

Issue

1

Monday
19 June 2023

FLIGHT DAILY NEWS



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Hybrid hero

VoltAero takes wraps off Cassio flight-test prototype as sustainability takes centre stage



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"Every take-off and landing is electric. That makes it a very low-noise aircraft that can do many

operations, not only carrying people, but it can take medical evacuations, it can transport cargo, and it can do it 24/7," he adds.

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VoltAero's hybrid-electric module combines the Kawasaki thermal engine, Safran Engineus 100 electric motor and a gearbox from French transmission specialist Akira. Batteries are supplied by US firm Electric Power Systems.



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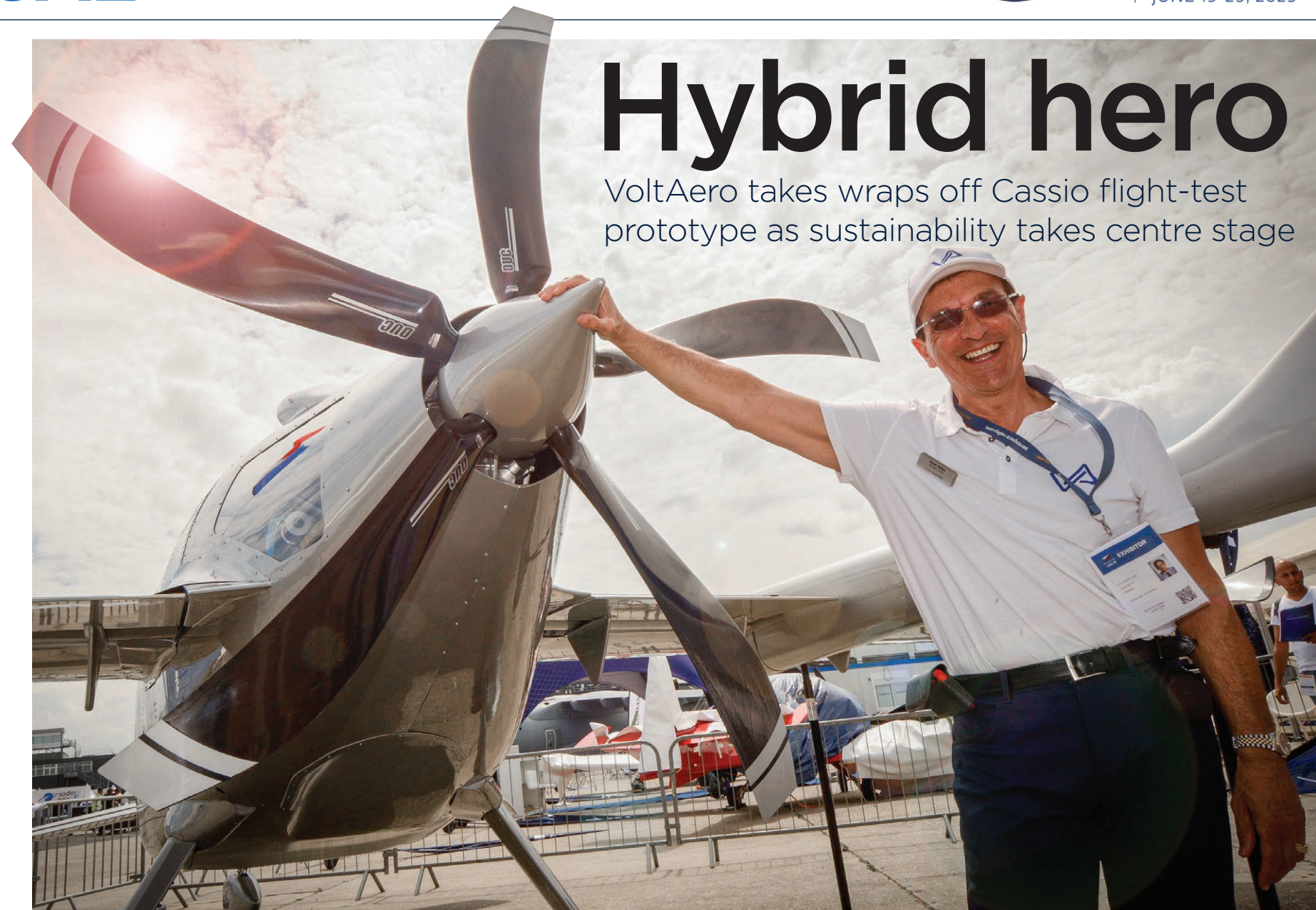
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Hybrid hero

VoltAero takes wraps off Cassio flight-test prototype as sustainability takes centre stage

Pilar Wolfsteller

As the air show returns after a four-year gap, the post-Covid industry is a changed place with sustainability now to the fore.

Attendees this week can expect a flurry of announcements on carbon-cutting technologies as aviation tries to convince the wider world of its green credentials.

First out the blocks was French

hybrid-electric aircraft developer VoltAero which yesterday unveiled at Le Bourget the initial flight-test prototype of its Cassio 330 five-seater.

VoltAero is now gearing up for the aircraft's maiden flight - expected to take place in the coming months - where it will be powered solely by its Kawasaki Motors 150kW (201hp) thermal engine.

That milestone will be the first step in the Cassio 330's certification journey, says chief executive Jean

Botti (pictured). Later, the company will replace the engine with a full hybrid-electric powertrain.

Contributing to the overall environmental performance, including noise, is a bespoke propeller design from Duc Helices. "This propeller is being developed specifically for us very, to travel at low speed, very high torque, no noise," says Botti.

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Raytheon's power play

Raytheon Technologies' ambitions to advance hybrid-electric flight have taken a significant step with the completion of a rated power test of a 1MW electric motor-generator developed by its Collins Aerospace arm.

The motor will subsequently be combined with a Pratt & Whitney Canada thermal engine to form the core of a new hybrid-electric propulsion system which will next year fly on a modified De Havilland Canada Dash 8-100.

Collins says the new electric motor will deliver four times the power and twice the voltage, with half the heat loss and half the weight, than its current best-performing units.

Collins is developing the motor in Solihull, UK, with testing taking place at the University of Nottingham's Institute for Aerospace Technology.

Eric Cunningham, vice-president electric power systems at Collins, says the design is scalable to cover a broad range of power classes, despite the test unit's 1MW rating.

"It's much easier to scale down than to scale up, and convince the world that you can make a 200kW motor after you have already demonstrated a 1MW motor," he says.

Completion of the rated power test means the motor has delivered the stated 1MW output in laboratory conditions.

The propulsion system and batteries will later be integrated on the Dash 8-100 aircraft, replacing one of its two PW120 turboprop engines, with flight testing targeted to begin in 2024.

RISE lifted by test campaign

First parts now being made for next-generation narrowbody engine as CFM keeps open-rotor demonstrator on track for mid-decade first flight

Dominic Perry

CFM International has begun manufacturing parts for its first RISE open-fan demonstrator as it ramps up component testing for the new powerplant.

Detailing progress on 17 June in Paris, Mohamed Ali, vice-president of engineering for GE Aerospace – a partner in CFM alongside Safran – said the RISE was moving from a "paper engine into real parts and real tests".

Behind its large composite fan – roughly the size of the 134in (340cm) fan on the GE9X – sits an ultra-compact core, smaller than that seen on small business jet engines, says Ali.

GE has designed, with the support of NASA, new turbine airfoils, nozzles and blades using supercomputing technology which yielded "fascinating results in terms of fuel-burn improvements, as well as durability" which were then validated through rig tests.

Components, notably the airfoils, have benefited from CFM's expertise in additive manufacturing and ceramic matrix composites. "They are already manufactured and made and as we speak today they are going through engine testing," says Ali.



Tests of high-pressure turbine components are taking place using F110 donor engine

Tests of the high-pressure turbine parts using a modified GE F110 military engine recently began at the company's Evendale facility in the USA.

Additional evaluations of low-pressure turbine blades, including static, vibration and impact tests – are under way at Safran's Villaroche

facility, says Michel Brioude, vice-president of engineering.

"We are getting good results from this. So it's a real test and a real part."

Windtunnel tests of a scaled model of the RISE have also been performed, he discloses. In addition, a separate campaign to eval-

uate the noise profile of the fan were conducted at an Airbus facility in Hamburg which "demonstrated that the noise level is lower than today's Leap," says Ali.

And, says Brioude, the manufacturing of parts for the demonstrator engine has started: "We have procured the raw material but now we are forging parts in our Gennevilliers plant north of Paris.

"If you go there, you may see some of our parts – it's real parts for a real engine."

Ali says the programme is on track to meet its target of ground and flight tests of the demonstrator by mid-decade.

CFM will also incorporate a hybrid-electric system into the RISE, further contributing to its 20% fuel-burn reduction goal.

While the RISE will be compatible with 100% sustainable aviation fuel from the beginning, CFM also intends for the powerplant to be capable of burning hydrogen as an alternative.

As a precursor, CFM will by mid-decade flight test a modified hydrogen-combusting Passport business jet engine aboard Airbus's A380 flying testbed.

Changes to the combustion and fuel system will be required, says Ali. Combustion tests are showing "quite encouraging" results, he adds.

He envisages a second RISE flight-test campaign taking place "towards the end of the decade" with the engine running on hydrogen.

Launched in 2021, the 35,000lb (156kN)-thrust class RISE demonstrator programme will allow the two CFM partners to mature the technologies required for a new narrowbody engine to potentially enter service in the mid-2030s.

CFM is working with both Airbus and Boeing to understand the integration requirements of the engine.

Embraer and Nidec are friends electric

Embraer plans to launch a joint venture with Japanese electric motor specialist Nidec to develop and sell electric propulsion systems for the aerospace industry.

Announcing the agreement at Le Bourget yesterday, the Sao Jose dos Campos-headquartered airframer said the new company would be called Nidec Aerospace.

They partners plan to develop propulsion systems for the electric vertical take-off and landing (eVTOL) segment, including for the air taxi under development by Embraer spin-off Eve Air Mobility. They plan to ex-

pand the technology for use with larger aircraft, possibly including future Embraer regional aircraft.

"We will start with the eVTOL, but the idea is to explore this partnership" and to power other aircraft, says Embraer chief executive Francisco Gomes Neto.

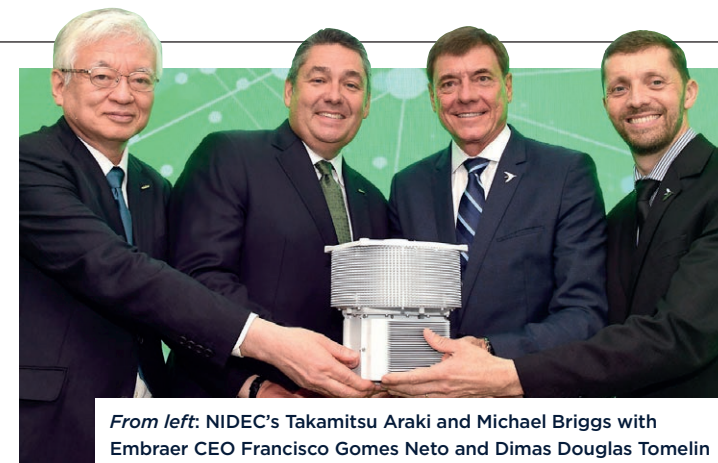
The deal still must be approved by the boards of both companies and clear regulatory approvals. Nidec Aerospace would be 51% owned by Nidec and 49% by Embraer, headquartered in St Louis, Missouri, and "supported by both companies' existing footprint in Brazil and Mexico". The deal

is expected to close before year-end.

Eve will be the launch customer for the joint venture's electric propulsion system, and the partnership's growth will be driven initially by the emergence of the broader urban air mobility (UAM) industry, the pair say. Embraer owns a majority of Eve.

But the partners plan to "go after the full market" and "design, certify and mass produce" the technology for aerospace segments beyond UAM, says Michael Briggs, Nidec president of motion and energy.

The deal represents Nidec's first venture into the



From left: NIDEC's Takamitsu Araki and Michael Briggs with Embraer CEO Francisco Gomes Neto and Dimas Douglas Tomelin

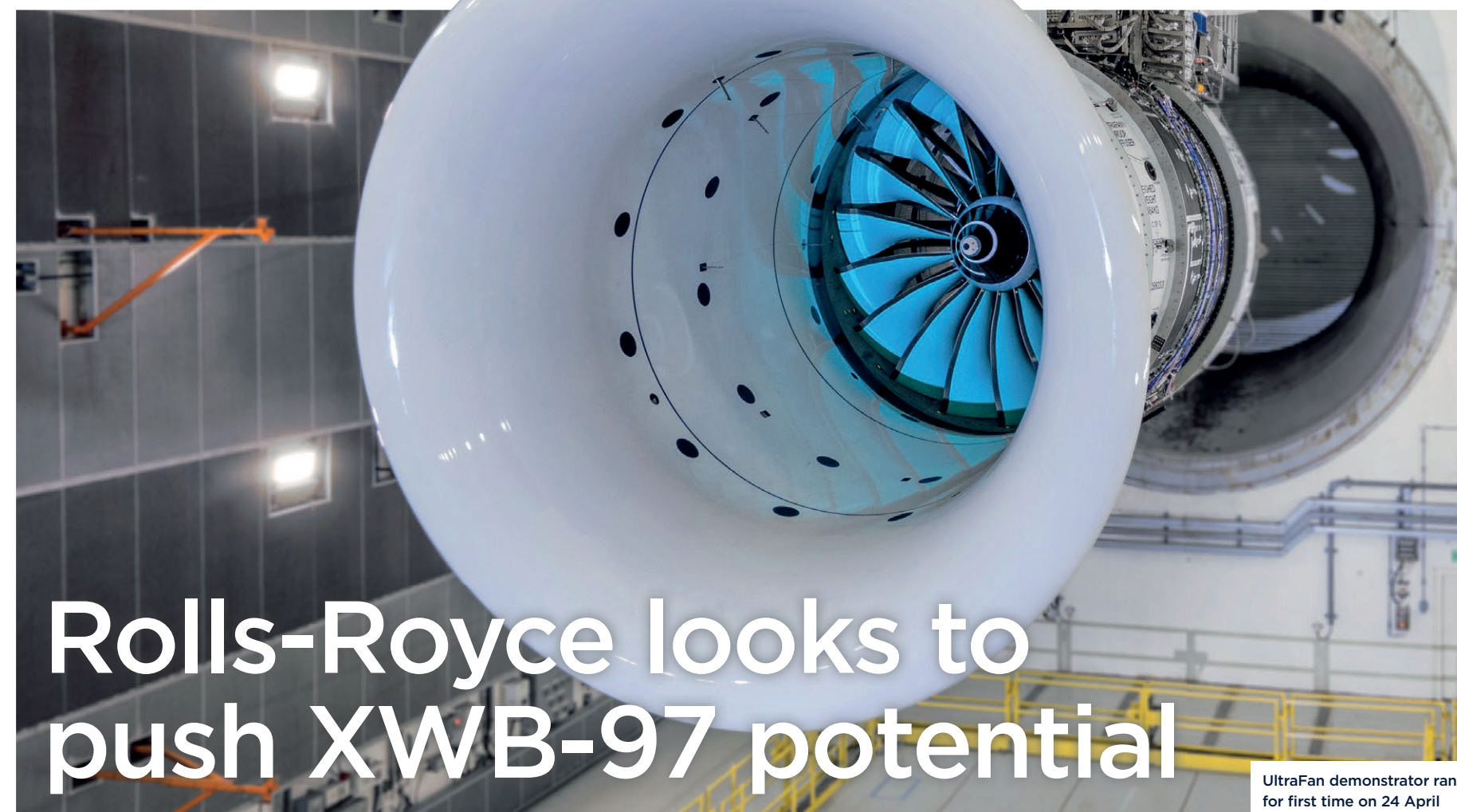
aerospace industry.

"Nidec believes in everything that spins and moves," Briggs says.

Meanwhile, Eve has also named BAE Systems as the battery supplier for the programme, while French firm

DUC Helices will provide the lift rotors and twin cruise propellers.

Andre Stein, Eve co-chief executive, says the move "is a key milestone in the development of our eVTOL aircraft".



Rolls-Royce looks to push XWB-97 potential

UltraFan demonstrator ran for first time on 24 April

Engine maker could introduce new hot section parts after performance validation

Dominic Perry

Rolls-Royce could introduce performance upgrades to the Trent XWB-97 for the Airbus A350-1000 within two to three years as the manufacturer seeks to enhance the "availability, efficiency and reliability" of its engines, according to the new head of its civil aerospace business.

Although executives are keen to stress that the propulsion specialist has yet to formally commit to an upgrade programme, it continues to validate on several test engines the next-generation components that could be used for such an effort.

Rob Watson, newly installed president of Rolls-Royce civil aerospace, says the company places "huge focus on delivering ever-more efficient engines and improving their performance in service though their life".

However, the "technology inserts" that will deliver better durability and time-on-wing will first be matured through demonstrator programmes, says Watson, highlighting the recent first runs of its UltraFan engine.

While its geared-fan architecture is clearly a major departure from Rolls-Royce's traditional three-spool widebody engine configuration, Watson stresses that the Ul-

traFan is a "suite of technologies" it can "use to improve our products today".

Incorporated in the UltraFan are carbon-titanium fan blades, a low-emission combustor, and high-temperature materials and components. It is these in particular – ceramic matrix composite (CMC) turbine seals and nozzle guide vanes, plus high-pressure turbine blades made using its CastBond process to reduce cooling requirements – that Rolls-Royce views as having the clearest route into its current engine portfolio.

"These technologies are critical to the next generation of aerospace engines and critical for us to introduce to our current fleet to give us more reliability, more efficiency and allows us to drive availability over time," he says.

In addition to the UltraFan demonstrator, Rolls-Royce is also evaluating the high-temperature parts in its HT3 test engine – a modified Trent XWB-97.

"It is going very well so far, so we are going to take them through a full test programme and then we'll roll it

out into the fleet."

Those technologies could start flowing into the Trent XWB – or other in-production engines – "over the next two to three years", says Watson.

Simon Burr, director of product development and technology, says the manufacturer intends to continue running the HT3 demonstrator this year as it seeks to further validate the performance benefits of the new components.

In his view, the low-thrust Trent XWB-84 – which powers the A350-

900 – is performing well and does not need modifications beyond those contained in the EP variant which is due to arrive in 2025.

"But as you go up in temperature and size, [an enhancement] becomes more applicable," he says.

Burr stresses, however, there is "no commitment to put this technology into an engine until we are absolutely sure it is robust".

Upgrades will rolled into new-build engines and will also be available for in-service powerplants during overhaul, he says.

Gas turbine engine readied for rig

Rolls-Royce will shortly begin rig tests of a clean-sheet small gas turbine engine that has been specifically designed as part of a new turbogenerator being developed for the advanced air mobility (AAM) market.

Announced at last year's ILA Berlin, Rolls-Royce has rapidly designed and built the gas turbine with the completed engine now installed in a testbed at its facility in Dahlewitz, Germany, a stone's throw from the air show site.

Intended for AAM applications which require more range and payload than can be provided with batteries alone, the turbogenerator is due to enter service in 2029, says Matheu Parr, customer director at Rolls-Royce Electrical.

Rolls-Royce was previously working on a turbogenerator built around its M250 helicopter engine, but Parr says better performance is enabled by

designing the system with the specific end-use in mind.

"What we are doing, which is very different to the other solutions on the market, is from the outset designing a gas turbine to support this turbogenerator focused on that role."

That has enabled optimisation of the design, including its rotational speed, and allowed weight to be stripped out, delivering power density of 4kW/kg. Initially capable of running on sustainable aviation fuel, the engine will also be designed to operate on hydrogen in the future.

Parr says the new gas turbine will be around 15% more fuel efficient than the M250, and the total system weight has been halved to around 200-250kg (440-550lb) through the optimised design. Other metrics such as noise and time-before-overhaul have also

been improved.

Rolls-Royce has incorporated new technology in the engine including a combustor "derived from larger civil products" and two-stage centrifugal compressor, says Uwe Minkus, chief engineer, future programmes and electrical – business aviation.

"It is markedly different from what you would find in smaller-size engines today."

Sized to produce 800kW of electrical power, the gas turbine has an output of a little over 1,000shp. However, the "versatile" design is scalable, says Minkus, allowing it to address applications requiring electrical power in the 500kW to 1.2MW range.

Tests of the gas turbine will continue for the remainder of the year and will be followed in 2024 by evaluations of the generator before the two parts are brought together.

Lilium blooms on back of Chinese deals

Electric vertical take-off and landing (eVTOL) aircraft developer Lilium has signed two agreements with Chinese entities to support its sales and development in the Asia-Pacific region.

Shenzhen Eastern General Aviation Company (Heli-Eastern), a major low-altitude general aviation carrier and helicopter service provider in the Guangdong-Hong Kong-Macao Greater Bay Area in China, is planning to order 100 Lilium Jets, and will partner with the German company to identify sites and partners for vertiports.

In addition, Heli-Eastern will operate the aircraft in the region and provide crewing and maintenance services on the type's certification, the company says.

"We see significant potential for Lilium's eVTOL network in the Greater Bay Area, both to reach this important premium market, as well as to offer the sustainable, time-saving benefits of the Lilium Jet to as many people as possible," adds Klaus Roewe, Lilium chief executive.

In addition, Lilium has signed a memorandum of understanding with Bao'an District of Shenzhen municipality for the opening of a regional headquarters.

Service entry is pegged for early 2030s



JetZero touts benefits of blended-wing-body

Developer sees gap for radical 50% fuel-burn saving design

Dominic Perry

JetZero is making its Paris air show debut this week as the Long Beach-based firm looks to gain momentum for its Z4 blended-wing-body aircraft after emerging from "stealth mode" earlier this year.

Pitched at the mid-market space occupied by the Boeing 767 and 787-8 – with 250 seats and range of 5,000nm (9,260km) – the Z4 will offer a fuel-burn reduction and weight saving of around 50% over both types.

Mark Page, founder and chief technology officer, sees a total addressable market for the Z4 running into thousands of aircraft.

He points out that the efficiency gains promised by the blended-wing-body configuration are achievable with current engine technology rather than requiring another leap in powerplant performance.

Under the company's current plan, it intends to fly a full-scale demonstrator in 2027, built by Northrop Grumman's Scaled Composites unit, leading to a certification prototype in 2029, followed by service entry in the "early 2030s", says Page.

Scaled Composites is the only declared partner to date, but talks are ongoing with several credible tier-one suppliers, he adds.

JetZero intends to use current-generation narrow-

body powerplants for the aircraft, mounted at the rear above the fuselage. Although its renderings show conventional ducted turbofans, the company believes installation of an open-rotor engine would also be feasible.

Inside the cabin, there are four distinct bays for seating, although due to the wider fuselage there are only 14 rows of seats.

While the Z4 is pitched at the middle-market, the concept could accommodate as few as 180 to tackle the narrowbody space, or scale up using a Y-shaped fuselage plug to seat 350 passengers.

Page estimates that it will need around \$5 billion to bring the aircraft to market

and the company has begun a Series A funding round.

In addition, JetZero is bidding for a \$245 million US Air Force requirement around a next-generation tanker that would also contribute to the development of the demonstrator.

Although Airbus and Boeing have previously touted such blended-wing-body designs, both are pursuing more conventional tube-and-wing designs for their next aircraft.

"They are still extracting lots of value from their [current] products – there is no motivation to take a risk and change that calculus.

"But once we enter the market they will have to follow," says Page.

Return of the Millennium

Embraer's C-390 Millennium is back at Paris with a double-display. The Brazilian tactical transport is once again taking to skies at the air show, accompanied for the first time by an export customer's aircraft on the

static display.

A demonstration flight on the eve of the show's opening today saw the Brazilian air force's KC-390 example climb to 8,000ft above the French countryside, including an in-flight opening

of the rear ramp, before landing back at Le Bourget airport.

Embraer says the manoeuvres demonstrate the C-390's versatility for cargo, in-flight refuelling and special operations support.

The airframer previously brought the twin-engined C-390 to Paris in 2019. This year's KC-390 showcase will feature the Brazilian jet, alongside a second example destined for lead export customer Portugal.

That aircraft will be delivered to Lisbon later this year, the first of five transports ordered by the European nation.

Embraer handed over the sixth KC-390 to Brazil earlier in June, its first in a full operational capability configuration. It also holds orders from Hungary and the Netherlands, for a total of seven aircraft.



Riyadh reveals livery on Paris catwalk

Saudi Arabian start-up Riyadh Air is displaying its livery for the first time at this week's Paris air show, presented on a Boeing 787-9 on the static display.

The Saudi government in March formally unveiled Riyadh Air as its new operation from the country's capital with the ambition to be serving more than 100 destinations by 2030. The airline, which aims to launch flights in 2025, placed a commitment for up to 72 Dreamliners in March.

Having earlier this month unveiled its livery, one of two it plans to deploy, on social channels, it is being displayed in public for the first time.

Alongside its 787 commitment, the airline is also working on a major narrowbody aircraft order.



Yesterday's flight over the show

Photo: Emmanuelle/FlightGlobal

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"I've been an engine module technician on CFM56 and CF6 engines for 10 years. Thanks to this experience I have joined the LEAP team. I'm determined to provide the best quality and TAT to meet our customers' expectations, while always looking for ways to improve our processes."

Leandro Rodrigues Oliveira, Engine Module Technician

AFI KLM E&M has extended its capability list to include maintenance for the LEAP* engine, with an MRO service offering that covers both On Wing/On Site support and shop visits. AFI KLM E&M, which has provided support when new engines go into service on a number of occasions in the past, is capitalizing on the know-how of its teams to support early-stage operations on the LEAP worldwide. We are ready to meet the needs of the airlines with services that are always the **Best4You**.

* LEAP engines are products of CFM International, a 50/50 joint company between GE and Safran Aircraft Engines.



A D A P T I V E N E S S ®

Boeing boost for Honeywell/Curtiss-Wright recorders

Honeywell Aerospace and Curtiss-Wright's jointly developed HCR-25 cockpit voice recorder and flight data recorder variants have received type certification for Boeing 737, 767 and 777 aircraft.

Airlines can now order the connected, 25h HCR-25 recorders directly from Boeing or Honeywell and instruct Boeing to install them on their aircraft.

It is the first time a Curtiss-Wright product has been type-certified on these aircraft types. Curtiss-Wright is the exclusive supplier of Honeywell's next-generation recorders for the air transport and business aviation markets.

"Reliable cockpit voice and flight data recorders are vital to flight safety, and since 2019 we've been working with Curtiss-Wright to design and develop the next generation of mandate-compliant voice and data recorders using real-time connectivity," says Honeywell vice-president services and connectivity Steve Haddon.

"Through increased connectivity, aircraft operators have another source of data collection to improve aircraft maintenance and performance."

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Bonanza at Le Bourget

Paris aircraft orders could reach up to 3,000, according to IBA

Kerry Reals

Aircraft orders announced during this year's Paris air show could total between 2,100 and 3,000, aviation consultancy IBA has predicted.

In a market forecast released in advance of the show, IBA chief economist Stuart Hatcher estimates that, taking into account all tentative aircraft orders inked so far and the possibility that they could be firmed up at the show - together with rumoured orders - the total number could reach "just shy of 3,000", which, he admits, "sounds crazy". A more likely number, he adds, would be just over 2,100.

"If I factor everything in, we could get to a number close to 3,000, which I think would be lunacy," says Hatcher. "Even if I trim that down to the ones most likely to firm up, I get to 2,154, which still sounds high based on precedent and prevailing economic conditions."

IBA has based its predictions on firm and tentative order levels so far this year, rumours of possible aircraft orders to come and its own analysis.

"Firm order levels thus far in 2023 have been largely below par when compared to any other year before 2019, which probably isn't that surprising given that delivery slots for narrow-



Turkish Airlines is among those which have signalled intentions to place large orders

bodies are in a different decade for 'normal' customers," says Hatcher. "Even in 2019, which was considered a good year, there was a very poor pre-show firm order tally leading into the start of the week."

If firm orders in the run-up to the show were the only factor to be considered, Hatcher says that "the outlook for orders would remain grim". However, he points to a number of headline-grabbing memorandums of understanding and letters of intent this year, including Air India's February agreement to buy 470 aircraft from Airbus and Boeing, plus 70 options, Saudi Arabian Airlines' and Riyadh Air's March agreement to take up to 121

Boeing 787s, and Ryanair's May MoU for 150 Boeing 737 Max 10s, plus 150 options.

"In terms of Paris agreements, we would therefore expect there to be something to cover the Air India and Saudi orders if nothing else - which would make the tally pretty good, based on historical levels," says Hatcher. "But then there are countless announcements and rumours that have been doing the rounds in the background."

For instance, Turkish Airlines has signalled its intention to order up to 600 Airbus and Boeing aircraft, IndiGo has said it plans to order 500 more aircraft, and Akasa Air has hinted that it could place a large

order before the end of the year. IBA also sees possible orders from the likes of Pegasus, Air France-KLM, Delta Air Lines and Aerolineas Argentinas.

Regional aircraft manufacturers could also potentially see "a fair number" of orders, with regional operators being "the ones most in need of fleet replacement", according to Hatcher.

On the lessor side, he expects to see an order from Air Lease Corporation (ALC) - possibly for the 737 Max 10 - as well as "some action" from leasing companies such as AerCap and Avolon. Compared to the operators, though, he does not expect to see any large orders from lessors.

Apollo veteran to inspire young into lifting off aerospace careers

Kallman Worldwide is hosting Paris air show's first-ever Workforce Weekend recruitment drive, in a bid to highlight the aerospace industry's "dire" staffing shortages and inspire future generations to consider a career in the sector.

The event will be held in the USA Partnership Pavilion on the show's public days, and will feature a STEM-focused (science, technology, engineering and maths) "classrooms-through-careers" fair, says the organiser.

During the weekend of 23-25 June, the pavilion in Hall 3 will be home to Spaceport USA, which Kallman Worldwide describes as "a space-themed, interactive show-



Apollo 16 lunar module pilot Charlie Duke will appear on 25 June to share his experiences

case of immersive activities, engineering innovations and technology demonstrations to engage and educate visitors of all ages."

Apollo 16 lunar module pilot brigadier general Charlie Duke and Space Shuttle commander Michael Bloomfield will make personal appearances on 25 June to share their experiences.

"Participating in Workforce Weekend gives those of us with aerospace experience the opportunity to talk about the importance of international collaboration in the aerospace sector and the satisfaction that comes with an aerospace-related career," says Duke. "By sharing insights I have picked up over the years, I hope to

inspire future generations of explorers, engineers and pioneers."

The Huntsville, Alabama-based US Space and Rocket Center will provide and staff a number of Spaceport attractions during the event, including; a planetarium depicting the surface of the moon where Duke walked during his Apollo mission; a Harry Potter "Quidditch-like" drone football pitch; paper aeroplane making and test flying; and star wheels for identifying constellations.

"Our goal is to have Spaceport USA visitors leave inspired to actively pursue careers in aerospace," says Kallman Worldwide chief executive Tom Kallman.

Jon Hemmerdinger
David Kaminski-Morrow &
Dominic Perry

As more carriers come forward to detail the operational disruption - and in the case of India's Go First, financial turmoil - being caused by problems with Pratt & Whitney (P&W) geared turbofan (GTF) engines, the long-term impact on the propulsion specialist is less clear-cut.

Airlines flying Airbus A220s and A320s, particularly those operating in harsh environments, have reported problems with the jets' respective PW1500G and PW1100G engines, or with P&W's ability to provide timely maintenance or spare powerplants. More recently, KLM Cityhopper indicated that it was struggling with the performance of the PW1900s equipping its Embraer 195-E2 fleet.

But while P&W's reputation is taking a battering, analysts think the firm will be able to weather the storm once it addresses the current problems - some of which are not of its making - and engine improvements are rolled out.

Gearbox fears

Richard Aboulafia, managing director at AeroDynamic Advisory, does not think the GTF architecture suffers from any fundamental defects; it is, he says, a conventional turbofan with the addition of a gearbox to allow the low-pressure spool and fan to spin at their optimal speeds.

Despite initial fears about the component's long-term durability, it has so far performed flawlessly, even as faults have been found elsewhere in the engine.

Aboulafia attributes the trouble to a "perfect storm" of factors - notably, a supply chain and maintenance operation pressured to ramp up output in the face of widespread labour and parts shortages.

P&W has suffered "a reputational black eye for now", Aboulafia says, "but given the market circumstances, it is not going to cause that much damage".

By which he means there is precious little opportunity for a customer, having selected P&W engines for their A320neo-family jets, to switch to the rival CFM International Leap-1A.

"How much latitude is there [for airlines] to switch to the Leap at this point? Realistically, not a great deal," Aboulafia says.

Because of Airbus's robust backlog, airlines placing new A320neo-family orders today will probably have to wait at least four years to receive



P&W is rolling out a series of improvements to GTF powerplants

The long game

Although operators continue to face difficulties with Pratt & Whitney geared turbofan engines, the issues may not impact the manufacturer in the longer term, analysts suggest

those jets, by which time P&W will likely have fixed the problems, Aboulafia says.

Airlines could modify existing A320neo orders - switching from the PW1100G to Leap-1A - but they would face a lengthy wait, too, owing to CFM's backlog.

"By the time you get on the list for a Leap-1A, [P&W] will probably have solved the problem," Aboulafia says. "This is likely fixed within two or three years."

Besides, Leap engines - both the -1A and the -1B for the Boeing 737 Max - have not been trouble-free: CFM and partner companies GE Aerospace and Safran are working on a series of durability improvements to increase time on wing.

And for A220 or E190- or E195-E2 operators, there is no alternative engine to select anyway.

Future customers for the A320neo family, or those yet to make an engine selection, may move towards the Leap, further increasing that engine's near-60% market share on the Airbus narrowbody.

"We have seen further leaning towards the Leap from customers, and that is fundamentally suggestive of recurring problems [with the GTF]," says aerospace ana-

lyst Michel Merluzeau from consultancy AIR. "There is definitely some direction toward the Leap."

Narrow options

A longer-term question may be whether the current travails are enough to discourage Airbus or Boeing from looking at a future P&W powerplant for what-ever replaces the A320neo or 737 Max.

The current narrowbody engine duopoly weighs against that scenario and it might require Rolls-Royce to re-emerge as a competitor in the segment for any significant shake-up to happen.

Besides, the fundamental architectural changes - and new fuel sources - likely to be implemented on the next generation of narrowbody engines add even more uncertainty to the mix.

But for those operators currently dealing with GTF-related problems there is little option to scabble for solutions while the manufacturer rolls out fixes and waits for the easing of supply chain disruption, which it expects to happen later this year.

That should "support increased output of new and overhauled engines", P&W adds.

"In the interim, we are providing direct logistical support to our suppliers as well as developing solutions to improve engine durability,"

But by its own admission, P&W is "only about 50%" through the durability upgrade programme.

P&W has progressively inserted updates into the PW1100G since it entered service in 2016, with new engines now built to the so-called Block D standard. In-service powerplants have received the upgrades during shop visits, but that process has not been as rapid as hoped.

Labour pains

Christopher Calio, chief operating officer at P&W parent Raytheon Technologies, says the firm is "running as fast as we can" to perform the Block D modifications, but admits it still has a significant population of engines to address.

"We are only about 50% of the way through the fleet in terms of those upgrades," he told analysts during a first-quarter results call on 25 April.

He blames the slow pace of the upgrade process on "part constraints and shortages [of] labour in our MRO

network". Additional MRO capacity is being brought on stream, Calio notes, which will help "accelerate" the roll-out of the Block D enhancement, which is "really aimed at the combustor hot section".

Raytheon Technologies chief executive Gregory Hayes says "we probably didn't spend enough time" on operational testing in harsh environments - "specifically places like India".

"That's where we have seen the lower life on the combustor. We have seen some lower life on the turbine blades just because of the harsh conditions there," he says.

But that is likely to offer little comfort to those affected - a list which grew recently with the addition of Iraqi Airways and KLM Cityhopper.

Iraq's civil aviation regulator has suspended operations for the carrier's five A220-300s, citing engine damage to two airframes.

The Iraq Civil Aviation Authority says an initial technical inspection of one aircraft on 30 April revealed damage to the inner engine lining and the fan blades after arrival at Baghdad. A second A220 suffered "the same damage to one of its engines" during a flight to Tunisia two days later, it adds.

The Civil Aviation Authority points out that several A220 operators have been "exposed to the same technical problems", referring specifically to EgyptAir and Swiss.

In fact, one-third of Swiss's A220 fleet is grounded because of engine issues, according to Carsten Spohr, chief executive of parent Lufthansa Group.

Alongside the Swiss A220 woes, powerplant problems have also grounded three "brand-new airplanes" at Lufthansa mainline, Spohr says, referring to PW1100G-equipped A320neo-family jets.

Amid the groundings, Swiss is currently wet-leasing six A220-300s from Air Baltic, according to Cirium fleets data, to support its 30 examples of the type.

Embraer too

Elsewhere, regional carrier KLM Cityhopper has gained the dubious distinction of becoming the first operator to disclose problems with the PW1900Gs that power its second-generation E-Jets.

"KLM Cityhopper is consulting with Embraer and engine manufacturer Pratt & Whitney to seek a solution for these issues, which have no impact on flight safety," it adds.

Additional reporting by
Graham Dunn & Lewis Harper

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MBDA to show off its collaborative effectors

Missiles specialist will demonstrate air-launched weapons with simulated raid

Craig Hoyle

MBDA will use the Paris air show to update its progress on designing a new class of so-called collaborative effectors: intelligent air-launched weapons which are expected to complement future European sixth-generation fighters. Military visitors will be invited "to immerse themselves in a unique simulated raid using network-enabled effectors, linked to each other, reacting live to the developments of a tactical situation", the guided weapons specialist says. This will include demonstrating features such as "pop-up threat avoidance, collaborative targeting and automatic target reallocation".

Also described as a pack operation, the conceptual mission involves glide and powered missiles and expendable remote carriers "sharing information about the battlespace as they approach targets, coordinating their actions".

Such tactics will be "key to overcoming enemy air defences, enhancing survivability of effectors and increasing efficiency on targets", MBDA argues.

Dubbed Orchestrike, the capability relies on technologies including "connectivity, software architecture and algorithms, including artificial intelligence with a human in the loop", MBDA says.

Collaborative effectors and remote carriers will be valuable adjuncts for the Future Combat Air System (FCAS) and Next Generation



The missile house's intelligent air-launched weapons are expected to complement future European sixth-generation fighters

Fighter being developed by France, Germany and Spain, and also the Italian/Japanese/UK Global Combat Air Programme (GCAP) and Tempest fighter.

Speaking last month, MBDA UK managing director Chris Allam told Flight-Global that the European company is well positioned to support both the FCAS

and GCAP efforts.

"We can have national programmes, as well as international ones at the same time - we are structured and expert at doing that with no issues," he notes. "But our strategic desire would be that those air dominance programmes are more common - at least when we get to the weapons domain."

"Our ideal objective is to maintain what is actually currently a very common set of weapons," Allam says. "We can hold a common weapons layer, even if it's in two programmes."

As an example, MBDA last year launched the assessment phase of the Anglo-France future cruise/anti-ship weapon (FCASW) programme. It is currently advancing work on two concepts: a stealthy, subsonic successor for the Storm Shadow/SCALP EG cruise missile; and a supersonic weapon which will employ "high speed as a mode of defeat". Both designs are in the roughly 1t weight category.

The FCASW programme will move into its development phase in 2025, with service entry scheduled before the end of this decade.

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Airbus chief on ramp-up challenges, launching a bigger A220, the carbon-cutting conundrum, and getting FCAS on course

Faury's frustrations



Airbus is confident A321XLR will meet its entry-into-service target of second quarter 2024

David Kaminski-Morrow & Dominic Perry

With new programmes, new agreements, and progress towards a fundamentally new era for aviation, chief executive Guillaume Faury is hardly likely to let Airbus slip quietly back onto the Le Bourget stage – four years after the last Paris show – even as a creaking supply-chain is frustrating the aerospace giant's efforts to regain its momentum.

Airbus is not planning an 'A220-500' launch at its home event but, when it finally takes the decision to proceed with the much-anticipated 150-seat twinjet, its development could end the A220's engine exclusivity arrangement.

Creation of the -500 would cement the A220's position as an aircraft family and – while the A220-

100 and -300 are solely powered by Pratt & Whitney PW1500Gs – moving to a dual-source engine would align the A220 with Airbus's long-established A320 line.

Faury tells FlightGlobal that such a decision "could make sense" when the -500 is introduced.

"We'll have three products, a complete family, and in that sense we think it could call for dual-sourcing of engines at the right point in time, if engine manufacturers are ready to go there," he says.

But the -500 is not an imminent project. "There's still a lot on our plates on the A220 programme as it is today," says Faury, pointing out that Airbus's immediate focus is the Pratt & Whitney in-service engine problems which are affecting A220 operators. The airframer is also still trying to reduce costs, in order to break even on the programme by mid-decade, at which point it wants

to be producing 14 A220s monthly.

As the A321neo – with its long-range A321LR and A321XLR variants – continues to emerge and evolve as a separate and distinct aircraft group, says Faury, it will create "some space for the -500" at the lower end of the A320neo family.

But the A220-500 remains low on the priority ladder. "I like to say we're wrong to be right too early," says Faury.

Offering a second A220 engine, as Airbus does for the A320neo, is a strategic consideration to broaden appeal. While it contrasts with Boeing's approach on the 737 family, Faury argues that single-aisle volumes justify the decision. "We're very happy to have double-source on single-aisle, that works very well," he says.

Faury states, however, that the airframer is turning to dual-sourcing more for contingency purposes in other parts of its business, reflecting

a cautious approach after the post-pandemic recovery exposed the vulnerability of the aerospace industry to supply-chain disruption.

"The overall geopolitical supply risk situation is calling for less exposure to single source of failure – single issues leading to disruption," Faury says.

"We're working today to de-risk our supply chain, and therefore double- or multiple-sourcing more than what we do today."

Pervasive supply-chain problems have resulted in Airbus's having to delay deliveries as well as rein-in its ambitious ramp-up schedule for A320neo production. With a second Tianjin single-aisle facility opening in 2025, the airframer is taking the number of A320neo final assembly lines to 10 – all of which will be capable of building the increasingly-popular A321neo, whose backlog exceeds 3,600.

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Faury says one of Airbus Helicopters' roles will be to 'manage the transition to decarbonisation'



This should enable it to take monthly output to 75 aircraft. But with supply of components and systems hamstrung at multiple aerospace tiers, this rate of production has been pushed back to 2026.

If Airbus is frustrated at the inability to accelerate manufacture, its customers are similarly aggrieved and sympathy over the airframer's position is not a given. US lessor Air Lease described the both Airbus and Boeing in May of suffering from "self-inflicted" problems, accusing them of having increased production rates too quickly against the background of difficulties with a corresponding supply-chain ramp-up.

Faury accepts that delivery delays have occurred since contract amendments were signed during the pandemic. But he asserts that Airbus has acted transparently and rationally and defends the airframer's decisions.

"I'd like to remind airlines that they were the ones to ask for postponement and delays, and pushing delivery dates to the right," he says.

He insists Airbus "communicated very clearly" on the ramp-up trajectory. "We wanted to give the clear indication, clear information, the clear path to the suppliers on the fact that we were going to ramp up and that they had to prepare for it. "This has been done after

consultation of the supply chain. I think we gave all we could reasonably give to the supply chain... for them to have the means and possibilities to do the ramp-up."

He acknowledges that the single-aisle ramp-up has been "much slower than we anticipated", owing to supply-chain hitches.

"Airbus today is oversized in its capability to produce and assemble [aircraft] compared to what the supply chain is providing to Airbus," says Faury, stressing that suppliers – particularly the smaller enterprises – have been placed in a "very difficult"



Faury believes Airbus was 'right' to start considering ramp-up as early as April 2021

environment, with shortages of raw material, logistics capacity, labour and equipment.

"Should we have anticipated better the difficulties to recover from [the pandemic]? Maybe, yes. It's always easier to be smarter afterwards. It's easy to criticise; there are always easy solutions to the problems of others."

He argues that the "vast majority" of Airbus's 3,000 suppliers "managed to open at the right pace", but adds that absence even of small parts can hold up production.

"We've been slowed down by a small number of suppliers. The few suppliers that didn't manage to execute the ramp-up as planned have slowed down the whole industry," he says.

"As soon as you have one not delivering correctly it slows down everybody. That's what the engine-makers suffered from. It's a complex system. It's what we suffer from. Things are progressively getting better but it's by far too early to declare victory."

Faury believes Airbus was "right" to start considering the ramp-up as early as April 2021. "With hindsight we should have been more prudent in the speed of ramp-up," he admits, but adds that this might have led to worse problems. "I think we took decisions that were not far from being the right ones when we took

[them]. And we were forced to adapt the speed of ramp-up, and now we're all late."

But he says the world has become "more complex", particularly with the Ukrainian conflict, and that this could not have easily been predicted.

The situation appears to be "slightly getting better", Faury cautiously suggests. "That's not visible in the acceleration of deliveries because we're still limited by a few critical suppliers that are on their recovery plans, and not doing better than [previous commitments]."

"We're still limited by the bottlenecks. The bottlenecks are not accelerating faster than what was expected. But the rest is doing OK."

Airbus is confident that the A321XLR, undergoing certification, will meet its current entry-into-service target of the second quarter 2024. Faury believes there is no need for design changes, and that the certification basis – while taking longer than intended – "has been frozen".

"We're making good progress on certification files, ground tests, documents. [Flight-tests] are moving forward at a good pace, and with good results," he says, and the service-entry outlook has been "stable" for "many months in a row".

Supply-chain issues will not alter the XLR's service-entry date. But

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Faury says the production and delivery schedule will – like other single-aisle models – be affected. “The XLR moved to the right with the other A321s as we had to adapt the schedule in recent months,” he states. “But it’s not an XLR topic, it’s a volume topic.”

Airbus has, however, shifted the debut of its other new programme, the A350 freighter, back a few months to 2026 – the result of assessments as development stages are reached.

But Faury is satisfied with the early take-up of the freighter. He says the backlog of 39 aircraft “fuels the first years of deliveries”, and adds: “That’s enough for us to ramp-up the programme as an industrial plan.”

Faury describes the market response to the A350F as “very good” for a new design, reiterating the twinjet’s capabilities and compliance with ICAO’s 2028 emissions requirements, and shrugging off Boeing’s rival 777-8F as well as the proliferation of 777 cargo-conversion lines.

“We would have been very surprised if Boeing would have completely abandoned the segment that’s been very successful for them over time. They’re incumbent in the market and trying to leverage the fact,” he says.

“Each and every campaign today, with the [777-8F] offer from Boeing, becomes very competitive. That’s what the airlines were expecting. From an airline perspective, having both [airframers] competing fiercely on the freighter is very good news.”

While the 777-8F has snared fleet-renewal agreements with several high-profile operators – among them Lufthansa Cargo, Qatar Airways, Cargolux and ANA Cargo – Faury is satisfied with the calibre of early A350F customers, which notably include Air France-KLM, Singapore Airlines, Etihad Airways and Air Lease. Crucially, some will be using the A350F to replace Boeing 747 freighter capacity, as Airbus had envisioned.

“We’ve launched the A350 freighter, I think, with the right timing. Now we have big replacements coming, of big fleets, especially the specialised cargo carriers like FedEx, DHL and others,” Faury says. “Boeing will not let it go easily.”

Although Airbus is increasing dual-sourcing across its supply chain, Faury feels no need to implement that policy on widebody platforms where a single firm has engine exclusivity as Rolls-Royce does on the A350 and A330neo. “We don’t feel the need to change the situation,” he says.

But with the UK propulsion specialist recently commencing test runs of its UltraFan demonstrator – sometimes characterized as a solution in search of a problem –



The non-commercial programme consuming the most engineering resources is FCAS

there is already speculation where that powerplant might fit in Airbus’s product range.

Faury says the UltraFan architecture, as a potential evolution of the current powerplants, could “make sense” for Rolls-Royce-equipped Airbus jets “if proven competitive by Rolls-Royce”.

“We are with Rolls-Royce engines on the A350 and the A330neo. So [UltraFan] is what Rolls-Royce is working on to power our planes in the future and, if the performance is validated, that could make sense to us,” says Faury.

Airbus is clear that it views hydrogen as the fuel source most likely to deliver decarbonisation in the long term, with its ZEROe initiative built around it. But Faury warned at the manufacturer’s Summit 2022 even in December that three conditions would need to be satisfied if Airbus was to launch a hydrogen-powered aircraft in 2027 or 2028. These were technology readiness, a regulatory environment that was capable of approving hydrogen aircraft and fueling infrastructure, and a conviction that by 2035 there will be green hydrogen “in the right quantity, in the right place, at the right price”.

On the technology side, Faury feels confident, but concedes the areas outside its control “might be more difficult than the airplane itself”.

However, he is pleased with

the progress to date, seeing a willingness from EASA to engage and prepare the regulatory framework for hydrogen aircraft; increasing government support for hydrogen-related projects is also sending a “very strong signal to many stakeholders that they have to be ready, that they have to invest”.

“Things are moving quickly. The fact that we have a hydrogen [aircraft] programme, very visible, experts that speak to other stakeholders, is also a way for those stakeholders to understand... that they have to be prepared and also to learn and exchange and discuss,” he says.

“But I have not suggested we will delay [a launch]. I have suggested there are other conditions that need to be in place in order to launch the programme – and those conditions are also challenging.”

Although progress is “accelerating” in certain areas, there is continued uncertainty about the surety of green hydrogen supply given the increased competition for the fuel from other energy-intensive industries such as steel making as they also look to decarbonise.

“So, it is premature to say everything will be ready by ‘27, ‘28 to launch but there is clearly an acceleration and that is positive,” says Faury.

Elsewhere in Airbus, the programme consuming the most

engineering resources is the Future Combat Air System (FCAS) being developed for France, Germany and Spain. Here an unusual period of calm has descended since an agreement was reached in December last year – between the nations and their industrial champions Airbus Defence & Space and Dassault – relating to the workshare and leadership roles for Phase IB of the programme which will see a demonstrator of the New Generation Fighter (NGF) built and flown.

Prior to that point, relations between Airbus D&S and Dassault had mostly been characterized by public bickering – “arm-twisting” Faury calls it – as each side jockeyed for position. But now, he says, “we are in execution – it’s no longer about transactional negotiation on who does what: we have agreed on the workshare and the lead-share and now we are executing”, which is proceeding “very smoothly and efficiently”.

And, Faury points out, although Dassault is the largest the project has “many partners”, running through the technology pillars, such as sensors, engines and weapons, required to develop the FCAS.

Still, every now and again, comments from Dassault’s combative chief executive Eric Trapier emerge to spoil the peace. For example, in March he told FlightGlobal that although the

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Leadership of Phase 1B was agreed, it did not guarantee the project would be a success.

"Eric Trappier is Eric Trappier," shrugs Faury, noting that the opinion of one partner "does not [alter] the will of Germany, France and Spain to build a programme that is at the scale and size and complexity required to be successful."

He also sees "an appetite from other countries" to join the FCAS effort, highlighting the fact that Lockheed Martin's F-35 programme initially accommodated eight partner nations in addition to the USA.

That might not be achieved without a fight, however: last month, Trappier told French lawmakers of his opposition to incorporate into the FCAS project countries, like Belgium, that had selected the F-35 over European solutions.

But Faury says whether to admit new partners will be a decision for the three nations currently funding the FCAS development.

Meanwhile, at Airbus Helicopters - a division formerly led by Faury - things are calmer. No new programmes are in development, albeit there is plenty of ongoing research and innovation work as the business looks to the future. On the civil side, the Racer high-speed rotorcraft demonstrator is due to make its maiden sortie this year, while the FlightLab and DisruptiveLab flying testbeds are already airborne and helping to mature technologies for future applications. And in the military side of the business, initial work has begun on a European Defence



Airbus has shifted the debut of the A350 freighter, back a few months to 2026

Fund-backed project looking at the technologies required for a next-generation military helicopter.

Against most measures, market share or customer satisfaction, for example, the division is "doing really well", says Faury, who praises its financial performance as "predictable and reliable".

Turnover last year was around €7 billion (\$7.5 billion) - a healthy 12% of the group's €58.7 billion total. While this figure will never match

that of commercial aerospace - "the trees cannot grow to the sky", says Faury - he praises Airbus Helicopters' strategy: "In terms of driving to sustainability and the technology roadmap, it is moving in that direction probably much better than other helicopter OEMs."

Its future role will be to "successfully manage the transition to decarbonisation for helicopters" and to be a "good player" in the market for urban air mobility

vehicles once that segment takes off. Plus, Faury envisions Airbus Helicopters as having a wider role "contributing in terms of technologies to the group when it comes to hybridisation, electric propulsion and electric technology and also being the partner that Europe needs for vertical flight for defence."

"Defence is, in my view, something that we need to be very mindful of in Europe," he says.

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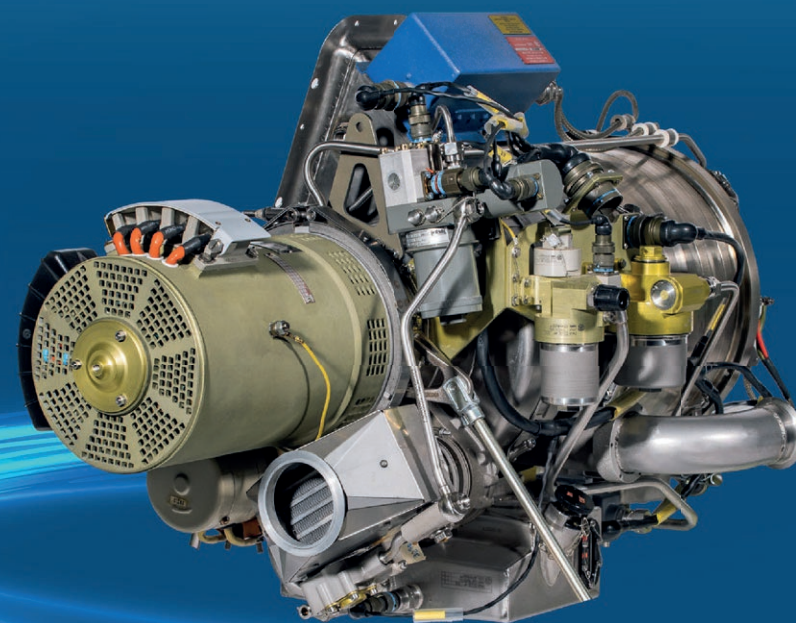


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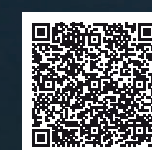
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Rampant rebounding demand for aircraft is welcome news for Boeing Commercial Airplanes. But that comes with its own challenges for its chief executive when it comes to managing customer expectations

Deals in the air

Graham Dunn

While a strong aircraft order environment means Boeing Commercial Airplanes chief Stan Deal arrives at Le Bourget with a bolstered backlog, supply chain, delivery and certification challenges remain time-consuming issues for the manufacturer.

"From my view, it is the tale of two stories," Deal tells FlightGlobal during an interview at the IATA AGM in Istanbul in early June ahead of this week's Paris air show.

"The positive surprise is how far the industry has rebounded, and that is represented by the amount of order decisions that have been made and order decisions that are in the works. It seem like every airline at once has woken up to the need to plan for a rebound in future, in terms of passenger growth - and the orders aren't small, they are big orders."

Boeing has won its share of recent large orders and commitments from the likes of United Airlines, Saudia and its new sister carrier Riyadh Air, Air India and Ryanair. More big orders may be in the works, including an expected 600-aircraft-strong deal from Turkish Airlines and a likely narrowbody aircraft order from Riyadh Air.

While Deal acknowledges the order rush might partly be fuelling itself - prompting some airlines to jump in with orders so as to secure remaining delivery slots - he also sees solid logic behind the strong order activity.

"Most of these airlines are trying to plan long-term demand. So, it's not 300 airplanes in a period of two years, it's 300 airplanes over a five-to-seven-year horizon," he says. "That's rational long-term fleet planning - being able to say, 'I have to plan my growth and secure capacity over a long horizon.'"

Demand may be healthy, but the supply chain has been struggling, with Deal conceding production has been "much harder to ramp up" than in any period prior.

"That shows the profound effect Covid had on the extended supply chain, not only for manufacturing... You see it at airports. You see it around the globe. The human capital toll of Covid was pretty devastating."

"Now [that] we are another year into it, a lot of our supply base has been able to get staffing, and I'd say the main challenge is how to get



Deal: 'I don't sense any real weakness relative to Airbus'

that staffing fully competent and trained so [that] net productivity can get back on the curve that it was once on. And it is not a big cap ex issue. It's more of, how do you get through the human-learning curve, a few material constraints, things of that nature? Eventually we will get through that, but it has taken longer than we anticipated.

"Unconstrained demand [with] constrained supply will still be the story for a while, I believe," Deal adds.

Fresh challenges emerged in mid-April when Boeing revealed it had stopped some 737 deliveries due to a fuselage issue involving fittings supplied by Spirit AeroSystems. The problem affects 737 Max 8s and 737NG-based P-8 military surveillance jets, including those already in service. It prompted fresh delivery delays at a time Airbus and Boeing were already struggling to meet delivery commitments.

"The initial plans we laid out and

communicated with the airlines [are] actually going as predicted, if not slightly better," says Deal.

It means Boeing can turn attention to increasing production. It was producing 52 737s monthly prior to the pandemic and has recently been aiming to maintain a 31-monthly rate, with rate steps in view. "We look ahead on each rate increase and [ask], where is each supplier in that readiness?" says Deal. "Most of the lights are green... There's a few yellows out there - I don't think those will get in the way."

"Now we are looking at the steps beyond that, as we think about 2024 and 2025 - that's where a lot of our focus is," he adds.

On the widebody front, Boeing recently stepped up Dreamliner production to four aircraft monthly. "Then we will look at another rate break as we approach the end of the year, and I think the supply chain is largely healthy," says Deal.

Max back in service

Given the 737 Max's troubled history, Deal is gratified by the type's performance since its return to service two and a half years ago, noting the jets are achieving 99.5% reliability.

"We have delivered over 777 Max's since the un-grounding. Ninety-nine-five on reliability is incredible, but that is what we sell to the airline," he says.

"There was a period [when], getting the Max ungrounded, a lot of people were saying, 'Is the Max going to be okay? Does Boeing need to reinvest?' We never thought we had to reinvest. I think there were third parties that were being critical."

"Probably most people see now that the product is back in the market, and its orders are flowing through, and the performance is there... It underpinned our belief in the product strategy. We are seeing a lot of volume around the -8, [and] you are seeing the -10, over the past two years, really pick up... That's nice to see because it is a great family."

Deal cites strong demand across Boeing's wider product family.

"I don't sense any real weakness relative to Airbus," he says. "That's why you hear us continue to reiterate our current focus to continue [to] enjoy the benefits of the product family while we invest in future capability that would some day bring a double-digit [fuel-efficiency] advantage to the market. But today, every one of our family members... has a demonstrable advantage over the ageing fleet." ▶

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The effort to certificate the smallest of Boeing's 737 Max family typifies the ongoing challenges the manufacturer still faces

Still hurdles ahead

Howard Hardee

Perhaps more than any other Boeing aircraft in development, the 737 Max 7 encapsulates the airframer's difficulty in moving past high-profile problems that have plagued it in recent years.

And no aircraft's certification pathway better illustrates the high-scrutiny regulatory environment Boeing now operates within, Mike Fleming, Boeing's senior vice-president for commercial development programmes and customer support, told a gathering of reporters in Charleston, South Carolina just weeks before the show.

"It is taking us a considerable amount of time to get this airplane certified – longer than a lot of people anticipated, including me," Fleming says. "I did not see [certification] moving into this year at all. Candidly, a couple of years ago, I did not see it moving into last year." However, he adds that "we still anticipate having the airplane certified this calendar year".

But as Boeing heads into this week's Paris air show, its likelihood of satisfying the Federal Aviation Administration's requirements and achieving certification of the already much-delayed Max 7 before the end of 2023 is in question.

The smallest of Boeing's family of next-generation narrowbody jets, the Max 7 is only a slight variation of the Max 8 and 9. It has a smaller cargo compartment and modest modifications to the environmental control system (ECS) that pressurises the cabin, Fleming says, representing "no real appreciable change" from already-certificated Max variants.

But the Max 7's entry to passenger service has been repeatedly delayed since the type's first flight in March 2018, as the Max programme has suffered a variety of quality and production issues and two catastrophic accidents.

After the FAA lifted the Max 8 and 9's grounding in November 2020, Boeing anticipated that both the Max 7 and Max 10 would be certificated by the FAA by the end of 2022.

That timeline was pushed back in November of last year, when Boeing said it expected to clear the Max 7 by early 2023 and the Max 10 in early 2024.

Now, the company is just hoping that the Max 7 will be certificated before the end of the year. "We are down to a handful of documents," Fleming says. "[We] expect to get those done in the near future, and to be able to present everything to the FAA to allow them to go do their job and push forward and certify this airplane."



Will the Max 7 be in service before the end of the year?

'Change in expectations'

Boeing cites new oversight requirements under US law as a major factor in certification delays. The Aircraft Certification, Safety and Accountability Act, passed by Congress in December 2020 in response to the Max crashes, places new requirements upon the FAA's certification process. The law also requires Boeing to provide far more technical documentation than under previous regulations.

Fleming describes a "change in expectations" and "differences of means of compliance" in the post Max-crash regulatory environment that have bogged down the process. Executives at other aircraft manufacturers, including business aircraft makers Textron Aviation and Gulfstream, have also cited heightened FAA oversight as forcing certification delays.

The yet-to-be-certificated Max 10 is being produced as an answer to the A321neo. Three Max 10 test aircraft have flown nearly 400 flights and 850 flight hours, Fleming says. "We have done just about everything we could do, [and we] are close to getting FAA approval to start flying certification flights.... The airplane itself is performing very, very well."

Boeing hopes to begin certification flights for the Max 10 this year and achieve an amended type certification in 2024, but that timeline could be pushed back.

"There have not really been any considerable technical issues

associated with the changes we have made to these airplanes which have created schedule problems for us," Fleming says. "It is really just about getting the documentation."

Boeing also has a widebody jet moving through FAA certification – the 777-9. As the only next-generation 400-seat jet poised to enter the market this decade, Boeing believes the opportunity is ripe for 777-9s to replace four-engine jets such as 747s and Airbus A380s, becoming the "large aircraft of the future".

Boeing has also repeatedly pushed back the 777-9's service-entry timeline, again citing increased regulatory scrutiny. It now expects the jet to be certificated in 2025, with deliveries beginning soon after. Boeing aims to deliver the first 777-8F in 2027.

Bracing for change

Although much of Boeing's attention is focused on certification struggles, the airframer is also turning toward the future of air travel.

Speaking to reporters at Boeing's 787 production facility on 30 May, Boeing chief executive David Calhoun says its next clean-sheet aircraft design – which is not likely to enter service before the mid-2030s – cannot be an "incremental" improvement over the 737.

He points to Boeing's partnership with NASA to develop the X-66A, a demonstrator of a truss-braced-wing narrowbody jet. Such a design

could help make the next generation of single-aisle commercial aircraft 30% more efficient. The conceptual aircraft is scheduled to begin a year-long flight-test programme in 2028.

"This transonic truss-braced wing is a very important technology to us as we go forward," Calhoun says. "We think we have a real shot at bringing that technology to bear on the next airplane."

"The technology allows for us not just to get more out of the wing aerodynamics but also the engine that sits under it, because it provides for a bigger bypass," he says. But the design would "not lend itself to something at the high end of seat capacity", Calhoun adds, seemingly ruling the technology out for use in future widebody jets.

Whether it adopts the truss-braced-wing design for the 737's eventual replacement, Boeing intends to apply its knowledge of carbon-fibre composites, gained through producing Dreamliners.

"We are simply going to continue to progress with the technologies that we have available to us," Calhoun says. "It is hard for me to imagine us not taking full advantage of everything we have learned on advanced composites.... I have no doubt that will play a pretty significant role."

The company is also developing advanced flight-control technologies for commercial aircraft, "including something as close to autonomous as we can conceivably get".

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Where Courage Meets Technology

Embraer's chief executive is targeting an ambitious growth in sales, as Brazil's aerospace champion emerges from the pandemic-driven downturn and a collapsed commercial aircraft pact with Boeing

Back stronger



E-Jet E2 family is attracting new customers around the world, with airframer targeting steady increase in its annual output

Craig Hoyle

Four years ago, Embraer participated in the Paris air show as a company readying for major transition, with its commercial aircraft business being prepared for sale to Boeing.

It also marked the first Le Bourget attendance for the newly arrived Francisco Gomes Neto, who in April 2019 had succeeded Paulo Cesar de Souza e Silva as the Brazilian airframer's chief executive.

Within months, Embraer had been plunged into twin crises.

"In early 2020 we had to face two problems. One was the drop in revenue because of the pandemic, but with costs much higher than usual, because we had duplicated a lot of resources internally to prepare the company for the carve-out of commercial aviation," Gomes Neto says. "And then they [Boeing] decided to pull the plug."

The parties remain in an arbitration process, with Embraer seeking financial compensation due to the impact of the US giant's abandoned action.

The pandemic and collapsed pact presented Embraer's new chief executive with the unenviable task of leading a business rationalisation

to stabilise the company and maintain its status as the third-ranked producer of commercial aircraft globally.

"I think we did a good job reorganising the company," he tells *Flight Daily News*, referring to its 'Fit for growth' programme, launched in mid-2020. "We adjusted the workforce, reducing by almost 4,000 people, and put in place a strategic plan. Since then we have been executing that plan with high levels of discipline."

The process also saw the company sell its Evora plant in Portugal, and rationalise its US industrial footprint to Melbourne, Florida.

"The period to 2022 was recovery," he explains. "From 2023 onwards, we see a growth period to capture Embraer's potential."

The company recorded a revenue of \$4.5 billion last year, and its expectation for 2023 is in the \$5.2-5.7 billion range – similar to pre-pandemic 2019. Meanwhile, its firm order backlog values some \$17.4 billion.

But Gomes Neto's ambition is to continually drive improved performance, having set a target to achieve a turnover of \$8 billion in 2027.

The pride of the company's product range is on show here,

including the largest of its E-Jet E2 regional jet family: the E195-E2. It also is exhibiting an A-29 Super Tucano military turboprop and two C/KC-390 transport/tankers: one from the Brazilian air force, and the programme's first export example, due for delivery to the Portuguese air force later this year.

Embraer has so far sold more than 2,000 E-Jets, after launching the E1 programme with a business target of 650 units. As of late-May, this sales total included 1,747 E1s and 270 E2s. Deliveries of the re-winged and re-engined E190-E2 and E195-E2 started in 2018 and 2019, respectively, and more than 70 examples of the Pratt & Whitney PW1900G-powered model have now been shipped.

Led by the unit's chief executive Arjan Meijer, Embraer Commercial Aircraft is currently running campaigns pursuing the potential sale of 200 E-Jet E2s. "We expect to close some deals this year, out of those 200," Gomes Neto says.

Opportunities include with airlines in need of replacing their E1-standard aircraft, plus more than a combined 1,000 ageing Airbus A319s and Boeing 737-700s which will leave use over the next few years. Embraer also is seeing increasing interest in a 100-150-seat

"crossover jet" market for regional aircraft to operate beneath carriers' narrowbody fleets. Recent examples have included E2 deals with Royal Jordanian, SalamAir and Scoot.

"Since I joined Embraer I have never seen so many sales campaigns in commercial aviation," Gomes Neto says. "The market is starting to come back for regional jets – with the exception of E1s, because of the pilot shortage in the US."

However, that situation could also soon change to the company's advantage, as it expects to secure a fresh wave of E175-E1 orders from US carriers. With there being no indication of potential changes to the scope clause agreements which restrict the operation of larger aircraft by these operators, work on the more efficient but heavier E175-E2 remains on hold.

Meanwhile, Gomes Neto notes that a major deal to supply Porter Airlines with 50 E195-E2s "might open some doors for us" in the North American market. The Canadian regional carrier took its first two of the 132-seat type last December.

"I hope the customers will consider the fact that to have more competition is good for them in the long-term," he notes.

Embraer's commercial aircraft

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At least eight nations are the subject of sales campaigns promoting the C/KC-390, first acquired by the Brazilian air force



Embraer

Shipments are expected to total 65-70 units this year – up from 57 in 2022. This will continue a steady recovery, having already climbed from 48 in 2021 and 44 the previous year. It delivered 89 E-Jets in pre-pandemic 2019 and 90 in 2018, and last achieved triple-figures – at 101 aircraft – in 2017.

“We are working to ramp up production to more than 100 [commercial] aircraft per year, as we did in the past,” Gomes Neto says. Embraer is targeting such an output around 2027-2028.

With international sales of huge importance to Brazil's aerospace champion – which generates 90% of its revenue from overseas – securing defence deals are also high on its agenda.

On the eve of the show, Embraer delivered the Brazilian air force's sixth of 19 on-order KC-390s, and has total commitments to supply 31 of the International Aero Engines V2500-powered type.

Making its international show debut, the first of five C-390s for the Portuguese air force is in the process of having its NATO-standard systems installed before service entry. Meanwhile, Hungary's first of two aircraft was in late May poised to achieve its power-on milestone, with its delivery slated for the first quarter of 2024.

And Embraer remains in negotiations with the Netherlands regarding NATO-standard updates to be implemented with its five jets, selected last year as replacements for aged Lockheed Martin C-130Hs.

Gomes Neto reveals that Embraer has active C/KC-390 sales campaigns with at least eight countries. Those understood to be interested include NATO member Romania, pending addition Sweden, and neutral Austria.

Interest in the twinjet has spiked due to the changed security situation in Europe following Russia's February 2022 invasion of Ukraine. And, Gomes Neto notes: “After the Netherlands' decision,

things have changed in our favour, because other European countries saw that.”

The company is well positioned to respond to the current high market interest, with its assembly line capable of completing 12-15 jets per year. “We just have to add resource, and the supply chain will improve in the next years, so this will not be an issue,” he says.

The C-390 also is being promoted in the Middle East via a partnership with the UK's BAE Systems, with Saudi Arabia as an initial focus. And a so-called Agile Tanker development is being offered to the US Air Force (USAF) with partner L3Harris. The platform is intended to support operations from dispersed and potentially austere landing strips located in the Asia-Pacific region.

Acting as prime contractor, L3Harris in March responded to a request for information, and the partners plan to conduct future flight testing of a KC-390 with a lightweight refuelling boom installed beneath its aft fuselage.

“We believe there are some supporters. Things are moving well, and we have the right partner,” Gomes Neto says. “If we succeed to sell a reasonable volume to the USAF, we would consider to do some assembly and production in the US, together with L3.”

Separately, Embraer expects to announce a first order for the NATO-optimised A-29N version of its Super Tucano later this year, having demonstrated the light attack turboprop to several alliance members, understood to include the Netherlands and Portugal.

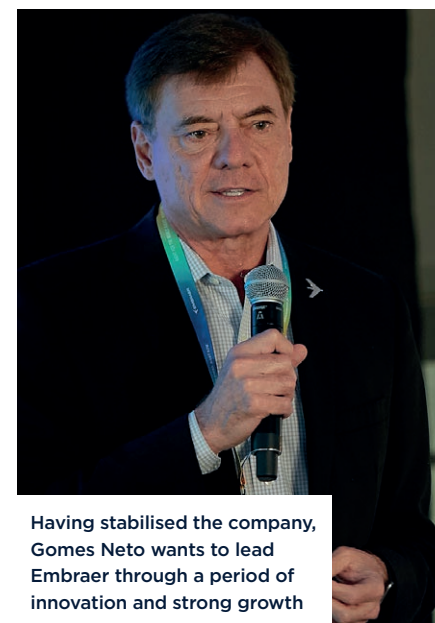
It also is supporting Latin American Gripen sales efforts led by Saab, with Colombia and Peru as near-term opportunities. “We are working very closely,” Gomes Neto says, confirming: “Embraer is a candidate to assemble the aircraft” for customers in the region. The company earlier this year opened a new final assembly line for the

Gripen E/F at its Gaviao Peixoto site, supporting output for the Brazilian air force.

Strong business performance also is expected from Embraer's Executive Jets unit, which is due to deliver 120-130 Phenom- and Praetor-series light and midsize business jets this year. It earlier this year secured a deal to produce up to 250 Praetor 500s for fractional ownership operator NetJets, and demand is so strong that it is currently offering new customers delivery slots from 2025-2026.

Gomes Neto notes that his \$8 billion turnover target “is with the existing products, excluding Eve [Air Mobility]”.

Embraer, which owns 90% of the electric vertical take-off and landing aircraft programme, span Eve out into a separate entity in late 2021. While the advanced air mobility sector is still in its gestation period, he points out that Eve has the largest volume of commitments in the industry, and a potential pipeline of business worth \$8 billion, with operations from 2026. “We are really progressing very



Having stabilised the company, Gomes Neto wants to lead Embraer through a period of innovation and strong growth

well. Our industrialisation plan is ready,” he says.

Eve is just one example of Embraer's current pursuit of transformational aerospace products.

“We want to be faster than the competition in innovation,” Gomes Neto says, “with roadmaps to integrate and accelerate technology maturity.” He cites focus areas as including zero-emission advances, artificial intelligence, data science and autonomous flight.

“We are working to have our products ready to fly with SAF [sustainable aviation fuel],” he adds, while its Energia project is exploring the potential of electric, hydrogen and hybrid propulsion. It also aims to have all its production facilities in Brazil running on 100% renewable electricity by 2024.

But having paused the development of a new family of turboprop airliners due to the lack of a suitable engine offer, their potential service entry has been pushed back from 2028 until the early 2030s.

Despite this, Gomes Neto believes the 70- and 90-seat aircraft, with quiet aft-mounted engines, two-by-two seating and large overhead luggage bins, “would be right to open new markets – even in the US”.

While Embraer could fund such a development effort alone, the required investment of around \$1.4 billion means it would prefer to do so with a partner.

Among other initiatives that will be pivotal to delivering growth are a major efficiency drive, which has seen Embraer work with automotive giant Toyota to find improvements to its production process.

The company is on a journey towards reducing its aircraft production cycle time by 30%, and a 17% improvement was recorded last year. It also is targeting cost reduction and an increased margin from sales.

Gomes Neto says detailed value stream mapping work is performed to identify areas of potential improvement. “Then we remove that waste and shorten the production cycle.”

“On some executive jets we have reduced the production cycle time by three or four months, and we have had good success on the EJs. As soon as the supply chain improves, we believe we can achieve our target of 30% on all aircraft.”

However, he stresses the critical importance of guaranteeing safety, quality and on-time delivery.

Separately, Embraer's boss also wants at least 20% of its senior leadership positions to be held by women by 2025 – this figure stood at 17% last year.

“I feel much more confident this time,” he says of his current Paris visit. “After four years I have had the opportunity to learn a lot, and to leave all the difficulties that we had.”

“Now at Embraer we have this ‘one team’ spirit. This helps a lot. We have all the plans under our control – it is much easier than it used to be with part of the company separate,” he says.

“We have a very modern and competitive portfolio of products, and even with the [supply chain] challenges that we have, we have a really bright future. We are really exiting the crisis much stronger.”

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The Embraer-founded eVTOL developer is closing on key supplier decisions as it looks to begin assembling a prototype this year ahead of a 2024 first flight

Eve of something big

Craig Hoyle

One of the front runners in the electric vertical take-off and landing (eVTOL) segment, Eve Air Mobility, is on track to fly a first prototype of its developmental aircraft next year, and to achieve service entry during 2026.

Outlining the developer's recent activities, Eve co-chief executive Andre Stein in late May said it was close to making main equipment supplier decisions, before commencing prototype assembly work in the second half of this year.

"We have been engaging with suppliers since the very beginning of the project - now we believe we are mature enough to actually select the suppliers," he says.

Eve also has already taken steps to de-risk its future production activities, with an industrialisation plan prepared following a collaboration with Porsche Consulting, which looked at factors including supply chain management.

Ground-based tests have recently been conducted on the eVTOL aircraft's lift and cruise propulsion system, which will employ eight rotors for vertical flight and two pusher propellers during wingborne operation.

Using a propeller rig, Eve says it assessed aerodynamic performance employing "multiple models to improve efficiency and reduce sound footprint and operating costs".

It also has evaluated the performance of the design's vertical lift rotors at flight transition speeds, by employing an adapted truck operating on the runway at Embraer's Gaviao Peixoto site in Brazil.

"The findings from the propeller

Stein says Eve's ability to draw on Embraer engineering talent helps differentiate it from many rivals



and truck-mounted rig [tests] are being used to increase the fidelity of the flight simulator and fly-by-wire system," Eve says. This work is also being supported with the results of windtunnel tests performed in the first quarter of this year by RUAG in Switzerland. Stein says simulator-based flights of the design also are helping "to develop our flight control laws".

Additional work has included completing the development of prototype urban air traffic management (ATM) software, in collaboration with Embraer's air traffic control subsidiary Atech.

Eve says it has been "conducting advisory groups with partners to ensure that [ATM] software development aligns with their needs", naming as examples Blade India, Ferrovia, and Halo Aviation.

It also hosted an inaugural infrastructure summit earlier this year, attended by 25 participants, including US regional and mainline carriers, helicopter operators and technology providers.

Stein notes that eVTOL operations will range from operations involving "a simple slab of concrete to a full vertiport with security screening".

Eve is 90% owned by Embraer, but was spun out into a separate entity by the airframer in late 2021. Stein notes that it is able to draw on its parent company's depth of engineering talent, which he argues differentiates it from other players in the eVTOL industry.

"Eve has around 150 people, and we have close to 300 engineers from Embraer engaged on the project right now - it is an advantage that we can flex that up and down," he says.

As of late May, Eve had secured letters of intent for up to 2,770 of its eVTOL aircraft.

"Today, we still have a very good cash position," Stein notes, with a series of successful financing rounds meaning that it has enough reserves to drive the programme through 2025.

The company's certification and entry into service objective is a

"realistic target", he argues, while noting that the company has held firm on its schedule, as multiple other developers who had been aiming to bring their products to market before Eve have extended theirs.

Flown by a single pilot, the Eve vehicle will be able to carry four passengers at service entry, while its capacity could later rise to six, if uncrewed operations secure approval. It should enter use with a range performance of 54nm (100km).

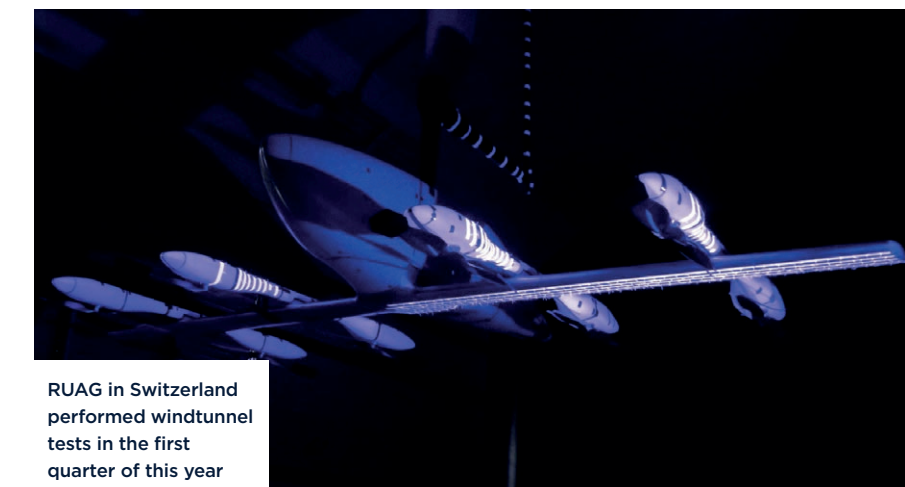
Key regulatory decisions have yet to be reached about eVTOL operations, such as around the level of experience that pilots will need to operate the platforms.

Eve is engaging with regulators in Brazil, Europe and the USA, and Stein suggests that the aircraft could be flown by trained helicopter or fixed-wing pilots, and also by those new to the industry.

"It's a fly-by-wire aircraft, so it's simpler," he notes. "You have a throttle and a sidestick, and fly a lot of the mission in the cruise."

Speaking during Embraer's pre-Paris air show media tour near Lisbon, Portugal, he suggested that new pilots could begin their careers by piloting AAM aircraft, before moving to fly with airlines at an entry level after gaining sufficient experience. "We can create a pipeline of new pilots," he says. "Some of our customers are really excited about that."

Eve is exhibiting its cabin mock-up at the Paris air show, and offering visitors an early "flight experience" via the use of virtual reality headsets. Stein will also be speaking at several related events about the eVTOL opportunity, including the ISTAT Sustainability Symposium, taking place in the French capital today.



RUAG in Switzerland performed windtunnel tests in the first quarter of this year

Eve has evaluated the performance of the design's vertical lift rotors at flight transition speeds, by employing an adapted truck



Ted Colbert says his goal for Boeing's sprawling military business is to reach traditional levels of revenue and annual growth, as he seeks to nurse challenged development programmes to health

BDS battling back

Ryan Finnerty

Just over a year into his role as chief executive of Boeing's sprawling military and space business, Ted Colbert's top priority is not a sleek new stealth fighter or prototyping an ultra-fast hypersonic missile.

Instead, Colbert gives an answer fitting for one who previously oversaw aircraft maintenance and parts delivery for the American aerospace giant.

"Our overarching priorities... are really driving stability, productivity and predictability into everything that we do," Colbert says.

When he took the helm at Boeing Defense, Space & Security (BDS) in 2022, Colbert inherited a business burdened by expensive, money-losing aircraft development programmes.

New jets such as the T-7A Red Hawk fighter trainer and VC-25B replacement to the USA's current Air Force One were hemorrhaging cash. Aggressively-bid, fixed-price contracts awarded before the Covid-19 pandemic were costing BDS billions, as price inflation, labour challenges and supply-chain delays triggered penalty charges from the Pentagon.

Another high-profile new aircraft programme, the KC-46 Pegasus tanker, has been plagued by engineering challenges and government-mandated redesigns to the refuelling boom and Remote Vision System.

Colbert acknowledges it has been a "tough couple of years" for BDS.

His focus since assuming the CEO position has been on finding ways to "de-risk" the programmes with high-profile challenges. This is being accomplished, he says, by focusing on the "fundamentals", including workforce proficiency, manufacturing competence and technology development.

Part of that process, Colbert adds, is taking a "realistic view of the world" when it comes to cost and delivery timelines, and then communicating that to customers.

"It reflects a baseline that is realistic, given where we're starting, but it also reflects a commitment, a commitment to continuous improvement," he says.

Getting to a more stable development and production state goes beyond just a matter of financial importance to Boeing, Colbert argues.

"Our ability to predict how well we will perform on our big, fixed-price



Colbert previously headed Boeing Global Services



The US government has mandated redesigns to the KC-46's refuelling boom

development programmes, and our enduring platforms, is of significant consequence from a global security perspective," he says, placing emphasis on the word significant.

The former head of Boeing Global Services also wants to return BDS to more "traditional" margins and revenue levels. In general, that means growth levels and margins in the high-single digits, the company says.

Despite their troubled beginnings, Colbert thinks programmes like the T-7 and VC-25B will be a part of that future growth. Boeing's developmental autonomous aircraft, including the MQ-25 Stingray

carrier-launched refueller for the US Navy (USN), will also play a significant role.

"These are all programmes that have tremendous potential in the long run," he argues. "We've just got to go through the process."

Defence programmes typically start with several years of low-margin engineering design and initial production phases, before transitioning to the more lucrative period of full-rate production.

"This is innovative work happening," Colbert adds. "So there's learning that has to happen."

Going forward, Colbert says BDS wants to make sure it has "the right

contracting profile in place" for all new programmes, in order to accurately reflect the cost and time that learning will require.

"It is ultimate transparency with the customer," he says. "Expected transparency from the supply chain, putting realism and experiential evidence and data into every estimate and programme plan that we have."

Colbert believes the approach, which he calls "starting right" will be key to putting Boeing's defence business on a more sustainable path.

"This is the way it gets done," he says. "When you start right, and you have a format and structure that that supports starting right, the probability of success goes up significantly."

Boeing will have no shortage of opportunities to apply that formula in the coming years.

Both the US Air Force and USN plan to acquire significant amounts of autonomous aircraft in the future decades. Boeing is off to a strong start in developing the nascent technology, both with its MQ-25 and the multi-role MQ-28 Ghost Bat being developed in partnership with the Royal Australian Air Force. BDS for the first time in May revealed it has brought an MQ-28 to the USA for testing.

The USAF envisions a prominent role for such pilotless jets, which the service is calling collaborative combat aircraft, as teamed assets for its Next-Generation Air Dominance (NGAD) initiative.

The USAF officially opened bidding on the sixth-generation fighter programme. Neither Colbert, nor his peers at the other US firms with experience developing stealth and fighter aircraft, are commenting publicly on their plans for NGAD.

"We continue to invest in areas of our business that are important to us across the spectrum," Colbert says, noting that includes investments in "next-generation fighters".

He specifically cites three new facilities in St. Louis, Missouri – where Boeing produces the latest F-15EX version of the venerable air superiority fighter – and a new advanced materials fabrication centre in Mesa, Arizona operated by the company's Phantom Works research and development unit.

"We are investing in the next generation of capabilities across the portfolio," Colbert says. "That will get us ready for any next big programme or requirement that comes out of the Department of Defense."

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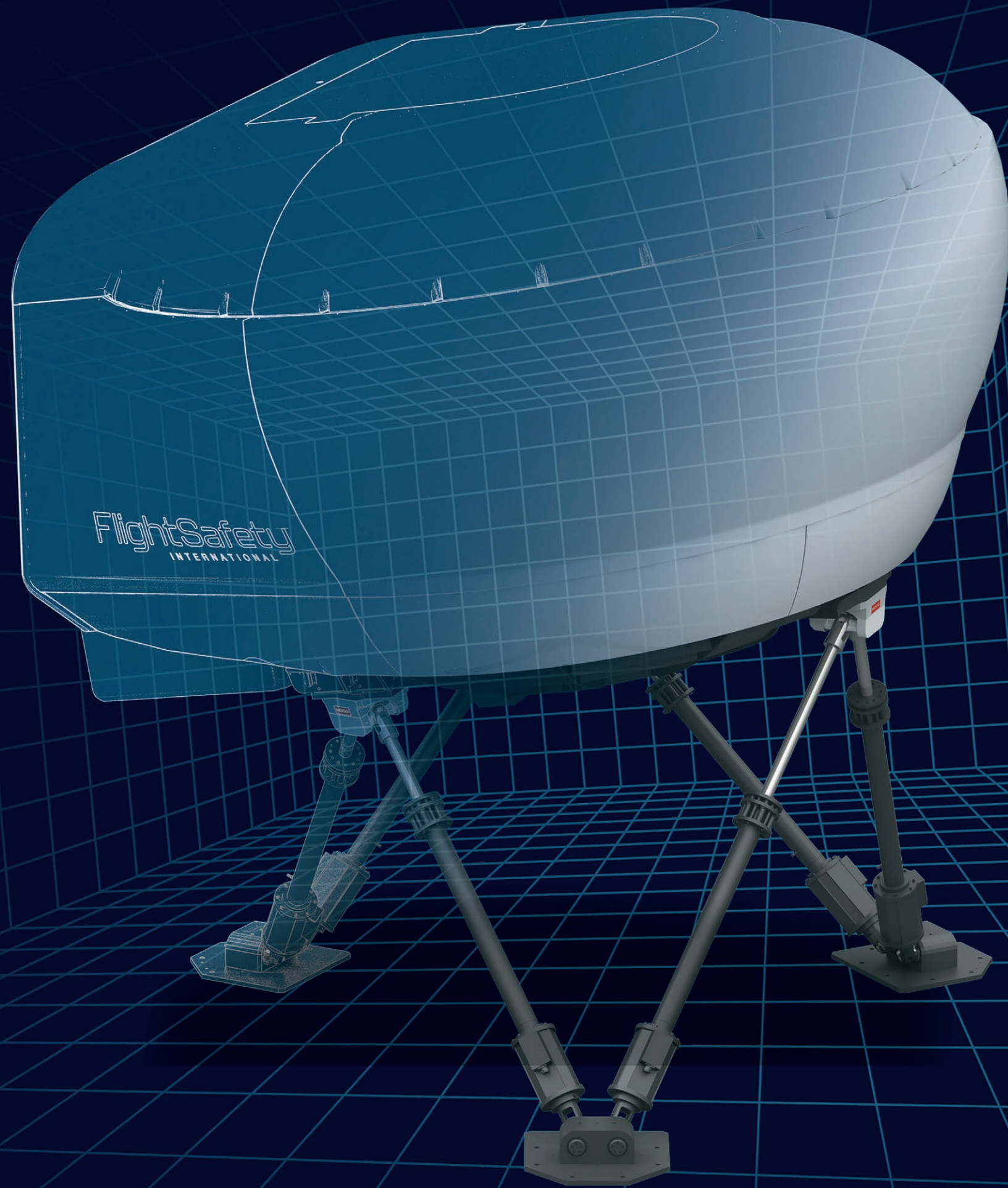
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Dassault is enjoying huge success with its ever-versatile fighter, with seven export customers having signed up for the type since 2015 and an additional domestic order on the near-horizon



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Rafale rising



The United Arab Emirates' 80-aircraft deal marks biggest international win for the French-built type

Craig Hoyle

After more than 20 years of operational duty, Dassault Aviation's Rafale has matured into a highly capable combat asset, and one which – after a decidedly slow start – is now enjoying strong international sales success.

Cirium fleets data shows that there were 243 Rafales in active use as of 25 April, with these operated by five nations: Egypt, France, Greece, India and Qatar.

During a bumper 12 months that the French manufacturer referred to as "a historic year", it in 2022 announced that contracts had come into effect with a trio of buyers

for a combined 92 Rafales. This total includes 80 for the United Arab Emirates (UAE), the first six of a planned 42 for Indonesia, and a further batch of six new-build examples for Greece.

Multiple customers

The company also delivered a combined 13 export aircraft to Greece, India and Qatar last year, along with the first French air force example since November 2018. A twin-seat variant, B359 is drawn from Paris's 60-aircraft fourth tranche production order, deliveries under which are due to conclude in 2025.

At the end of 2022, the Rafale's order backlog stood at 164 aircraft, of which 125 are for export

customers and 39 for domestic use.

Production output for 2023 is expected to total 13 units, all for the French air force, but Dassault is planning to boost this to a record rate of three per month by the middle of this decade, in order to keep pace with soaring demand.

Developed to meet French requirements, the twin-Snecma M88-engined Rafale is produced in three variants: the single-seat C and twin-seat B for air force use, and the aircraft carrier-compatible single-seat M. It was first flown as a technology demonstrator in July 1986, and in production guise from May 1991.

The French navy took its first M-model jets in December 2000, and placed the type into squadron

use the following year. It today has 41 in active service, with two more on contract and another 10 the subject of potential future acquisition.

Some 93 of the type are in French air force service currently, according to Cirium: 53 Bs and 40 Cs, with another 37 (6 Bs and 31 Cs) on order. Another two C-model fighters are recorded as stored.

To support the nation's frontline fleet, the DGA defence procurement agency's Essais en vol flight-test unit also operates a further five Rafales: three Bs, and single examples of the C and M.

And in a pending further boost for its already healthy backlog, Dassault expects to later this year sign a fifth tranche production



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order with France. To cover a total of 42 aircraft, these will help to keep the nation's industry busy until Paris begins purchasing the New Generation Fighter (NGF) being designed for France, Germany and Spain, with Dassault as the platform development lead. Operations with the new model are expected to commence from 2040.

Meanwhile, the Rafale's new F4.1 operating standard achieved qualification by the DGA in mid-March.

System updates

Capability updates include the ability to carry three Safran Electronics & Defense AASM 1,000kg (2,200lb) laser/GPS-guided bombs, sensor enhancements, and updated communications and cyber-

Gatar operates 36 examples, with options to double fleet



US Air Force

protection. It also has Thales's Scorpion helmet-mounted sight, plus fire control system enhancements which enable another Rafale to manage MBDA Meteor beyond-visual-range air-to-air missiles after launch.

"Operational experimentation by the [French] Air and Space Force and the French Navy began on 3 March," the DGA says, ahead of trials "during the spring" aboard the aircraft carrier Charles de Gaulle.

France's entire in-service Rafale fleet will be retrofitted to the new standard, which also will be used on new-build examples.

For many years following its introduction to domestic service - including participating in successful combat operations over Afghanistan, Libya and Mali - Dassault was unsuccessful in its

efforts to sell the Rafale to overseas customers. But that situation changed dramatically during the first few months of 2015.

In February of that year, Egypt announced a 24-aircraft purchase, with this first international success followed only two months later by a commitment from Qatar for the same number of jets.

Rapid delivery

Cairo's initial acquisition was split between 16 Bs and eight Cs. Deliveries rapidly commenced to the north African nation from July 2015, with Dassault diverting aircraft that had already been in production for France. Another 30 examples were ordered in 2021 for the Egyptian air force, in a mix between the two variants.

NGF project gaining momentum after faltering start

Four years ago, France, Germany and Spain used the opening day of the Paris air show to formally launch their joint Future Combat Air System (FCAS) programme, with Dassault Aviation also unveiling a conceptual full-size model of a New Generation Fighter (NGF).

The "sixth-generation" combat asset is planned to enter frontline use from 2040, replacing the partner nations' oldest Dassault Rafales and Eurofighter Typhoons.

During this week's show, the collaborative effort will again be a high-profile talking point, after what has been a somewhat faltering start.

An initial 18-month Phase 1A study activity kicked off in February 2020, but wrangling swiftly began with partner Airbus Defence & Space over Dassault's status as development lead for the NGF. This contributed to a significant delay of almost one year, until a Phase 1B agreement was finally reached last December.

Working in collaboration with Airbus's defence unit, Dassault will build the project's lone NGF prototype as part of the latest €3.2 billion (\$3.5 billion) phase of work. The aircraft is expected to make its first flight towards the end of this decade.

Lead role

Speaking to FlightGlobal earlier this year, Dassault chief executive Eric Trappier outlined the critical importance of his company securing the lead role on the manned fighter's development.

"The key question when you are developing a new product like this is that you need an architect, an organiser," he says. "If you have some kind of co-development, it doesn't mean anything. At the end, it is not about how many jobs can be created in one country, but the ability to deliver on time, and on budget."

However, with such discussions to be required in the future around issues such as workshare during series production, Trappier on 9 March cautioned: "The question of who is in charge has been resolved - but the question of whether it will work is still not resolved."

A contract for the programme's next, Phase 2 stage should be

finalised during 2025. The European FCAS endeavour also involves Indra as Spain's national industry lead, and EUMET propulsion system partners ITP Aero, MTU, and Safran.

Welcoming the official launch of Phase 1B, the partners said the project will deliver "a powerful, innovative and fully European weapon system to meet the operational needs of the countries' armed forces".

The NGF activity is just one of a swathe of new fighter projects under way around the globe.

A joint programme between Italy, Japan and the UK, the Global Combat Air Programme (GCAP) aims to deliver a manned Tempest fighter to enter frontline use in 2035.

Both GCAP and NGF will be accompanied by a range of complementary capabilities, including accompanying unmanned remote carrier or 'loyal wingman' vehicles, sophisticated precision-strike weapons and underpinning communication networks dubbed combat clouds.

Across the Atlantic, meanwhile, the US Air Force's secretive Next-Generation Air Dominance effort will deliver a sixth-generation successor for its Lockheed Martin F-22 air superiority fighter - and the US Navy also is looking beyond the Boeing F/A-18E/F Super Hornet - production of which will end for the service in late 2025 - as it works to define its future F/A-XX requirement.

Other high-profile national fighter development projects are currently under way in both South Korea and Turkey.

Korea Aerospace Industries has made rapid progress with its KF-21 since a first flight in July 2022. Five of an eventual six prototypes are now involved in a test campaign which has already achieved supersonic flight and the release of inert air-to-air missiles.

Turkish Aerospace, meanwhile, has been working for several years on its TF-X project, and formally unveiled the result of its efforts on 1 May, also naming the fighter Kaan.

Additional reporting by Murdo Morrison



New Generation Fighter design was unveiled at 2019's Paris air show

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Egypt became first export customer with an initial order for 24 Rafales in February 2015



Dassault Aviation

In March 2023, Dassault announced that Rafales had completed their first 10,000h in Egyptian air force service – the most accumulated so far by an export customer for the type.

“This important milestone confirms the Rafale’s technological and operational excellence, and attests to the quality of the training Egyptian crews received in France,” Dassault says.

Also citing the importance of its provision of in-service support, the manufacturer points to “the great skill of the Egyptian air force, which has carried out the transformation of its pilots and mechanics to the Rafale with ease and fluidity”.

Dassault’s second export buyer, Qatar, has now fielded 36 Rafales, having increased the scope of its original order via a 2017 deal for 12 more.

Deliveries to the Qatar Emiri Air Force began in February 2019, with the service now having 27 locally-designated EQ single-seaters and nine two-seat DQs. Doha – which has pursued an ambitious fighter expansion programme by also acquiring Boeing F-15QAs and Eurofighter Typhoons – has an option to eventually double the size of its French-supplied fleet.

Following the collapse of its keenly contested Medium Multi-Role Combat Aircraft (MMRCA) programme, through which it had selected the Rafale for a planned 126-aircraft acquisition, India in 2016 opted to buy 36 in a so-called “flyaway” condition. The original plan for MMRCA had been for Dassault to produce the first 18 in France, with a local partner to be responsible for assembling the remaining 108 in India.

“Following the Rafale contract, Dassault Aviation and its partners are also contributing to the ‘Make

in India’ policy, through a vast procurement, training and industrial subcontracting network involving dozens of companies, in accordance with our offset obligations,” the company says.

The Indian air force’s first five examples arrived at Ambala air base in July 2020, and the type was formally inducted to service late the same year. It now fields 28 Rafale Cs and eight Bs, with these assigned to two squadrons.

In a potential further opportunity for Dassault, the Indian air force retains a need to acquire additional new western fighters, but New Delhi has yet to advance this to a formal request for proposals. Other potential candidates include the F-15, Eurofighter Typhoon, Lockheed Martin’s F-21 – an Indian-optimised version of the F-16, and the Saab Gripen.

Naval requirement

Dassault also is pursuing an Indian navy requirement to acquire 57 carrier-based fighters. At the Aero India show in Bengaluru in February

2023, it exhibited a Rafale M mock-up, as it eyes the potential to land its first international buyer for the ‘Marine’ model.

Boeing’s F/A-18F is also in contention for an order, which could potentially represent the last success for the type before its manufacturer halts production. The US airframer earlier this year announced that it will deliver its final Super Hornets in 2025, but noted that success with an international customer could extend this schedule by up to a further two years.

Dassault’s rival is pointing to several claimed advantages with its Super Hornet design. These include its two-seat configuration – a stated requirement for the Indian customer – and an ability to fit on lifts on current Indian navy vessels. Both the Rafale M and US type have already demonstrated ski-jump ramp take-offs during trials at a land-based facility in Goa.

“We will do everything in our power to develop our industrial presence in this great country and meet its military needs, both today

and for the future,” Dassault chief executive Eric Trappier said ahead of the Aero India show.

Another export buyer, Greece, in September 2020 sealed a rapid acquisition of 18 Rafales, with its purchase divided between a dozen used jets drawn from French air force stocks and six new jets. Its first six of the second-hand assets – to be replaced in the French air force with new-build examples – were transferred to Tanagra air base in January 2022, and it has now received a total of 13: nine Cs and four Bs.

Athens in March 2022 signed for another six new-build Rafales, with these due for delivery from mid-2024.

Another transfer deal had been signed in November 2021, meanwhile, with Croatia also to acquire a dozen ex-French air force fighters.

Zagreb will take eight aircraft next year, with the remainder to follow during 2025. The type will replace the NATO nation’s remaining Mikoyan MiG-21s.

But Dassault’s biggest success to date with the Rafale came in December 2021, when the UAE announced a shock 80-unit order. Its commitment was revealed one month after a Dubai air show that had been dominated by talk of the Lockheed F-35 and developmental RAC MiG-75 Checkmate.

Valued by Paris at €16 billion (\$17.5 billion), the UAE deal came into effect in April 2022, on the receipt of an initial contractual payment from Abu Dhabi. Deliveries of its F4-standard aircraft are scheduled to run between 2027 and 2031.

The UAE’s acquisition includes an extensive armaments package worth an estimated €2 billion, with Europe’s MBDA to be the main provider.



India’s air force has 36 B/C-model fighters, flown by two squadrons

AirTeamImages

IAI’s Unmanned Aerial Systems Set New Standards in ISTAR Operations



Heron TP | Credit: IAI

Since their introduction, Unmanned Aerial Systems (UAS) have firmly established their role in modern warfare, initially as intelligence and reconnaissance collection tools and subsequently as Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) systems.

Israel Aerospace Industries (IAI) has been at the forefront of unmanned system development for over forty years. Currently, the company offers a broad spectrum of unmanned systems, ranging from the giant, more than five-ton HERON TP, HERON Mk2, and HERON 1 Medium Altitude Long Endurance (MALE) UAS solutions down to tactical, mini, and micro UAS used in aerial, land and naval applications. The latest models from IAI, built upon its rich heritage of over 2,200,000 UAS operational flight hours globally, adhere to NATO standards such as STANAG 4671, a military airworthiness standard enabling operation in civilian airspace, a process successfully completed in 2022.

The HERON family is a highly efficient platform for Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) missions, boasting the ability to operate multiple sensor payloads simultaneously. These payloads mounted on the fuselage, booms, and wings collect real-time reconnaissance, surveillance, and intelligence data over large areas. The Heron can carry large, specialized sensors allowing long-range standoff reconnaissance and wide-area persistent surveillance. Synthetic Aperture Radar (SAR), Electronic Intelligence (ELINT), and Communications Intelligence (COMINT) capabilities further enhance surveillance and intelligence gathering.

Control of such a multifaceted system is complex. With its extensive experience, IAI has simplified this task by creating an intuitive, mission-focused control system for its Unified Control System (UCS), the standard control system for the HERON family. UCS automates all the operator functions through all mission phases and controls different platforms, flight systems, and payloads via an intuitive touchscreen interface. Its modular design supports various configurations for tactical deployment in armored vehicles, maritime, and airborne platforms, allowing a single operator to control a UAS or larger crews to handle complex missions.

In addition to the UCS function in flight control, the system provides dedicated

resources for mission control. IAI has pioneered unique autonomous mission systems to provide situational awareness and assist human operators, such as the ELS-8994 STARLIGHT. This next-generation cloud-based Multi-INT analysis system offers decision support tools for UAS operators. STARLIGHT employs artificial intelligence, machine

learning, and video processing tools to filter, assess, and analyze all data sources delivered by the UAS. It provides a mission-specific situational overview, delivers critical alerts, and conducts predictive analytics based on big data mining and analytics on time-sensitive targets and threats. The system also produces target sets and performs intelligence analysis utilizing GEOINT and multi-modal ISR. The data collected can be broadcast to individual users via IAI’s data dissemination tools, such as the Commander’s Remote Imagery Situation Picture (CRISP).

In summary, IAI’s progressive advancements in UAS technology are leveraging the advanced capabilities of the HERON family UAS, the multitude of payloads they operate, and the STARLIGHT system that exploits those data streams in real time by integrating cutting-edge AI and machine learning technologies. These systems provide invaluable situational awareness, comprehensive mission control, and enhanced data analysis – the essential capabilities the modern warfighter needs.



Starlight | Credit: IAI ELTA

Last year also brought confirmation of a planned Indonesian air force acquisition of 42 Rafales, with the first six aircraft having been placed under contract in February 2022. This saw Jakarta confirmed as the first Asia-Pacific buyer, becoming Dassault's seventh export customer for the type.

Indonesia is currently spending big on new-generation fighters,

with its shopping list also including the F-15IQ and Korea Aerospace Industries KF-21 designs.

Long heritage

While Dassault's international successes to date have in some instances formed part of broader defence equipment packages promoted by the French government, the company is quick to point out that it has a decades-long heritage in providing equipment to multiple customers that are now moving to the Rafale.

Notably, Egypt, Greece, India, Qatar and the UAE all are current users of its Mirage 2000-series fighter, while the Egyptian air force also still flies the older Mirage 5.

Dassault notes that the Indian air force has operated its aircraft since 1953, making the service its "longest standing export customer".

Croatia and Indonesia are the only buyers to date for the Rafale to have not previously relied on a Dassault product for their combat air power.

Other current sales targets include Colombia, Trappier confirmed earlier this year.

Analysis of the current in-service fleet shows that there are 90 Rafale



There are 90 Rafale Bs currently in service, representing 37% of the total inventory

Bs in service, representing 37% of the 243-unit total. The single-seat C is the most widely employed variant, with 112 aircraft, or 46%. The maritime M-model – operated only by the French navy – accounts for the remaining 17%, with 41 aircraft in use.

A total of five Rafales have been lost to accidents since its operational introduction: four French navy Ms and one French air

force-operated B.

With its seventh export customer now in formation, a new operating standard to deliver enhanced capability for the French military and international operators, and an already healthy backlog that is set to grow further this year, Dassault's Rafale programme will remain fighting fit until its successor NGF enters use.

Rafale active fleet

Nation (service)	Active	Ordered
Croatia		12**
Egypt	24	30
France (air force)	93	37+84*
France (navy)	41	2+10*
Greece	13	11
India	36	
Indonesia		6+36*
Qatar	36	36*
United Arab Emirates		80
Total	243	164***

Source: Cirium fleets data (as of 25 April)
 Notes: *pending confirmation, **ex-French air force aircraft, ***firm backlog at end of 2022

How 'Rastaban' mission tested Rafale M's endurance

French navy deployment from *Charles de Gaulle* aircraft carrier saw a trio of jets cover 2,160nm nonstop, ahead of joint exercise in Singapore

Greg Waldron

Early this year, a trio of Dassault Aviation Rafale Ms completed the longest-ever operational mission undertaken by French navy combat aircraft, dubbed 'Rastaban'.

After launching from the aircraft carrier *Charles de Gaulle* in the western Indian Ocean, the single-seat 'Marine' fighters staged a nonstop, 2,160nm (4,000km) flight to Paya Lebar air base in Singapore in late January. Their mission was supported by a French air force Airbus Defence & Space A330 multi-role tanker transport.

"The Rastaban manoeuvre is the furthest projection that the French navy has ever conducted from the sea," says Rear Admiral Christophe Cluzel, who commanded the French Carrier Strike Group (CSG) which was headed by its lone such vessel.

"It proves how much the Rafale Marine operated by the French navy is reliable to operate from the sea, in a large carrier strike group's operation area as well as much further, with partners far beyond the CSG horizon," Cluzel notes. The recent naval deployment also involved operations in the Mediterranean Sea and Red Sea.

French naval airpower places a high priority on working with allies, and during the recent deployment this included co-ordinating with the US Navy's (USN's) Nimitz-class carrier USS *George H.W. Bush*.

"Cross-deck" work saw Rafales landing and taking off from the USN vessel, and Boeing F/A-18E/F Super Hornet fighters and Grumman C-2 transports conducting flight operations aboard *Charles de Gaulle*.

"We are used to operating with US carrier strike groups because we share the same expertise and our pilots are trained in the US," Cluzel notes.

Following their arrival, the Rafale Ms participated in exercises with the Republic of Singapore Air Force (RSAF).

"Flying with our RSAF friends is a proof of the high level of trust and interoperability that links Singapore and France," says Cluzel.

The Rastaban activity represented the second visit by French-operated Rafales to Singapore within several months. In September 2022, three French air force examples visited the island state as part of Mission Pegase: a major French deployment to the region that also included participation in Australia's Pitch Black exercise.

During their stay in Singapore, the Rafale Ms were supported by a logistics team sent from the type's home base at Landivisiau in northwestern France.

"We have to thank these guys and all the technicians working on the carrier," Cluzel says. "Their dedication and expertise allow us to launch our aircraft daily. There are also other jobs involved in this manoeuvre, of course, and crew spirit plays a strong part in this shared success."

Cirium fleets data shows that the French navy has 41 Rafale Ms in active use, with the type capable of deploying the MBDA ASMP-A missile from *Charles de Gaulle* as part of France's nuclear deterrent.

Speaking to FlightGlobal in Singapore, Cluzel also offered some insights into the future air wing of France's next aircraft carrier, which is likely to replace *Charles de Gaulle* in the late 2030s.

Initially, an advanced version of the Rafale and the Northrop Grumman E-2D Advanced Hawkeye airborne early warning and control system aircraft will fly from the ship. Later, the air wing will incorporate the New Generation Fighter to be developed via the French-German-Spanish Future Combat Air System programme, which will be fully integrated with unmanned 'remote carrier' loyal wingman assets.

'Cross-deck' work saw Rafales launched from *Charles de Gaulle*, along with the US Navy's USS *George H.W. Bush*



Carrier-based fighters touched down at Paya Lebar air base

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The chief executive of Lockheed Martin says the company is seeing strong demand for existing programmes like the F-35 and F-16, plus healthy potential for new products amid a defence spending boom

Ryan Finnerty

Despite continued supply chain headwinds, and the recent loss of the multi-billion-dollar contract to provide the US Army's next vertical lift platform, the chief executive of defence heavyweight Lockheed Martin is bullish on the coming year.

Lockheed Martin is now producing F-16 fighters at plant in Greenville, South Carolina. The military airframer has a backlog of 127 aircraft in its F-16 programme, with interest growing around the world. "I think we're in a real strong position at this point," James Taiclet said on 1 June at the annual Bernstein Research Strategic Decisions Conference, citing the US government's plans for military spending in 2024.

The recent \$886 billion Pentagon budget request from the Biden Administration represents a 3.3% increase in defence spending from the previous year.

Taiclet, who was formerly a US Air Force pilot, notes the fiscal year 2024 presidential budget request includes funds for 83 Lockheed Martin F-35 stealth fighters, slightly above the company's target level needed to maximise annual production.

"That's the level we need," Taiclet says. "We don't need to ask for more production aircraft to fill the factory."

Lockheed produced 141 of the advanced single-engine jets in 2022. The company has a goal of churning out 156 F-35s annually by 2025.

Taiclet notes the remainder of that yearly target will come from foreign orders, as US allies such as Poland prepare to receive their first F-35s. Lockheed's closing in on the long-term F-35 production target comes as interest is surging in another single-engine fighter the company makes: the F-16 Fighting Falcon.

"You see things in the news about the F-16, it's very relevant," says chief financial officer Jay Malave.

Company officials often refer to the latest Block 70/72 as a "4.5-generation fighter" - citing the advanced sensors, software and weapons with which the fourth-generation airframe has been upgraded.

Turkey is seeking to acquire 40 of the type, albeit thus far unsuccessfully. Firm orders have been logged from Eastern Europe, the Middle East and Asia in recent years.

Malave says Lockheed currently has a backlog of 127 F-16s, with expectations of a further 20 orders by year end. The company is well positioned to meet the renewed demand, having in January flown its first Falcon from a new production line in Greenville, South Carolina.

Developments have not all been positive, however. In April, government auditors denied a Lockheed challenge to the US Army's selection of Bell to design its



An F-35 bound for Denmark is moved through final assembly at Lockheed Martin's production line in Fort Worth, Texas

Fighting fit

Future Long-Range Assault Aircraft, over a proposal from Lockheed-subsubsidiary Sikorsky.

The army estimates the deal will be worth upwards of \$70 billion dollars over several decades. Malave says Lockheed had been expecting some \$4 billion in revenue for Sikorsky from the FLRAA contract over the next five years.

While executives are optimistic that overseas sales of the Sikorsky UH-60 Black Hawk and the maturing Sikorsky CH-53K heavy-lift programme will soften the blow, Malave notes that Lockheed as a whole has already been able to cancel out the revenue loss through higher-than-expected sales of precision munitions.

"It's more than offset the impact we had from the FLRAA loss," Malave says.

Fuelled by the Russia-Ukraine war, demand for rocket artillery and air defence systems has surged in the USA, Europe and the Indo-Pacific. Lockheed's ultra-precise High-Mobility Artillery Rocket System has been lauded for its performance in Ukraine.

The company's PAC-3 interceptor missiles have also proven effective in Ukraine, where they are fired by the Raytheon Patriot air defence batteries. Kyiv in May claimed to have shot down a Russian Kinzhal hypersonic using a Patriot system.

Malave says Lockheed expects to reap an extra \$6 billion in revenue through 2027 from the boom in precision munition sales - \$2 billion more than the expectations for FLRAA, he is quick to note.

The company also has its own hypersonics development efforts underway, which Taiclet calls "an incredibly challenging technology". The USAF plans to wind down Lockheed's effort at developing the Air-launched Rapid Response Weapon, after the hypersonic cruise missile suffered a failed test in March.

The company is separately under contract for other offensive hypersonic weapons programmes, a concept called the Hypersonic Air-breathing Weapon Concept being developed with DARPA and the joint army-navy Conventional Prompt Strike boost-glide missile.

Unlike ballistic missiles, with their easier-to-predict parabolic trajectories, Taiclet says "true" hypersonic missiles are defined by the ability to "manoeuvre at the end of their flight path", in addition to reach speeds of Mach 5 and above.

"We will continue to do the move-counter-move development of understanding how hypersonic missiles can be manoeuvrable and what we need to do to intercept them," Taiclet says of the effort to defend against the ultra-fast weapons.

Perhaps the greatest opportunity of all is the USAF's secretive sixth-generation fighter development initiative - the Next-Generation Air Dominance (NGAD) programme.

The service officially began accepting design proposals for the programme in May, in what is expected to be a so-called "family of systems" worth many billions of dollars over several decades.

Although defence industry executives are remaining tight-lipped about their participation in the effort, Lockheed, Boeing and Northrop Grumman are all considered contenders.

Lockheed is the only American company building crewed stealth fighters, while Northrop is producing the USAF's next-generation B-21 stealth bomber - which Northrop describes as the world's first sixth-generation aircraft.

Boeing is the country's only other provider of fighter aircraft - with the F-15EX, F/A-18 and EA-18G.

Taiclet notes Lockheed has a long history of success developing combat stealth aircraft, including the fifth-generation F-35 and F-22 air superiority fighter.

"Our Skunk Works operation is famous for stealth," Taiclet says of Lockheed's secretive technology development unit that produced the world's first stealth aircraft - the F-117 Nighthawk.

"Both the shape of the aircraft - the outer mold line of the aircraft - and the surface coatings and infrared coatings on the engine inlet and tailpipe are really, really critical," the CEO notes.

"We invest a lot, and we have the main operations cohorts that can deliver on those technologies," he adds, indicating Lockheed is positioning itself for an NGAD bid.

The USAF is expected to make its choice for the sixth-generation fighter and award an initial development contract sometime in 2024. ▶

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An elevation of 259.08 meters (850 feet). A flight time of 42 to 45 seconds. And an ordinary egg, unscathed. That is the criteria that teenagers from France, Japan, the United Kingdom and the United States will try to hit during this year's International Rocketry Challenge at the Paris Air Show. Raytheon Technologies, now RTX, is a longtime sponsor of the competition and the American Rocketry Challenge - a reflection of the company's commitment to promoting STEM education.

"One of the remarkable aspects of the International Rocketry Competition is how it encapsulates everything it is to be an engineer - designing to specific requirements, testing, redesigning, collaborating, even presenting your work to others," said Pam Erickson, chief communications officer of RTX. "That's what makes it such a great fit with our efforts to secure the STEM workforce of the future." During the competition, teams will fly rockets they designed, built and tested themselves. The

rules require a payload - in this case, an egg - to be entirely enclosed within the rocket and to return from flight without cracks or external damage. Part of each team's score comes from a presentation before a panel of judges - a chance for participants to practice explaining their work and design choices. Team Japan (standing, left, in white coats) won the 2022 competition, marking the first victory for an all-female team since the challenge began in 2015. ▶



Evolutionary technology could be key to helping the industry meet its carbon reduction targets. GE Aerospace and its CFM International affiliate are at the forefront of efforts to deliver improvements

Jon Hemmerdinger

Engine makers are quick to note that their newest turbofans are significantly more efficient than those they replace. Perhaps so, but the old adage "What have you done for me lately?" still rings true, evidenced by government and public demand for next generation airliners to deliver a revolutionary efficiency bump. For an industry that historically achieves perhaps 15% better efficiency with each aircraft generation, "revolutionary" does not mean the next narrowbody jets, expected in the 2030s, will be buzzing around on battery power. But the aerospace industry does have ambitious goals: for those aircraft to be 20-30% more efficient than today's Airbus A320neos and Boeing 737 Max.

"I think we are on track to deliver more than 20% [additional] fuel efficiency. That is just the propulsion system. The aircraft would add on that," says GE Aerospace general manager of advanced technologies Arjan Hegeman. "The remainder of this decade is going to be filled with demonstrators to ensure the maturity of all those technologies."

NASA is backing industry efforts through various projects, including its Sustainable Flight National Partnership, under which it and Boeing are developing a truss-braced-wing demonstrator. But to get close to a 30% CO2 reduction, engine makers like GE Aerospace and Pratt & Whitney (P&W) must deliver.

Hegeman says GE Aerospace and affiliate CFM International are pursuing a three-prong approach toward the 20% target: developing an open-fan engine, working to shrink engine cores and advancing the state of electric aircraft systems. "There are 400 to 500... tests in our plan," Hegeman says. "On any given day we have 20 or 30 of them running."

Many of those tests involve the open-fan engine that CFM (jointly owned by GE Aerospace and Safran Aircraft Engines) is developing under its Revolutionary Innovation for Sustainable Engines (RISE)



programme, launched in 2021. Considering technological change comes slow as molasses in the aviation industry, open-fan engines are fairly radical. They are similar to traditional turbofans except in one glaring way: their fans are not enclosed in nacelles, but rather spin freely in the outside air.

Ditching nacelles means less weight and drag, providing an immediate efficiency bump, says Hegeman. But also, without bulky and restrictive nacelles, engineers can give open-fan engines wider fans (and hence greater bypass ratios), which improves efficiency - all without increasing overall width.

Such designs are not new. GE Aerospace test flew such an engine in the 1980s but shelved the effort as fuel prices declined. Open fans have also been stymied by their propensity to be screaming loud and due to the risk that, because they lack containment rings, engine failures could fire components into passenger cabins.

But Hegeman says GE Aerospace and its partners have solutions. "Our computing capability has

massively increased [to] where we can now be so exact and precise in our analytic predictions," he says. "We have been able to optimise those airfoil shapes to get sound levels below today's narrowbody engines".

He says armoured aircraft fuselages can mitigate failure risks and that composite fan blades are exceptionally durable. CFM aims this decade to begin flight testing its open-rotor demonstrator with support from Airbus, using an A380.

GE Aerospace and P&W, a Raytheon Technologies subsidiary, are also each working to squeeze more power from smaller turbofan cores. They both won contracts under NASA's Hybrid Thermally Efficient Core (HyTEC) effort to develop a smaller engine with a 15:1 bypass ratio that burns 5-10% less fuel than today's turbofans. It also seeks to extract 10-20% of the engine's power as electricity - enabling expansion of electric systems.

NASA hopes to begin HyTEC ground demonstrations around 2026 and to have such technologies ready for prime time in the 2030s.

The companies are also creating hybrid-electric propulsion systems with megawatt-class electric motors, which could potentially be fitted to regional turboprop aircraft or mated to turbofans on larger jets.

Raytheon subsidiary Collins Aerospace has been developing a megawatt-class hybrid-electric system for testing in partnership with Pratt & Whitney Canada and De Havilland Aircraft.

That effort involves fitting the system on a Dash 8 turboprop. P&W is also working under a European Union project to develop a hybrid-electric modification of its geared turbofan.

GE Aerospace, meanwhile, is conducting its hybrid-electric work partly through NASA's Electric Powertrain Flight Demonstration (EPFD) programme, which the agency hopes will culminate in new electric systems entering service no later than 2035.

Progress is being made, with GE Aerospace having tested its megawatt-class hybrid-electric system at simulated altitudes up to 45,000ft. The company expects in the mid-2020s to begin ground and flight tests using a Saab 340B turboprop.

Additionally, GE Aerospace in May disclosed plans to invest \$20 million to expand its hybrid-electric testing capabilities.

Hegeman stresses that technologies under development by his team would be capable with engines burning either hydrogen or sustainable aviation fuel (SAF) - both of which have been garnering recent hype as potential solutions to aviation's emissions problems.

"To top it all off, all this is agnostic to the energy source, whether hydrogen or SAF," he says.

The aviation industry has been leaning heaviest on SAF, which is typically a biofuel, as its saviour. That, despite SAF remaining prohibitively expensive, largely unavailable due to meagre production volumes, and having debatable environmental benefits.

The viability of hydrogen also remains unclear. Though Airbus has pitched development of hydrogen airliners entering service in the 2030s, Boeing has held back.

Hegeman is likewise more sceptical of hydrogen. "We are not that far along on [the hydrogen] journey... Hydrogen is the least mature and has the longest way to go," he says. ▶



With a first set of projects under way, EU-backed Clean Aviation is thinking about next steps, including an eventual flight-test campaign, as it looks to help aviation meet ambitious decarbonisation goals

Green shoots



Airbus's ZEROe programme will require many of the technologies being matured by Clean Aviation

Dominic Perry

It has been a busy few months for Axel Krein, executive director of Clean Aviation – the EU's research and innovation body helping to fund commercial aviation's drive towards net-zero by 2050.

Back in September 2022 it announced the first 20 projects selected to share €654 million (\$721 million) under the programme's first phase, with initiatives officially kicking off in January.

Then in February this year Clean Aviation launched its second call for proposals as part of its phase one activity, and in April there was the small matter of a two-day

conference in Brussels – described by Krein as “our best yet”.

There is a sense, particularly given the often-slow pace of change in both aerospace and a notoriously bureaucratic body like the EU, that events are moving quickly.

The first “deliverables” from the two-score Clean Aviation projects are due by mid-year, and will be followed by the organisation's initial annual report in December.

Second call

In the meantime, it will also have allocated over €137 million to projects selected under its second call. Those proposals, designed to fill in any gaps left over from the first round, will be evaluated before

the summer break and recipients selected before year-end, to enable them to kick off in January 2024.

And then there is the organisation's all-new High Five Awards, which will be presented to “five trailblazers revolutionising the future of climate-neutral aviation” at a 20 June ceremony at the Paris air show.

Several things appear to be behind the rapid shift in gear: the sheer scale of the challenge; the short, three-year duration of most phase one projects; and, arguably, Krein himself. Even on our video call he projects an air of drive and enthusiasm, delivering answers in an animated rapid-fire staccato. On balance he has much to be

excited – if not nervous – about. Those initial 20 projects, each delivered by a consortium, involve 244 participants: a mix of industry, aerospace research institutes like Germany's DLR, and universities. And among those 244 entities, 52 are new to Clean Aviation and its Clean Sky predecessors. “It's important to bring in companies from outside the known spectrum that might have competencies or expertise we can benefit from,” says Krein.

As you would expect, those companies are drawn from across the EU, essential to ensuring continued bloc-wide political support. There are even 20 companies from the UK involved

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Newborn

A rarity among Clean Aviation projects for its lack of a snappy acronym, Project Newborn will culminate in 2026 with ground tests of a 1MW liquid hydrogen fuel cell powertrain. Led by Honeywell Aerospace from its facility in Brno, Czech Republic, the consortium includes 18 entities from 10 different countries – including the UK.

Although the system will only be taken to TRL 4 – or TRL5 for most components – Honeywell insists the programme is focussed on eventual commercial applications, not just building a demonstrator.

Key to that is the company's pre-existing work with consortium member Pipistrel Vertical Solutions – part of Textron since April last year – to drive understanding of what would make a system commercially viable. Additionally, having an airframer as part of the project could ease the transition to flight testing under Clean Aviation's second phase.

Other partners in Newborn include Aciturri of Spain, which is building the system's cryogenic hydrogen storage tank, Sweden's PowerCell, which is providing aviation-optimised fuel cell stacks, and Germany's Fraunhofer Institute, supplying high-power-density electrical systems. Additionally, the consortium includes two members from the UK: the University of Nottingham will deliver a high-power-density electric motor, and Reaction Engines its heat-exchanger technology.

Honeywell says the technology being developed is scalable to provide up to 8MW of power – suitable for a future regional aircraft.



Clean Aviation

“It's important to bring in companies from outside aerospace with expertise we can benefit from”

Axel Krein Executive director, Clean Aviation



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— although due to post-Brexit complications, none can lead projects and funding is provided by the UK Research & Innovation body rather than Clean Aviation.

Clean Aviation's projects are grouped into three broad aircraft-based workstreams – or “thrusters” as Krein calls them – hybrid-electric regional, ultra-efficient short-medium range (SMR), and hydrogen-powered. There is additionally a fourth “transversal” strand, with projects looking at certification requirements and how individual technologies will interact on conceptual regional and SMR aircraft designs.

By the end of phase one, ground testing of the systems under development will be complete, having been taken to technology readiness level (TRL) 4 or 5. Phase two, planned to kick off in 2026, will see some but not necessarily all of those projects selected to proceed to extensive ground or flight testing, with the aim of achieving TRL6 by 2028 or 2029. Sticking to that timeframe is

key if the products or systems being matured are to be selected for a next-generation aircraft with a service-entry target of 2035.

The EU is providing a total budget of €1.7 billion – split between around €800 million in phase one and €900 million in phase two – with industry's contribution mandated to be at least 1.5 times that figure. However, Krein says that so far the private sector's contribution is significantly higher.

While the ratio is higher than that seen in the Clean Sky programmes, Krein is not astounded at the private sector's willingness to invest.

“It's no surprise because now we are entering into what I call the window of opportunity. Those new aircraft are so imminent. There is such an urgency to put those new aircraft into the market that the effort from the private side is huge,” he says. “There is a huge pull and push demand from society, from politics, from everyone.”

On top of this, new technologies are “becoming available” and there is a “huge appetite now to go for it

and to make them work”, he says.

A crucial aspect of Clean Aviation's approach is that it is not focussed on one single technology, even within a broader strand of research. Take the ultra-efficient engines under consideration for the SMR aircraft, where three distinct designs are being researched by consortia led by MTU Aero Engines, Rolls-Royce Deutschland, and Safran Aircraft Engines. Respectively, these are SWITCH (a water-enhanced turbofan concept), HEAVEN (an evolution of R-R's UltraFan architecture), and OFELIA (an open fan engine). As well as offering a substantial reduction in fuel burn, the three engines should also be capable of running on sustainable aviation fuel (SAF) or hydrogen.

Consuming a substantial part of the phase one budget – the OFELIA project has been awarded €100 million alone – the trio are “really core parts” of the SMR thrust, Krein says. While the propulsion architectures under consideration all appear promising – and in the case

of HEAVEN and OFELIA build on work carried out under Clean Sky 2 – he cautions there is no guarantee that all will be taken to flight testing by Clean Aviation.

“We are pursuing all three [designs] – at the moment, it is impossible to say which will be the one for the next short- to medium-range aircraft. We may – although this is not clear yet – decide, by 2025, in phase two to downselect one or two.”

Any decision will depend on progress over the next two years “in order to see whether all three still

HECATE (hybrid-electric regional aircraft technologies)

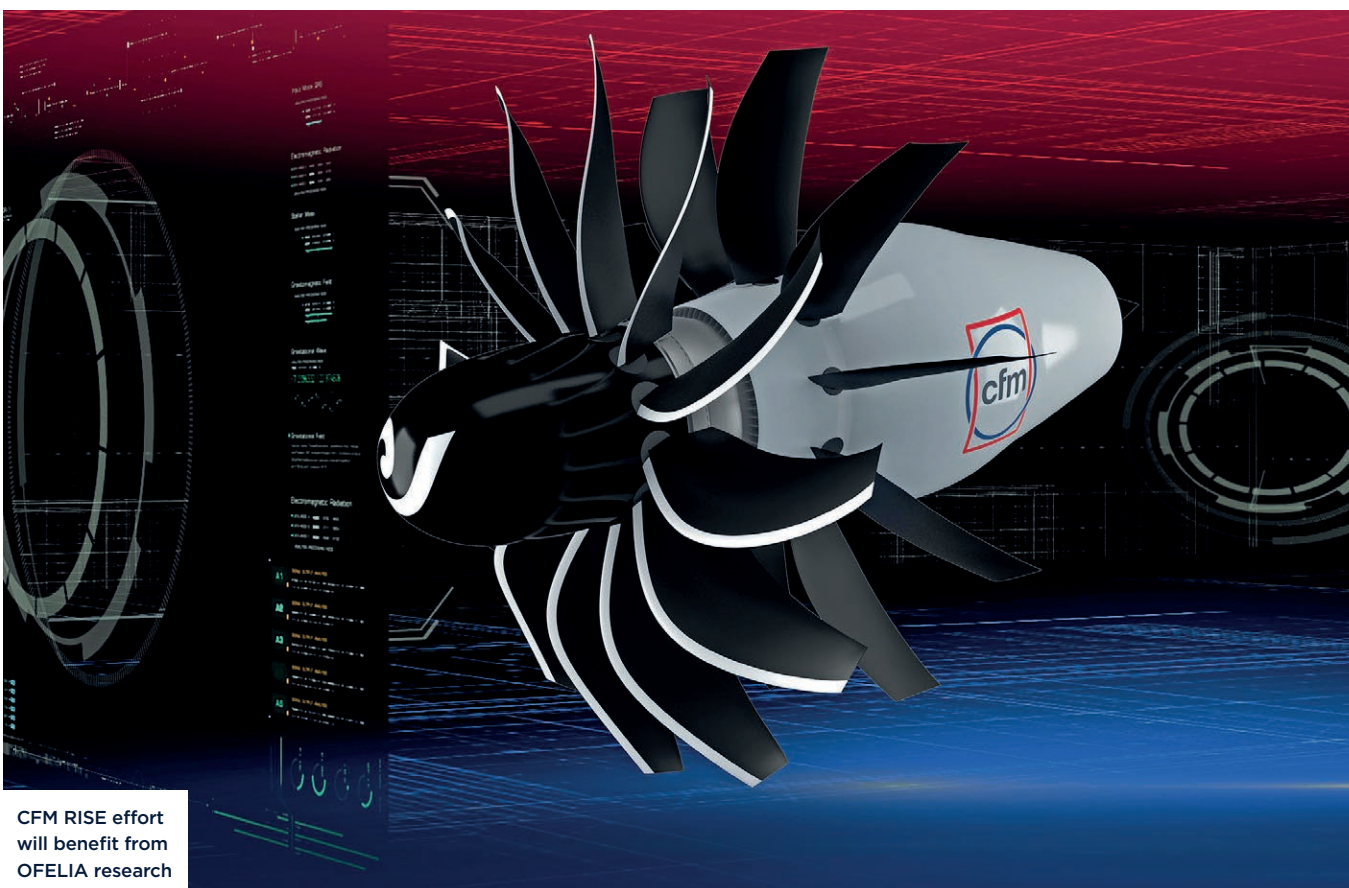
The recipient of €40 million in combined Clean Aviation and UK Research & Innovation funding, project HECATE – named after a Greek goddess associated with witchcraft – is developing a high-voltage electrical distribution system for regional aircraft.

Led by Collins Aerospace's Applied Research and Technology unit in Cork, Ireland, HECATE also involves the manufacturer's sites in Nordlingen, Germany and Solihull in the UK, alongside Diehl Aerospace, Safran Electrical & Power, and Thales, plus Airbus Defence & Space and Leonardo who will provide an airframer perspective.

Full testing of the 500kW-plus system at technology readiness level 5 is envisaged in 2025. It will mature both the individual components or sub-systems – power switches, protection and power conversion systems – and the integrated distribution system.

Although lacking the glamour of advanced engines or structures, mastering high-power electric distribution for aviation is vital for future regional aircraft designs that envisage hybrid- or hydrogen-electric powertrains.

With future aircraft power requirements likely to be higher than that of the system on test, Collins says there will be growth potential in its design.



CFM RISE effort will benefit from OFELIA research

CFM International

SAF offers one route to decarbonisation, but Krein believes hydrogen power will be a more energy-efficient path



Av/Boonimages

I have the same promise that we have analysed now" and if they have advanced quickly enough.

"But at the moment I am rather positive to see all three moving ahead at full steam, full power, and maybe we will be in a lucky situation and have all three more or less at the same level, and we will pursue all three," Krein adds.

Earlier work

Many of the projects selected by Clean Aviation are leveraging earlier work performed under the Clean

Sky programmes, he notes. "We are benefitting now from those findings, those results and we have now picked the most promising ones for entry into service with the new regional aircraft and for the use of the SMR aircraft."

Take Safran's open-rotor concept - a version of which was tested through a Clean Sky project.

"Without that pre-work it would be impossible now to think that there is a realistic chance that such a very unconventional configuration - but a very rewarding one in terms of

performance - has a very serious and significant chance to be selected [for a future programme]," Krein says. It is also worth noting that CFM International, in which Safran is a joint-venture partner with GE Aerospace, is already pursuing the concept through its self-funded RISE demonstrator programme.

Clean Aviation has also made sure of European Union Aviation Safety Agency (EASA) involvement in the programme. This will allow the regulator to tackle, early in the process, certification concerns

around the new technologies being contemplated - for example electric or hydrogen propulsion, where no means of compliance currently exist. "I think that will be invaluable in terms of results and speed to market," says Krein. "And I think EASA will benefit because their experts will grow and will understand about the technology with us, and then be in a much better position to define those means of compliance."

And, he argues, that process needs to begin now rather than "in five years' time when there is high pressure because certification [targets are] getting closer".

While the first tranche of projects is under way, Clean Aviation is still building its phase one portfolio through a second call for proposals; submissions closed on 11 May.

Krein says there is a wide distribution of topics contained in its second call - several of which, such as a multi-megawatt-class fuel cell propulsion system, were already addressed in the first round. In that case, additional expertise was needed "because we saw that we need to reinforce this".

Fuel cells are simple in a sense - they use hydrogen to generate electricity - but come with particular complexities, notably the fact that alongside the electricity, they also generate a phenomenal amount of heat: about 1MW for every 1MW of power.

There is, he says, "a tremendous amount of work to be done, and not just blast out the heat with aerodynamic inefficiencies".

"This thermal management is a key element of the future programme and probably the most, I don't want to say challenging, but one of the most difficult to pursue

SWITCH (sustainable water-injecting turbofan comprising hybrid-electrics)

Another big-ticket propulsion programme backed by Clean Aviation, the MTU Aero Engines-led SWITCH project will build on the German powertrain specialist's research on its WET - or water-enhanced turbofan - concept.

The WET engine system 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, while also reducing greenhouse gas emissions and contrail formation.

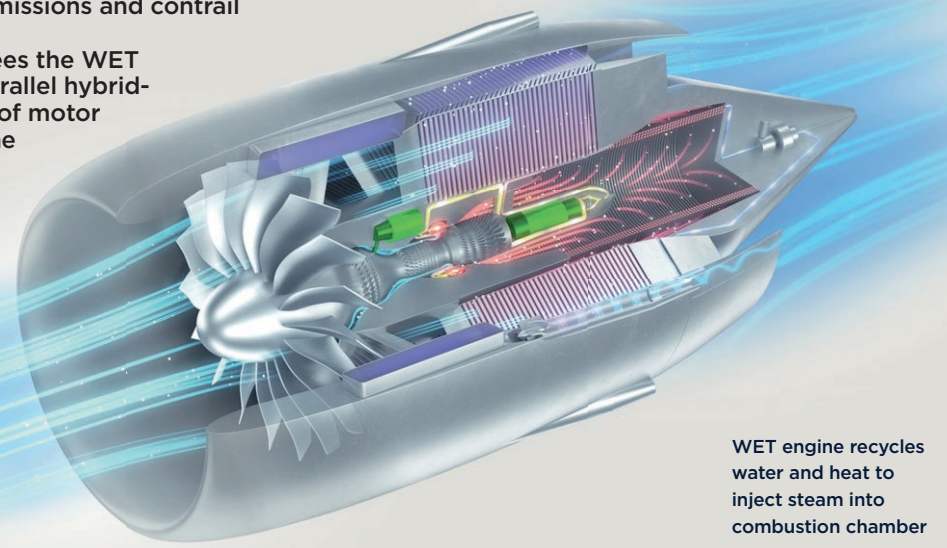
However, the Switch project sees the WET architecture combined with a parallel hybrid-electric system, including a pair of motor generators - a 500kW unit on the high-pressure spool and a 1MW unit on the low-pressure spool - to further optimise the performance of the gas turbine.

Those efficiency gains should help offset some of the weight and drag penalties that such an engine will incur.

Also included in the MTU-headed consortium

are Airbus, Collins Aerospace, GKN Aerospace and Pratt & Whitney, alongside several research bodies and universities.

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



WET engine recycles water and heat to inject steam into combustion chamber

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produce efuels out of it?” He points to both the cost of production and the ultimate sustainable energy required to produce efuels compared with hydrogen as weighing in the latter’s favour in the longer term.

“Today’s aircraft can’t take hydrogen, and that is why I think it is so important now to invest and push the boundaries so that this hydrogen aircraft will become a reality and the more efficient energy carrier can be used,” he says.

Clean Aviation’s inaugural projects may only be a few months old, but Krein offers a “strong yes” when asked if he is pleased with the progress so far.

“At the beginning it was not an easy journey because there was a huge effort in alignment to be done between all the different participants in the sector, and between the public and private sectors.

“I think this is probably a big achievement, not just for us, but of the whole community to foster this alignment and reinforce it over the last few years,” he says.

Intense discussion

Those disagreements were largely centred on timing – “in terms of what the final target is and when it can be achieved” and the likely service-entry date – the technologies to be prioritised, and the thorny issue of budgets. All required some “quite intense discussion” to achieve a consensus, he adds.

And while Krein thinks it “would have been better to start a year or so earlier” the projects are now running “at full steam”, he says. “I think we are on the right track to make it work, but I don’t think we have a choice – I mean, we can’t say ‘We are coming five years late, OK, bad luck.’ This is not an option.”

Managing to secure a position on a future aircraft with such cutting-edge technology is “more or less a once-in-a-lifetime opportunity,” Krein says. ▶

in the context we are speaking about now because it’s a first at aircraft level – it has never been done at aircraft level.”

Structural change

Also included in the second call are projects looking at the fuselage and empennage design of regional aircraft and a wing for the SMR aircraft.

“This is complementary and filling in a few of the gaps, the holes, so that basically those results can be taken into account when we decide on the demonstrators in 2025.”

The plan for flying demonstrators – and their attendant cost and complexity – is reflected in the higher budget for phase two,

although Krein says at this stage it is unclear how many it will fund, given the “huge variety” of projects across Clean Aviation.

It will also hinge on the progress made over the coming years: “For me it depends very much on the successes of the technology programmes we are running over the next two years. So, by the end of 2024 or the beginning of 2025 we will know more,” he says.

Additionally, several different technologies could be combined into a single platform, Krein suggests, for instance a high-power electrical distribution system with a fuel cell powertrain, or a particular fuselage and wing combination.

One argument frequently levelled

against research programmes like Clean Aviation is that, given the unproven nature of the technologies being pursued and however well-intentioned they are, a more effective way of achieving the net-zero goals would be to spend the organisation’s sizeable budget on ramping up SAF production, particularly of synthetic efuels.

While he says he understands the argument, Krein points to the cost of efuels and the green energy required to produce them – noting that the feedstock is essentially hydrogen. “The big question is, do you produce the hydrogen and stop there and use it, either through direct burn or in a fuel cell, or do you put more energy into it and then

OFELIA (open-fan for environmental low impact of aviation)

One of the three ultra-efficient engines that are being funded by Clean Aviation under its short- and medium-range aircraft stream, the OFELIA programme is seeking to mature technologies required for a future open-fan engine.

Led by Safran Aircraft Engines, the project supports work on the RISE open-fan demonstrator being conducted by the CFM International joint venture in which the French firm is a partner alongside GE Aerospace.

The 27-strong OFELIA consortium will receive €100 million for the three-year project, which is scheduled to run until December 2025.

OFELIA’s aim is to demonstrate the benefits of an open-fan architecture for a new narrowbody engine to enter service in 2035; critically it should deliver a 20% fuel-burn saving over today’s powerplants, the same figure as targeted by RISE.

CFM launched the RISE demonstrator programme in June 2021 with flight-tests due to begin by the middle of the decade.

Safran and partners Avio Aero – owned by GE Aerospace – and GKN Aerospace will work together to design and manufacture components for the demonstrator engine. Topics to be researched by the OFELIA consortium include whirl flutter, the unducted fan – comprising a single-stage propeller and a row of static vanes – high-speed booster, and high-speed low-pressure turbine aerodynamics.

Maturation work will focus on a high-power compact reduction gearbox, lightweight engine components, combustor emissions, high-pressure compressor aerodynamics, and hybrid-electric technology.

OFELIA consortium members include Safran’s nacelle, transmission and booster businesses, GKN Aerospace, Avio Aero and GE’s German unit, aerospace research institutes Cenaero, DLR, NLR, ONERA and VZLU, plus universities in Dresden, Graz and Turin.



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The reinvention of GKN



The company is a key partner in Airbus's Wing of Tomorrow programme

Dominic Perry

David Paja, the understated chief executive of GKN Aerospace, would probably not put it in quite these terms, but the business appears to have attained the status of golden child with its owner Melrose.

Back when it was bought by Melrose in 2018, GKN Plc was composed of several different divisions – automotive, aerospace, powder metallurgy – and joined a holding company which also owned businesses in the power-generation and air conditioning sectors.

Fast-forward to 2023 and all that remains is GKN Aerospace, with Melrose having in mid-April spun-off the other parts of GKN into a UK stock market-listed business called Dowlais (a Welsh engineering firm of the same name was one of GKN's forebears).

Melrose's long-term strategy is to acquire underperforming businesses, transform them and then dispose of

them – “buy, improve, sell” it terms it – but the UK-headquartered firm has given little sign of seeking an exit from aerospace.

Indeed, Melrose appears to be in the industry for the long-haul, despite the elapsing of a covenant this year preventing a sale, and the obvious pain caused by the pandemic-related downturn.

Releasing a trading update in May, Melrose indicated that it would for the foreseeable future remain a “pure-play” aerospace company and ruled out any acquisitions outside of the sector.

“For the next 12 months the focus is to create further substantial value for shareholders by maximising the embedded quality and potential of [GKN] Aerospace,” it says.

“Beyond that, Melrose will continue as a pure-play aerospace company. Consequently, the board will not seek to do another acquisition of an unrelated industrial business or, in the near term, a material aerospace business.”

Later briefing investors during

a capital markets day event, Peter Dilnot, Melrose chief operating officer, said he was “excited about GKN's prospects”.

The business, he says, is a “unique tier-one technology supplier” specialising in engines, structures and electrical distribution with positions on “all the highest volume commercial aircraft and leading military platforms”.

Total revenues for 2023 are forecast to be £3.4 billion (\$4.2 billion), split between engines at £1.3 billion and structures, including electrical distribution, at £2.1 billion. But the engines business, with a 22% margin, accounts for the larger share of operating profits: £290 million versus just £60 million for structures.

Structures is lagging its sister division, in relative terms, as aircraft build rates have yet to return to pre-Covid levels – particularly of the Airbus widebodies to which it is proportionally more exposed – and because the engines unit generates much more of its profit

from aftermarket services, currently a booming business.

Nonetheless, with the return of twin-aisle traffic and soaring demand, plus the structural changes it has made, GKN sees both units delivering even better returns in future: it forecasts that by 2025 the engines business will have increased its margin to 28%, delivering £500 million of operating profit on revenue of £1.8 billion, while structures will have an 8% margin, generating £200 million on £2.2 billion revenues.

For the group, that translates to revenue of £4 billion with operating profit of £700 million and a margin of 17-18%.

Engines will be the big driver of that improvement as more in-service powerplants enter their profitable phase that begins after around 15 years in operation, what Paja calls their “sweet spot”; by 2025, the aftermarket will be generating 85% of the division's profit, he adds.

GKN will benefit from its position as a risk and revenue sharing

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partner (RRSP) on 19 current powerplants, including the CFM International CFM56 and Leap, International Aero Engines V2500, Pratt & Whitney PW1000-series geared turbofans (GTFs), GE Aerospace GEnx, and Rolls-Royce Trent XWB.

Of those 19 RRSP agreements, “17 are already generating cash and the other two [the Leap and GTF] will in the next five years,” Paja notes.

GKN supplies mostly non-rotating parts creating the unusual – and lucrative – situation whereby it earns “aftermarket profit even though most of our parts last for the duration of the engine”.

As part of a broader restructuring, by the end of 2023, GKN will have closed four sites in the engines business, leaving just nine facilities, including three dedicated to repair work. At others, production capabilities have been relocated to create “dedicated centres of excellence”.

For example, where there used to be significant overlap – both

made fabricated structures and cases – between the activities at two of GKN’s engine facilities in Scandinavia, now each site is specialised: Norway handles the structures and Sweden the cases.

“We get substantial benefits in terms of quality improvements, in terms of productivity, in terms of scale,” Paja says.

But to further increase profitability, he says the company has to “think about technologies that will change the game for decades to come”.

In this instance, there is an increased focus on additive manufacturing, though which, he says, GKN “has the potential to replace 30% of all our purchased parts over time” offering “massive improvements in quality, inventory and sustainability”; shorter supply chains are another benefit, he argues.

The first load-bearing part – to enter service later this year – is a fan case mount ring (FCMR) for the Airbus A220-powering PW1500G engine, but Paja says the company has an “aggressive” strategy to produce more components through additive processes, including cases, structures and ducts over the coming years (see box).

“We are planning to invest £80 million over the next few years to add this capability to more components as fast as possible,” he says; a dedicated unit within the engines business has been created to facilitate that goal.

“We are really excited by this technology – we see a significant impact from 2025 onwards.”

Although not as profitable as the engines unit, the structures business remains an important contributor and is well-positioned for future growth, not least due to aviation’s push for net-zero flying by 2050.

In the short-term, the division – a “super tier one” – will be buoyed



Laser welding on a Trent XWB

by rising production rates at its airframe customers, notably through the supply of wing parts: GKN’s contribution is £0.5 million on every A320neo and £2.2 million for each A350.

“If the market recovers faster than expected... this could be very positive for us,” he says.

Reshaping of its production operation and an exit of unprofitable build-to-print work – especially on defence programmes – will also be a strong contributor to the division’s improving performance.

By the end of 2023, GKN’s production footprint in aerostructures will have been reduced to 24 sites – a 40% cut since 2018 – and the process will be “largely complete over the next 12 months”.

But, stresses Paja, there has been “no loss of capacity to that could hamper our ability to support the ramp-up”.

He argues that the site rationalisation was overdue: prior to Melrose’s takeover, GKN had grown through acquisition – buying Volvo Aero in 2012 and Fokker Technologies in 2015 – “but we never really integrated our footprint well so we had a lot of sites that were doing similar things.”

As in the engines business, although some sites have been closed, work has been consolidated at others to create centres of excellence. Elsewhere, non-core businesses like MRO provider Fokker Services and completions company Fokker Techniek have been sold.



Paja expects a surge in engine aftermarket revenues

Why additive adds up

GKN Aerospace is eyeing a rapid expansion of its additive manufacturing (AM) capabilities as it looks to leverage two decades of experience in the space.

A first step will be the entry into service later this year of a fan case mount ring (FCMR) for a Pratt & Whitney PW1500G engine. It will be the first load-bearing component to be produced through an additive method.

Developed at its campus in Trollhattan, Sweden, certification of the additive-manufactured component has been achieved and serial production of the part will start in the fourth quarter of this year.

“It’s a pretty big moment for us when that goes into production,” says chief executive David Paja.

The FCMR is currently made via a traditional subtractive process during which GKN machines away over 90% of a 440kg (970lb) titanium forging to produce the final sub-40kg part.

But instead the new process starts with a slim forged ring, and the requisite flanges are added to the part through laser metal deposition by wire.

GKN says the amount of material required to manufacture the part is reduced by 72% through the additive technology, which also cuts the overall CO2 emissions from the production of each component by 6.5t.

While production costs will be slightly lower, GKN sees “massive benefits in terms of quality,

supply chain management and sustainability”, says Paja.

Lead times will be drastically shortened, he says, as AM eliminates several processes in the chain: “You are talking months to produce one of these parts, end to end. By bringing everything in house you are talking weeks.”

GKN’s success in producing and validating the FCMR via additive manufacturing has “created a tipping point for us with our customers”, says chief technology officer Russ Dunn.

“This is probably as simple as it gets in terms of what we are looking to do in the future because this is one process being deposited

around a relatively simple piece of structure.

“But the depth of the process knowledge that’s gone to get to that point can also be applied to a lot of other more complex things.”

Next in line is an engine case for an undisclosed customer, with additional mounts, cases, ducts and other structures also planned, says Dunn.

“Over the course of the next three to four years we have a whole series of products that we have already agreed with our customers are on our roadmap,” he says.

GKN’s growth in the sector has been aided by the October 2022 acquisition of Gothenburg, Sweden-based additive manufacturing partner Permanova Lasersystem.

Dunn argues that a combination of process and material knowledge, industrialisation capabilities, and product design competence “puts [GKN] in a unique position”.

“We are 20 years ahead of people who are starting now. We have got that much history and knowledge.

“It’s not just about having a robot and a machine that can do it, it’s about understanding the exact details of how you deposit, how you change your [material] feed, how you change your wire temperature... there’s a significant amount of background work that has gone on to get to the point where we can confidently develop and certify AM and that’s the difference.”



GKN acquired Sweden’s Permanova in October 2022



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But it has not all been about cuts or sell-offs under Melrose's ownership: GKN will this year open a new aerostructures joint venture in China - a partnership with Comac and AVIC - which will "position us to take advantage of the [indigenously developed] C919 and ARJ21" says Paja.

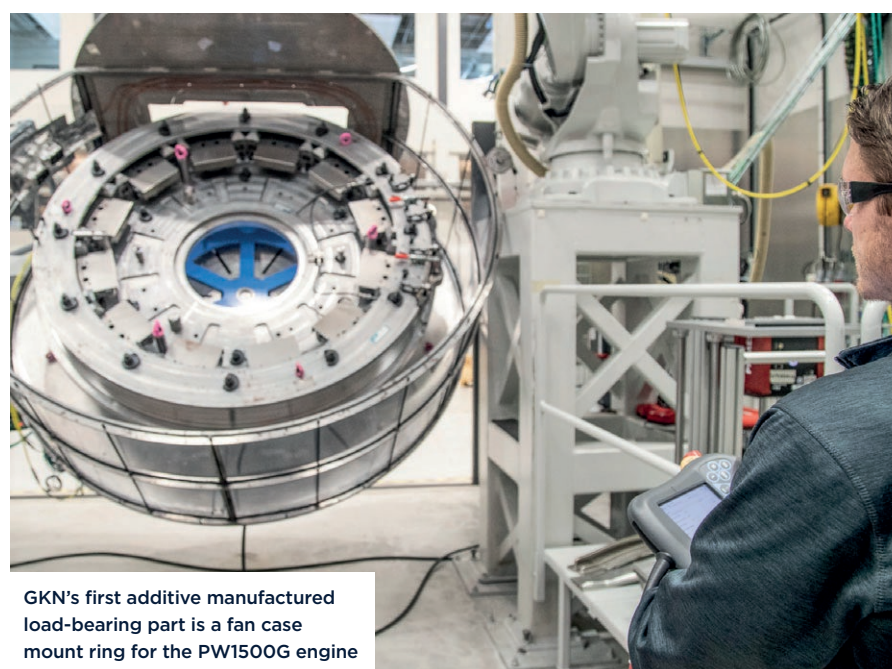
The new plant adds to two existing facilities in China and its opening is a "really significant event", he adds. "It is a brand new site that will be ready in 2023 and the orderbook is already filling up quickly."

Overall, Paja thinks Melrose has been an excellent owner "because a lot of the things that you see [presented] will not generate any returns during Melrose's tenure."

"They have been incredibly supportive in making the right investments to position the company for the future. They are a very good owner in terms of long-term thinking."

That means a willingness to spend on sites - aside from the production shake-up, GKN has established a network of Global Technology Centres in Europe and the USA - training, and technology.

Research and investment spending is seen as critical in positioning GKN to support the next generation of commercial aircraft. For example, it has participated in the EU Clean Sky



GKN's first additive manufactured load-bearing part is a fan case mount ring for the PW1500G engine

2-funded STUNNING project, which last year produced a thermoplastic fuselage barrel demonstrator that is both lighter and cheaper than the metallic equivalent.

Additionally, GKN is a core partner in Airbus's Wing of Tomorrow programme, using resin transfer moulded composite to enable the "high-volume, low-cost" production of narrowbody wing parts. GKN is

making a one-piece fixed trailing edge and the wing spar, and with just three shipsets delivered is "already delivering parts close to production maturity level," says Paja.

Chief technical officer Russ Dunn, a former Airbus engineer responsible for the A350's wings, adds: "We have improved the quality through the first three shipsets to a point where... if I were the customer

I'd be saying 'yes, we are confident and ready to go'."

Dunn says the design and production techniques being refined through Wing of Tomorrow are "fundamentally different" to those currently used and will allow GKN to "really refine the detail of the process to get an incredibly high level of quality before we even have [a new product development] programme."

"So we are now in a position where we can confidently position ourselves and be selected onto those [next-generation] platforms."

GKN's expertise in lightweight materials and electrical distribution will position the company to take advantage of the efficiency improvements demanded of the next generation of commercial aircraft. Allied to which is a growing expertise in hydrogen-based propulsion through its H2GEAR project (see box).

"With the investments we are making and what we are doing, we are going to be more relevant to the industry in the future."

In fact, says Paja, the company's mission is to be the "most trusted and sustainable partner in the sky", describing that goal as GKN's "northstar".

"We are really walking the talk in becoming the most sustainable company in the industry," he adds. ▶

By Stephane Dion, vice president of Engineering & Technology for Advanced Structures at Collins Aerospace

Thermoplastics are a key technology for the future of sustainable aerospace

Thermoplastic composites, and their accompanying environmental advantages, are getting a lot of attention. The aerospace industry is increasingly using them to replace various metallic and thermoset composite parts. Thanks to their higher impact resistance, unique processing possibilities, lightweight properties, strength and environmental advantages, thermoplastic composites significantly improve high-rate composite manufacturing and enable more optimized aircraft structures to achieve fuel burn efficiency. Collins Aerospace, an RTX business, is actively developing these to accelerate the industry's transformation toward more sustainable aviation.

Because thermoplastics can be manufactured at cycle times that are reduced by as much as 80 percent and with higher levels of automation, they provide significant cost savings compared to thermosets. In addition, their high durability and impact resistance can be tailored to withstand harsher environments while their low density and unique material characteristics can reduce the overall weight of an aircraft's structures by as much as 50 percent compared to metal, thereby increasing fuel efficiency and lowering emissions.

Thermoplastics are already in use today across multiple platforms, but they are for the most part in production for medium-sized, less structural parts. To make the step changes required by next generation aircraft high-rate production, the aerospace industry is moving to develop manufacturing processes that enable the design and manufacturing of large, complex, more integrated, stiffened structures. These could initially include nacelle cowlings and flight control surfaces, and then ultimately lead to fuselage segments and wing components.

While thermoplastics manufacturing is quicker and more efficient, it also provides sustainability benefits because the resulting components can be broken down into re-moldable material that is inherently recyclable. Excess material and scraps can be repurposed and used to make assembly detail parts such as clips and brackets - reducing waste and getting us closer to a circular economy. Although thermoplastics have been around for decades, Collins is developing state-of-the-art technologies that enable them to be structurally joined together to achieve optimized structural designs with fewer - or no - fasteners and eliminating bonded joints. Leveraging the properties of thermoplastics to



design and build more integrated structures without metallic fasteners or adhesives directly results in lower-weight more efficient products.

Today, Collins produces more than 2,000 different thermoplastic composite parts that are currently supplied to 20 different types of aircraft ranging from widebodies to single aisle, and business jets to helicopter platforms. As the company pursues larger, more advanced parts and fastener-less assemblies with the plan of introducing them into service on existing commercial and military aircraft platforms as product improvements, sustainability benefits can be realized sooner without having to wait for a new clean sheet airplane design. Additionally, this will allow these

manufacturing processes and product improvements to be proven out and matured well ahead of a next generation airplane.

Going forward, Collins is leveraging this unique expertise as part of a broader industry initiative to develop a new level of advanced thermoplastics capabilities and a distinctive product portfolio for current and future customers. The company is collaborating with other leading industry members, well-known universities, associations, and consortiums who are specialized in thermoplastic composites, robotics, and manufacturing to ensure continued developments and innovation to positively impact aerospace sustainability. ▶

GKN's power play

Although GKN Aerospace is making advances in its traditional areas of expertise such as structures and engine components, a UK government-backed research project could also see the company expand its interests as the industry gears up for a propulsion revolution.

Through the H2GEAR programme, GKN is developing a 1MW hydrogen fuel cell powertrain demonstrator, larger versions of which could eventually equip a future zero-emission airliner with around 100 seats.

Work on the demonstrator will culminate in 2025 with a ground test of the full system. But ahead of that milestone GKN this year will perform a series of trials to bring certain sub-systems, notably the cryogenic motor and electrical distribution network, to technology readiness level (TRL) 4.

"Our technology, which is unique in the industry, is that we are actually using the cryogenic temperature of the fuel as a heat sink; we are using it, via an alternative safer medium, to cool down our electrical network," says chief technology officer Russ Dunn.

Cooling the electrical network to cryogenic levels lowers the resistance of the wiring, allowing higher power levels to be distributed at lower voltages and enabling the thickness - and therefore weight - of the wiring to be reduced; the efficiency of the motor and its power density are also significantly improved.

At the heart of the design is liquid hydrogen, which needs to be stored at -253°C (-423°F). GKN uses that source of incredible cold to lower the temperature of an "intermediary substance" - in this case

helium gas - which is in turn used to cool the motors and electrical wiring.

The use of cryogenic cooling is a "fundamental differentiating step" over the design of other fuel cell powertrains, says Dunn, and provides confidence that the system can be scaled up to an aircraft of at least 100 seats, or even beyond.

Although Airbus is also pursuing research into cryogenic cooling for electrical distribution as part of its ZEROe programme, Dunn declines to say whether GKN is participating in that effort.

"Airbus is very interested in what we are doing - I'll leave it at that," he says. "All I can say is that we have shared that concept with Airbus, and we are happy to continue to support them."

In addition, Dunn says GKN has solved the issue of thermal management for the fuel cells. As a rule of thumb, fuel cells generate around 1MW of heat for every 1MW of power produced and integrating systems to deal with that waste heat runs the risk of adding substantial weight and drag to the aircraft.

"We have a solution that we believe works in terms of thermal management," says Dunn, although he declines to offer more detail, citing a current lack of patent protection for the internally developed design.

Tests of the full powertrain - including an electric motor

Dunn: Cryogenic cooling a 'fundamental differentiating step' over design of other fuel cell powertrains



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Its recovery has been slower than hoped, but ATR's first female chief executive insists the turboprop manufacturer has its sights firmly on output levels last seen in the middle of the previous decade

Regaining altitude

Murdo Morrison

ATR's new chief executive admits the manufacturer's 25 deliveries and 26 orders in 2022 were "below where we wanted to be", but promises a return to annual production of more than 80 aircraft "by the second half of the decade".

Nathalie Tarnaud Laude - who took over at the Airbus/Leonardo joint venture last October as part of the shareholders' agreement to rotate bosses on a four-year cycle - blames labour shortages, supply chain snags and long-lasting pandemic travel restrictions in its core Asia-Pacific market for the turboprop manufacturer's sluggish rebound from the pandemic.

The Toulouse-based airframer was consistently delivering at least 80 aircraft throughout much of last decade, but its output has been dropping since 2017, falling to just 10 in 2020. Just over a year ago, then-chief executive Stefano Bortoli, who had steered ATR through the turbulence of Covid-19, hailed 2021's 31 deliveries as a step to recovery, and predicted shipments in the "mid- to high 30s" in 2022. That did not happen.

Speaking to FlightGlobal ahead of the show, Laude says ATR is now "close to break even and generating cash again", while its support and services business has enjoyed a record year in revenue terms. She points to the fact that 85% of ATR's global fleet - close to 1,200 aircraft - was back in service last year, and that ATR has a "solid" 160-strong backlog.

Gross orders fell from 35 in 2021. Laude says a lack of Chinese travellers in Asia-Pacific, which has traditionally made up almost half of ATR orders, together with inflationary pressures that have made "customers quite cautious", contributed to the slump in demand.

A glut of used ATRs - which some airlines were buying instead of new aircraft - was also a factor, but Laude, who joined Airbus in 2006 and formerly ran Airbus unit NH Industries, says most of these are now off the market.

She welcomes as an "important step" China's decision to certificate the ATR 42-600, and says ATR will now have "to work to really turn that to orders". ATR has forecast a market for 280 new turboprops in the country over the next 20 years.

ATR recorded record annual deliveries of 88 aircraft in 2015, and



Laude: ATR is close to break even and generating cash again

80 shipments in the following two years. Laude says the company must be "honest with ourselves" about the likelihood of returning to those levels of production, committing only to achieve it by the end of the decade.

As with other manufacturers, shortages and delays of raw materials and components have hit ATR in the past year, and Laude admits: "We are still struggling." She says it is likely problems will persist into 2024, although the company is "working hand in hand with suppliers" to minimise disruption.

ATR is "progressing" with its flight test programme for a short take-off (STOL) version of the ATR 42-600 after flying the variant for the first time in May last year. The company, which is targeting certification in "late 2024 or early 2025", has 21 orders for the 42-600S and "we plan to acquire more in 2023", says Laude.

An "initial flight test phase" of about 80 hours, intended to test the STOL systems, ended in March, after which ATR will fit a larger rudder, which Leonardo is manufacturing in Foggia, Italy, and perform ground tests. A final, 400h certification campaign will begin in the final quarter.

ATR says the objective of the tests is to validate the handling characteristics of the aircraft, fine-tune avionics and cockpit alerting systems, and demonstrate the

enhanced take-off and landing performance on short airfields. So far, says the manufacturer, "aircraft performance is in line with our expectations".

Laude says ATR has been making strides on the environmental front, performing in 2022 the first commercial aircraft flight powered by 100% sustainable aviation fuel, and gaining European approval for 42-500 and 72-600 turboprops powered by the upgraded Pratt & Whitney Canada PW127XT-M engine, which the engine maker claims cuts fuel consumption by 3%.

ATR shareholders Airbus and Leonardo are also conducting a feasibility study into the possible launch of the Evo, a hybrid-electric variant of its turboprop family, which could enter production by the end of the decade.

Laude says "the concept makes a lot of sense in terms of technology, but it also has to make sense from an economic and market standpoint". ATR and its owners expect to take a launch decision in 2024.

She welcomes the emergence of possible new competitors in the turboprop sector - including Embraer and a flurry of start-ups developing their own hybrid-electric or electric platforms - saying they are "an endorsement of the value proposition of turboprop technology to improve efficiency and reduce CO2".



ATR is progressing with flight testing of STOL version of ATR 42-600

We look at what was making the news at the previous Le Bourget air show – in what seems now a different era for the industry

The last time



Murdo Morrison

It is four years since the last air show at Le Bourget – the longest gap since the industry's biggest gathering began its biennial cycle in the aftermath of the Second World War. Much has happened in aerospace in those four years, not least a global pandemic, which, as well as causing the cancellation of dozens of events, grounded aviation almost entirely, costing tens of billions in lost revenue.

A crisis at Boeing, sparked by the grounding of the 737 Max a few weeks before the 2019 show, continued from bad to worse, compounded by Covid-19, technical faults that halted production of the 787, and further delays to the 777X. Only in late 2022 did Seattle slowly

begin to repair the massive damage to its balance sheet.

One side effect of Boeing's troubles was the cancellation as the pandemic began of its planned joint venture with Embraer – effectively a takeover of the Brazilian manufacturer's regional airliner business. The jilting at the altar infuriated Embraer, forcing it to remain an independent company with all the financial vulnerability that entails in such a high-investment, high-risk industry.

One merger in 2020 that did take place was that of Raytheon Systems and United Technologies, creating the largest tier one supplier and second largest US defence contractor by bringing together the legacy Raytheon military businesses with the Pratt & Whitney and Collins Aerospace brands. This is the first

Paris at which the new Raytheon Technologies will be a major exhibitor.

What had been the world's two largest aircraft stopped production. Airbus announced a few months ahead of the last Paris air show that it was axing the A380 superjumbo, with the last example delivered just under two years later. After more than five decades of 747 production, Boeing handed over its final Jumbo – a -8 freighter – in February.

Russia's full-scale invasion of Ukraine in February 2022 made a pariah of the Putin regime, isolating a revamped commercial aerospace sector that just a few years earlier Moscow had hoped could rival those of the USA, Europe and an emerging China in the global market with new generation airliners such as the Irkut MC-21 and Superjet that deployed Western technology.

The fallout from a combination of international sanctions on Russia, Chinese factory closures, and a pandemic recovery that has seen demand for flying rebound quicker than production capacity created shortages of materials and labour in the aerospace supply chain. This in turn has led to aircraft manufacturers missing delivery deadlines, and some airlines unable to launch new routes.

All that makes Paris 2019 feel like a golden age for the industry, a high point in terms of orders and confidence. No one knew that nine months later airports terminals would be empty, with rows of aircraft parked on the taxiways, and governments the world over handing out "free" money to businesses and individuals to keep their economies from collapsing.



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group IAG - led by Willie Walsh - announced a deal for 200 examples of the grounded narrowbody.

Meanwhile, Eviation announced US regional airline Cape Air as launch customer for its all-electric Alice commuter transport. Another would-be disruptor, Boom, pushed back first flight of its XB-1 demonstrator as it continued to work with Japan Air Lines, its launch customer for the supersonic Overture airliner.

Air Lease was in the news again, ordering 15 Boeing 787s, with executive chairman Steven Udvar-Hazy giving the manufacturer further public advice on the configuration of its planned New Mid-Market Airplane or MMA.

ISSUE FOUR: Thursday 20 June
Our final daily's front page splash was headlined "Dutch of class". A busy day three had seen a spate of orders, the most memorable of which was KLM's commitment for up to 35 E195-E2s, becoming the first "marquee customer" for the re-engined regional jet.

Airbus chief executive Guillaume Faury warned the UK of the "huge risk" of finalising a "no-deal" Brexit arrangement with the EU. He admitted he preferred to use "different words" to his more forthright predecessor Tom Enders, but insisted the company's position as regards its investment in its so-called fourth home nation remained the same.

Qatar Airways boss Akbar Al Baker is rarely out of the news when he attends any air show, and so it was at Paris 2019, when he was urging Boeing to rename the Max, as the grounding had tainted the type's image.

ATR's chief executive Stefano Bortoli said he was confident the manufacturer would launch a short take-off and landing version of the ATR 42-600.

To mark the return of the greatest air show on earth, we look back at the biggest stories of Paris 2019, as reported by *Flight Daily News*.

ISSUE ONE: Monday 17 June
The first visitors arriving at the Le Bourget expo picked up a daily produced on the eve of the show that had as its front-page image Embraer's E195-E2 in its latest leonine livery. The Brazilian manufacturer had been displaying one of its latest generation jets in a striking, wildlife-themed design at air shows for several years.

Our lead story was confirmation that Airbus planned to extend the range of its A321LR to beyond 4,000nm (7,400km), and make the formal announcement at the show.

Elsewhere in the issue, CFM insisted it was sticking to its plan to increase Leap output by 10% in 2020 to 2,000 engines, despite the grounding of the Max, whose customers accounted for around three-quarters of its deliveries.

Boeing's KC-46A tanker made its show debut, flown in by operator the US Air Force's 931st Refueling Wing. European missile house MBDA unveiled a range of weapons for a future class of combat aircraft being studied by the UK and by France and Germany.

ISSUE TWO: Tuesday 18 June
Our second edition is always the strongest for news, following a first day of the show during which manufacturers tend to make their landmark announcements. The big story was Air Lease and Middle Eastern Airlines signing for 31 examples of the A321XLR, after we trailed the variant's launch the previous day.

Air Lease also committed to 50 Airbus A220-300s, the first major order for the former CSeries after the transfer of the programme from struggling Bombardier.

For Boeing, there were fresh problems for the in-development 777-9 as a result of delays with certification of the GE9X engine. However, both the airframer and GE Aviation were insisting the twinjet would still be delivered in 2020.

The US Department of Defense warned the European Union that it might shut the region's suppliers out of Pentagon procurement should Brussels adopt rules favouring European companies for home-grown projects.

Dassault took the wraps off a full-

scale model of its next generation fighter concept, as it prepared to work with partner Airbus Defence and Space in taking the Future Combat Air System project to demonstration phase.

Not to be outdone, Turkish Aerospace showed a 1:1 scale model of its TF-X, its planned contender in the fifth-generation fighter arena.

ISSUE THREE: Wednesday 19 June
"Willie backs the Max" was our front-page headline to a welcome good news story for Boeing. Airline



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Boeing commercial training vice-president Chris Broom believes a move to competencies-based training and assessment will help create more resilient pilots and maintenance crew

Routine change

Graham Dunn

Boeing is reporting progress in its shift to a competency-based assessment approach (CBTA) to pilot and maintenance training programmes, an initiative now already embedded in the manufacturer's own 737 training.

"Our biggest effort right now is around competency-based training and assessment," explained Boeing vice-president, commercial training Chris Broom, speaking during a briefing ahead of the Paris air show at Boeing Global Services' Frankfurt facility. The initiative is aimed at shifting from task-based training to one focused on developing competencies and which utilises available data to better tailor courses for pilots.

The aim of the CBTA approach is to create more resilient pilots and maintenance staff and it forms part of the wider Boeing Global Aerospace Safety Initiative. That in turn was born out of its response to issues stemming from the two fatal 737 Max accidents and subsequent prolonged grounding of the type which has seen Boeing assess its safety culture and processes.

Broom says Boeing recognises there is "a wide spectrum of people flying our aircraft and flying them differently". He adds: "So we had to make sure our training programme is comprehensive."

The CBTA framework is based around a range of nine pilot



Competency-based training and assessment is used in Boeing's 737 programmes at its Miami training campus

competencies. Broom says: "The competencies increase resilience of pilots, so when something goes wrong, you are more resilient and capable of reacting more easily. That is the goal of CBTA."

"Whether it's commercial pilot training, early career [training] or maintainers, we are implementing CBTA in all of these courses. Over time, all of these courses will have CBTA philosophy embedded in it and it's already being embedded in our type-rating and recurrent [training] courses."

Boeing began receiving the first regulatory approvals for its 737

aircraft about a year and a half ago. "Over 20 regulators have participated in our workshops for airline training leaders. We've had two regulators approve the 787 programme, and the 787 is with multiple [other] regulators for approval right now." He says it's a long process because they have to design the curricula for each aircraft programme, but that Boeing has a five-year plan to move all the fleets across to CBTA.

"It starts with the curricula," Broom explains. "As an example, our curricula on our Miami campus is actually longer than our task-based training and it's really based on data."

He highlights the importance of utilising operational data in supporting the CBTA approach, noting for example how this can help shape the structuring of an airline's recurrent training.

"If you think about a pilot's normal career at an airline, they start with type-rating training – so a long course, multiple-weeks of training to get a type-rating at the end of it. Their next training most likely is going to be recurrent training. In different parts of the world that can be anywhere between six to 12 months apart. When they come back, it is really important to collect data. Are you seeing a certain event? If so, do you need to train that more?"

"The key with the recurrent training with CBTA is taking that data... and tailoring the course to fit the pilot's needs. So what you might see at a very well established airline might end up being very different than a start-up airline that has less experienced pilots."

Boeing is rolling out the new CBTA curricula at its own training campuses in Miami, London, Seattle, Shanghai and Singapore, as well as facilities in Delhi, Istanbul and Seoul.

However, it is not just on its own campuses that Boeing is working to bring a more competency-based approach. "They [airlines] are still training their own pilots for the most part, but it is us helping them to do that."

"For us the more people that implement this [CBTA], the safety bar raises," Broom says.

Boeing charts new ground with digital integration push

There was an irony that Boeing Global Services chose to host a pre-Paris air show briefing to highlight its increasing range of digital offerings at the Frankfurt facility from which navigation specialist Jeppesen had for many years produced the hard copy charts which were so central to pilot operations.

"When you think about it, this facility opened in the fifties, but the company itself Jeppesen started in 1934. So I'm running a software business that started before computers were invented," says Boeing's Brad Surak, who joined the US manufacturer as vice-president, digital aviation solutions and analytics at the start of the year. "This company has its history in innovation and aviation."

The Jeppesen business, which Boeing acquired more than two decades ago, has long made the shift from paper to digital delivery for its mapping business, and the Frankfurt facility is now at the heart of Boeing Global Services' innovation activities.

"This is an innovation centre for us," Surak says. "What we utilise this facility for is to help us explore new use cases and new aspects of the products that we are working with our customers to develop new applications."

Boeing Global Services managing director Germany, Jens Schiefele, explains one of the key focuses the company is looking at is integrating



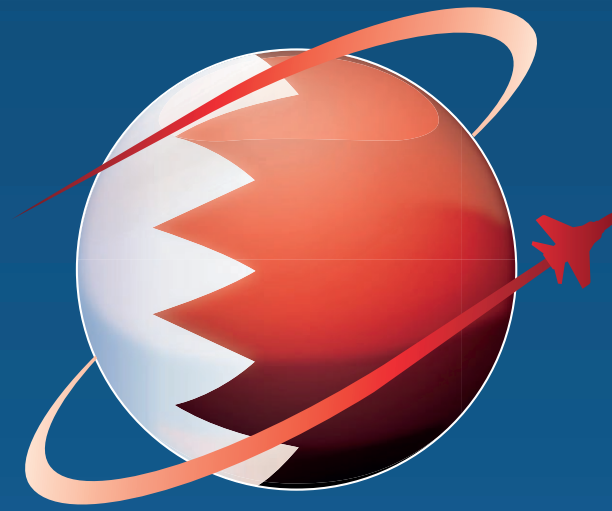
Boeing in 2022 tested technologies aimed at improving operational efficiency as part of its ecoDemonstrator programme

the various data and information it can deliver. "We are expanding what we do. We are also looking at flight positioning data, we are looking at weather data, we are looking at NOTAM data. We as part of Boeing are looking at some of the aircraft data that we have access to. So we become more management of aviation data rather than just navigation data," he says.

"What you see is what we call the integration of information and one of the big topics that we are driving ...is the integration of the different functions, from the ground to the air, and also including the maintenance side."

The Frankfurt facility forms part of a digital business that sits within Boeing Global Services and employs 3,500 employees across 28 locations.

"I think an important part of being a modern digital company is not coming in prescribing a certain stack of technology," Surak says. "We really want to be open, because every airline has different needs."



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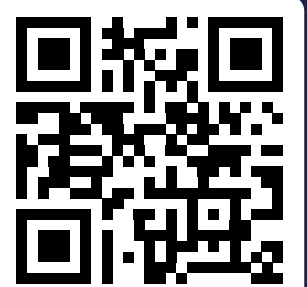
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Rolls-Royce's 30-year-old German venture has proven a lucrative investment. However, the wider propulsion business faces short-term challenges over reliability and availability



The Pearl family of business jet engines is among those built at Dahlewitz

Gearing up

Dominic Perry

In early June, Rolls-Royce celebrated the 30th anniversary of its site in Dahlewitz near Berlin. What began as a joint venture with BMW in the early 1990s and an investment of 30 million Deutschmarks – then about \$18 million – has grown into a key part of the company's industrial footprint that will in 2023 build upwards of 250 engines for business jet applications.

But the facility's importance to Rolls-Royce stretches beyond just making engines for private jets: Dahlewitz has a central role in the company's research and innovation activities as it prepares for the next generation of propulsion systems (and thanks to the disruption of Brexit, it also holds the type certificates for the entire Trent family of widebody powerplants).

If you look closely enough, the plant also bears testament to Rolls-Royce's fluctuating fortunes and industrial strategy: an assembly line for the International Aero Engines V2500 went first – R-R in 2012 having relinquished its share in the programme, and any interest in the narrowbody market – to be followed in 2020 by a Trent XWB-84 line, a

victim of the Covid-19 pandemic's impact on widebody demand.

The not unreasonable decision to centralise Trent XWB-84 production in Derby was taken by former chief executive Warren East during one of the several bouts of restructuring that took place during his tenure. But now East has gone, replaced by Tufan Erginbilgic, who marked the start of his reign by declaring that Rolls-Royce was a "burning platform" that had one last chance to get its house in order.

Erginbilgic is in the process of defining, if not another restructure exactly, then at least a reshaping of the business. His transformation plan is due to be presented later this year but there has already been management churn: the civil aerospace unit has a new president, with Rob Watson moving across from the same post at Rolls-Royce Electrical; there his role has been taken by Olaf Otto; and in defence, Adam Riddle replaced Tom Bell as president.

Back in Dahlewitz, the 30-year milestone was marked at a special event held at the factory. Against the backdrop of a Trent XWB, Dr Dirk Geisinger, chief executive of Rolls-Royce Deutschland, praised

the development of the site: "It is not a fairy story – it's reality; a beautiful story written by life," he says.

Geisinger remembers that early business plans foresaw the operation expanding to around 600 people – 30 years later it has more than 2,500 employees and has built over 8,500 engines which have accumulated in excess of 30 million flying hours.

Dahlewitz is best known as Rolls-Royce's centre of excellence for business jet engines. As Geisinger puts it "we are proud to be the market leader in the top-end segment of business aviation". What he means is that the site's current products – the BR710, BR725 and the three-strong Pearl family – equip some of the longest-range private jets available.

That includes the Bombardier Global 5000 and 6000 – powered by the BR710 – and the Pearl 15-equipped Global 5500 and 6500. Watson too was present, outlining his pride "to work for an organisation that 30 years ago had the vision to commit to the future" which delivered "the capability we have today".

Although barely two months into his new role, he is clear about

Rolls-Royce's immediate strategy in commercial engines: its three focus areas are "availability, efficiency and reliability", he says.

In part that is an attempt to draw a line under the severe durability problems seen pre-pandemic by operators of Trent 1000-equipped Boeing 787s that, at its height, saw around 50 jets taken out of service.

"We are really pleased with how the [Trent 1000] is doing," says Watson. "It has had its problems earlier in its life, but it has largely recovered."

There are still "a couple of upgrades we need to deliver into this engine," he admits, with those already having been implemented to the derivative Trent 7000 for the Airbus A330neo, which have "doubled the time on wing", says Watson.

"That modification we have just taken through certification with the [US regulator] and we'll roll that in to the Trent 1000 towards the end of this year."

"In the next 18 months we'll have those engines back where customers would expect that engine to be performing," says Watson.

The Trent 1000 holds a claimed 30% market share on the 787 against the GE Aerospace GENx "and we

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Rolls-Royce is putting to the test technology it is banking on to propel the airliners likely to arrive on the market next decade

Dominic Perry

In the cathedral-like space of its new Testbed 80, Rolls-Royce is ramping up evaluations of the geared-fan engine architecture it is backing to equip the next generation of commercial aircraft arriving from the mid-2030s.

Having run for the first time on 24 April, the UltraFan technology demonstrator had by early June been taken to around 60% power, says Simon Burr, director of product development and technology, "and we are incrementing up".

Testing has proceeded at a steady but considered pace, says Burr, pointing to the size of the engine - with its 140in (355cm) fan, it is the largest ever jet engine - the infancy of the testbed and that it is a "completely novel engine".

In fact, it is the first time in 54 years and the development of the RB211 that Rolls-Royce has developed a new engine architecture. "It's a big change because you're calibrated on how a three-shaft engine works and you have to build up your knowledge of how an [new] engine will behave differently," he says.

Incorporating a suite of new technologies - including carbon-titanium fan blades, Advance3 core, a new combustor, a high-power gearbox - the UltraFan should deliver a 10% fuel-burn improvement over manufacturer's newest engine, the Trent XWB, or 25% over earlier Trent models.

In the longer term, the propulsion specialist sees the "scalable" architecture - covering the 25,000-100,000lb (111-444kN)-thrust range - as suitable for future single- or twin-aisle applications likely to emerge in the 2030s.

The test engine has a bypass ratio of around 15:1 and is sized to produce 80,000lb of thrust.

Initial evaluations have included operability tests - looking at the dynamic response of the engine and how its large fan and gearbox

affect inertia and response to throttle movement - alongside tweaks to its operation, such as to optimize performance.

"We are working through those now before we get to full power," says Burr, while admitting he is "very, very happy" with progress to date.

Test activities will be paused during the summer for updates to Testbed 80, notably the installation of a dynamic X-ray capability.

However, once the initial test period is complete, the UltraFan demonstrator will essentially be mothballed as Rolls-Royce waits for customer interest in a new powerplant to materialise.

Speaking at an event held in its Testbed 80 facility in Derby on 18 May to celebrate the engine's first runs, Tufan Erginbilgic, Rolls-Royce chief executive, said the tests would "continue for a number of months" but would then be stopped.

"Once we have finished this phase of testing on UltraFan we will be putting the whole engine demonstrator programme on hold until one of our airframe customers is ready to take this new engine architecture," he says.

However, he says Rolls-Royce will be "taking the technology [used in UltraFan] and applying it to in-production engines".

Grazia Vittadini, Rolls-Royce chief technology officer, says the initial test programme is scheduled to last for a minimum of three months "and we will take it from there" if additional evaluations are required.

But the absence of any new widebody development programme from either of the big two airframers means that, for now, she sees no need to take the UltraFan to flight test.

"Flight testing an engine means you would have the first flight of a [new] aircraft coming," she says.

However, Vittadini - formerly chief technology officer at Airbus - adds: "Dear airframers: give me an aircraft and we will have your engines."

But she points out that Rolls-Royce is already



Rolls-Royce has been testing its UltraFan demonstrator in Derby

considering applications for the technologies and systems brought together on the UltraFan.

In particular, the Advance3 core and high-temperature materials used in the hot section are "100% applicable to the Trent XWB".

While any engine in the Trent family could in theory gain UltraFan-derived upgrades, improvements to the XWB "would make sense" as it is the "most advanced [engine] in our portfolio".

Although no further testing of the current demonstrator is envisaged beyond the first phase, Rolls-Royce will use the UltraFan architecture to develop a new narrowbody powerplant ready for potential service entry in the mid-2030s through a project funded by the EU's Clean Aviation organisation.

Led by the manufacturer's German unit, Project HEAVEN will seek to scale the engine down to a size suitable for a single-aisle jet, says Newby, alongside analysing how it could be run on liquid hydrogen.

Additionally, he sees aerodynamic improvements being made to the second-generation UltraFan, alongside "micro-hybridisation" through the installation of small motor-generators.



Rolls-Royce says Trent XWB is 'really powering the future of the business'

are looking to protect that and grow that where we can", he adds.

But the star of the show as far as Watson is concerned is the Trent XWB on the A350, which is "really powering the future of the business". Two variants of the widebody engine are in production - the XWB-84 for the -900 and the XWB-97 for the -1000, respectively delivering 84,000lb and 97,000lb of thrust -

providing "really good reliability and great efficiency".

Future improvements, particularly around durability, are being considered, with technologies matured on the UltraFan demonstrator, particularly high-temperature materials, the most likely to be incorporated.

Although the UltraFan engine is often thought of as a powerplant

in search of a platform, Watson suggests it offers more than that.

"Actually from a Rolls-Royce perspective, when I talk about all these durability improvements that we make to our engines, a lot of it is driven by the technology on UltraFan today," he says.

But by far the biggest change between the UltraFan and its predecessors is the use of a

gearbox, marking a complete change of architecture for Rolls-Royce compared with its ubiquitous three-spool design.

Rolls-Royce has selected a planetary arrangement for the component, against the star-gear layout seen in Pratt & Whitney's geared turbofan narrowbody engines. This, says Simon Burr, director of engineering and technology, enables the higher bypass ratios necessary for future engine designs.

Built in conjunction with Liebherr Aerospace, the component has been designed to handle loads of 51MW and "we have run it well into the 60s", says Burr.

While it is easy to perceive UltraFan as a UK-only project, Dahlewitz has played a key role in its development. Employment of two rigs - one for attitude, one for power - inside the site's Mechanical Test Operations Centre enabled maturation of the component prior to its joining with the rest of the UltraFan engine.

Tests of multiple gearboxes have focused not only on the component itself "but the design parameters that enable us to scale", says Burr.

"If you start large, you can scale down and we are doing studies across the range, particularly on the bearing design." ▀



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-Henry Maier, President and CEO, FedEx Ground



North Carolina witnessed the birth of powered flight. Governor Roy Cooper lays out why the state is still central to the world's aerospace industry today

The cradle of aviation

Q Why is it important for the State of North Carolina to be represented at the Paris air show?

A Our state is a key leader in the aerospace industry and our presence at Paris is vital to showcase how North Carolina is an ideal location for aerospace companies. Our aviation history began with the Wright Brothers' first flight at Kitty Hawk and continues through to today's leading research in aerial vehicles at NC State University. Last year, North Carolina was ranked the number one state to do business by CNBC and the number three state in PwC's rankings for aerospace attractiveness.

Q North Carolina is home to several military bases. What role has North Carolina's military heritage played in the growth of its aerospace sector?

A North Carolina has one of the largest military footprints of any state in the country, representing five out of six branches of services. Military and defence industries are the state's second-largest employers and major drivers in the community. We are home to the Marine Corps Air Station Cherry Point, Seymour Johnson Air Force Base, US Coast Guard Aviation Logistics Center, Navy Fleet Readiness Center-East - just to name a few. We are proud of our involvement with these bases as they continue to fuel our aerospace industry. Families and local businesses can thrive with the

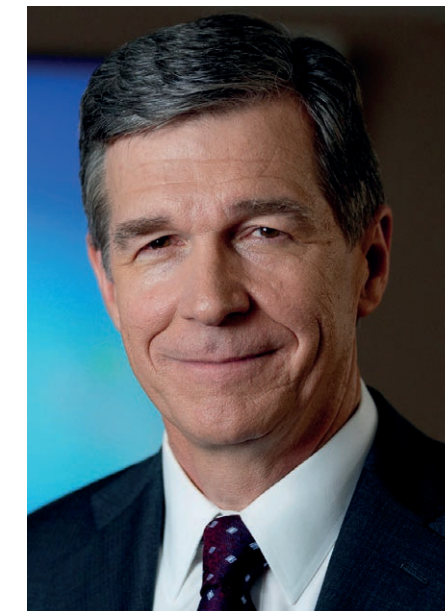
partnerships that develop between local and state governments.

Q What other ways do you encourage aerospace investment in the state?

A North Carolina is committed to seeing the aerospace industry flourish and one standout way we do that is through our academic landscape. We have three R1 research universities - the University of North Carolina at Chapel Hill, North Carolina State University and Duke University. North Carolina State University conferred over 450 aerospace engineering degrees over the past five years, and the historically black institutions of North Carolina A&T State University and Elizabeth City State University both offer acclaimed aerospace programmes.

We also offer a workforce development programme, NCWorks, featuring a free job screening, recruiting and training programme for new and expanding businesses. In fiscal year 2020-2021, the Customized Training Program trained more than 21,000 employees from over 750 companies across the state, including GE Aviation, HAECO Airframe Services, and Michelin Aircraft Tire.

In terms of financial investment, the legislature has approved \$106.7 million for improvements at Piedmont Triad International Airport to help secure the aerospace manufacturer, Boom Supersonic. The Global TransPark, located in the eastern part of our state, offers aviation companies a multimodal,



Greensboro. In January 2022, it announced plans to manufacture its new Overture supersonic passenger aircraft at the Piedmont Triad International Airport (PTI). Through 2030, the Overture Superfactory campus at PTI is expected to bring an investment of more than \$500 million and create 1,761 jobs with an annual salary average of \$68K. Boom Supersonic is developing a sustainable, supersonic aircraft capable of speeds twice as fast as today's commercial airliners. The company plans to have Overture ready to enter service in 2029.

Pratt & Whitney will have a new facility in Asheville that will be home to advanced casting foundry and conduct machining, coating and finishing of airfoils onsite. Within the first year of production, the facility will have 100% connected machines and digital information flow for employees. The \$650 million investment is also expected to create 800 new jobs through 2027, and to date, the majority of the current 150 positions have been filled by local hires.

Along with Boom Supersonic and Pratt & Whitney, North Carolina is also home to many top aerospace and defence companies, including GE Aviation, Raytheon, Honda Aircraft, Honeywell, Lockheed Martin, General Dynamics, Spirit Aerosystems, Curtiss-Wright and others.

2,500 acre industrial and business park featuring one of the longest runways on the east coast.

We understand that our aerospace industry will only grow as much as we invest in it and are eager to continue doing so.

Q Who are the main aerospace players in North Carolina?

A While we have many players throughout North Carolina, there are a few that recently invested in the region: Boom Supersonic and Pratt & Whitney.

Boom Supersonic's goal is to reignite supersonic travel with its Overture Superfactory in

Q Perhaps North Carolina's biggest aviation claim to fame was hosting the Wright Brothers' first flight near Kitty Hawk. How do you celebrate that remarkable link to the birth of the industry today?

A Kitty Hawk is where it all started, and the Wright Brothers effectively set North Carolina up as a legacy leader in aerospace and aviation. We celebrate that milestone by continuing to grow the industry that they paved the way for.

Our aerospace industry will continue to thrive as both industry giants and smaller manufacturers consistently choose North Carolina as their base due to our convenient market access, strong business environment, skilled workforce and industry support, among other things.

We hope to become home to even more "claim to fame" projects in the aerospace industry and we are that much closer to doing so with our 200 leading aerospace manufacturing companies, and more than 450 aerospace suppliers.

North Carolina has positioned itself as a hub for the aerospace industry and we are eager to continue our growth in the sector and find new markets to break into.

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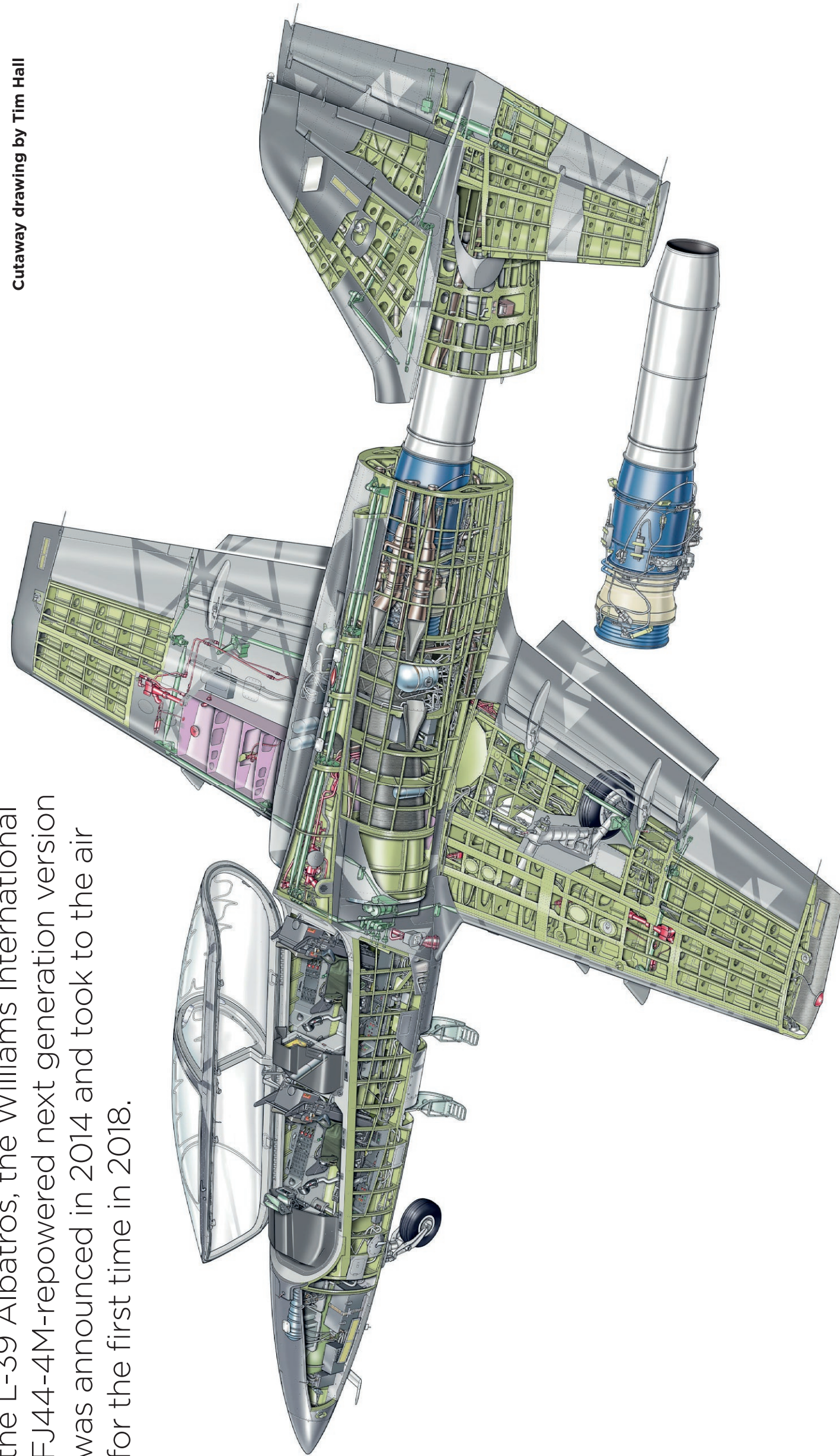


Past and future: the Wright Flyer and Boom's Overture

Aero Vodochody L-39NG

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