capacity caps through until the end of 2022, Heathrow lifted departures caps at the end of October – but flagged it was looking at other mechanisms to balance demand and capacity at peak times. Heathrow has played down the likelihood of caps returning, but airlines have left it – and other airports – in little doubt of their expectations.

Seeking solutions

"People ask me, 'are we going to face these same problems next summer?' If we do, heads should roll. There is no excuse for not getting the problems sorted," says Walsh.

Walsh does not expect other markets to face the same ramp-up problems when remaining Covid restrictions are ultimately lifted, most notably in China. "If you look at China, the government is conscious of what has happened elsewhere and they are telling their airlines, 'you better be ready if and when the market opens'," Walsh says. "They have plenty of advance notice, they've seen the challenges in the US and Europe, and they don't want to repeat that."

One of the challenges in readying for increased flight activity is the issue of enticing staff back to roles that may have lost their appeal. Brussels Airports chief executive Arnaud Feist, speaking at a Eurocontrol event in October, said: "Our biggest challenge [in the industry] is the working conditions,

Belgium, Poland, Italy, Romania and even long-reluctant Germany. UK defence secretary Ben Wallace said in September that London would boost funding to the UK armed forces by £52 billion (\$58 billion), although it is unclear whether that plan will survive under the Sunak government.

Across the Atlantic, lawmakers in Washington are poised to approve another annual increase in the defence budget for fiscal year 2023, likely at funding

\$18bn

Value of military hardware shipped to Ukrainian forces by Washington since the start of the conflict in February 2022



Fey Iswandy/Shutterstock



Schiphol airport implemented capacity caps after struggling to keep pace with strong demand in summer 2022

“Our biggest challenge [in the industry] is the working conditions, the salaries. I think they should be reviewed to make the sector attractive again. We are not attractive any more”

Arnaud Feist Chief executive, Brussels Airports

levels even beyond what the Pentagon requested. Despite those increases, the vast majority of NATO’s 30 member states are still not spending the 2% of gross domestic product on collective defence that the alliance requires.

Diminished potential

It remains difficult to predict what 2023 has in store. As the war drags on, Russia is increasingly diminished, both militarily and economically. Sanctions are already making it difficult for the country’s arms and aerospace industries to access the vital inputs, such as computer chips, required to build modern weapons and aircraft.

While NATO is as focused and united as it has been in decades, the months of conflict Moscow’s forces have endured in Ukraine are making Russia less of a threat to the western bloc now than it was one year ago.

the salaries. I think they should be reviewed to make the sector attractive again. We are not attractive any more. It is not just airports, we see it with border control,” he says.

“Also maybe [we need to] think about ways of automating some of these tasks which are not attractive to people, to digitise. Baggage is still a very manual process, how can we automate it?”

Livia Spera, general secretary of the European Transport Workers Federation, also highlights the problem in securing ground staff. “People do not want to work in ground handling any more,” she says. “It doesn’t come as a surprise. Why should people go and work unsocial shifts to be paid much less than what they are paid in towns? The job is very hard. If you want to have people involved in a tough profession, you need to pay them.”

Other contributing factors to disruption include the all-too familiar issues of air traffic delays, labour strife and weather impact. Within Europe in particular, Eurocontrol director general Eamonn Brennan flags an additional supply/demand airspace pressure that results from the continued conflict in Ukraine.

The closure of Russian skies means the Eurocontrol area has effectively been handling 90% of 2019 capacity in 80% of the airspace. That is an issue that will only intensify as capacity further returns.

“Next summer doesn’t look that good at the moment,” Brennan says. “Why? The carriers are all putting extra aircraft on – we can see that from the deliveries and we have discussed it with the main carriers. [But] we still think there will be airspace closures. What I mean by that is the war [in Ukraine] is not likely to go away by next summer.” ▶

While further increases in defence spending are expected in the coming year, headwinds may yet arise.

Particularly in European capitals, where treasury pockets are not as deep as in Washington, the degradation of Russia’s conventional forces – combined with high levels of public debt accrued during the pandemic, and fears of a looming recession – may see military expenditures plateau or even return to pre-war levels. Following a summer and autumn of battlefield defeats for Russia, much of the rhetoric from defence executives in the USA has shifted more toward a focus on China and the Indo-Pacific theatre (see p56).

The Biden administration’s 2022 national defence strategy names China, rather than Russia, as the country’s primary adversary. Uniformed and civil leaders within the US defence apparatus are quick to name Beijing as the USA’s current “pacing threat” – the strategic challenge around which defence policy and procurement are oriented.]

Cockpit crisis

The pilot shortage could get worse before it gets better, as pandemic era downsizing and a failure to prepare for recovery continues to have an effect

Pilar Wolfsteller Las Vegas

While the USA has been grappling with a severe flightcrew shortage since before the coronavirus crisis, other regions too will be facing a dearth of candidates to fill their cockpits in the coming years. The global pilot shortage could make itself felt as early as 2023.

“The return of airline demand combined with substantial pilot supply shocks means the pilot shortage has already emerged in North America and is expected to grow throughout the decade,” says Geoff Murray, Oliver Wyman partner and aerospace sector leader in the management consultancy’s transportation practice.

An Oliver Wyman analysis shows that the difference between supply and demand in North America will be about 17,000 pilots by 2032. Jefferies, however, puts that figure at closer to 26,000. In any case, it is a sizeable number, with no easy solution.

Most other regions, too, are poised to experience a shortage of flightcrew. Oliver Wyman says the number of missing pilots could rise to 68,000 globally.

“After North America, the next region to be affected will be the Middle East,” Murray writes in a report

published on *Brink News*. “Driven by a projected sharp increase in air travel demand over the next few years, the region could face a shortage of 3,000 pilots by 2023 and 18,000 by 2032.”

In Europe, that shortfall will be only about 1,000 pilots in the short term, rising to around 19,000 over the next 10 years.

With travel in Asia currently still curtailed due to ongoing Covid-19-related restrictions, there is a surplus of flightcrew in that region. That, too, will shift towards the end of the decade, as passenger demand once again returns. Murray adds that Latin America and Africa will probably not face similar issues.

The most significant problem will still lie in North America – the largest air transport market in the world.

With mainline carriers like Delta Air Lines, United Airlines and American Airlines recruiting aggressively and competing for a small pool of applicants, it is their regional partners – airlines which with they contract to

500

Regional aircraft parked in North America because there are no pilots to fly them, according to the RAA

fly shorter routes in smaller aircraft, and which tend to pay their crews lower wages – that are suffering most.

The Regional Airline Association (RAA), which represents US-based regional carriers, says that 324, – or 76% – of US airports have lost service in the past three years due to airlines permanently cancelling flights because of crew shortages.

“We now have more than 500 regional aircraft parked without pilots to fly them and an associated air service retraction at 324 communities,” says RAA chief executive Faye Malarkey Black. “Fourteen airports have lost all scheduled commercial air service – a number that is still rising.”

► Pentagon service chiefs for the US Marine Corps and US Air Force are open about objectives of redesigning their forces for operations across that region’s vast expanse of ocean and many chains of small islands.

Although public statements from defence industry executives appear to be optimistic about near-term spending increases, their financial projections tell a different story.

While some contractors, including Lockheed and Northrop Grumman, have posted strong profits, others such as Boeing spent 2022 deep in the red, suffering from still-depressed commercial sales and a defence division fraught with aggressively bid, money-losing programmes.

Few of the major players expect sales of military hardware to drive profits in 2023.

Northrop says space will be its profit engine going forward. Boeing told investors to expect more losses

Lockheed expects F-35 production figures to be flat over the coming year



“We are on the precipice of a wholesale collapse of small community air service,” she adds.

Murray agrees. “Absent a downturn in future demand and industry efforts to bolster the supply of pilots, travellers should anticipate continued near-term cancellations and delays until airlines are better able to accommodate traffic with scaled-back flight schedules,” he says. “These would more accurately reflect the size of the pilot workforce and

new bases, better benefits, aircraft upgrades and enhanced promotion opportunities, has raised the attractiveness of a pilot career.

“Weighing job offers against each other has become akin to watching the stock market, as figures are ever-changing while companies try to outsell each other,” says pilot consultancy Future and Active Pilot Advisors (FAPA). As of the end of November, FAPA says the top 12 US airlines filled 11,372 pilot roles, with the projected total for 2022 at 13,646. In 2021, that number was 5,426.

“What we have seen this year is a pilot hiring frenzy,” says Raymond James managing director for global airlines Savanthy Syth. “This was a pilot shortage on steroids.

“The pilot supply was tight before the pandemic, and I think it’s going to remain tight well into the latter part of this decade,” she adds. “But I think we need to differentiate between tight supply and what we saw this year.”

Lost capacity

Airlines were rattled as passenger demand exploded with ‘revenge travel’ and the carriers quickly realised there was no way to restore their capacity to pre-pandemic levels with the staff they had.

The biggest need right now is for captains – professional pilots who have several thousand hours of flight experience. In November, Piedmont Airlines, PSA Airlines and Envoy Air – all regional carriers for American – raised eyebrows when they announced sign-on bonuses of between \$75,000 and \$100,000.

But will these higher wages and other incentives be enough to alleviate the shortage? And more importantly, will regional airlines be able to continue to pay them? Experts say maybe not.

“The regional industry just has to be smaller than it was in 2019 because of economics 101,” Syth adds. “You have to shrink or at some point some of these regional airlines go bankrupt and you reset pilot rates through bankruptcy or the threat of bankruptcy.”

At the moment, there is no sign of that, and commercial pilot certificate holders will continue to ride on a wave they hope will not crash for a very long time. ▶



An Oliver Wyman analysis shows that North American airlines will be short of 17,000 pilots by 2032

L.J. Jones/Shutterstock

are likely to involve further reductions in service to smaller markets.”

Airlines complained about the shortage even before Covid-19, and some carriers have had to change their post-pandemic growth plans because of it. In early November, regional carrier Republic Airways cancelled an order for 31 Embraer 175 jets due to a dearth of pilots. The Brazilian airfamer said the move was a joint decision between the companies, and that the order was “no longer suitable” for either party.

A slew of new pilot salary contracts in 2022, which improved pay and working conditions, offered

on defence programmes in the coming year, on top of the billions racked up in 2022. Raytheon posted solid gains in its commercial business, but defence sales were flat or down across its engine, avionics and precision munitions units over the third quarter.

Even Lockheed expects production figures on the eminently popular F-35 to be flat over the coming year, citing competing budget priorities at the Pentagon.

Political divides

With divided government returning to Washington in 2023, and a presidential election looming in 2024, future military assistance to Ukraine may be substantially constrained from current levels.

The USA’s own defence budget typically becomes a fraught tool of political jockeying during such periods of division, with the Department of Defense and its thousands of suppliers occasionally falling victim to a lapsed budget or government shutdown.

The solution is often a series of short-term stopgap measures, known as continuing resolutions, to keep the US military funded. Senior leaders say this approach makes long-term planning nearly impossible.

That uncertainty comes at a time when the USA, as the guarantor of security in Europe and the Western Pacific, is set to make decisions on several major programmes.

Procurement numbers for the Northrop B-21 strategic bomber, development of the Next Generation Air Dominance sixth-generation fighter programme, the ultimate size of the F-35 fleet and delivery of the US Army’s next generation of rotorcraft all face major milestones in the coming years.

The ability of those platforms to deter further aggression, and win future wars in Europe or the Pacific, may come down to funding decisions made in Washington over the coming year, amid what is likely to be an explosive political environment. ▶

Direction of travel

Despite soaring inflation and other economic headwinds, forward demand for flights remains strong. However, can this momentum continue?

Graham Dunn London

Airlines planning for the year ahead must balance the seeming paradox of continued strong demand and robust pricing with conventional wisdom on what happens to air travel when economic growth goes down and costs go up.

The causes for concern are clear. Recessionary and inflationary pressures are high, as too are energy prices – both for airlines and consumers – while exchange rates have largely been weak for anyone outside of the USA. Then there are the continued supply chain, geopolitical and Covid pressures to factor in.

Yet summer demand, at the very least relative to supply, has seldom been stronger. Revenues outstripped previous highs in the third quarter, almost regardless of airline model or market, even though capacity for most was still not fully restored.

That revenue jump – bringing with it much improved bottom lines – reflects higher yields as pricing held firm. The drive for that was so-called ‘revenge tourism’, as people resolved to travel almost regardless of cost because they had not been able to do so during the crisis, and had built up savings to pay for it.

Optimistic outlook

But if one swallow doesn’t make a summer, surely one summer doesn’t make a recovery? What is giving airlines optimism is that as 2022 drew to a close, the strong demand showed little sign of faltering. As one airline executive told FlightGlobal recently, this is not pent-up demand, this is demand.

Ed Bastian, chief executive of the biggest and most profitable airline of the last decade, Delta Air Lines, shares that optimism. “There’s no way you are going to satisfy that demand in a six- or nine-month timeframe; I think this is going to continue for several years,” he said in early November.

While acknowledging economic headwinds – and that US carriers have benefited from the demand tailwind of a strong dollar – Bastian believes customers are prioritising travel. “Consumers are funding a



Airbus

lot of travel by stopping spending on stuff. We see the traditional lines in services and experiences coming back to more normal trends, and they still haven’t caught up to where they need to be.

“But the consumer still has a decent amount saved for this post-pandemic period and they are no longer getting boxes piling up on their doorsteps. They are actually leaving their doors to go see someone else’s boxes in some other part of the world.”

IATA director general Willie Walsh is similarly upbeat, taking heart from third-quarter load factors, which he believes illustrate that the industry performance is sustainable.

“I think it is sustainable, because the average seat factor across the third quarter was still in the order of 82-83%, which is similar to what the industry was doing in 2019, actually slightly less than 2019,” Walsh said in November.

“I think the profitability for the quarter was good and important for the industry given the significant financial losses that were encountered in 2020 and 2021, and at an industry level 2022 will be more profitable,” he says.

Will that be enough to return to the black in 2023? IATA believes it will be, forecasting a collective industry profit of \$4.7 billion. While modest in comparison to pre-crisis profitability, it would mark a return to profit for the first time since 2019. That is particularly welcome after more than \$185 billion worth of net losses racked up in the last three years.

Delta Air Lines' chief executive is among those highly optimistic about the year ahead



While the headwinds have appeared to get stronger, he remains bullish. "We are going into these downturns with very high demand. That's not like what we have witnessed before," says Walsh, who describes the headwinds as 'business as usual' challenges. "We have faced these challenges before and airlines know what they need to do to respond."

Price action

He also believes the historical precedence of previous crises shows that passenger levels are not necessarily impacted by recession. "It's not often that passenger numbers decrease with a global crisis," he observes. "What you see are airlines taking price action to ensure people still travel."

What is clear, however, is that the fortunes for airlines and markets will remain mixed. So while the airline industry as a whole may be profitable, much of that will be driven by strongly performing US carriers. IATA already expects these carriers to be profitable in 2022. For other regions, airline profits may be negligible or have to wait until 2024 before they emerge.

Moreover, barring the rapid resolution of the Ukraine conflict and Russia's political isolation, the lifting of Covid restrictions in China and the easing of supply chain issues – none of which seem imminent – the industry is unlikely to return to pre-crisis levels of activity in 2023. But these artificial caps may at least help prop up pricing by ensuring there is not overcapacity in the market. ▶

Air freight

Post-Covid cargo

The unique conditions of the pandemic were always going to create a high point for commerce, but that does not mean the sector is now dwindling

Lewis Harper London

The air cargo boom seen in 2020 and 2021 was always likely to make subsequent years appear weak by comparison.

That is because the factors that drove the record performance during the pandemic were, in some cases, temporary. They include supply chain snarl-ups, capacity shortages and the challenges in the shipping industry that meant more forwarders looked to air freight as an alternative, despite the latter being structurally more expensive.

As those factors subside, air cargo demand has been softening against 2021 levels for several months, IATA data shows. But that does not mean longer-term trends are heading in the wrong direction.

The chief executive of LATAM Cargo, Andres Bianchi, characterises the current period as the "stabilisation" phase of the freight sector's journey out of the Covid-19 crisis.

"Volumes are stabilising, supply chains are starting to [be] more normal, and you have to start thinking about what the post-Covid world is going to look like," Bianchi tells FlightGlobal.

That post-Covid normality is likely to emerge gradually during "a very uncertain" couple of years, he suggests.

Indeed, while a 'normalisation' period was always baked in, the wider economic and geopolitical uncertainties that form the backdrop today were not.

"We don't need to tell you that challenges are mounting," said Brendan Sullivan, IATA's global head of air cargo, during the association's World Cargo Symposium in late September.

Economic volatility

Alongside high jet fuel prices, "the war in Ukraine has grounded some key players", Sullivan says. "Economic volatility has brought inflation, a weaker trading environment, shifting currency rates and slower GDP growth."

But those short-term challenges are manageable, insists Sullivan, noting that the air cargo industry "is in a better place than it was in 2019 – financially stronger, more efficient with advances in digitalisation, and better appreciated for the heroic efforts that we all made to keep cargo going during a very difficult crisis". ▶

Notably, 2019 – the last full year unaffected by the pandemic – was a tough period for air cargo, due to US-China trade tensions.

“The challenges and opportunities that we face are those that we are used to dealing with,” Sullivan says.

IATA chief economist Marie Owens Thomsen paints a similarly positive picture, saying that while global GDP growth is predicted to slow in 2023, the performance will still compare favourably with historic growth levels.

Amid the uncertainties created by several global factors, she urges people to fight the instinct to view a slowdown in economic growth as a negative development for air freight, pointing out that “growth is still growth”.

And offsetting the challenges to an extent is the rise of e-commerce, which accelerated during the pandemic and appears to offer genuine long-term opportunities to the air cargo sector.

“Some of these big e-commerce guys... we had a relationship with them pre-Covid but now it’s even more important,” Cathay Pacific’s director of cargo Tom Owen tells FlightGlobal.



The effect of e-commerce on demand for air cargo will persist

Jaromir Chalabala/Shutterstock

Crucially, airlines offer the only solution to quickly moving goods over long distances within countries and across borders – a prerequisite for meeting demand for speedy e-commerce deliveries. For parts of the air cargo sector that grapple with the volatility that comes with competing against shipping, for example, such a built-in advantage is highly attractive.

That development helps to explain why aircraft conversion specialists in particular are reporting strong demand for slots well into the future, and why the big airframers are confident about future demand for line-built freighters.

Amid those broadly positive indicators, the outlook for 2023 very much depends on “what kind of glasses you have on”, suggests Marco Bloeman, managing director at Seabury Cargo, speaking during the IATA conference.

He puts recent developments into context: “[2021] was super-stellar. [2022] will not be that, but it’s still one of the record years that we’ve seen in air cargo.”

And his view is that while there are “significant headwinds” in the short term, “economic indicators suggest continued long-term growth”. ■

Supersonic

Slow progress

2023 will mark the 20th anniversary of the final flight of Concorde, but a return to supersonic air travel still seems an uncertain prospect

Jon Hemmerdinger Tampa

The prospect of a return to civil supersonic flight was looking increasingly uncertain as 2023 approached, after several major engine manufacturers confirmed they had no intention to develop powerplants for the application.

However, that has not deterred Boom Supersonic, the most visible player in the segment. Following the collapse of its tie-up with Rolls-Royce, it announced on 13 December plans to develop its own supersonic engine with Florida Turbine Technologies (FTT).

Another player, Massachusetts-based Spike Aerospace, is progressing with its plans, but in “semi-stealth mode”, its chief executive Max Kachoria tells FlightGlobal. “What we are doing is well known. But the specifics are reserved for our key stakeholders.”

The supersonic space grew decidedly less crowded in 2021 when US supersonic business jet developer Aerion failed amid financial trouble.

Until recently, Boom, with offices in Colorado, had seemingly been humming along with the development of its Overture, a conceptual airliner the company says will cruise at Mach 1.7 and have range of 4,250nm (7,860km). It intends to deliver the first Overture in 2029.

Increasing commitments

In 2022, the company revealed plans to manufacture the Overture at Piedmont Triad International airport in North Carolina, and landed several aerospace partners. It also revealed design changes that included a higher aspect-ratio wing and a shift from two to four engines. Additionally in 2022, American Airlines committed to order up to 20 Overtures, building on a similar promise from United Airlines.

But that momentum stalled in September when R-R said it had stopped working with Boom, after performing engine studies.

“After careful consideration, Rolls-Royce has determined that the commercial aviation supersonic market is not currently a priority for us and, therefore,

Boom Supersonic

will not pursue further work on the programme at this time,” the UK engine maker said.

Boom reported the news differently, saying “it became clear that Rolls’ proposed engine design and legacy business model is not the best option for Overture’s future airline operators or passengers”.

Within days, other engine makers – GE Aerospace, Honeywell, Pratt & Whitney and Safran – confirmed that they, too, are not developing supersonic civil aircraft engines.

Fast track

Despite that lack of interest from the propulsion community, Boom promised to make an announcement on its engine by the end of the year, a prospect that seemed to grow more remote as Christmas drew closer. However, over the weekend of 10 December, reports emerged that, against all odds, Boom had a solution.

The Symphony engine will be a twin-spool, medium-bypass design, with no afterburner, delivering 35,000lb (156kN) of thrust at take-off.

FTT will work with Boom on the engine architecture, with GE Additive providing consultancy on additive technologies, and StandardAero taking the lead on maintenance.

However, Boom has not disclosed how or where the engine will be built, or indeed how much development work has already been carried out. The 2029 entry into service target for the Overture gives the company less than seven years to develop, construct, fly and certificate both an all-new engine and an all-new airframe, an ambitious timescale by the standard of even the industry’s most seasoned manufacturers.

Uncertainty also surrounds Spike’s plan to develop a supersonic business jet called the S-512.

In a 2022 blog post, Kachoria conceded companies like his face challenges now that engine makers have seemingly backed off from supersonic civilian aircraft engines.

“Does supersonic flight face difficulties in designing a new civil jet without an engine? Yes, absolutely. Super difficult,” he wrote. “But that is not the end of the story... this is just the beginning of a long road to supersonic flight.”

Kachoria declines to specify Spike’s progress in developing the S-512 but insists work continues.

“The Spike S-512 programme is moving along very nicely, and we are very excited about the progress made in the last few years,” he says. “Developing a supersonic aircraft will take years of engineering, testing and certification.

“We have taken on the slogan ‘It’s good to be quiet’ rather than issuing constant press releases about timing, funding or customers.”

“Does supersonic flight face difficulties in designing a new civil jet without an engine? Yes, absolutely. Super difficult”

Max Kachoria Chief executive, Spike Aerospace



Boom in 2022 changed the design of its conceptual supersonic aircraft Overture to have four engines, not two

China

Going solo

Mixed signals on border reopening – and rhetoric on the importance of homegrown technology – suggests Beijing is bent on forging its own path

Alfred Chua Singapore

If 2022 was the year of misguided optimism over a ‘China reopening’, then expect 2023 to be similar – except this time much of the rest of the world will have moved on, leaving China behind.

As the rest of the world – even the once-restrictive Japan and Taiwan – eases border restrictions, the “elephant in the room” remains China sticking, until late 2022 at least, to a zero-Covid policy.

The country remains the sole major economy that has not reopened its international borders, and it has been tight-lipped about when or how it may do so. The mixed signals from Beijing are not helpful in deciphering when or how China hopes to reopen.

However, some observers are optimistic that China could further open up once a high-level plenary meeting – known as the Two Sessions – wraps up in the first quarter of 2023.



Bryan van der Beek/Comac

There was also some optimism over a flurry of announcements in November 2022 that eased a number of restrictions, including the infamous “circuit breaker” suspension system, which penalises airlines found to carry passengers who test positive for the coronavirus.

But even as China announced these easing of measures, it quickly stressed it was still committed to zero Covid – at least for the foreseeable future.

Furthermore, in the weeks after, parts of China began seeing a surge in infections again, with Beijing reporting its first coronavirus-related deaths in six months. This prompted fears that parts of

Asia defence

China watch

Beijing’s neighbours are continuing to improve their airpower capabilities in response to what they view as threatening moves in the region

Greg Waldron Singapore

Beijing’s arms build-up and its aggressive foreign policy will only continue to spur airpower improvements among its North Asian neighbours.

The Airshow China 2022 event in Zhuhai was a tour de force of Chinese military capabilities. The Chengdu J-20 was the star of the show, appearing on the static display for the first time. Critically, the aircraft at the show were powered by a local engine, the Shenyang WS-10.

Beijing also used the show to display a plethora of unmanned air vehicles (UAVs), from small drones up to a model of the high-speed FH-97, a clone of the Boeing Australia MQ-28 Ghost Bat. The FH-97’s development status is far from clear, but a video at the show suggests it will one day accompany J-20s into combat as a so-called ‘loyal-wingman’, or attritable aircraft.

Although the show attracted few foreign visitors owing to Beijing’s strict zero-Covid policy, images and video from the event flooded social media and enjoyed broad coverage from international news outlets.

Zhuhai’s bombast followed a year in which Beijing’s military ambitions were abundantly clear. In June, a Shenyang J-16 forced a Royal Australian Air Force Boeing P-8A flying in international airspace to return to base after what Canberra referred to as a “very dangerous” intercept. Australian media reported that the fighter deployed chaff, which was sucked into one of the P-8A’s CFM International CFM56 engines.



The Comac C919 narrowbody achieved certification in 2022

the country would be plunged back into lockdown. In what could spell trouble for the country's air transport sector, officials in Beijing have also urged residents to avoid "non-imperative" travel.

Uncertain outlook

It is this uncertainty that will underpin China's hard-hit air transport sector as 2023 rolls in.

Already bleeding heavily from pandemic-related losses, China's three largest carriers are seeing domestic traffic slip further below pre-pandemic levels – a far cry from the robust recovery they experienced in the early days of the pandemic.

While international traffic is improving, it is – and will likely remain – well below 2019 levels.

International carriers have also been slow to add back capacity into China, with restrictions still in place by Chinese regulators. Airlines from countries dependent on Chinese visitors – like Thailand and Vietnam – are also in the midst of shifting capacity to other areas in the network, even while they eagerly await a reopening.

China's aerospace sector hit a significant milestone in 2022 despite rolling pandemic curbs, with the certification of Comac's C919 narrowbody – followed by an order for 300 examples from seven Chinese lessors.

The first example should enter service with launch customer China Eastern Airlines, which has five units on order.

Nonetheless – and as the euphoria settles in 2023 – expect China to confront the bigger question about its aerospace sector's reliance on Western technologies for its new aircraft programmes.

The C919, though a Chinese aircraft programme, has several key components, including its engines, from Western aerospace companies.

The need to build up its own aerospace programmes, be they for aircraft, engines, or other components, is voiced by many.

More crucially, looming geopolitical tensions with the West have resulted in trade sanctions that could impact homegrown aircraft programmes. These are not likely to go away in 2023 and could be increased, should relations sour further.

While work is under way to develop domestically produced engines and other aerospace technologies, these will take time – and expertise. They also risk stalling Chinese aircraft programmes – something that would be anathema to Beijing's dream of developing an aerospace sector to rival that of the Western world. ▶



Japan is in the process of upgrading its F-15Js

US Air Force

During the same month, Beijing launched its third aircraft carrier, CNS *Fujian*. Displacing 80,000t, *Fujian* will carry a far more potent air wing than China's two in-service carriers, the CNS *Liaoning* and *Shandong*.

In August, China conducted aggressive military drills against Taiwan following a visit to Taipei by US House Speaker Nancy Pelosi. The drills effectively closed sea lanes around Taiwan for several days. While the drills have stopped, China continues to mount aircraft sorties in the Taiwan Strait, some crossing the 'median-line' at its centre.

Geopolitical tensions

Beijing refuses to rule out the use of force to unify Taiwan with mainland China. Given the actions of China's military, the martial rhetoric of the Chinese Communist Party and China's massive arms build-up, North Asia faces geopolitical tensions the likes of which have not been seen since the darkest days of the Cold War.

In this context, governments will continue to beef up their defensive capabilities with an eye to deterring Beijing. The year 2023 should see Taiwan complete a major upgrade of 140 Lockheed Martin F-16A/Bs to the F-16V standard, which includes an active electronically scanned array (AESA) radar in the form ▶

140

Number of Taiwanese Lockheed Martin F-16A/Bs set to be upgraded to the F-16V standard, including AESA radar

Transfer of power

Disruptive propulsion is on the horizon, but do not expect market change too quickly – technologies will take time to come to maturity

Dominic Perry London

Anyone expecting 2023 to provide a breakthrough moment for alternative propulsion systems is likely to be sorely disappointed. That is, in no small part, due to the maturity, or otherwise, of the various technologies under development.

While none of the powertrain technologies being considered are in their infancy – electric, hybrid and fuel cell systems are all in service in the automotive world – their adaptation to the aerospace market will take time.

of the Northrop Grumman APG-83, as well as several other improvements.

Taiwan could also start receiving 66 new F-16Vs in 2023, according to a report in the state-run CNA news outlet, quoting the country's air force.

Japan, which could find itself embroiled in any conflict involving Taiwan, has a programme under way to upgrade 70 Boeing/Mitsubishi F-15Js to a new 'Japanese Super Interceptor' standard. In addition to a new AESA radar and other systems, the jets will get a new cockpit and updated weapons capabilities. Japanese media outlets have suggested that the upgrade could even provide the fighters with an anti-ship capability in the form of the Mitsubishi ASM-3 missile – cost concerns saw the US-made Lockheed AGM-158 JASSM cut from the original programme.

Tokyo will also continue work on its Future Fighter programme to replace its Mitsubishi F-2s in the 2030s. In December 2022 it signed up to a Global Combat Air Programme with Italy and the UK, to deliver a Tempest fighter from 2035.

The trilateral effort will also be of intense interest for the USA, which wants the new platform to be interoperable with US forces.



Ampaire

Weight and durability issues will need to be overcome, and regulators convinced of their safety; a particular challenge when rules may need writing from scratch.

Although developers say the technologies are understood and there is a clear path to their application in aerospace, these novel propulsion systems are unlikely to enter service before 2025.

But if there is no eureka moment in 2023, neither will it be a year of stasis.

In fact, several developers in 2022 demonstrated significant progress, with Ampaire (hybrid) and Eviation (full electric) chalking up first flights, and ZeroAvia (fuel cells) closing on the milestone.

Tokyo will also continue adding Lockheed F-35s. Cirium fleets data shows the Japan Air Self-Defence Force operates 27 F-35As, with commitments for 77 more. It has also ordered 42 F-35Bs, the short take-off and vertical landing variant, which will one day operate from two Japan Maritime Self-Defense Force flat tops, the *JS Izumo* and *JS Kaga*.

Testing times

South Korea, eyeing the danger posed by North Korea, will continue testing its new Korea Aerospace Industries KF-21. The type had its first flight in July 2022 and a second prototype took to the air four months later.

China's arms build-up is also driving defence acquisitions in the USA, including serious work on attritable aircraft that can operate in the Asia-Pacific region, as well as upgrade work for existing programmes. Similarly, Australia is beefing up its air force in several areas.

In the 2020s, the greatest geopolitical challenge facing the USA and its allies is deterring China from trying to reunify Taiwan by force. Advanced, interoperable allied airpower will play a key role in achieving this objective. ▶



Ampaire was among the developers who completed a first flight of an alternative-powered aircraft in 2022

More will undoubtedly follow in 2023 as design and development activities progress.

Funding is crucial too: expect to see more money arrive in the segment as investors bank on aviation decarbonisation as a solid bet. And do not rule out more airlines jumping into the fray as well, either by placing orders or becoming shareholders.

What is interesting to observe is the focus by many propulsion system developers on older aircraft designs for their initial go-to-market products.

At an extreme, that has seen Vancouver-based operator Harbour Air retrofit a Magnix electric powertrain onto a 1950s-era De Havilland Canada DHC-2 Beaver – a curious champion for the next-generation of aerospace propulsion systems.

Converted Caravan

However, others are focused on a more modern – in so much that it dates from the 1980s – aircraft in the form of the Cessna Caravan. The venerable turboprop type is the baseline aircraft for at least four different conversion programmes from Ampaire, Dovetail Electric Aviation, SurfAir, and ZeroAvia. Magnix too has tested its electric motors on the utility type.

Most of the above also have their eyes on follow-on programmes as they look to scale their technologies, with the DHC-6 Twin Otter and Beechcraft King Air already emerging as favourites.

But what is unclear is the degree of market acceptance any of these technologies will attain. Developers make the case that sub-regional aviation flourished due to the high operating and maintenance costs of turbine-powered aircraft, something their novel propulsion systems will address. However, until there is real-world operational data much will remain unknown.

Scalability will also need to be tested. A number of big players – GKN and MTU, for instance – believe that fuel cells can be used to power an aircraft with up to 100 seats, but we are not yet at that point.

Nonetheless we are likely to gain a better indication of the technology's potential in 2023 as Universal Hydrogen pushes ahead with flight testing a Dash 8-300 and ATR 72-500 adapted to run on fuel cells. ▶

Sustainability

SAF bet

Airlines need a clear roadmap to eliminate net carbon emissions by the century's mid-point, and that includes much wider use of sustainable fuel

Lewis Harper London

While there was relief among airlines in October when ICAO adopted a long-term aspirational goal of net-zero carbon emissions from air transport by 2050, the deal concurrently upped the ante for everyone involved.

With commitments from governments now aligned with those of industry, there are few excuses left for avoiding the difficult task of implementation.

Realistically, opportunities for significant sustainability breakthroughs will be few and far between in 2023. But two big themes are likely to underpin the industry's efforts: continued investment in new-generation aircraft that deliver fuel savings in the 15-20% range, and the push towards the sustainable aviation fuel (SAF) 'tipping point', where its use becomes mainstream and starts to chip away at jet kerosene's current dominance in whole-percentage-point terms.

The USA is setting the standards regarding the latter issue, having recently detailed plans for a massive scale-up of domestic SAF production from 5 million gallons in 2021 to 3 billion in 2030 and 35 billion in 2050.

Tipping point

Airlines will strive to send strong SAF demand signals in 2023, as they work with governments and the energy sector to deliver that tipping point by 2030.

Aside from those key themes, other developments are likely over the next 12 months.

European airlines in particular will continue to highlight airspace reform as a way of delivering emissions reductions of 10%-plus in one fell swoop. Given ▶

35bn

Gallons of sustainable aviation fuel the USA aims to produce annually by 2050 – up from 5 million gallons in 2021

the long history of failed attempts to introduce a 'Single European Sky' amid national airspace security concerns, however, progress seems unlikely.

2023 will also bring some focus on the roll-out of market-based measures, such as the voluntary stage of ICAO's CORSIA offsetting scheme, which play a significant role in many net-zero roadmaps - but one that most stakeholders hope will get smaller as other developments deliver emissions reductions at source.

In the meantime, the industry will continue to push back against government attempts to introduce or expand competing programmes, such as the EU's Emissions Trading System.

Furthermore, the coming 12 months are likely to see continued airline support for the development of breakthrough aircraft and propulsion technologies - and concepts such as carbon-capture - that might aid the net-zero push as 2050 gets closer.

The concept of 'green-hushing' is also a topic to look out for in 2023. Amid the lawsuits faced by



ICAO announced its 2050 net-zero pledge in October

some businesses - including Dutch flag carrier KLM - over allegedly misleading sustainability boasts, 'green-hushing' describes firms becoming less willing to trumpet their progress towards net-zero CO₂ for fear of attracting similar lawsuits.

In a related issue, many stakeholders complain that the airline industry's lack of universal sustainability metrics is weighing on its ability to confidently shout about progress on the topic - whether to sceptical pressure groups, the travelling public or investors seeking reassurance on the sector's credentials. Airline association IATA is working on a set of metrics that might be the solution to that problem going into 2023.

Ultimately, the coming year is likely to see airlines make steady progress on the net-zero effort with a new-found confidence that governments and industry are aligned.

It might not bring the big leaps that are probably needed to win over sceptics, but no serious roadmap suggested it would. Hard work in the coming months will, however, ensure such points can be reached sooner rather than later. ▀

Business aviation

Business as usual?

The sector thrived through the pandemic and its aftermath, with a flurry of programme launches. Will the next 12 months see a return to pre-Covid patterns?

Murdo Morrison London

Along with cargo, business aviation was a pandemic success story - it prospered as the commercial passenger sector faltered. Demand for private jet travel continued strongly into 2022 even as airliners returned to the skies. However, are the next 12 months when things start to slow?

Towards the end of 2022, data specialist WingX was reporting that the "post-Covid rebound in bizjet flights in Europe is ebbing fast" and that while the US market is "holding onto its gains... the charter market is softening".

This is a result of weaker business confidence, inflation and higher interest rates discouraging investment. Meanwhile, airlines are aggressively tempting back premium travellers that might have been lured to charter, with loyalty programmes and schedules that are more reliable.

Much was made of the effect first-time users had on the Covid-19 boom in business aviation, with some estimates suggesting that 30-40% of those flying on private aircraft during the period were new to the industry.

However, consultant Brian Foley is sceptical. He concedes many were persuaded to sample business aviation for the first time in 2020 and 2021, but most were one-off travellers, nervous about contracting the virus or who needed to get somewhere, and are unlikely to repeat the experience.

"Although there was a pretty good spike in utilisation during the pandemic, and bragging about first-time users, a lot of it was grandma and grandpa flying it once," he says. "It wasn't a fundamental shift in demand."

However, he does suspect that enough converts will remain loyal to business aviation to ensure that demand will "normalise" at around 10% higher than 2019 figures in 2023. "I think we will end up with a slightly higher baseline as a result of some of these new users remaining," he says.



The past year and a half has witnessed launches from the big three airframers

Dassault Aviation

The Covid-19 period and its aftermath also saw a raft of programme announcements, especially at the upper end of the market. Although all these aircraft had been on the drawing board well before the pandemic, manufacturers were confident enough to go ahead with launches.

All three rivals in the ultra-long-range segment revealed new types within 18 months. Despite the cancellation of that month's EBACE industry convention, Dassault started the trend in May 2021 with the unveiling of the 7,500nm (13,900km)-range Falcon 10X, its largest business jet (see p72).

Gulfstream followed in October that year with its longest-legged product, the 8,000nm-range G800, which, like the 10X, is powered by a variant of Rolls-Royce's Pearl engine family. The airframer rolled out the first test aircraft during a ceremony at its Savannah headquarters.

Range finder

Last to the party at 2022's EBACE in Geneva was Bombardier with the Global 8000, a reworked version of an earlier planned stablemate to its Global 7500. Like the G800, the Global 8000 has, as its name suggests, a range of 8,000nm.

There has been less activity elsewhere. At the same time as it revealed the G800, Gulfstream announced the 4,200nm-range G400, which completes a trio of large-cabin types with the G500 and G600, and gives the US manufacturer the most comprehensive range in that part of the market.

Meanwhile, also that month, Honda Aircraft took the wraps off its 10-passenger 2600 concept. Although not a formal launch, the aircraft, if it ends up built, will straddle the light-jet and midsize segments and be a sibling to the original HondaJet light jet.

The launches at the top end of the market mean the big three competitors have caught up with each other and have their hands full for the next few years certifying and delivering their latest products.

Dassault's smaller 5,500nm-range Falcon 6X is also due to enter service in mid-2023.

However, Foley is surprised that there have been few significant developments in other segments. Embraer launched its Praetor 500 and 600 pairing in 2018, but they were updates of its Legacy 450 and Legacy 500, already a decade or so old.

The last all-new model from Textron to enter service was the super-midsize Longitude in 2019. The manufacturer has been preoccupied with the certification of its single-engined Beechcraft Denali, due for certification in 2023, and its Cessna SkyCourier utility twin-turboprop, which entered service in 2022.

Meanwhile, other than name changes and updates, the designs of Bombardier's Challenger 3500 and Challenger 6500 date from the late 1990s and 1970s, respectively. With both still selling fairly strongly, Foley doubts whether the debt-laden airframer is ready to "roll the dice" with replacements.

At this end of the market, says Foley, manufacturers have traditionally substantially updated their offering every seven to 10 years, but in recent years they have tended to take "shortcuts", making small design tweaks, and "adding a zero", a reference to Bombardier's practice of refreshing its Challenger brand. "Several of them are now stuck with older products, and they will need to make some major improvements on performance, range or cabin size, instead of just moving a cabin ledge," he remarks.

Production across the industry is likely to continue at a "slight uptick" on 2022 levels, says Foley. Although lead times for newer aircraft at the top end of the market in particular can be upwards of two years, most manufacturers are not planning to speed up output.

This is because most customers are prepared to wait, and airframers are happy because it means they can maintain book to bill ratios and avoid discounting, suggests Foley. Keeping production steady also suits manufacturers faced with supply chain pressures and labour shortages. ▀

Archer revealed its latest airframe in November



Forever in electric dreams?

eVTOL

Will 2023 be a year of breakthroughs in urban air mobility, or has the hype around the sector exceeded commercial, technical and regulatory reality?

Pilar Wolfsteller Las Vegas

Futurists have been talking up personal air transport vehicles for years, but the electric vertical take-off and landing (eVTOL) market has made slow progress. Technology development, certification by regulators and public acceptance of the new airframes is a lot more difficult than it might seem.

As dozens of companies aim to fly their vehicles commercially by the middle of this decade, what are the short-term milestones that will signal success? Will 2023 be a year of achievements, or is the eVTOL bubble on its way to bursting?

Robin Riedel, a partner at management consultancy McKinsey & Company, and global leader of the Disruptive Aerospace sector within the Aerospace & Defense practice, says that in 2023 eVTOL companies are going to have to step up their game. They are also going to have to pull in a lot more money.

He has identified four major themes for the coming year: certification, manufacturing ramp-up, supply chain plans and funding.

“2023 is going to be about rolling up the sleeves and getting stuff done,” he says. “It will move away from the conceptual, higher-level discussions into actually doing things, especially if they want to certify their vehicles by the end of 2024.”

“Second, the players will have to start building conforming prototypes. They’ll have to figure out how they are going to manufacture them because the FAA [Federal Aviation Administration] wants to see that they have the quality assurance and the process in place to build the same thing over and over again.”

And after manufacturing is addressed, what about the supply chain?

“A lot of the parts are still going to come from suppliers,” he says. “So how do they build a supply chain, especially with the uncertainty about when does [production] actually start, and how much volume is actually going to be needed. It’s an interesting challenge.”

In November, Archer Aviation, one of the leaders in the space, unveiled its second airframe, a four-passenger-plus-pilot vehicle called Midnight, and set out an aggressive certification timeline for the aircraft. It is aiming to conduct a maiden flight in the first half of 2023, and to be the first to have a vehicle approved by the FAA, in 2024.

But it is no surprise that creating all this new technology – and getting the FAA’s blessing – takes a staggering amount of money.

Archer’s chief executive Adam Goldstein says the price-tag for one aircraft design to reach certification could be up to \$1 billion.

“He who has the money is the winner,” says Cowen aviation analyst and managing director Helene Becker. “These companies are creating a whole new industry from scratch, and there will obviously be winners and losers.”

A big loser in 2022 was Kittyhawk, one of the first eVTOL companies to hit prime time, but which folded in September when it ran out of capital.

"Everything is going to take longer and cost more than anybody thinks right now," Becker says.

Riedel says that "about a dozen" companies have the potential to march through the next phase of development, but even the most advanced players like Archer and Joby Aviation do not currently have enough cash on hand to make it to commercialisation.

"Funding of these vehicles is much more risky than if you were to finance a traditional aircraft," he says. "If you build a 737 you get pre-delivery payments, money up front, leasing companies know what the residual value is, and therefore people are willing to lend against it." That is not the case with eVTOL products.

"What's the economic value of these aircraft? How long are they going to be in service? How quickly do they become obsolete? There's a billion [dollars] more needed just to finance the first couple of hundred aircraft," he says.

On the flip side, though, "there's a lot of dry powder out there - billions and billions of dollars - that needs to get deployed", he adds.

Recent McKinsey data shows that venture capital cash, waiting to be invested, is about \$550 billion, up from \$375 billion a year ago. Growth funds, family offices and other major investors are also looking at the space. The total, he says, is potentially about \$1 trillion.

Inevitable effects

Consolidation is inevitable and failures will occur, analysts say.

"I wouldn't be shocked if we see two or three of the names that we always talk about call it quits next year because they can't find the funding or they realise they're not going to be competitive or that going together with someone else is better," Riedel says.

And once the technology is stable, aerospace conglomerates might swoop in.

"You're going to see some giants buying and bringing these technologies in-house because now they're proven out and they have a good runway for growth," says Raymond James managing director for global airlines Savanthi Syth.

"Airbus and Boeing want to be in this space, but I don't think they've figured out how," Becker adds. "They will do something. Maybe [they're] waiting to see who has the best design, who's closest to development, and then buy the company to scale it."

For now, the eVTOL field is wide open, there is no clear winner, and there won't be for quite some time. The current pack leaders still have a lot of work to do. But they are offering a diversity of projects and ideas which the industry has never seen.

"I think in the next decade you'll still have a lot of companies because they're all addressing very different things," Syth says.

"In traditional aerospace everything kind of looks the same," Riedel says. "But here we're taking real risks, trying out things to see what could work."

"That's great because it will accelerate the industry, and we'll get to innovation faster."

"I'm generally very, very bullish on this industry, but I'm also a realist," he adds. "And we shouldn't be surprised when a bunch of these players fail." ▀

Production

Breaking the chain

The supply problems that have been affecting aerospace manufacturers show few signs of easing - and could take a year or more to resolve

Jon Hemmerdinger Tampa

The supply and labour troubles that hindered aerospace production in 2022 seem likely to continue in the near term, with inflation and parts shortages expected to leave airframers and their suppliers continuing to struggle to ramp up production over the coming year.

"In 2023, we are going to see the same disruptions, or possibly more," says Alex Krutz, managing director at aerospace and defence advisory Patriot Industrial Partners. "I think it is going to take all of next year to correct some of these fundamental issues, and I think there are going to be some changes in the supply chain because of it."

Such disruptions defined the aerospace industry and other manufacturing sectors in 2022, with executives up and down the aerospace supply chain citing inflation and parts and labour shortages as holding them back.

Long list

On 3 November, the chief executive of Wichita aircraft structures supplier Spirit AeroSystems listed his various troubles.

"Supply chain disruption resulting in part shortages for our factories, labour shortages and elevated levels of attrition, and high levels of inflation - we expect some of these challenges to continue into 2023," chief executive Tom Gentile said.

Those issues contributed to Spirit's \$128 million third-quarter loss and prompted the company to launch a cost-cutting effort.

"Supply chain constraints continue to be a headwind, leading to delays in sales in the quarter," Daniel Crowley, chief executive of aerospace company Triumph Group, said on 8 November.

He says that Triumph's suppliers are delivering components on time in the mid-80% range, up from the mid-70% range earlier in 2022. "Castings and forging providers have been the largest sources of

Marriage season

Could supply chain challenges and higher defence spending spur mergers and acquisitions? And, if so, who might be buying and what will be up for sale?

Murdo Morrison London

After a relatively sedate year on the aerospace merger and acquisition front, will a commercial aviation supply chain short of cash and struggling to meet demand spur marriages of convenience in 2023? Will growing defence budgets prompt opportunistic approaches in that sector?

Will we see further liaisons among Top 100 companies after the 2020 mega merger of Raytheon with United Technologies units Collins Aerospace and Pratt & Whitney, and the smaller but significant amalgamations in 2022 of Parker and Meggitt, and Cobham with Ultra Electronics?

shortages,” Crowley adds. He expects on-time deliveries will exceed 90% by the end of March 2023.

In late October Boeing – for the second time in the year – cut its expected 2022 737 delivery estimate, this time to 375 aircraft. “We are short of engines,” chief executive David Calhoun said.

A few days later, during a 2 November presentation for investors, Boeing Commercial Airplanes chief executive Stan Deal also called out shortages of electrical and galley components, and cited “quality issues”.

Michel Merluzeau, aerospace consultant with AIR, thinks the lack of enough skilled workers is more a problem for Boeing than its executives are letting on.

Inflation impact

Inflation, which has been running at about 8% in the USA and 10% in Europe, is chief among challenges facing the supply chain, says Krutz. Companies suddenly find themselves paying much more for

As we enter the New Year, there are few obvious signs of serious activity. Analysts have been talking up the likelihood of a Rolls-Royce takeover for years, and rumours the UK engine maker was for sale sparked a short-lived share price spike in March.

Lockheed Martin’s snoop in 2022 for Aerojet Rocketdyne was more than a rumour, but the defence giant abandoned its agreement to acquire the propulsion specialist in February after US Federal Trade Commission opposition. In mid-December, L3Harris Technologies moved to buy Aerojet for \$4.3 billion, with a deal expected to close during 2023.

The commercial aerostructures sector has been finding the recovery tough, with three of the biggest suppliers, France’s Latecoere, and Spirit AeroSystems and Triumph in the USA, adopting different post-pandemic strategies as they look to return to profit.

Divestment options

Pennsylvania-based Triumph has been divesting businesses, including a Florida site to Daher, manufacturer of the TBM 940 and Kodiak 100 turboprops. The French company, which was already in aerostructures, had been keen to reinforce its tier one status with stateside customers including Boeing and Gulfstream.

That followed the 2021 sale by Triumph of three sites to a private equity buyer. A year earlier, Gulfstream took G650 wing production in-house after purchasing the line, and in 2019, TECT Aerospace (now owned by Boeing) bought a structures factory in Nashville.

After the 2021 divestments, chief executive Dan Crowley said Triumph “continues to execute on its transformation plan, divesting non-core businesses to enable debt reduction and reinvestment in new areas of opportunity”. However, as the company returns to profit and prepares for a production ramp-up, it may have now ticked that box.

Spirit bought Bombardier’s Belfast, Northern Ireland-based aerostructures business at the

materials and labour, which will “lead to cash constraints in [the] supply chain”.

He also suggests that some companies might in 2023 face unpleasant fallout from creative

pandemic-era financing arrangements that helped them weather the recent aerospace downturn.

Specifically, during the pandemic some manufacturers stabilised teetering supply chains by providing “forward” capital – such as through debt purchases or advance-payment arrangements – to smaller, financially struggling suppliers. Companies also received pandemic-related government aid. Some also

borrowed cash at unbelievably low interest rates.

However government aid has dried up, interest rates have skyrocketed and those creative forward-capital arrangements are starting to stink.



Spirit AeroSystems has predicted that its supply chain challenges will continue into 2023



Rumours of a Rolls-Royce sale sparked a share price spike in March

David Vardi/Shutterstock

height of the pandemic in 2020. Since then, the Boeing-dependent supplier has struggled, recently recording a \$128 million quarterly loss, its third deficit this financial year.

Wichita-based Spirit abandoned a long-in-gestation move to buy Belgium's Asco, which Swiss company Montana Aerospace picked up instead. The deal for the aerostructures specialist, which employs 1,000 staff across plants in Belgium, Canada, Germany and the USA, closed in April 2022.

Aerostructures and wiring group Latecoere, which also lost money in the first half of 2022, has continued to expand after sourcing additional capital. Its latest purchase, in November 2022, was Canada's Avcorp Industries, which makes structural parts for the Boeing 737 and Lockheed Martin F-35 among others.

Over the past two years, Latecoere has bought Spanish electronics supplier Malaga Aerospace Defence & Electronics Systems (MADES) and the Mexican plant of fellow French tier one supplier Figeac Aero, which it says have boosted its presence in the North American and defence markets.

"Someone is either going to have to write off bad debts, or go... for some period of time... without cash flow," says Krutz. "Some of that stuff starts to shake out in 2023. I don't see how it doesn't."

Production hike

Most suppliers, big and small, ultimately support large manufacturers like Airbus and Boeing, and those companies are working feverishly to hike production of narrowbody jets.

Boeing now aims to deliver 400 to 450 737s in 2023 - or 33-38 monthly. Some will come from its stockpile of already produced 737s, but hitting its goal will require faster production rates.

Boeing had, earlier in 2022, aimed to produce 31 737s monthly, but its actual output seems far behind.

The company does not disclose actual monthly output figures, but data provider Cirium tracks first flights, which serve as a rough proxy for production. In the first 10 months of 2022, 220 737s got airborne for the first time - an average of 20 monthly, which aligns with financial analysts' estimates.

Supply chain issues led Airbus in July to delay by six months, until early 2024, its goal of producing 65

The acquisitions, maintains the Toulouse-headquartered company, are part of a "2025 roadmap to achieve profitable growth and participate in global aerospace industry consolidation". On that basis, more takeovers could be on the cards for 2023.

Advisory firm PwC identifies a recent slowing in merger activity, including among so-called special purpose acquisition companies or SPACs. These organisations obtain a market listing with the aim of buying start-ups with promising or disruptive technologies. They were very active in 2021 in the commercial spaceflight and fast emerging electric vertical take-off and landing (eVTOL) segments.

SPACs own, or are heavily invested in, Archer Aviation, Embraer spin-off Eve, Joby Aviation, Lilium and Vertical Aerospace, although several of these saw their share values drop during 2022 as they strive to meet ambitious timelines to bring their platforms to certification, and introduce the world to urban air mobility.

Programme maturity

Several eVTOL developers are at similar stages of programme maturity, and have the necessary funding to certificate their designs. It therefore appears likely the next 12 months will see less SPAC activity as the market awaits to see which business models make it to the finish line. It is almost certain that not all of them will.

Another large aerospace player preparing to make big divestments, but not in its core market, is GE. The industrial giant is changing its name to GE Aerospace and spinning off its sister healthcare and energy businesses, a process it expects to complete by early 2024.

Part of the reason for the switch in nomenclature is an intention to expand in non-engine segments of aerospace, including in aircraft systems, currently a \$3 billion business for the company. While it is saying little about precise areas for expansion, do not rule out acquisitions as the now aerospace-focused group raises a divestment war chest. ▶

A320neo-family jets monthly. Then in December, the airframer said it would slow the ramp-up pace further, while sticking to its goal of hitting rate-75 in 2025.

Airbus also indicated that it would fall short of a target to deliver 700 commercial aircraft in 2022, with 565 shipped by the end of November.

Engine supply appears to be the major pacing item. In late October Safran revealed that CFM International - of which Safran and GE Aerospace are co-owners - is still running behind its delivery schedule for Leap turbofans. Leap-1As are one of two engine options for A320neo-family aircraft, and Leap-1Bs are the exclusive engine for the 737 Max.

"We are late with Boeing, as we are late with Airbus on deliveries," said Safran chief executive Olivier Andries. He and other executives have attributed engine shortages partly to insufficient supply of cast-metal parts.

Krutz says such issues will take time to work through. He sees 2023 as a "bumpy" year for suppliers, saying some firms could fail or be pushed into mergers that, pre-Covid, they would not have considered. "I think the supply chain will get restructured," he says. ▶

Nine-seater Alice made an 8min
debut flight on 27 September



Electric avenues

The hype about electric, hybrid-electric and hydrogen-powered aircraft to help solve aviation's carbon emission problem is huge, but how much progress is being made bringing them to market?

Mark Pilling London

Andre Borschberg wonders out loud if his flight time of around 800h piloting electric aircraft is still a world record: “It may still be on top of the list, or maybe people are beating my experience – I hope so, this would be a good sign,” he says of the fledgling genre of aircraft powered by something other than fossil fuels.

Swiss entrepreneur and engineer Borschberg has flown four electric types in his career: *Solar Impulse 1* and *Solar Impulse 2*, the more than 60m (197ft)-wingspan, solar-powered, long-endurance aircraft each with four small electric motors; the Bristell B23 Energic, a two-seat trainer made by Czech firm BRM Aero; and an electric version of the Twister aerobatic model made by Silence Aircraft of Germany.

Borschberg is a pioneer in electric aircraft development. In tandem with fellow Swiss national Bertrand Piccard, he founded Solar Impulse in 2002. *Solar Impulse 1*, which took off on 3 December 2009, was the result. Their second aircraft, *Solar Impulse 2*, completed the first circumnavigation of the Earth by a piloted fixed-wing type using only solar power in a total of 17 stages over 17 months in July 2016.

Carbon target

Turning this remarkable feat into a commercial venture led Borschberg to found H55, a technological spin-off of the Solar Impulse project. Its mission is to develop electric propulsion systems to power aircraft that can enable the aviation industry to reach its net-zero carbon dioxide emission targets by 2050.

Borschberg is a member of an exclusive – and growing – club of individuals and companies that lay claim to developing and flying aircraft powered either wholly or partly by electricity, or hydrogen, dedicated to the task of aviation decarbonisation.

According to Gabriel Hanot, the former head of Airbus Consulting and now an independent Toulouse-based consultant, the upcoming low-emission aircraft projects can be charted, comparing entry into service, maximum range, seating capacity and technology employed.

He identifies three distinct types: full-electric aircraft with small capacity and short range; hybrid-electric aircraft with small capacity and longer range; and hydrogen-electric aircraft able to accommodate higher-power electric engines, with higher seat capacity but medium range.

2050

Target year for the aviation industry to reach net-zero carbon dioxide emissions

This article will focus on those developing conventional aircraft, leaving the nascent advanced air mobility sector for future examination.

First flights of conventional aircraft are coming thick and fast, with more to follow in the coming months. One of the latest is Eviation's Alice. On 27 September the US company celebrated the maiden flight of its all-electric nine-seater at Moses Lake in Washington.

Integrated propulsion

Another is California-based Ampaire. On 18 November it flew the Eco Caravan, a hybrid-electric version of the Cessna Grand Caravan fitted with Ampaire's integrated propulsion system – a Red Aircraft piston engine, batteries and an electric motor – from its base at Camarillo airport, north of Los Angeles. This powertrain replaces the standard Pratt & Whitney Canada PT6 turboprop.

Other pioneers that have flown all-electric, hybrid-electric or hydrogen-powered types are H2Fly,



“It may still be on top of the list, or maybe people are beating my experience – I hope so, this would be a good sign”

Andre Borschberg
Swiss entrepreneur and engineer

Pipistrel, Tecnam, VoltAero, and ZeroAvia. They are a mixture of established manufacturers, such as Italy's Tecnam, with a history dating back to 1948 making general aviation aircraft, to start-ups riding the aviation sustainability wave, such as ZeroAvia, which is promising hydrogen-electric (fuel cell-based) power solutions.

Over the past year all the manufacturers interviewed have been gaining momentum towards their goal of being the first to market. However, there are many outstanding questions, and almost all have taken a reality check on aspects of their plans.

Ambitious timescales

The list of debating points round this new class of aircraft is lengthy. There is the question about a retrofit versus a clean-sheet aircraft design, and whether the choice of a hybrid aircraft configuration as a first step towards all-electric or hydrogen fuel cell designs is the better one? There also are doubts over battery performance and cynicism with over-ambitious certification and entry-into-service timescales. Many cite the challenge of bringing regulators on the journey.]



Jean-Marie Uriacher/VoltAero

Cassio 1, an adapted Cessna 337 Skymaster, uses VoltAero's 600kW parallel hybrid-electric powertrain

› All these questions must be answered alongside the constant pressure to attract and retain investors.

The programme that produces the strongest reaction – and one that has taken a reality check with design changes and pushed out its in-service timeline – is Eviation's Alice. There are plenty who tell FlightGlobal that this firm, whose product name was inspired by the Lewis Carroll fantasy story *Alice in Wonderland*, lives in cloud cuckoo land when it comes to delivering on its promise of a nine-seater able to fly up to 250nm (462km). They say limits on battery performance make this a fantasy.

High stakes

Fabio Russo, head of research and development at Tecnam, would love to see a revolution in battery technology enabling electric aviation, but says basing an aircraft programme on it happening is a high-stakes game and not one that his firm will bet on. In addition, while the talk on batteries focuses on improvements in energy density to boost performance, few talk about the carbon emissions it takes to make them, he notes.

"There is no weak link in this," Eviation chief executive Greg Davis tells FlightGlobal, specifically referring to batteries. However, he recognises that improved batteries will be needed to meet the company's target of beginning certification test flights by 2025.

"It's one of the exciting things about it as we learn more about how the technology works," Davis says.

250nm

Range that Eviation has promised for its all-electric Alice aircraft, a figure many in the industry feel is unrealistic

"We showed that you can fly an aeroplane on battery power. And we did it knowing what was going to be safe. We are there in terms of understanding the architecture and how you build an energy storage system certifiable for safe flight. I don't think I have ever had the opportunity to express it that way before."

Davis is unfazed by those who pour scorn on the Alice project, with the prototype taking to the air for 8min, flying "on the numbers" and generating terabytes of data. "What we did in our first flight was we proved all this technology can work together – the energy storage system, the EPU's [electrical power units]. On top of it was the first flight of an electric aircraft of this scale. It was the first time a Part 23 fly-by-wire aircraft [US Federal Aviation Administration rules that apply to a type with fewer than 19 seats] ever flew."

Davis recognises that flying a prototype is only a first step and acknowledges that a fully certified production aircraft is probably five years away.

This timeline appears far more realistic than past statements about certifying the Alice by 2023 or 2024. These ambitious early promises, in addition to statements about aircraft range, are the ones that most irk experienced players.

Davis takes care to strike a more realistic tone as the firm moves to its next stage of maturity. “We are a technology start-up that is growing into being an aircraft manufacturer,” he says. “We absolutely needed to focus on innovation, and invest in the technology, because it didn’t exist. We had to invent it.”

Now the hard work of certifying the Alice begins in earnest, and Eviation is already “deep” into this work with the FAA and soon will be with the European Union Aviation Safety Agency (EASA), says Davis. He also stresses that 80% of the design is part of the “normal development cycle” for an aircraft, with just 20% relating to the electric powertrain.

Charging ahead

While Eviation divides opinions and grabs headlines, others are quietly making what they claim is significant progress on aircraft development and powertrain certification. Jean Botti’s experience in defining and developing electric aircraft goes back to 2011, when a team including the EADS Innovation Works flew the Electric Cri Cri, a tiny aerobatic single seater with just 20kW of propulsive power. Botti was EADS chief technology officer and part of the team that developed another electric aircraft, the Airbus e-Fan two-seater, with 60kW of electric power, which flew in 2014 but was cancelled in 2017.

He saw such potential in electric aviation that he founded VoltAero in France to go it alone and develop what he describes as “a realistic answer to sustainable regional transportation”.

Drawing on his experience, Botti believes the pragmatic answer to bringing an aircraft into service as

early as possible is the hybrid route. Advocates of the hybrid solution say it is vital because batteries alone will not allow sufficient aircraft size or range.

VoltAero first flew its 600kW Cassio parallel electric-hybrid powertrain fitted in the aft fuselage of an adapted Cessna 337 Skymaster, dubbed Cassio 1, in October 2020. The powertrain design combines three 60kW electric motors with a Nissan combustion engine, all attached to a common propeller shaft. Its concept is for the electric motors to be used for take-off, landing and primary flight, and for the internal combustion engine to serve as a range-extender, battery recharger and back-up.



“We absolutely needed to focus on innovation, and invest in the technology, because it didn’t exist. We had to invent it”

Greg Davis
Chief executive, Eviation

VoltAero’s Cassio powertrain is being certified on the Cassio 1 and will provide the electric-hybrid propulsion system for use in a clean-sheet family of three aircraft from the five-seat Cassio 330 to the six-seat 480 and the 10-12-seat 600. “We have been flying for two years now and we have a powertrain that has been in certification since October 2021,” Botti says.

Certification of the Cassio 330 is expected in the second half of 2024, with production aircraft being delivered by the end of that year, Botti says. Like others, this is later than planned – an early 2023 entry into service date was mooted back in 2020. “The big reason [for the delay] is the requests from EASA for the proof from the safety standpoint, including batteries, which are the weak link. They are very picky, and rightly so, on the batteries,” Botti says.

Clean sheet

“We are willing to sell our technology of hybrid modules – for example, if someone wants to convert a [Cessna] Caravan and they can do the refurbishment themselves,” Botti says. However, VoltAero will not enter this market, because it wants to take “full advantage” of a clean-sheet design that is optimised for the chosen propulsion system and airframe configuration, he says.

Ampaire’s development of the hybrid Eco Caravan is a “practical and compelling” approach that brings speed to market with the promise of delivering emissions reduction long before an all-electric or

Ampaire modified its Eco Caravan with hybrid-electric propulsion



hydrogen type is service-ready, says Susan Ying, senior vice-president global partnerships at the US firm.

The inherent advantage of a hybrid – with its use of a combustion engine that is smaller and lighter than the aircraft’s original engine – is that the overall weight of the powertrain, even taking into account the batteries and electric motor, will be drastically less than an equivalently sized all-electric design, Ying explains.

Critically for Ampaire, the learnings it has gained from demonstration flight campaigns in the UK and the USA in 2020 and 2021 with its Electric EEL aircraft, a modified Skymaster, have confirmed its hybrid approach and rejection of the all-electric route, she says.

From its operational experience, the challenge of ensuring 30-45min of fuel reserves with these novel propulsion types in case of diversion for reasons such as bad weather became crystal clear. “For a nine-seat aircraft, the laws of physics dictate you have your battery for 30 minutes [reserve],” Ying explains.

“With today’s technology, and that will be there for the next two to five years, the reserve requirement alone for the battery is 2,000lb [907kg],” Ying says. Add the weight of passengers and baggage and “you basically kill the business case. No matter if your trip is one mile or 200 miles, you really don’t have the capacity to make a buck,” she adds. “We saw this from very early on and that’s why we decided to do the hybrid.”

Ampaire has been working with the FAA on approval for the Eco Caravan conversion for a year, Ying says. Past aircraft modification projects have taken one to two years to gain a supplemental type certificate (STC) for replacing the engines in an existing airframe, she says. “So, we think it will take three years because

we have new disruptive technologies. We are estimating certification completion by the end of 2024.”

The hybrid-electric route is one Pipistrel will take with a version of its in-development Panthera four-seat general aviation aircraft before the end of the decade. The tiny Slovenian aircraft manufacturer, founded by Ivo Boscarol in 1989, is a pioneer in electric aircraft, having flown the Taurus Electro, the world’s first two-seat fully-electric motor glider, in 2007.

First certification

It is also the only manufacturer producing an all-electric aircraft “you can buy and take home and use today”, explains the company’s group chief technical officer, Tine Tomazic. He is referring to its two-seat Velis Electro, a pilot trainer that became the world’s first type-certificated electric-powered aircraft in 2020. To date, about 75 Velis Electros are in operation, with aircraft serial number 102 on the production line when FlightGlobal talked to Tomazic in mid-November.

Tomazic likens Pipistrel’s approach of bringing the Velis Electro to market to the way the pharmaceutical industry certifies a new drug using clinic trials. “For us, it really mattered that we were able to pursue a staged approach that was collaborative, to have what you would call pre-production aircraft out with actual customers and stakeholders, and through their feedback shape what is now a type-certified product,” he says.

For Tomazic, the relatively slow pace of electric aircraft development is not down to technical progress, but for another reason. “What was slower was essentially the process of bringing these products to the market through certification,” he says.



Pipistrel

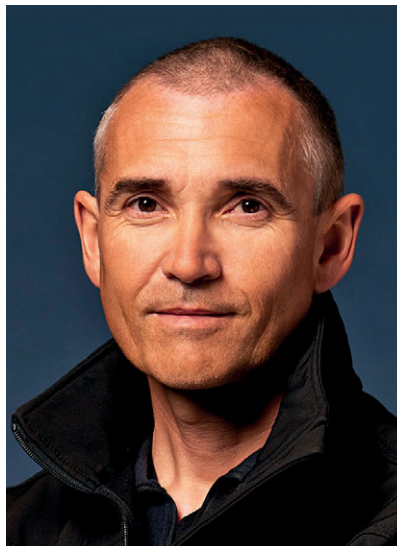
Pipistrel’s Velis Electro became the first type-certificated electric-powered aircraft in 2020

“The whole discussion about what constitutes a safe product with the regulator took longer than expected,” Tomazic says. “But looking back, that’s not a bad thing. The more people you expose your design and your rationale to, the more adjacent thoughts you will get – some of them are outrageous, but some of them are interesting and help you understand that you have perhaps completely disregarded a certain aspect.”

ZeroAvia chief executive Val Miftakhov says his aim when the company was formed in 2017 was for the first service entry of an aircraft featuring its certified hydrogen-electric powertrain in 2023. That target has slipped by around two years, partly because of delays caused by the pandemic, and partly down to understandable conservatism from airframers becoming comfortable that the technology is real, he explains.

“There was a lot of good education, good collaboration and workshopping involved with regulators and I think we’re getting to a good place”

Val Miftakhov
Chief executive, ZeroAvia



Additionally, “I think we have probably underestimated the amount of regulatory scrutiny that would be required,” Miftakhov says. “There was a lot of good education, good collaboration and workshopping involved with regulators and I think we are getting to a good place, but it took us some time. A lot of the regulators did not really have a lot of experience with even the electric part of technology, let alone the hydrogen side.”

Essential standards

Tomazic echoes the comments about the need for close collaboration with certification bodies and encourages more players in this sector to get involved in helping establish the essential standards these aircraft and the surrounding infrastructure need to enable them to operate successfully. It is not a competitive issue and will pay dividends in bringing industry stakeholders in general and specifically large OEMs on board. “It would be helpful if people who are serious about productising their efforts would join such groups earlier,” he notes.

The established aerospace players are paying more attention to these emerging technologies, and the companies developing them. “It’s incredibly important, because it is a voice of confidence about the technology and our market,” Tomazic says. “It also represents a

certain elevated security around the whole thing.”

US firm Textron, which owns the Beechcraft and Cessna brands under the Textron Aviation banner, has recognised the leadership of Pipistrel in this space and acquired the firm in April 2022. “If you look at the silos now, there are tiny companies who want to prove to a Rolls-Royce or Safran that they can do a better engine,” Tomazic says. “They might. But even if they do not, there is still a pathway for these people and innovations, perhaps to be absorbed by a tier one giant.”

Reviewing the ambitions of the leading players, the indications are that Ampaire and VoltAero with their hybrid-electric designs will follow Pipistrel with in-service models in the conventional aircraft category around 2025. Eviation’s all-electric Alice is set for service entry from 2027.

In the hydrogen-electric powertrain game, two of the most advanced players are Germany’s H2Fly, and ZeroAvia. Production aircraft featuring their technology are likely to arrive in the second half of the decade. They believe that using hydrogen fuel cells rather than batteries to power electric motors is attractive because hydrogen offers the prospect of zero-emissions flying and sidesteps the performance limitations of conventional batteries.

Gas power

As ever, the leaders are the ones that have flown an aircraft with the new technology. H2Fly’s origins date back to the first manned flight of a hydrogen-powered aircraft – the tiny Antares in 2009 – and the firm is now on its sixth-generation

hydrogen-electric powertrain, says company founder and chief executive Professor Josef Kallo.

Joby Aviation-backed H2Fly is modifying its twin-boom HY4 demonstrator aircraft, which is currently operated with pressurised gaseous hydrogen, to receive a liquid hydrogen tank. This will double the range of the HY4 and is a critical milestone in its pursuit of longer-range zero-emission flight. Ground-testing of the aircraft will take place in early 2023, with first flight later in the year.

In September, ZeroAvia and Textron Aviation signed a joint development agreement to obtain a STC to retrofit the Grand Caravan with ZeroAvia’s ZA600 hydrogen-electric powertrain. Certification could happen as early as 2025.

Miftakhov says the company has performed full take-off speed and endurance tests with its ZA600 powertrain installed on a Dornier 228 demonstrator, and is anticipating the green light from the UK Civil Aviation Authority to make a first flight within a month.

As the months tick by, the pioneers in this space are making the vital first flights with their aircraft. “At H2Fly we have always been focused on delivering and demonstrating new technology, rather than just talking about it,” Kallo says.

“We are able to say ‘been there, done that,’” says Botti of VoltAero. ▀

Twinjet will have range of 7,500nm, top speed of M0.925 and a roomier cabin than its competitors



Luxury aloft

Due to take flight in 2024, Dassault Aviation's flagship Falcon 10X will combine home comforts with ultra-long-range performance and flight-control technology derived from the Rafale fighter

Dominic Perry London
Cutaway **Tim Hall**

In developing the Falcon 10X, Dassault Aviation had one overarching consideration: what could it bring to the very top of the business jet sector that was unique and desirable?

“We asked what a newcomer would bring to the market,” says Carlos Brana, executive vice-president, civil aircraft at the French airframer.

Range and speed were two prime attributes – in this case 7,500nm (13,900km) and Mach 0.925 – but, says Brana, Dassault then thought “and what else?”

“When we looked at the range of the airplane and the duration of the maximum flight – more than 15 hours – ‘what else’ clearly needed to be more interior space.”

Home comforts

Brana argues that passengers aboard such a flight are not sitting passively for the full duration – they move around the cabin, interacting with each other and their surroundings. Dassault wanted to make the experience as close as possible to enjoying the comfort of one’s home.

In addition, with such long trips, it was vital also to consider the pilots, “so that they could feel rested even after a more than 15-hour flight”.

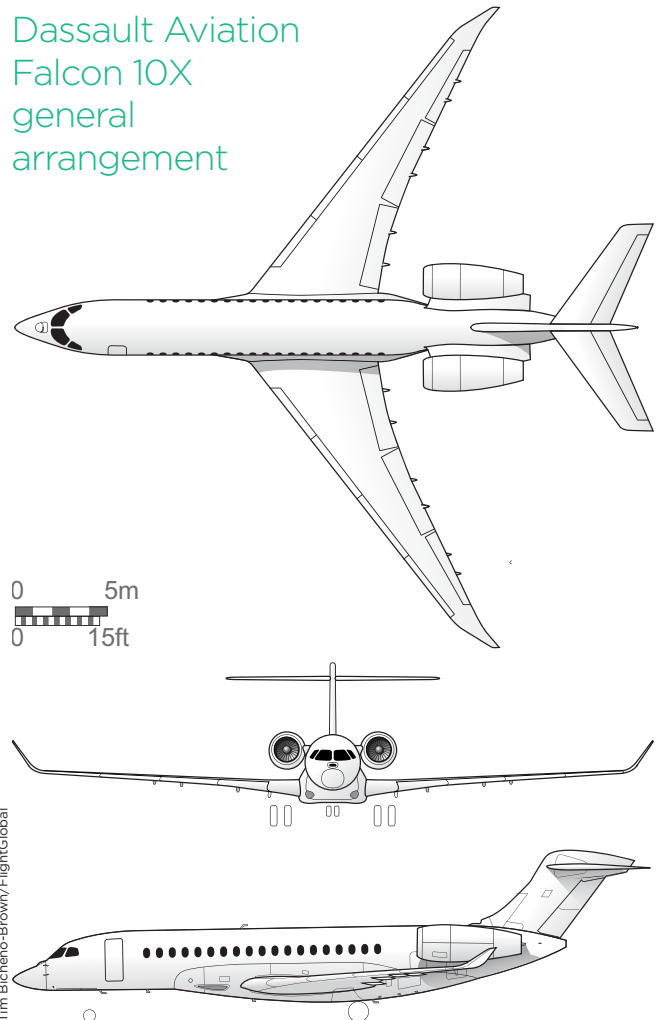
As a result, the cabin, at 2.77m (9.1ft) wide and 2.03m high, is considerably roomier than those of the Falcon 10X’s ultra-long-range rivals, the Bombardier Global 7500/8000, and Gulfstream G700/G800.

It is also larger than the cabin on Dassault’s own Falcon 6X, which at 2.58m wide and 1.98m high is billed by the airframer as an “extra-wide-body” jet.

A roomy fuselage is clearly a benefit to passengers, but only in concert with the other elements delivering comfort. Brana cites low-altitude cabin pressure (3,000ft at a 41,000ft cruising altitude); a uniform diffusion of natural light thanks to 38 cabin windows; ultra-low noise levels owing to next-generation vibration isolators and other tricks of the noise reduction trade; and a smooth ride thanks to a digital flight control system (DFCS) that removes the bumps.

In combination, these are a persuasive mix of attributes for customers, he argues. Additionally,

Dassault Aviation Falcon 10X general arrangement



Tim Bicheno-Brown/FlightGlobal

“The interior possibilities truly differentiate the aircraft. One can have not just a bed, but a full, queen-size bed. Not just a small shower, but a spacious, 6ft 2in shower with an electro-chromatic window and a generous 30-minute supply of hot water. Not just a dining table, but one you can seat yourself at without the indignity of wriggling in and out of the seats. Instead, occupants can separate the seats and easily step in and out.”

Interior designers have great flexibility to create longer lounge spaces or shorter ones – for a cosy entertainment centre, for example. This adaptability goes with the philosophy of creating a homelike environment with personalised spaces, Brana says.

In practice, what that means is rather than having four cabin zones of equal length, they can be customised – say, for a larger state room to suit the owner’s requirements.

Command centre

There are only two places in life where an executive might spend 15h consecutively – their home and their office, Brana notes, adding: “Our aim is a homelike environment that also functions as an airborne command centre for the CEO, where he or she can work in comfort with a core team and communicate over high-speed internet from anywhere in the world.”

The 10X’s cabin can also include one or more optional Falcon Privacy Suites, a recent innovation from Dassault Aviation’s engineering and interior



Type’s all-composite wing is assembled in Biarritz

Dassault Aviation

Dassault Aviation

design teams. Separated from the cabin aisle by an adjustable mid-height partition, the seat is electrically operated and reclines to a full-flat position to create a comfortable 2.03m-long bed. When not fully reclined, the extra seat serves as an ottoman for a second occupant.

Privacy, Brana suggests, is another important ingredient for a restful experience, adding that, even on a large business jet, true privacy is at a premium, especially for sleeping.

“The Falcon Privacy Suite answers a need that has not been addressed previously in business aviation,” he says. “It’s a delightful personal space and a great place to retreat to work on one’s own or rest.”

The art and science of proper rest also extends to the flightdeck. “We put more space in the flightdeck, with the idea that in the future we will be able to certify a rest position where a pilot could recline one of the seats to have a sort of lie-flat bed. One pilot could be flying and the other resting.”

Brana says this feature will not be available at service entry, but that Dassault is working on developing the systems that would enable at least a rest interval for one pilot.

In the here and now, the Falcon 10X’s flightdeck still brims with new technology and innovations. It has the latest generation of DFCS derived from the Rafale

“[The 10X] is all-new and embodies our best thinking on what makes for an exceptional passenger experience”

Carlos Brana Executive vice-president, civil aircraft, Dassault Aviation

fighter and first introduced on Falcon business jets with the 7X in 2005.

The system’s fly-by-wire smart sidesticks feature flightpath stability, removing the need to manually trim the aircraft. A single throttle lever – which Dassault calls the Smart Throttle – controls both engines, with the reverse thrust and airbrake controls also integrated into the lever. This too is technology derived from the twin-engined Rafale and intended to aid pilots in high-workload phases of flight.

The Smart Throttle is linked to the DFCS, which can control the engines – for instance, increasing thrust as necessary as the sidestick is pulled back.

Linking the Smart Throttle to the digital flight controls permits Dassault to introduce an upset recovery function (activated by a single button on the main panel) which will return the jet to straight and level flight. That system, another carry-over from the Rafale, has already been evaluated on the company’s Falcon 7X testbed.

Advanced autothrottle and autopilot modes have been added, such as ‘soft go-around’, emergency descent, reduced take-off thrust, and noise abatement climb.

A simplified digital checklist is incorporated, while enhancements have been made to the head-up display (HUD)-based FalconEye combined vision system, enabling its use as primary instrumentation. Optional dual HUDs will probably lead to approval in the future to land in near zero-zero conditions.

The overhead panel is also slimmed down, with many switches now transferred to touchscreen displays.

The Falcon 10X marks the first use of a Rolls-Royce engine on a Falcon. The Pearl 10X engine is the latest and largest in the Pearl series, delivering more than 18,000lb (80kN) of thrust. New materials and internal aerodynamics make it one of the most efficient engines in business aviation. It also features new self-diagnostics for reduced maintenance.

The Pearl 10X has already logged more than 1,000h of testing, including runs on 100% sustainable aviation fuel.

Pearl progress

In total, R-R will use eight engines for the Pearl 10X test programme: four for ground-based evaluations and another four for flight testing. Those flight tests are set to be conducted in 2023 using the manufacturer’s Boeing 747-200 flying testbed (N787RR) in Tucson, Arizona.

Flight testing should take about six to nine months, as the Pearl 10X benefits from its similarity to the Pearl 700, says Philipp Zeller, head of the Pearl 10X programme. The powerplants share a common architecture and dimensions, including a 132cm (52in)-diameter fan.

However, there are some internal differences, including the application of 3D-printed tiles in the Pearl 10X’s combustion chamber, allowing it to better manage the increased temperatures driven by higher-thrust operations.

Long accustomed to building large and strong composite structures for the Rafale, Dassault elected to build its first all-composite wing for the 10X (the fuselage is aluminium). The carbonfibre wing

Dassault Aviation Falcon 10X specifications

Dimensions

Length	33.4m
Height	8.4m
Wingspan	33.6m
Cabin (L x W x H)*	16.4 x 2.77 x 2.03m

Accommodation

Passengers (maximum)	Not disclosed
----------------------	---------------

Powerplant

Engine (x2)	Rolls-Royce Pearl 10X
Engine thrust (x2)	18,000lb-plus

Performance

Maximum take-off weight	52,163kg
Maximum zero-fuel weight	30,754kg
Range (at Mach 0.85**)	7,500nm
Maximum operating Mach speed	M0.925
Operating ceiling	51,000ft

Source: Dassault Aviation *Excluding baggage compartment **8 passengers, 4 crew



Like the passenger cabin, the cockpit has been designed with comfort in mind

Dassault Aviation



Dassault Aviation



Dassault Aviation



Dassault Aviation

provides ultra-precise aerodynamics and weight reductions, Brana says.

At 33.6m, the wingspan is almost 8m more than on the Falcon 6X. The new wing has a sweep angle that delivers efficiency at the jet's higher cruise speeds of M0.85 and above. It also features retractable high-lift devices, ensuring short-field and steep approach performance.

The first 10X wing, built in a new assembly hall at the airframer's site in Biarritz, southwest France, is now undergoing fatigue and static testing.

Final assembly

Manufacturing of long-lead items for the Falcon 10X is already under way throughout Dassault's network of factories and those of its suppliers. Final assembly will take place during 2023 at the airframer's site in Merignac, near Bordeaux, ahead of a first flight tentatively scheduled in 2024.

A company demonstrator aircraft will be the first production serial unit and should enter service in 2025, before the start of customer deliveries the following year. Brana, as per company policy, declines to reveal the backlog for the jet, but says

"interest is high", with potential customers "seduced by what we are proposing".

"We promoted the airplane as a penthouse in the sky and when you visit the cabin mock-up you really see that," he says.

While its competitors have slightly longer range, at up to 8,000nm, Dassault believes the 10X's combination of range and speed are ideal for the global travel requirements of its customers.

"Range beyond 7,500nm is quite rarely required. Dassault's idea is to provide the most attractive package, including accessibility to smaller airports, fuel efficiency, advanced safety technology and, above all, comfort - where the 10X has no rivals," Brana says.

"It is all-new, embodying the most advanced technology and our best thinking on what makes for an exceptional passenger experience. We are certain many customers will agree." ▶

● This issue should contain a cutaway poster of the Dassault Aviation Falcon 10X. If yours is missing or damaged, please contact flight.international@flightglobal.com

Falcon 10X



Nexus flight deck

Structure and general

- 1 Composite nosecone which opens by rotating upwards
- 2 Machined front-pressure bulkhead - aluminium alloy
- 3 EVS fairing
- 4 Two-piece front windshield with aluminium alloy frame
- 5 Fixed side cockpit windows
- 6 Semi-monocoque aluminium alloy fuselage structure with machined and built up frames for front and centre sections
- 7 Two-crew flightdeck
- 8 Third crew member seat
- 9 Main entrance door and steps
- 10 Interior operating lever
- 11 Folding handrail
- 12 Cabin windows
- 13 Forward lavatories
- 14 Forward closet
- 15 Ovens
- 16 Passenger seats - two forward facing and two aft facing
- 17 Console fold-down tables - 4. Three shown in opened position
- 18 Galley
- 19 Cabin side panels
- 20 Lighting controls
- 21 Side ledges with cupholders
- 22 Type three escape exit
- 23 Cushion
- 24 Crew rest foldable one-place divan
- 25 Electrically actuated dining/conference table
- 26 Orenduz
- 27 Double passenger seats
- 28 Two-place divan
- 29 Three-place divan
- 30 Cabin dividers
- 31 Toilet
- 32 Washroom
- 33 Vanity unit
- 34 Credenza in bedroom
- 35 Bed
- 36 Closet on right hand side

- 37 Closet on left hand side
- 38 Baggage compartment door to pressurised air conditioned baggage compartment
- 39 Machined rear-pressure bulkhead - aluminium alloy
- 40 Pylon - aluminium alloy
- 41 Wing to fuselage body fairing - composite
- 42 Landing light casing
- 43 Fin-box structure - aluminium alloy and composite ribs. With composite skin
- 44 Fin leading-edge - two composite panels
- 45 Attachment and pivot point for horizontal tailplane
- 46 Fintip fairing skin - composite
- 47 Spring-loaded fairing - composite
- 48 Fintip fairing structure - composite
- 49 Aft fuselage to fin attachment points
- 50 Semi-monocoque aluminium alloy fuselage structure with machined and built up frames for aft section
- 51 Tailplane outer box - composite
- 52 Tailplane tip - composite
- 53 Tailplane leading-edge - composite
- 54 Elevators - composite
- 55 "Piano" wing-to-fuselage bolt attachment (multi-bolt) to centre-wing box structure
- 56 Centrewing box structure - aluminium alloy construction
- 57 Composite and aluminium wing ribs
- 58 Front spars - composite and machined titanium
- 59 Rear spars - composite and machined titanium
- 60 Upper-surface composite skin panels
- 61 Lower-surface composite skin panels
- 62 Blended winglet - composite with metallic leading edge
- 63 Firewall - composite
- 64 Tailcone structure - composite

- Air conditioning**
- A1 Heat-exchanger air scoop
 - A2 Outlet duct for air bleed supply for ECS
 - A3 ECS pack
 - A4 Hot air supply from engine
 - A5 Air supply from APU
 - A6 Warm air duct for feet
 - A7 Air conditioning duct
 - A8 Mixer duct
 - A9 Wing anti-icing ducting
 - A10 Slat piccolo tubes
 - A11 Telescopic supply ducts from anti-icing hot air ducts to piccolo tubes
 - A12 Conditioned air for cockpit
 - A13 Outlet vents on glareshield for cockpit window demist
 - A14 Cabin air distribution duct

- Electrics and electronics**
- C1 Sidestick
 - C2 Rudder pedals
 - C3 Inboard leading-edge slat - aluminium alloy
 - C4 Slat tracks
 - C5 Slat actuators
 - C6 Mid leading-edge slats - aluminium alloy
 - C7 Outer leading-edge slat - aluminium alloy
 - C8 Ailerons - composite
 - C9 Three spoilers on each wing - composite
 - C10 Outboard flap - composite
 - C11 Inboard flap - composite
 - C12 Spoiler actuators
 - C13 Aileron servo-actuator unit
 - C14 Outboard flap electro-mechanical actuators
 - C15 Flap tracks
 - C16 Outboard flap electro-mechanical actuators

- Flight track fairings**
- C17 Flight track fairings
 - C18 Rudder servo-actuator unit
 - C19 Elevator servo-actuator unit
 - C20 Horizontal tailplane trim actuator
 - C21 Rudder - composite

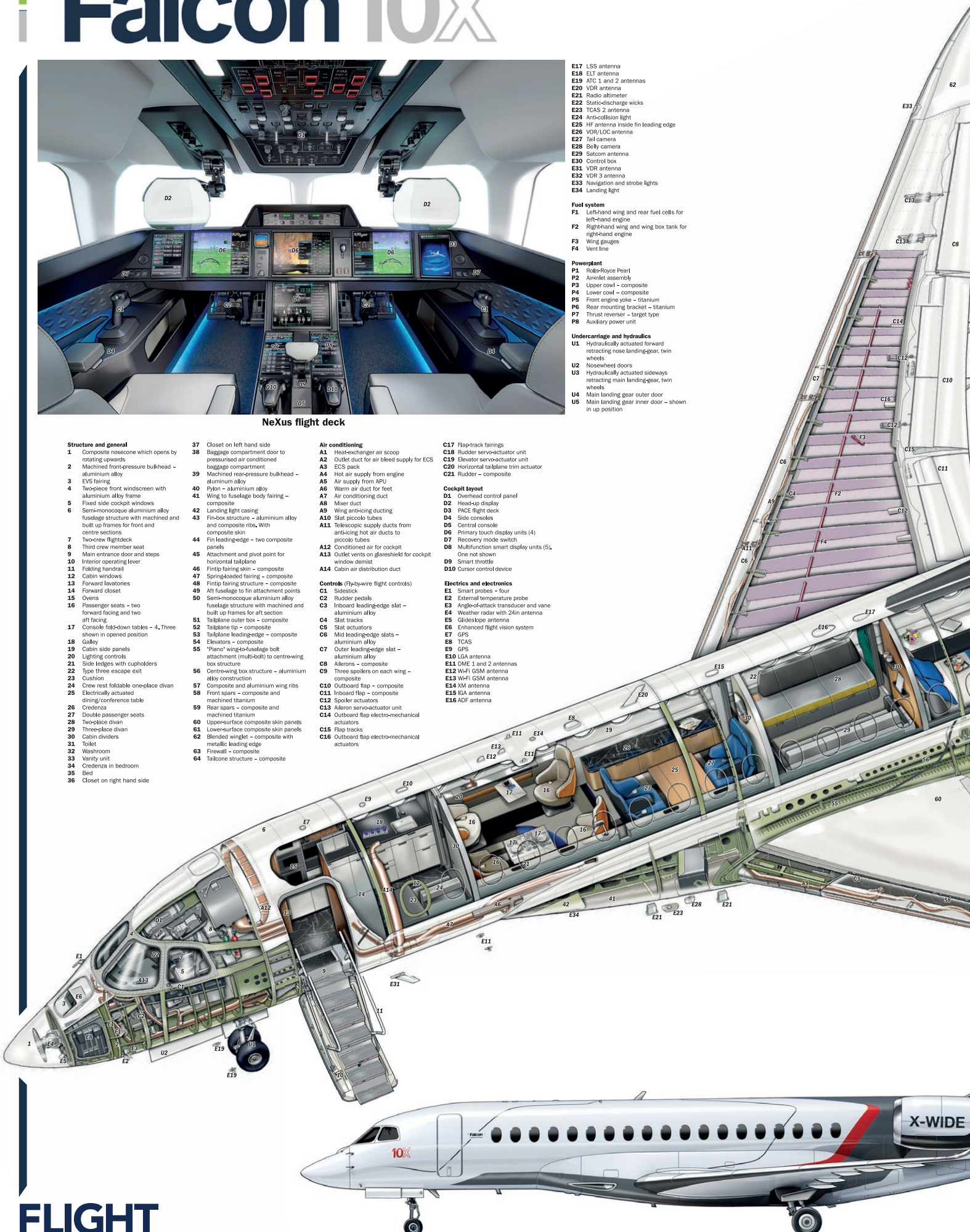
- Cockpit layout**
- D1 Overhead control panel
 - D2 Head-up display
 - D3 PACE flight deck
 - D4 Side console
 - D5 Central console
 - D6 Primary touch display units (4)
 - D7 Recovery mode switch
 - D8 Multifunction smart display units (5). One not shown
 - D9 Smart throttle
 - D10 Cursor control device

- E17 LSS antenna
- E18 ELT antenna
- E19 ATC 1 and 2 antennas
- E20 VDR antenna
- E21 Radio altimeter
- E22 Static-discharge wicks
- E23 TCAS 2 antenna
- E24 Anti-collision light
- E25 IIF antenna inside fin leading edge
- E26 VDR/LOC antenna
- E27 Tail camera
- E28 Belly camera
- E29 Satcom antenna
- E30 Control box
- E31 VDR antenna
- E32 VDR 3 antenna
- E33 Navigation and strobe lights
- E34 Landing light

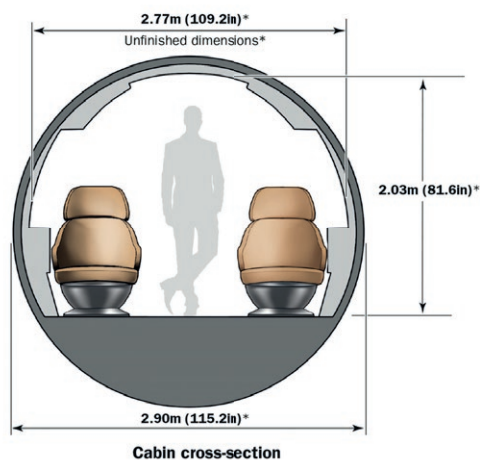
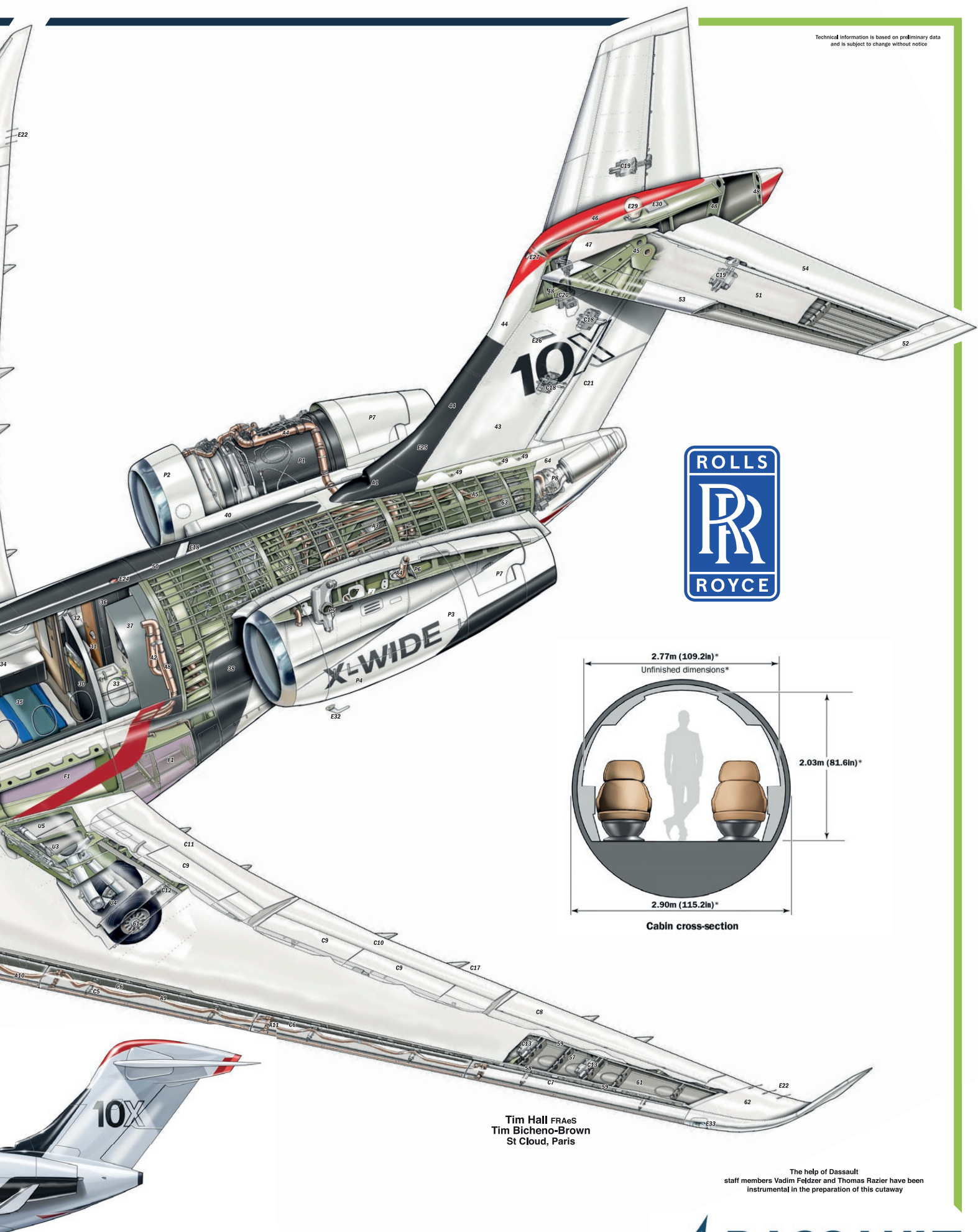
- Fuel system**
- F1 Left-hand wing and rear fuel cells for left-hand engine
 - F2 Right-hand wing and wing box tank for right-hand engine
 - F3 Wing gauges
 - F4 Vent line

- Powerplant**
- P1 Rolls-Royce Pearl
 - P2 Air-inlet assembly
 - P3 Upper cowl - composite
 - P4 Lower cowl - composite
 - P5 Front engine yoke - titanium
 - P6 Rear mounting bracket - titanium
 - P7 Thrust reverser - target type
 - P8 Auxiliary power unit

- Undercarriage and hydraulics**
- U1 Hydraulically actuated forward retracting nose landing-gear, twin wheels
 - U2 Nosewheel doors
 - U3 Hydraulically actuated sideways retracting main landing-gear, twin wheels
 - U4 Main landing gear outer door
 - U5 Main landing gear inner door - shown in up position



Technical information is based on preliminary data and is subject to change without notice



Tim Hall FRAeS
Tim Bicheno-Brown
St Cloud, Paris

The help of Dassault staff members Vadim Feldzer and Thomas Razier have been instrumental in the preparation of this cutaway



Time machine

Developer Archer Aviation is to build a manufacturing plant for its Midnight electric vertical take-off and landing aircraft in Covington, near Atlanta (see p34). In other words, it is taking the Midnight plane to Georgia.

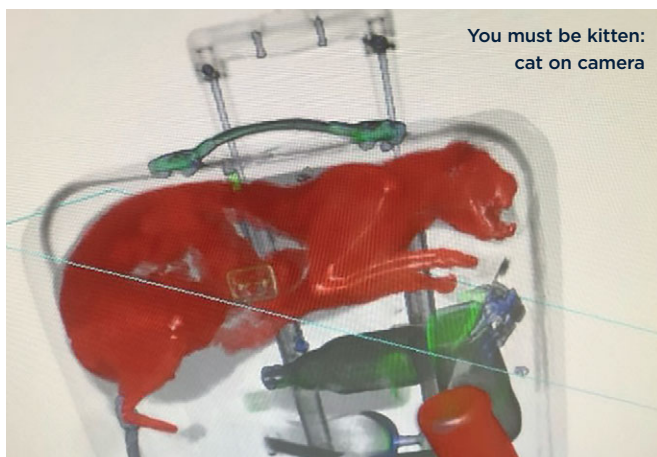
Near cat-astrophe

Airport security staff were feline shocked when an X-ray of a passenger's luggage showed a live cat inside.

An officer at New York's JFK opened the bag to find the furry stowaway after the owner of the suitcase had checked in, bound for Orlando. The passenger explained the moggy belonged to another member of his household and got into the baggage undetected.

The Transport Security Administration, which released the images, tweeted: "On the bright side, the cat's out of the bag and safely back home."

The passenger, on the other hand, missed his flight by a whisker and had to rebook for the next day.



TSA



Emirates shuns Weiss advice

Sponsoring football clubs does not provide value for money for airlines, which is why Virgin Atlantic will not do it, its chief executive Shai Weiss remarked to Aviation Club luncheon guests the other week.

Fortunately perhaps for Weiss, it is wisdom a prominent competitor chooses to ignore. The former banker and tank commander is a season ticket holder at the Emirates Stadium in London, and the Dubai carrier's generosity has helped keep his beloved Arsenal at the top of the English Premier League for much of the season.

From the archive

100

1923 America accelerates

To those who follow at all closely the progress in aviation, there have been enormous steps made recently by the United States in the matter of sporting aviation. Although America was the country which gave flying to the world, it was nevertheless the fact that never, after other countries commenced to take up aviation, did America approach again to the leading position which the work of the brothers Wright should have given her. But then America decided to hold her Pulitzer race, and at once several very fast machines were produced. In last year's Pulitzer a number of machines were entered by the Navy and Army air services, and what has been the immediate result? All the world's speed records have passed to the United States.

75

1948 Autogiro's attractions

Tomorrow, January 9th, is the 25th anniversary of the first successful flight made by Senor Juan de la Cierva in the type of aircraft which later became familiar as the Autogiro. It is thus fitting that we should pay a tribute to the man who laid the foundations for all subsequent rotary-wing development, including the modern helicopter, and whose perseverance, in spite of all obstacles, led him so far along the road to complete success before his untimely death in an airline accident near Croydon in December, 1936. There are many, and we count ourselves among them, who regret that the Autogiro principle was abandoned after it had been developed so far. The simplicity compared with the helicopter was very attractive, and the machine did nearly all that the helicopter can do.



One of the few:
the new Airfix
Spitfire kit

Return of a super model

"For the first time since WWII, thousands of Spitfires are to be mass-produced in the UK."

Full marks to the long-established model kit manufacturer Airfix for the arresting press release headline, which accompanies the news that the production of one of its kits – of a particularly iconic aircraft – is returning to the British Isles to mark the firm's 70th anniversary.

The one-time household brand off-shored production in the mid-1990s, and has been manufacturing its kits in China, India and France.

But the company says that with the launch of its latest Supermarine Spitfire Mk.IXc kit, it has taken the decision to "move the production of such a British icon back to the UK".

Airfix aficionados will be interested to know that the 433-part kit results in a 1:24 scale model.

Mushroom for improvement

CTT, which makes humidity controls for premium airline cabins, has come up with a novel way of convincing sceptics of dehydration's effect on the human body – mushrooms.

One of the firm's managers bought a fresh mushroom in Copenhagen ahead of boarding a business-class flight to Chicago (the airline was presumably not a CTT customer), posting before and after images of the fungus, noting it had "shrunk in size", and "developed wrinkles" and "a hard skin" after the 8h journey.

That'll be the DAA

Kenny Jacobs, the new head of the DAA – the operator of Dublin and Cork airports – may be looking back anxiously at statements issued in his name during the six years he spent as Ryanair marketing head between 2014 and 2020.

The Dublin-based low-cost carrier has long had a fractious relationship with its home airport, particularly over the charges it imposes on operators, and has never held back when it comes to expressing its frank opinions.

Last summer, Ryanair accused the DAA of "incompetence" and having caused Ireland international embarrassment after staff shortages led to lengthy queues and flight disruption.

1973 B-52s over Vietnam

Following a breakdown in the Vietnam peace talks the Americans resumed bombing above the 20th parallel, which runs 70 miles (112km) south of Hanoi, on December 18. For the first time B-52s have been used to hit heavily defended targets in and around Hanoi and the port of Haiphong, and the intensity of the air war has overshadowed the continuing ground war in the South. The raids on the cities of North Vietnam have been the heaviest of the war with up to 100 B-52s being involved each day in raids on Hanoi. The heavy bombers are believed to fly in formation above 30,000ft and each delivers 30 tons of 500lb high-explosive bombs. The 18,000 tons of bombs dropped in the week before Christmas brought the total since April to 500,000 tons.

1998 Bird flu strikes Cathay

Cathay Pacific Airways plans to begin laying off about 800 of its ground staff towards the end of this month, as the airline's fortunes continue to nose dive and the Hong Kong-based carrier faces the possibility of recording a first half loss in 1998. The planned 800 redundancies will affect ground staff across the airline's network, including those at the level of senior general manager and downward. The cuts are in addition to those made in 1997. It is understood that further retrenchments are in the pipeline, as the airline's problems continue to worsen. A recent outbreak of fatal "bird-flu" influenza in Hong Kong has served partially to undermine Cathay's recent two-for-one fare discount, which boosted bookings by 80,000 passengers.

Aircraft Interiors | EXPO®

6 - 8 JUNE 2023
HAMBURG, GERMANY

WHERE CABIN CONCEPTS TAKE OFF

Join us in Hamburg
from June 6 - 8, 2023.

Aircraft Interiors Expo is
the definitive marketplace
where everyone involved in
developing cabin interiors
needs to be.



Co-located with:

World Travel Catering
& Onboard Services
EXPO | 14 - 16 JUNE 2022
HAMBURG, GERMANY

Passenger
Experience
CONFERENCE | 13 - 15 JUNE 2022
HAMBURG, GERMANY

Organised by:

RX In the business of
building businesses

In co-operation with:

H Hamburg
Messe + Congress

Visit us at: aircraftinteriorexpo.com/Flnt



Engines of recovery: the A380 is increasingly returning to service

Big is beautiful

For some time, I have been watching the planes coming in from the east towards Heathrow, and it has reminded me of the fashion a few years ago to talk about the demise of the Airbus A380. I never believed it then, but what a difference now!

People flying now seemingly have had a change of heart: they do not want to be carried in a long tube with only two engines for hours and hours. Suddenly, the fashionable new way to travel is in a four-engined plane offering more space, more toilets and – for those living under the flightpath – less noise.

Since the pandemic lockdown, seasoned travellers are thinking a little more carefully about their comfort and amenities on long-haul flights, and the high proportion of A380s now back in the air shows that their preferences are being catered for with this oft-criticised airliner.

Additionally, having a choice, most thinking people will choose a four-engined plane for safety's sake: a one-engine failure will be a loss of 25% power, not 50%, which is quite a difference.

As a mere observer from the ground, I am very pleased with the lack of screaming noise and can enjoy the aesthetic pleasure of watching a beautiful, bird-like shape passing overhead so often.

I say well done to the Middle Eastern countries who started off this recent surge in restoring use of the beautiful A380.

WD Barbut
London, UK

Editor's reply: The A380's increasing reintroduction to service by the type's operator airlines is indeed to be welcomed, but with just 130 of the superjumbos in current use (according to Cirium fleets data) this is more likely to be as a result of financial and scheduling practicality than a shift in broader airline industry fashion.

A design H2 far?

One can only be sceptical about H2 Clipper's rather ambitious plans to haul frozen hydrogen around with its airship (*Flight International*, November 2022).

It is also quite a good thing – at least in my opinion – that the flights will be cargo only, and preferably with artificial intelligence, and not any humans, at the controls.

Using gaseous hydrogen for lift unfortunately evokes graphic memories of the *Hindenburg* disaster – one of those aerial conflagrations is enough.

Chris Skillern
San Diego, California, USA



Rising ambition: H2 Clipper plans a return to hydrogen lift

We welcome your letters about the coverage in *Flight International* and online at FlightGlobal.com – or about any other aerospace-related topic. Letters should be no longer than 500 words in length, and supplied with the correspondent's name and location. They may also be featured anonymously, on request. Please email flight.international@flightglobal.com or write to: The Editor, Flight International, 1st Floor, Chancery House, St Nicholas Way, Sutton, Surrey, SM1 1JB. Letters may also be published on FlightGlobal.com, and do not necessarily represent the views of the editor.

EDITORIAL

1st Floor, Chancery House, St Nicholas Way,
Sutton, Surrey, SM1 1JB, UK
flight.international@flightglobal.com

Editor Craig Hoyle
+44 7795 486691
craig.hoyle@flightglobal.com

Deputy Editor Dominic Perry
+44 20 8912 2164
dominic.perry@flightglobal.com

Head of Strategic Content
Murdo Morrison FRAeS
+44 20 8722 8389
murdo.morrison@flightglobal.com

Consulting Editor David Learmount
+44 7785 901787
david.learmount@ntlworld.com

Contributing Editor Mark Pilling
markpilling55@gmail.com

Magazine Enquiries
flight.international@flightglobal.com

AIR TRANSPORT TEAM

Executive Editor Graham Dunn
graham.dunn@flightglobal.com

Editor – Airline Business Lewis Harper
lewis.harper@flightglobal.com

Air Transport Editor David Kaminski-Morrow
david.kaminski-morrow@flightglobal.com

AMERICAS

Americas Managing Editor
Jon Hemmerdinger
+1 617 397 2809
jon.hemmerdinger@flightglobal.com

Americas Air Transport Editor
Pilar Wolfsteller
+1 510 634 3496
pilar.wolfsteller@flightglobal.com

Americas Defence Reporter Ryan Finnerty
+1 802 373 5720
ryan.finnerty@flightglobal.com

Americas Aviation Reporter Howard Hardee
+1 530 354 5365
howard.hardee@flightglobal.com

ASIA/PACIFIC

Asia Editor Greg Waldron
+65 9489 4153
greg.waldron@flightglobal.com

Reporter Alfred Chua
+65 9643 4228
alfred.chua@flightglobal.com

FLIGHTGLOBAL.COM

Online Content Manager Amber Elias
+44 7816 991648
amber.elias@flightglobal.com

EDITORIAL PRODUCTION

Group Production Manager Isabel Burton
Art Editor Tim Noonan
Layout Copy Editor Tim Norman
Consulting Technical Artist Tim Hall

DISPLAY ADVERTISEMENT SALES

1st Floor, Chancery House, St Nicholas Way,
Sutton, Surrey, SM1 1JB, UK

EUROPE

Sales Manager
Katie Mann
+44 7792 152097
katie.mann@flightglobal.com

Key Account Manager Grace Murphy
+44 20 8092 4080
grace.murphy@flightglobal.com

Sales Support Gillian Cumming
+44 20 8092 4082

NORTH & SOUTH AMERICA

Sales Director, USA & Canada
Brett Ryden +1 630 450 1164
brett.ryden@flightglobal.com

Sales Director, USA
Susan Joyce +1 303 641 5505
susan.joyce@flightglobal.com

ITALY

Sales Manager Riccardo Laureri
+39 (02) 236 2500
media@laureriassociates.it
Laureri Associates SRL, Via Alessandro
Volta, 40, 22100 Como, Italy

ISRAEL

Sales Executive Asa Talbar
+972 77 562 1900
Fax: +972 77 562 1903 talbar@talbar.co.il
Talbar Media, 41 HaGiva'a St, PO Box 3184,
Givat Ada 37808, Israel

RECRUITMENT

Business Development Manager
Nick Lee
+44 7786 851880
nick.lee@flightglobal.com

Commercial Director – Jobs
Louise Rees
+44 20 3957 4566
louise.rees@personneltoday.com

ADVERTISEMENT PRODUCTION

Production Manager Sean Behan
+44 20 8092 4078

PUBLISHING MANAGEMENT

Managing Director Andy Salter
Divisional Director Sophie Wild
+44 7715 364765
sophie.wild@flightglobal.com

SUBSCRIPTIONS

Flight International Subscriptions,
Abacus, 107-111 Fleet Street,
London, EC4A 2AB

Account Manager – Corporate Subscriptions

Joseph Henrit
+44 7503 644895
joseph.henrit@flightglobal.com

Subscription Enquiries

If you have any subscription queries,
please contact customer service:
+44 20 8955 7034
FlightGlobal@abacusemedia.zendesk.com

To purchase a FlightGlobal Premium
subscription, visit FlightGlobal.com/
subscribe

Print & Digital Subscription Rates

(best rates are quoted)

1 year: £220/€235.60/\$310
2 years: £465/€498.91/\$655
3 years: £620/€655.21/\$870
Quarterly: £60/€62.36/\$83

Digital Subscription Rates

(best rates are quoted)

1 year: £195/€211.96/\$280
2 years: £410/€448.85/\$585
3 years: £545/€598.47/\$785

Only paid subscriptions available.
Cheques payable to Flight International

Flight International is one of FlightGlobal's (publishing, events and FlightJobs) products and services.

Flight International welcomes unsolicited
contributions from readers but cannot
guarantee to return photographs safely.

© and Database Rights 2023 DVV Media
International Ltd. All rights reserved.
No part of this publication may be
reproduced, stored in a retrieval system or
transmitted in any form or by any means,
electronic, mechanical, photocopying,
recording or otherwise, without the prior
permission in writing of the publishers.

Registered at the Post Office as a newspaper
Published by DVV Media International Ltd,
1st Floor, Chancery House, St Nicholas Way,
Sutton, Surrey, SM1 1JB, UK.

Newstrade distributed by Marketforce (UK),
2nd Floor, 5 Churchill Place, Canary Wharf,
London, E14 5HU, UK. Tel: +44 20 3787 9001

Classified advertising prepress by CCM.
Printed in Great Britain by William Gibbons
and Sons

Flight International published monthly 12
issues a year.

This periodical is sold subject to the
following conditions: namely that it is not,
without the written consent of the publishers
first given, lent, re-sold, hired out or in any
unauthorised cover by way of trade, or
affixed to, or as part of, any publication
of advertising, literary or pictorial matter
whatsoever. No part of the content may
be stored electronically, or reproduced or
transmitted in any form without the written
permission of the Publisher.

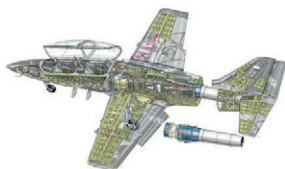
ISSN 0015-3710 (Print)
ISSN 2059-3864 (Online)



DVV Media International



When you have finished with
this magazine please recycle it.



Check out Flight International's Image Store

Browse or customise a gift or memento from our **CUTAWAY ARCHIVE**
of more than 1000 aircraft drawings

www.flightglobalimages.com



FlightGlobal

Equipment, maintenance and service

mt-propeller

FLY GREEN - FLY MT *Development & Production*



Piper PA-31T () with 5-blade MTV-27

Airport Straubing-Wallmuehle, EDMS
94348 Atting / Germany
Phone: +49(0)9429-9409-0
Fax: +49(0)9429-8432
sales@mt-propeller.com
www.mt-propeller.com

of high performance
2-blade to 7-blade
hydraulically controlled
variable pitch propeller
and
2-blade to 4-blade
electrically controlled
variable pitch propeller.

Sales & Service for
products made by
McCauley,
Hartzell,
Sensenich,
Woodward,
Goodrich.



FlightJobs

Take your career
to new levels

Register your CV and start your job search today

Start your journey today
Register at Jobs.flightglobal.com/register

[@flightjob](https://twitter.com/flightjob)
[@flightglobaljobs](https://www.facebook.com/flightglobaljobs)
[in FlightJobs](https://www.linkedin.com/company/flightjobs)

Training



We are pleased to announce that our Airbus A320 has now been Qualified by the UK CAA as an FSTD (Generic Multi-Engine Turbine Aeroplane – representative of A320-200 MTOW 77000kg) to FNPTII (APS-MCC) Standard. Available for hire by ATO's and professional pilots.

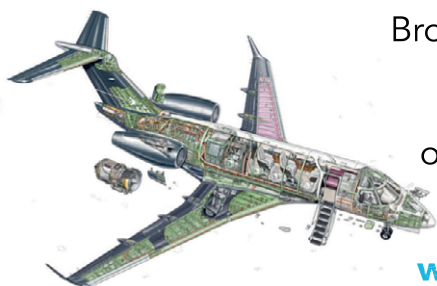
e: sales@deesideflighttraining.co.uk
t: 0151 348 8926



Unit 18, FlexSpace Business Park,
North Road,
Ellesmere Port,
Cheshire,
CH65 1AE
UK



Check out Flight International's Image Store



Browse or customise a gift or memento
from our
CUTAWAY ARCHIVE
of more than 1000 aircraft drawings

www.flightglobalimages.com



Hooked on aviation since her pre-teen years, **Shivani Kulkarni** has progressed from flying Indian air force An-32 turboprops to A320neos for the nation's most popular domestic carrier

From Antonovs to IndiGo

Greg Waldron Singapore

IndiGo captain Shivani Kulkarni loves the automation in the Airbus A320's cockpit, but it was flying Antonov An-32s for the Indian air force that made her the pilot she is today.

Speaking to FlightGlobal from Bengaluru, Kulkarni recounts her girlhood in Nagpur, a city with a large military presence. She remembers asking a retired air force officer giving a talk about his career when she was 11 or 12 what it would take to become a military pilot.

The answer was to focus on maths and physics, deemed essential knowledge for those with a dream of flying.

"I completely oriented myself on this, and I was completely crazy about joining aviation," she says. After finishing university, she joined the Indian air force as a cadet.

During training she flew the Hindustan Aeronautics HPT-32 Deepak and HJT-16 Kiran jet trainer. Flying solo at a young age afforded the opportunity to perform loops, spins and rolls, which Kulkarni feels was crucial for building her confidence as a pilot.

Following this stage of training pilots can go on to fly fighters, transports or helicopters, but because the fighter option was closed to women at that time in India, Kulkarni went for transports.

"Of course, I was attracted to planes and that's how I flew An-32s," she says.

She feels that flying the An-32 gave her a tremendous feel for piloting aircraft, as the type lacked modern features such as an automatic throttle and automatic brakes.

"With those two huge turboprop engines, you could just take off and land at any short airfield," she says. "I'm very, very fortunate to have done those kinds of basic things."

Family matters

Between her time on An-32s and joining IndiGo, Kulkarni spent five years flying Embraer Phenom 100 business jets for a local operator. As a single mother with two young daughters, this role gave her more flexibility to spend time at home than if she had gone straight into an airliner cockpit.

The Phenom 100 also afforded Kulkarni's first experience with a modern flightdeck. "The Embraer was a beautiful aircraft with a beautiful cockpit, with three big screens," she says.

Moving from the An-32 to a small jet was not a huge leap, she notes, given her previous experience in the HJT-16.

Once her daughters were a bit older, Kulkarni joined IndiGo. She says she was attracted to the company's professional way of doing business.

"I was more than happy to get into IndiGo... at the time I joined about seven years back, it was the most disciplined airline and very by the book. They just don't randomly go from here to there."

Indeed, IndiGo is India's top carrier, with more than 50% of the country's domestic market share. Cirium fleets data indicates that it has a fleet of 292 aircraft, the vast majority of which are A320-family jets. But with orders for 505 A320neo-family single-aisles, it is poised to keep growing.

An-32's lack of modern features gave Kulkarni her feel for flying



Joe Raw/Shutterstock



Kulkarni says commercial aviation is more 'welcoming' to aspiring pilots

“The machine doesn't know whether it's a man or a woman flying it. It's your skill and experience and how passionately you do it”

IndiGo

Asked to compare the turboprop-powered An-32 with the modern A320 and A320neo that dominate IndiGo's fleet, Kulkarni says there is a world of difference. Still, as a pilot there are always common threads.

One thing she always reminds younger pilots is that it is critical to keep an eye out of the cockpit. Even if the autopilot is counting down the altitude during a landing, pilots need to look outside and judge things for themselves.

As for her favourite airfield in India, Kulkarni says she views them all pretty much equally, and says each take-off and landing presents its own challenges.

She recounts a departure from the northeastern city of Patna. Hemmed in on all sides by houses, Patna airport's apron is cramped and its single runway lacks a parallel taxiway, with only two linkways to the apron.

Her A320 was fully loaded, and owing to bad weather at Bengaluru, the jet was also carrying extra fuel. To take off into the wind, Kulkarni requested the reciprocal runway to the one that been assigned. This, however, would require another aircraft to backtrack. The other pilot questioned air traffic control, but ultimately Kulkarni explained the problem.

“I think it is at the pilot's discretion what the safest and best option is,” she says. “I literally had to explain very politely that there were some challenges.”

Kulkarni, who had a female co-pilot during that flight, indicates that her request may have been questioned because the pilot in the other aircraft heard a woman's voice over the radio.

On the advice she gives to aspiring pilots, Kulkarni says that commercial aviation is probably a more “welcoming” environment than the military.

“In India, civil aviation had female captains and first officers even before the defence services,” she says.

Career choice

She also tells young women that being an airline pilot is a well-respected, well-paid career choice.

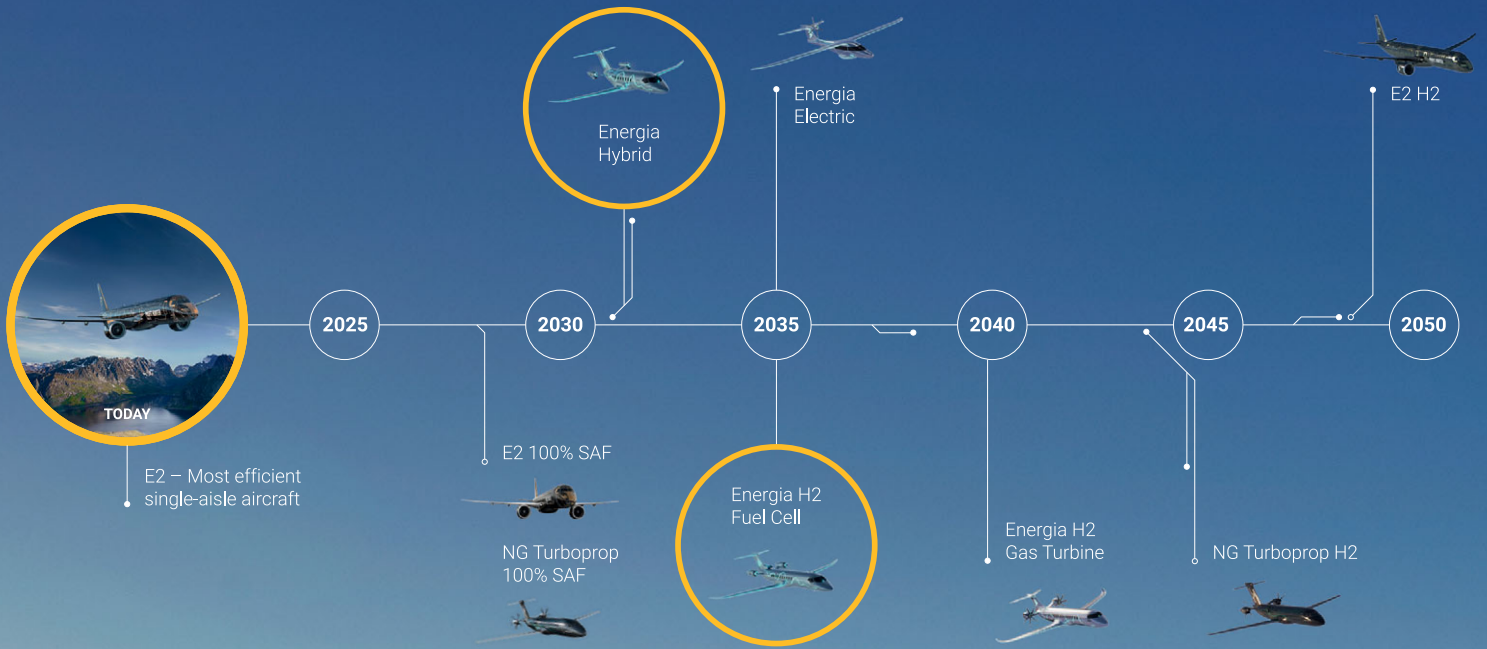
“As for a girl's parents, they should know that she is in a safe environment,” adds Kulkarni. “There is a very well-respected person sitting next to her, everything is monitored, everything is documented, everything is observed.”

For those who are wary about joining the industry given the periodic shocks, such as during the coronavirus pandemic, Kulkarni observes that people will always return to flying, and that India is a fast-growing market.

And she notes: “The machine doesn't know whether it's a man or a woman flying it. It's your skill and your experience and how passionately you do it.” ▶

SUBSCRIBE TO FLIGHTGLOBAL
PREMIUM AND SAVE UP TO 15%

Subscribe today at www.FlightGlobal.com/subscribe



SUSTAINABILITY IN ACTION.

Net zero carbon emissions by 2050. Making regional aviation cleaner and quieter. Our sustainability roadmap and product development plan have been constructed to help us achieve these goals. Our new generation E2 is the most fuel efficient single-aisle aircraft in the market today with a potential reduction of CO2 emissions up to 30%. In 2025 we are planning the first flight of our hydrogen-powered electric demonstrator.

mid-2030s we are planning to introduce the sustainable Energia family of aircraft, powered by revolutionary propulsion architectures. 2045 will likely see the flight of our first hydrogen-powered turboprop and finally, in 2050, a hydrogen-powered E2 or similar sized aircraft will take to the skies.

Between 2027 and 2030 expect to see our next generation turboprop and E2 flying 100% SAF compatible. By the

Undoubtedly these are bold and ambitious steps, but with over 50 years of market knowledge and expertise behind us, we are confident that we will deliver what we set out to do, transforming the way we all fly.