

FLIGHT

INTERNATIONAL



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More answers needed



Fatal flaws

Although investigators examining the Ethiopian Airlines Max crash are rightly critical of Boeing, their failure to adequately probe the pilots' actions leaves us with an incomplete picture

Ethiopian investigators' final analysis of the Boeing 737 Max crash that spurred the fleet's worldwide grounding contained no surprises, and among those non-surprises was the inquiry's airbrushing of the pilots' operational performance.

Boeing has been rightly castigated over the flawed development of the Maneuvering Characteristics Augmentation System (MCAS) stabiliser-trim function, redesign of which might not have happened for a considerable time had the Ethiopian 737 Max not suffered a remarkably improbable bird-strike on its most vulnerable component, the angle-of-attack vane on which MCAS depended.

After a fatal Lion Air Max accident in October 2018, Boeing had insisted the Max was safe and that pilots had been told how to de-activate MCAS if necessary.

But the Ethiopian crash, just five months later, forced the airframer to adopt a more humble and conciliatory tone, under an onslaught of accusations that it was trying to blame crews who had fallen victim to a fundamentally impaired design.

Assessment of crew comprehension, skill and response – which should have underpinned the MCAS safety case – is essential for a full understanding of any accident, especially one involving human-versus-automation conflict.

To ignore crew actions and avoid exploring training adequacy or pilot competence is to deny such understanding and inevitably raise suspicion over what exactly is being kept out of the spotlight.

Ethiopian authorities already have form in delusional attempts at deflection. Witness the aftermath of the Ethiopian 737-800 accident off Beirut in 2010, when officials concocted ludicrous claims that lightning or sabotage brought down the jet after Lebanese investigators concluded that a badly paired crew became disoriented and lost control over the sea at night.

But this behaviour is not confined to one nation. US investigators clashed with Egyptian counterparts over the loss of an EgyptAir 767 in 1999, while French investigators sharply criticised the probe into another EgyptAir accident, involving an Airbus A320, in 2016.

They also strongly disputed Egyptian findings from the Flash Airlines 737 crash in 2004 – another over-water departure in the dark – which tried to pin fault on technical malfunction, rather than the crew's spatial confusion. Examination of operational and human factors was “minimal” and “not fully developed”, comments almost identical to those levelled at the 737 Max probe two decades later.

There is no doubt that MCAS contributed to the Max pilots' sense of overload as they fought to regain control of the jet. But the crew effectively lost control at wheels-up, long before MCAS entered the frame, which is why their decisions and reactions under stress deserve closer inspection.

Ethiopian investigators called MCAS a “hidden threat”. That threat was exposed, and addressed, and the 737 Max is back in service because humility prevailed over hubris, and admission of weakness became the first step to remedy. Pilots are human. Which means pilots are fallible. Accepting this is crucial to making them, and the aircraft they fly, less so. ▶

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Mulugeta Ayene/AP/Shutterstock

In focus

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Additional sensors include cameras mounted on widebody's nose

Airbus insists A350-1000 autonomy tests are aimed at dual-pilot cockpit

Airframer trials technologies with goal of improving safety – but says they are not designed to allow flightcrew reduction

David Kaminski-Morrow London

Airbus has trialled further autonomous flight concepts using an A350-1000 test aircraft, including emergency diversion and automatic landing, but insists they are aimed at supporting a dual-pilot cockpit.

Part of the airframer's UpNext initiative, the DragonFly programme takes its inspiration from insects of the same name – using biomimicry of dragonflies' combination of high-speed senses, spanning a wide field of view, feature recognition and precision flight control.

DragonFly has focused on three aspects of autonomous operation – diversion, landing and taxiing – including assistance during a simulated incident of pilot incapacitation.

The aircraft relies on automatic intelligent decision-making based on flight data obtained through a combination of sensors, including cameras on the A350's nose.

DragonFly head of demonstrator Isabelle Lacaze says the programme has been running for two years, but flight-testing using aircraft MSN59 commenced in July 2022 and the airframer is "enthusiastic about the first promising results".

Among the achievements, she says, was the simulation of sudden pilot incapacitation over Limoges

during a flight to Lyon, in a real air traffic environment.

"The system took over and diverted the [aircraft] safely to the nearest appropriate airport – Toulouse in that scenario," Lacaze says.

She states that the diversion function can activate automatically or act as a support to the pilots.

Addressing the possibility of incapacitation is one of the contentious issues when considering a possible shift to single-pilot operations.

But Lacaze says DragonFly is intended to develop and evaluate assistance to a two-pilot crew, to help manage workload during intensive phases of flight, such as diversion.

Sensitive criteria

"We consider there is already huge value [in this]," she says. "We are in an exploratory field of research. Our framework – to mature, to explore, to see what we can do with the new technology – is really focusing on... assistance for dual-pilot operations, the current crew composition."

But DragonFly does envision support for extreme circumstances in which pilots are no longer able to control the aircraft.

The criteria for detecting incapacitation are "sensitive", says Lacaze, and she does not elaborate on the techniques involved, but says that the system is designed to take over "seconds" after detection.

Lacaze says the DragonFly programme is intended not only to offer diversion assistance but also to support crews in taxiing at congested airports, through computer-vision obstacle detection, to maintain speed control and centreline tracking, as well as alerting pilots to the risk of runway crossing.

Earlier autonomous flight testing using an A350-1000, under a programme named ATTOL, demonstrated a fully autonomous take-off using vision systems to track the runway, and carry out automatic rotation.

DragonFly has extended this to automatic landing, including in low-visibility conditions using sensors and vision systems, and Airbus believes the capability could be broadened to approaches to any airport, even those not equipped with the ground technology to support landing automation.

Airbus says its demonstrator takes into account a range of external factors – including terrain, weather and military flight zones – as part of its assessment of where to land.

Lacaze says the UpNext unit is launching a project to advance landing and taxi assistance with a view to taking advantage of new-generation computer-vision algorithms. Meanwhile, tests under the DragonFly programme will continue for a further three months. ▶

Airframers to stay off target

Leading lessor predicts Airbus and Boeing will again miss narrowbody goals in 2023, as supply chain woes continue

Murdo Morrison Dublin

The big two airframers will miss their narrowbody aircraft delivery targets in 2023 as supply chain hold-ups continue to plague the industry, a leading lessor has warned.

Since the Covid-19 recovery in passenger traffic began in 2021, the “OEMs have grossly misjudged how many aircraft they could build, and the trend is not improving”, Steven Udvar-Hazy, executive chairman of leasing giant Air Lease, told the Airline Economics Growth Frontiers Dublin conference on 16 January.

Airbus and Boeing delivered 15% fewer aircraft than they promised in the final quarter of 2021, and “we expect continued delays this year”, the leasing industry veteran says.

Udvar-Hazy maintains that “a lot of aircraft” scheduled for delivery to Air Lease in the second half of 2022 “still have not been delivered”. He adds: “I can speak from our own experience that both OEMs are struggling to meet their contractual commitments.”

He says Airbus and Boeing have not achieved production targets because their suppliers have struggled to ship the components and raw materials needed.

“It is not that [the OEMs] don’t want to meet [their targets],” he says. “There are not enough

engines, titanium, forgings, landing-gears. They are the victims of a very complex supply chain, down to mom-and-pop shops.”

Speaking at the same event, Aengus Kelly, chief executive of the industry’s largest lessor, AerCap, said Airbus in particular had been guilty of overpromising in terms of deliveries, and then leaving it too late to inform customers.

“The challenge for the OEMs today is the short [notice] of telling airlines the bad news,” he says. “Airlines make almost all their money in three months. Imagine if you have everything in place, and then you are told... your aircraft isn’t coming in time for summer.”

Downward revision

The European airframer missed its 2022 delivery goal by almost 40 aircraft, handing over 661 units. At the beginning of the year it had pledged to deliver 720 aircraft, but faced with supply chain delays revised this to 700 in July.

Boeing, meanwhile, did achieve the 480 deliveries it promised for 2022, but at the third attempt, having lowered its 737 target twice during the year.

The two leasing bosses were also in agreement that 2023 will see continued recovery for the airline industry.

That upbeat assessment comes despite ongoing problems with the supply chain, the impact of

inflation on consumer confidence, and geopolitical upheavals including the Ukraine conflict.

“There is good news and bad, but the tailwinds are better than the headwinds,” Udvar-Hazy says. “As we emerge into 2023, we foresee that we are on our way to a multi-year recovery cycle.”

Kelly says he is seeing a “very strong and steady rebound in travel”, dismissing suggestions made during the Covid-19 crisis that the explosion in virtual meetings and other societal changes would drive structural changes in flying habits.

He predicts that, with travel to and from China now open, there will be a “full return” to 2019 global traffic levels by the middle of the year.

Udvar-Hazy says that he is confident about prospects this year despite a host of challenges, which also include rising interest rates and an end to “years of cheap money funded by government stimulus”, together with high labour and fuel costs.

Recent large orders from the likes of United Airlines, Air India and several Chinese carriers show there is “momentum” in the market, he adds.

Udvar-Hazy also paid tribute to governments that financially supported airlines through the pandemic, saying it “saved our industry from being wiped out”. ▀

See p8



Boeing will face continued pressure to ship sufficient number of 737 Max jets



Making progress

While Airbus may have bested rival Boeing again, both airframers took positives from their performance in 2022

Jon Hemmerdinger Tampa

For the fourth consecutive year, European airframer Airbus in 2022 delivered more aircraft and received more net orders than its arch-rival Boeing.

The companies disclosed their 2022 order and delivery figures on 10 January, revealing that Airbus continues to lead both categories but that Boeing is catching up, having resumed 787 deliveries, ramped up 737 Max shipments and bested Airbus in the widebody segment.

The year-end delivery totals also reflect production systems hampered by shortages of aircraft components, say executives.

"Boeing had a good last-quarter upturn in deliveries. But in orders, market position, backlog and most other indicators it continues to fall behind Airbus," says aerospace analyst Richard Aboulafia with AeroDynamic Advisory.

Airbus ended 2022 having delivered 661 aircraft, with Boeing following with 480 shipments.

Both figures remain significantly depressed from the heady years

preceding the 737 Max grounding and Covid-19-driven downturn – in 2018 Airbus and Boeing each delivered about 800 jets.

Still, both airframers' 2022 delivery totals were up significantly year on year – most notably Boeing's. That improvement came as the manufacturers addressed production challenges and rode the broader commercial aviation rebound.

Revised targets

While Airbus led in deliveries, it missed its 2022 goal by 40 aircraft. Boeing, on the other hand, actually exceeded its 2022 737 delivery target by several units, albeit that the airframer had revised the objective downward twice during the year.

By aircraft type, Airbus's A320neo-family programme led the pack in 2022. The company delivered 516 of the those jets last year, more than half of which, or 264 units, were the increasingly popular A321neo. Including 53 A220 deliveries, Airbus shipped a total 569 narrowbody jets in 2022.

Boeing closed 2022 having delivered 387 737s, including 13 737NGs – mostly for military conversion – and 374 737 Max. It had aimed to hand over 375 737s in 2022.

Airbus's 2022 orders and deliveries

Type	Orders	Cancellations	Net orders*	Deliveries	End-2022 backlog
A220-100	4	3	1	6	37
A220-300	123	19	104	47	490
A319	17	2	15	6	83
A320	370	40	330	246	2,325
A321	501	76	425	264	3,685
Total narrowbodies	1,015	140	875	569	6,620
A330	0	0	0	9	19
A330neo	19	84	-65	23	196
A350	44	34	10	60	404
Total widebodies	63	118	-55	92	619
Total	1,078	258	820	661	7,239

*Net orders includes orders minus cancellations Source: Airbus

“The significant order intake [for] all our aircraft families reflects the strength of our product line”

Guillaume Faury Chief executive, Airbus



More than half of the 516 A320neo-family jets delivered last year were A321neos

The US company eked out a lead in the widebody delivery category, shipping 93 twin-aisles last year, including five 747s, 33 767s – 15 for conversion into military tankers – 24 777s and 31 787s.

Those numbers would have been greater had Boeing's Dreamliner deliveries not been halted for more than half of 2022. It did not ship any examples of the twinjet while developing rework needed to fix fuselage-related manufacturing quality problems; Boeing resumed 787 deliveries in August 2022.

Airbus delivered one fewer widebody jet than Boeing last year – 92 aircraft in total, including 32 A330s and 60 A350s.

On the order front, Airbus bested Boeing by a modest amount, ending the year having logged new firm commitments for 1,078 aircraft.

“The significant order intake covering all our aircraft families, including freighters, reflects the strength and competitiveness of our product line,” says Airbus chief executive Guillaume Faury. “We continue our ramp-up trajectory to deliver on our backlog.”

But 258 cancellations – including for 118 widebodies – winnowed Airbus's net orders last year to

Boeing's 2022 orders and deliveries

Type	Orders	Cancellations	Net orders*	Deliveries	End-2022 backlog
737NG				13**	25
737 Max	697	136	561	374	3,628
Total narrowbodies	697	136	561	387	3,653
747			0	5	1
767	31†		31	33††	106
777	68		68	24	313
787	139	25	114	31	505
Total widebodies	238	25	213	93	925
Total	935	161	774	480	4,578

*Net orders includes orders minus cancellations.

Note: **12 for military conversion, one BBJ 121 for tanker conversion †15 for tanker conversion Source: Boeing

820 aircraft, including 105 A220s and 770 A320neo-family aircraft. It closed the year with net negative orders for 55 widebody aircraft.

Freight market

Long-haul activity did pick up slightly in the closing weeks of the year, with the airframer recording an order for four A350 freighters from an undisclosed customer.

It also booked 10 A330neos from lessor Avolon and a pair of A350-900s from a client identified as “financial institutions” in December.

Chief commercial officer Christian Scherer says the figures show

evidence of a recovering market, with customers placing “strategic and significant” new orders, demonstrating an “endorsement” of the airframer's portfolio.

“Our customer base is comfortably growing,” he says. Scherer claims there were just 13 passenger widebody deals globally last year, and Airbus “won eight of them”.

Notably, 65% of the A320neo-family orders last year, or 501 aircraft, were for A321neos – a high-capacity variant that has enjoyed strong recent sales success. In fact, the A321neo – including the developmental A321XLR

“As the airline industry expands its recovery, we are seeing strong demand, particularly [for] the 737 Max and 787 Dreamliner”

Stan Deal President, Boeing Commercial Airplanes



787 deliveries only resumed in August following safety pause

– now represents 61%, or 3,678 units, of the undelivered backlog of A320neo-family jets.

Boeing's ostensible competing jet – the 737 Max 10 – cannot match the A321neo's range and has not yet been certificated. Boeing does not break out Max orders by variant, but Cirium fleets data records 776 total firm orders for the 737 Max 10.

737 replacement

“The A321neo continues to gather steam, and Boeing continues to deny that it needs to develop a new jet,” says Aboulafia, who has repeatedly warned that Boeing will bleed market share until it develops a narrowbody replacement. “Worse, [Boeing will] risk losing the engineering and design teams needed in order to create a new jet,” he adds.

But Boeing did make significant order gains in 2022, ending the year not far behind Airbus. It received a major boost in December when United Airlines said it had ordered 100 737 Max and 100 787s. Boeing now confirms that those figures included existing undisclosed orders for 10 of each type.

Also in December, lessor BOC Aviation handed Boeing a 40-strong 737 Max order – a win partly offset by BOC's prior cancellations for the narrowbody – while Hawaiian Airlines ordered two more 787s.

Such deals brought Boeing's full-year 2022 gross order intake to 935 aircraft, offset by 161 cancellations to 774 net orders, including

Airbus v Boeing performance

	Airbus		Boeing	
	Net orders*	Deliveries	Net orders*	Deliveries
2022	820	661	774	480
2021	507	609	479	340
2020	268	566	-471	157
2019	768	863	54	380
2018	747	800	893	806
2017	109	718	912	763

*Net orders includes orders minus cancellations Source: Airbus and Boeing

for 561 737 Max. The numbers mark a massive improvement from the 479 net orders Boeing reported in 2021 and its negative 471 net orders in 2020.

Also, in contrast to Airbus, the US manufacturer enjoyed broad demand for widebody jets last

774

Boeing's full-year net orders, including 561 737 Max, after 935 gross order total was winnowed by 161 cancellations

year, taking net new orders for 213 twin-aisles, including 31 767s – 10 freighters and 21 for tanker conversion – 68 777s and 114 787s.

“As the airline industry expands its recovery, we are seeing strong demand across our product family, particularly the highly efficient 737 Max and the 787 Dreamliner,”

says Boeing Commercial Airplanes president Stan Deal.

In all, the 2022 figures show both companies are making progress in building their businesses back after the Covid-19 market shock. But they remain far from fully recovered, with both firms repeatedly reporting that production remains constrained due to nagging shortages of parts – from cabin interior components to wiring, windows and engines.

Fauray says Airbus's 2022 delivery performance is “obviously less than was targeted”, citing the “complexity of the operating environment”.

Labour issues and quality shortcomings also hindered Boeing's 737 Max production.

“We worked hard in 2022 to stabilise 737 production, resume 787 deliveries, launch the 777-8 Freighter,” says Deal. “We will stay focused on driving stability within our operations and the supply chain.”

Additional reporting by David Kaminski-Morrow in London

Aircraft was destroyed when it came down in a ravine around 1nm from runway threshold

Yeti ATR crash kills 72

Investigators probe factors leading to apparent loss of control of turboprop while on final approach to Pokhara airport

Yunish Gurung/EPA-EFE/Shutterstock

Alfred Chua Singapore

Nepal suffered its worst aviation disaster in more than 30 years on 15 January, when a Yeti Airlines ATR 72-500 crashed near Pokhara airport, killing all 68 passengers and four crew.

The twin-turboprop (9N-ANC) had been operating flight YT691 from Kathmandu and was on final approach when it was lost, crashing around 1nm (2km) short of the runway 12 threshold.

Social media footage that captured the final seconds before the accident shows the aircraft descending in a nose-high attitude before it rolls left through more than 90° and crashes into a ravine.

On 16 January, the Civil Aviation Authority of Nepal confirmed that the aircraft's flight-data and cockpit-voice recorders had been

recovered in good condition and would be sent for analysis.

Airframer ATR says its specialists are "fully engaged to support both the investigation and the customer". French air accident investigators have also said they will participate.

Cirium fleets data shows the accident aircraft was delivered new to India's now-defunct Kingfisher Airlines in 2007. It served with Thailand's Nok Air from 2013 to 2019, before being leased to Yeti Airlines.

Accident record

The incident was the latest in a line of commuter turboprop crashes in Nepal, most recently the controlled flight into terrain of a Tara Air De Havilland Canada Twin Otter in May 2022, which killed 22 people.

Cirium accident data records Yeti Airlines as having had eight other safety incidents over the past two decades. In July 2019, another of its

ATRs (9N-AMM) suffered a runway excursion at Kathmandu while landing in rainy conditions. Three fatal accidents involving Twin Otters operated by the carrier – recorded in 2004, 2006 and 2008 – killed a combined 30 people.

The latest accident was Nepal's deadliest crash since September 1992, when a Pakistan International Airlines Airbus A300 crashed on approach to Kathmandu with the loss of all 167 people on board.

Meanwhile, our annual review of airline safety (see p46) shows that there were 12 fatal accidents and 229 related deaths in 2022. Losses included a China Eastern Airlines Boeing 737-800, with all 132 passengers and crew, and a Precision Air ATR 42-500 crash which killed 19 people. ▶

Additional reporting by Greg Waldron



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Wear on Rolls-Royce/Safran Adour powerplant has hit readiness



Engine issue derails RAF Hawk T2 training

Continuing poor availability of aircraft at Valley base will force UK to send fast jet students overseas to complete instruction

Dominic Perry London

The UK is so short of operational jet trainer aircraft because of an engine issue afflicting the Royal Air Force's (RAF's) fleet of BAE Systems Hawk T2s that it is having to send student pilots abroad to finish their training.

Revealed in written evidence to the House of Commons Defence Select Committee as part of an inquiry into aviation procurement, the admission shows the difficulties currently faced by the UK's Military Flying Training System (MFTS).

Delivered by Ascent Flight Training – a joint venture between Babcock and Lockheed Martin UK – the fast jet portion of the MFTS syllabus relies on the use of Hawk T2s supplied directly by the RAF.

Low Hawk T2 availability has been a long-running issue faced by the service, but a recently disclosed problem with

accelerated wear affecting the type's Rolls-Royce/Safran Adour engine will further diminish that capacity, Lockheed says.

As of 31 October – the halfway point of the current 2022/2023 financial year – Ascent had been able to use just 1,711 flight hours, “generating only two fast jet trainee graduates”. This compares with annual averages over the previous four years of just over 5,500h and 22 pilots respectively, Lockheed figures show.

Data provided by the company shows that availability was a problem even before the engine issue came to light last year. The MoD is “obligated to provide up to 9,200 hours of Hawk T2 flying to Ascent” each financial year, to cater for a maximum of 43 students.

“Historic issues with Hawk T2 availability” have resulted in “significantly reduced hours” since the 2018/2019 financial year, it says, leading to a “corresponding reduction in trainee capacity”.

With the engine issue forecast to persist for the next two to three years, Lockheed says Hawk T2 flights from RAF Valley, on Anglesey, have been cut to a maximum of 18 per day, against the 53 the Ministry of Defence (MoD) is obliged to provide to Ascent.

Lockheed says planning for the next financial year, beginning on 1 April, is based on a throughput of 24 trainees. However, “This will

not be possible within the heavily restricted Hawk T2 hours and constrained daily flying rates, as a continuing direct result of the Hawk engine issue.

“Ascent understands the additional UK trainees will be trained overseas as a mitigation for the lack of available Hawk T2 hours,” the company adds.

Alternative options

Unlike the remainder of the MFTS programme's fixed-wing and rotary training aircraft, which were acquired by industry, the RAF's 28 Hawk T2s were directly purchased by the MoD. Operations with the type began in 2009.

“Due to the Hawk T2 engine issue and the impact aircraft availability will have on flying training over the next three years, alternative fast jet pilot training options are being negotiated,” the MoD says. “Details are commercial in confidence,” it adds.

Options previously outlined in the House of Commons to potentially deal with the Hawk T2 shortfall include sending further trainees to the Euro-NATO Joint Jet Pilot Training programme at Sheppard AFB in Texas, the USA; accelerating planning for the Hawk 167-equipped 11 Squadron – a joint Qatar/UK unit – at RAF Leeming to train UK pilots until 2027; and working with other allies and partners to examine overseas training opportunities. ▀

UK fast jet training

Financial year	Fast jet trainee graduates	Hawk T2 flying hours used
2018/2019	21	5,714
2019/2020	19	5,392
2020/2021	22	5,663
2021/2022	29	5,414
2022/2023*	2	1,711

Source: Lockheed Martin UK *As of 31 October 2022

Demand strong despite consumer spending concern, says O'Leary

Ryanair chief executive shrugs off worries about recession in key markets as carrier reports a positive start to 2023

Lewis Harper London

Bookings and fares are proving resilient to Europe's economic challenges, according to Ryanair group chief executive Michael O'Leary.

Speaking in London on 17 January, as the low-cost giant launched its UK summer schedule, O'Leary said Ryanair is "alert all the time" to factors such as high inflation, rising interest rates and fears of recession, and the impact they might have on consumer demand. But, he says, the business is so far seeing "no indication of a cut in spending".

Rather, he reports "a lot of strength in the demand picture", with Ryanair taking 2 million bookings over the weekend of 14-15 January – far above its previous record for the period of 1.6 million in 2019. He describes as "remarkable" that such strong demand is being seen when Ryanair's current "seat sale" features baseline fares that are much higher than those historically offered.

"Thus far, into the first quarter and second quarter [of 2023], while we admittedly have higher oil prices this year, bookings are strong, fares are rising and I suspect, if there is no unforeseen development in Ukraine or on Covid, we are likely to see a second year of reasonably robust pricing this year – rising high single digits for the second year running," O'Leary says.

Priority travel

He believes pent-up post-Covid-19 travel demand is still a significant factor for consumers, with people keen to fly after two years of restrictions – and having the means to do so thanks to money saved during that period.

Consumers are therefore prioritising spending on travel, with spending on "bigger ticket" items reduced, he says.



Low-cost giant took 2 million bookings on 14-15 January, O'Leary says

Furthermore, "it's the first recession we have had in my lifetime where we have had zero unemployment", O'Leary says of key markets such as Ireland and the UK, where unemployment is low. That echoes comments from IATA chief economist Marie Owens Thomsen, who last year cited low unemployment as a reason for airline optimism regarding the demand picture, even amid fears of recessions in key markets.

O'Leary cites other factors supporting strong demand and pricing, including that many of Europe's legacy airlines are yet to reinstate all their pre-Covid-19 short-haul capacity. Combined with the collapse of carriers such as Thomas Cook, overall pan-European capacity still has some way to go to match 2019 levels, even as Ryanair powers way past its 2019 capacity amid the arrival of dozens of Boeing 737 Max jets.

Further aiding the demand for pan-European travel, O'Leary highlights buoyant inbound flows from the transatlantic market thanks to the strong US dollar, which makes

Europe a relatively cheap and attractive destination.

"I think that is going to continue through this summer," he states.

The strong dollar also means Europeans are less minded to travel to North America, O'Leary suggests; instead they are "far more likely to holiday in Europe".

Increasing traffic

And with Asia-Pacific markets finally achieving significant recovery momentum, 2023 might see greater numbers of travellers from that region undertaking pan-European flights, he believes.

"There's a lot more traffic moving around, while Europeans are continuing to holiday at home," he states.

O'Leary also reasserts his belief that low-cost carriers tend to do well during economic slowdowns, as consumers become more price-conscious.

Ryanair in early January disclosed it carried 11.5 million passengers in December, taking the carrier's total for the calendar year to just over 160 million – 5% above the same period in pre-pandemic 2019. ■

Crew determined emergency
evacuation was unnecessary



Ryanair revises inspection regime after 737 brake-fire incident at Manchester

Carrier introduces ultrasonic-based technique to help identify potential fatigue cracking in wheels triggered by corrosion

David Kaminski-Morrow London

Ryanair has introduced a revised ultrasonic inspection method to detect internal wheel hub cracks, after a Boeing 737-800 brake-fire incident at Manchester last year.

The fire in the left-hand main landing-gear broke out as the twinjet (EI-ENF), having landed on runway 23R, taxied to its stand on 17 March 2022.

UK Air Accidents Investigation Branch (AAIB) analysis found that the outboard wheel's inner hub had fractured, owing to a fatigue crack originating at a corrosion pit.

The resulting misalignment of the wheel damaged the brake piston and caused a leak of hydraulic fluid.

Heat generated by the misaligned wheel, as the aircraft was taxiing, was sufficient to ignite the leaking fluid.

After vacating the runway the crew had found the aircraft needed more thrust – around 40% of the N1 level – than normally required to maintain its taxi speed, and had suspected a flat tyre.

Parking procedure

But as the jet approached the stand, the crew overheard a radio transmission requesting fire-fighters to attend a brake fire and, realising their aircraft was involved, completed the parking procedure and shut down the engines.

“As the fire was quickly extinguished, the flightcrew considered that an emergency evacuation was unnecessary and, therefore, the passengers disembarked normally,” says the inquiry.

Analysis by the wheel and brake manufacturer subsequently identified that the inboard wheel hub had fractured radially in four locations; it also identified a circumferential

crack around the hub. Three of the four radial fractures and the circumferential fracture were all consistent with overload.

Besides the critical fatigue crack, a number of other fatigue cracks, all originating from corrosion pits, were also found in the inner wheel half bearing bore.

The AAIB states that the wheel manufacturer has developed an ultrasonic inspection technique to assess the condition of the internal bore of the wheel hub, and that Ryanair – which experienced a similar event in Spain, following the UK occurrence – has introduced this inspection on its 737 fleet.

Spanish investigation authority CIAIAC is probing a 31 March 2022 incident in which a Ryanair 737-800 landed on runway 32R at Madrid Barajas, and came to a halt on the taxiway after damage to the wheel and brakes on the left-hand main landing-gear. ▀

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Provisions will apply to both transport and commuter aircraft

5G-tolerant altimeters mandated as FAA warns of 'catastrophic' risk

AirTeamImages

Regulatory move follows growing number of reports from pilots regarding potential aircraft system interference

Jon Hemmerdinger Tampa

US regulators will require all transport aircraft to be equipped with updated altimeters by February 2024, citing concern about a potential "catastrophic incident" caused by interference from new 5G networks.

The Federal Aviation Administration (FAA) proposed new altimeter standards in a 9 January regulatory filing, saying it has had some 100 reports of potential 5G interference.

"As flightcrew become more desensitised to erroneous warnings, they are less likely to react to an accurate warning, negating the safety benefits of the warning altogether and likely leading to a catastrophic incident," the proposal says.

It has provisions applying to both transport and commuter aircraft – around 8,000 in total.

If finalised, the FAA will mandate that all aircraft operating under FAA Part 121 rules – which apply to airlines – have radio altimeters that meet "minimum performance standards" by 1 February 2024.

Also, by June this year, it would permit aircraft already meeting such standards to conduct otherwise prohibited operations at some US airports.

"The Federal Aviation Administration is proposing an Airworthiness Directive that would continue to allow aviation and 5G C-Band [networks] to safely coexist," the agency says.

"This longer-term solution... will enable the wireless companies to

achieve full use of their networks while maintaining aviation safety."

Cellular providers AT&T and Verizon activated the first US 5G networks in January 2022.

The networks use the 3,700-3,980MHz radio range, which sits close to the 4,200-4,400MHz range used by radio altimeters. The FAA and aviation groups have for several years warned about possible interference, noting that radio altimeters feed data to critical aircraft systems.

However, the potential impact of the FAA's proposal on airlines and other operators remains unclear.

Certain altimeters do "not require a substantial redesign, allowing operators to replace radio altimeters or install filters that allowed the aircraft to operate safely in a mitigated 5G environment", the FAA says.

The FAA is accepting comments on its proposal for 30 days.

Deadline doubts

But trade group Airlines for America (A4A) has warned that supply chain trouble could impact the ability of operators to meet the deadline.

"A4A member carriers are working diligently to ensure fleets are equipped with compliant radio altimeters, but supply chains continue to lag behind current demand," the group says. "Any government deadline must consider this reality."

The FAA has already prohibited some aircraft operations at airports deemed subject to interference from 5G. It has also worked with cellular companies, which initially agreed to limit 5G transmissions near some airports.

In addition, the FAA says airlines are already working to update radio altimeters and that its proposal simply mandates those updates.

Despite earlier FAA efforts, instances of interference have occurred. In November 2022, FlightGlobal reported that 5G transmissions may have caused around 80 instances of altimeter problems affecting large passenger jets.

The FAA now puts that number at about 100, saying errors included faulty altimeter data, erroneous terrain and collision avoidance system warnings, and incorrect landing gear alerts.

It warns that risks will increase as more US cellular providers launch 5G networks, and companies expand the bandwidth they use.

Although AT&T and Verizon's initial 5G networks transmit in the 3,700-3,800MHz range, the FAA says another 19 telecommunications firms will begin C-Band transmissions after June, and after July will start using the "higher end" of their band allotment, up to 3,980MHz.

"These higher frequencies are nearer to the spectrum allocation where radio altimeters operate, which means the potential for interference to radio altimeters from in-band and spurious emissions may be more likely," the FAA warns.

The telecommunications industry has long insisted its 5G networks do not jeopardise aviation safety.

"5G in the C-band coexists safely with air traffic and we look forward to continuing to work together with all stakeholders to meet the FAA's deadlines," says trade group CTIA. ▶

A career off course

FlightGlobal/Goose Recruitment survey finds discontentment among flightcrew, despite the post-pandemic recovery

Murdo Morrison London

Last year's rebound in air travel may have seen pilots return to the cockpit in droves after the mass layoffs and furloughs of the pandemic – but the profession remains a largely unhappy one.

That is according to the latest annual survey of pilot attitudes by Goose Recruitment and FlightGlobal, which finds that more than half of respondents have not had a salary increase for five years, and for one in three pay has fallen.

Only 15% of pilots believe their salary is keeping pace with the cost of living, and almost 70% think that current levels of pay will persuade fellow aviators to leave the sector.

Sixty-three percent want to change jobs in the next 12 months – the highest figure in the four years of the poll. Meanwhile, the 62% who say that, given the chance to start again, they would choose to become a pilot is also at its lowest. Just 45% would encourage young people to join the profession, another record low.

A majority of pilots – 55% – are concerned about their job security – but less than last year's 61%, or the 82% at the height of the crisis.

The survey polled 1,184 pilots across the world during the final quarter of 2022, a period where many airlines – particularly in North America – were reporting difficulty in recruiting flightcrew following an unexpectedly strong recovery in passenger demand.

Normally, this would suggest a market in which pilots in work or seeking employment have the upper hand. In fact, 77% of those polled are currently flying, compared with 62% a year earlier and just 43% who were polled in late 2020 for the 2021 survey.

63%

Almost two-thirds of pilots plan to change jobs within the next year – the highest figure in four years of polling

However, responses do not seem to reflect this, suggesting a community still in trauma and adjusting career expectations after the collapse in air travel when governments enforced Covid-19 restrictions.

In fact, 57% of respondents say they have had to change the type

of flying they do because of the pandemic, with that figure as high as 81% among pilots in the Asia-Pacific region.

This is almost certainly because long-haul international travel has recovered more slowly than many domestic or regional markets, leading widebody pilots to transfer to single-aisle, regional, cargo or agency operations, where pay rates are often lower.

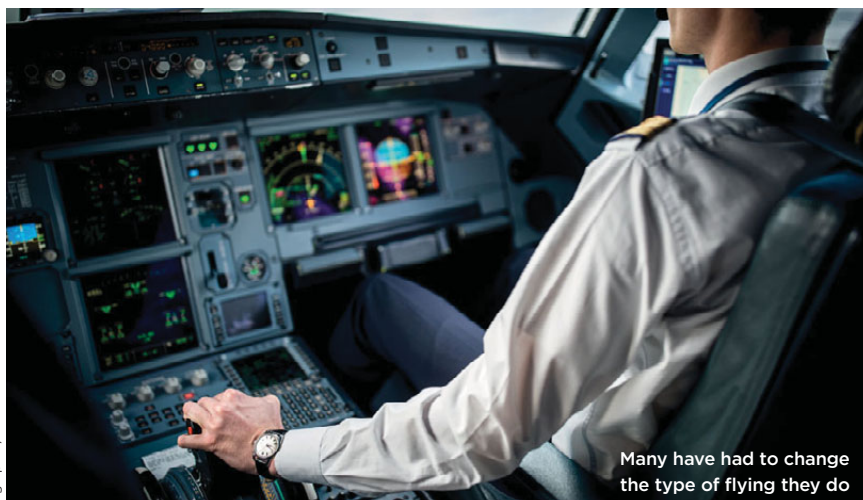
One captain says that when their airline went out of business during the pandemic, the only option was working for a private-aircraft owner and “living in his hotel on call 24/7”. Instead they chose to freelance at a UK airport “to have a life, but I earn about half”.

Night flying

Another reports that, after losing their job with a passenger airline they moved to piloting a freighter, but “this is mostly night flying which is more tiring”.

Some have returned to the cockpit after moving out of the profession altogether. One respondent lost their job as a long-haul captain and worked as a correctional officer for two and a half years.

The Asia-Pacific region is worst affected when it comes to pay.



Many have had to change the type of flying they do

Lightpoet/Shutterstock



Global recovery is likely to drive up salaries as airlines compete for crews

Jon Chica/Shutterstock

“If the respondents are right about the future, this is not going to be a war for pilot talent for long, but an out-and-out pilot-shortage crisis”

Mark Charman Chief executive, Goose Recruitment

There, 48% of pilots have had salaries cut. In South America, the figure is 36%. By contrast, in North America, where the traffic recovery began more than 18 months ago, and airlines have at times struggled to find pilots, 73% of respondents have seen their pay increase.

Despite the gloom in the profession, it seems likely that continuing global recovery, including in the long-haul market, will begin to drive up salaries as airlines compete for talent in short supply. In fact, 52% of pilots think salaries will increase over the next two years, with 32% believing they will stay the same.

Moreover, 89% of respondents to the survey believe there will be a shortage of pilots over the next five years, compared with 66% in 2021.

Mark Charman, founder and chief executive of Goose Recruitment,

suggests that during the pandemic, most pilots understood cuts were necessary and sacrificed salaries and benefits for the good of their airline and the industry at large.

“I don’t see this goodwill holding out for much longer,” he says. “Pilots will want to see their pay return to what it was. I predict that 2023 will be a year with more remuneration crisis talks than ever before.”

The vast majority of those who took part in the survey report that pay and conditions have deteriorated, with one describing airlines treating pilots “like bus drivers”.

However, a captain flying in North America believes his colleagues already hold the trump cards when it comes to salary. “Pilot pay is crazy right now. It is easy to job-hop for more money. So many jobs, and so few pilots,” he says.

While 77% of pilots polled are currently flying, the picture in the regions is mixed. In North America, 82% are employed, while in China the figure is only 53%, the result of the country’s long-running zero-Covid policies, which effectively banned international flying as well as much domestic travel, and were only relaxed at the end of 2022.

Whether pilots plan to fly to retirement age gives another impression of what the future jobs market might look like. In our first survey, just before the pandemic, 71% of pilots said they planned to stay in the job until retirement. That has risen to 75%. However, among pilots in the 25-34 years age group, the figure is just 67%.

Improved salary

Perhaps one of the most surprising findings is the record 63% who plan to switch jobs in the next 12 months, including 65% of captains. A better salary and benefits package are the main reason for seeking the change, followed by an improved work-life balance.

While this may reflect general discontentment or growing optimism about job prospects, and does not mean all will end up leaving their employment, the prospect of potentially having to replace almost two in three of their flightcrew this year will cause airlines concern.

From a pilot point of view, Charman believes a tightening labour market will boost pay in the short term, but may also spur airlines to rethink their hiring philosophy, paying more attention to creating career pathways for new pilots to retain them, rather than competing for experience in the market.

“If the respondents are right about the future, this is not going to be a war for pilot talent for long, but an out-and-out pilot-shortage crisis. We have already seen in North America the difficulties they have through the lack of pilots,” he says.

“In other skill-short sectors, we have seen salaries doubling just to retain people. I don’t see pay being a sustainable strategy to be successful in recruitment. I believe hiring and recruiting new pilots into training programmes early on would not only be beneficial to loyalty and retention, but will benefit the sector as a whole.”

To download the full report, visit flightglobal.com/pilotsurvey2023

Enhancements will allow
operation until at least 2042



Cormorant upgrade set to bolster RCAF search and rescue provision

Leonardo Helicopters

Mid-life modernisation activity will boost capability of AW101s and provide additional three airframes to expand SAR fleet

Dominic Perry London

Ottawa will spend C\$1.16 billion (\$840 million) to upgrade its fleet of Leonardo Helicopters CH-149 Cormorant search and rescue (SAR) rotorcraft, enabling their operation until at least 2042.

Although centred on its current 13-strong fleet, the mid-life upgrade (MLU) will see the Royal Canadian Air Force (RCAF) gain an additional three aircraft.

Canada's Department of National Defence (DND) says "additional airframes/parts will be acquired from Leonardo UK" – the airframer's site in Yeovil, southwest England builds the AW101 – but will also incorporate used components.

In the latter case, that will comprise parts already in storage from the existing CH-149s and those salvaged from nine AW101-based VH-71 Kestrel airframes, which Canada acquired from the USA in 2009 following that programme's cancellation.

Led by Lockheed Martin, the VH-71 programme had been due to deliver new presidential transport helicopters for operation by the US Marine Corps.

Recycled components will include transmissions, landing gears and control surfaces "to reduce costs and ensure value for money", says the DND of the upgrade.

Under the MLU, the CH-149s will be raised to the same standard as currently being delivered to Norway via the nation's AW101 'SAR Queen' acquisition.

Digital control

Enhancements to the 20-year-old aircraft will include the installation of a new glass cockpit, more powerful digitally-controlled GE Aerospace CT7-8E engines, wireless in-cabin communications, and new sensors to support the SAR mission.

To be led by Leonardo, the modernisation will be performed by the Team Cormorant grouping, which also includes Collins Aerospace Canada, GE Canada and IMP

Aerospace and Defence. Most of the work will be conducted in the nation, primarily at IMP's facilities in Halifax, Nova Scotia.

The RCAF's current CH-149s are assigned to 19 Wing, based at Comox, British Columbia; 9 Wing in Gander, Newfoundland and Labrador; and 14 Wing in Greenwood, Nova Scotia. The fleet expansion enabled by the MLU programme will also enable operations to be established at 8 Wing in Trenton, Ontario.

In a related deal, the DND has awarded Canadian training provider CAE a C\$78 million contract to supply a flight simulator that will be "representative" of the modernised rotorcraft.

To be located in-country, the DND says the solution will remove the need for RCAF crews to "travel to the UK to train on simulators that may not be consistent with our aircraft".

Leonardo says Canada's Cormorant fleet has accumulated more than 100,000 flight hours since the type made its debut operational sortie in 2002. ▶

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Ottawa agrees \$14bn F-35 deal

Negotiations completed around the production of 88 stealth fighters to replace Hornet fleet, with first delivery due in 2026

Ryan Finnerty Tampa

Canada has finalised an agreement to purchase 88 Lockheed Martin F-35As, cementing its place in the bloc of 17 nations committed to fielding the stealth fighter.

The Canadian government and Lockheed on 9 January announced that they had finalised the terms for the acquisition, which is valued at C\$19 billion (\$14.2 billion).

"This is an important milestone in the significant process to purchase modern fighter jets for the Royal Canadian Air Force [RCAF] and an example of an open, fair and transparent competitive procurement," says Helena Jaczek, the minister overseeing public procurement.

Canada selected the F-35 in March 2022, before entering into final negotiations.

Operational capability

The incoming aircraft will replace the RCAF's operational fleet of Boeing F/A-18A/B Hornets, which currently totals 76 aircraft, Ottawa says. The government anticipates receiving the first F-35A in 2026, with the RCAF expected to achieve full operational capability with the jets between 2032 and 2034.

"We are committed to ensuring that our current and future aviators have the most-advanced equipment possible," says defence minister Anita Anand. "Canada requires a fighter fleet to contribute to the safety and security of Canadians and protect the sovereignty of one of the largest expanses of airspace in the world."

Canada is one of the original eight F-35 programme participants that contributed funding to develop the single-engined fighter. However, Ottawa opted to stage a competition under its Future Fighter Capability project, with the candidates eventually narrowed to the Lockheed design and Saab's Gripen E.

The Swedish firm's Canadian subsidiary last October voiced opposition to the negotiations with Lockheed, saying that the terms should have been included in its rival's bid package. The Canadian government rebuffed those claims, stating that the negotiations were part of a "finalisation phase" that was laid out in its original bid solicitation.

"During this phase, the top-ranked bidder must successfully demonstrate that a resulting contract would meet all of Canada's requirements and outcomes, including value for money, flexibility, protection against risks, and performance and delivery assurances, as well as high-value economic benefits for Canada's aerospace and defence industry," Public Services and Procurement Canada said.

Lockheed says the RCAF's introduction of the F-35 will strengthen Canada's operational capability with allies, and be a "cornerstone for interoperability" with NATO and the joint US-Canada North American Aerospace Defense Command.

Meanwhile, the airframer on 30 December 2022 announced that it had secured a contract from the US Department of Defense (DoD)

to produce another 398 of the fifth-generation fighters. The \$30 billion deal covers production Lot 15 and 16, along with options for Lot 17.

"This contract strikes the right balance between what's best for the US taxpayers, military services, allies and our Foreign Military Sales customers," says Lieutenant General Mike Schmidt, head of the DoD's F-35 Joint Program Office.

"The modernised Block 4 capabilities these new aircraft will bring to bear strengthens not just capability, but interoperability with our allies and partners across land, sea, air and cyber domains," Schmidt adds.

Updated hardware

Lockheed says the Lot 15-17 aircraft will be the first F-35s to include updated hardware needed to power Block 4 capabilities, known as Technical Refresh-3. This includes a new integrated core processor with greater computing power, a panoramic cockpit display and an enhanced memory unit.

The contract covers aircraft for the US armed services, as well as several allied nations. Belgium, Finland and Poland will all receive their first F-35s under the deal.

Lockheed handed over 141 F-35s last year; seven fewer than its production target. The company attributes the shortfall to a break in flight operations introduced following the crash of a short take-off and vertical landing F-35B during a pre-delivery test flight at its Fort Worth site in Texas on 15 December. The aircraft's pilot ejected following a hard landing and loss of control.

As of year-end, the company had delivered a total of 894 F-35s. ▶



Canada confirmed its place as one of 17 nations fielding fifth-generation type

March 2019 accident resulted in worldwide grounding of the type



Mulugeta Ayens/AP/Shutterstock

NTSB dismayed as 737 Max crash inquiry overlooks human factors

Ethiopian report focuses too tightly on technical failings, US agency says, with support from French counterpart BEA

David Kaminski-Morrow London

US investigators have dissented over findings of an Ethiopian inquiry into the fatal Boeing 737 Max 8 crash outside Addis Ababa nearly four years ago, arguing that the conclusions focus on technical design issues and fail to take sufficient account of human factors and inadequate pilot responses to the loss of control.

The accident, involving Ethiopian Airlines flight ET302 in March 2019, was the second to involve a 737 Max in less than five months and led to a worldwide grounding of the type over concerns that failure of a single angle-of-attack (AoA) sensor could generate false air data and lead the horizontal stabiliser trimming system to push the aircraft into a rapid descent.

Ethiopia's aircraft accident investigation bureau has concluded that the trimming system – the

Maneuvering Characteristics Augmentation System (MCAS) – was responsible for the crash, echoing the Indonesian Lion Air 737 Max accident in October 2018.

It claims that a defective AoA sensor exposed the vulnerability of MCAS, which would have otherwise remained as a “hidden threat”.

The US National Transportation Safety Board (NTSB) fully concurs that the MCAS behaviour was part of the accident sequence.

Sensor damage

But it disagrees that the AoA sensor was defective, arguing instead that a bird-strike on the instrument, causing its vane to break away, was more likely (see p23).

Crucially it also contests the inquiry's suggestion that the aircraft was “unrecoverable” by the crew.

“We believe that the probable cause also needs to acknowledge that appropriate crew management of the event, per the procedures

that existed at the time, would have allowed the crew to recover the airplane even when faced with the uncommanded nose-down inputs,” says the NTSB.

It has separately published its dissension over the draft report, after it was not attached to the final report issued in late December by the Ethiopian bureau.

The Ethiopian inquiry found that the aircraft's throttle levers remained at take-off thrust, and the stick-shaker activated as the jet became airborne from Addis Ababa.

Its captain attempted to engage the autopilot, despite this being inconsistent with stick-shaker procedures, but the crew “did not discuss any issue” relating to the stick-shaker, it states. The autopilot activated at the third attempt.

According to the inquiry the false AoA sensor data led to incorrect calculation of a minimum operational airspeed – which exceeded the maximum operational airspeed



“Absence of flightcrew performance information limits the opportunity to address broader and equally important safety issues”

US National Transportation Safety Board

But the “unbearable” manual forces needed to trim the aircraft and maintain the climb were too much for the pilots, and the captain called, “Put them up” – an apparent command to disconnect the trim cut-out switches which, critically, would also re-activate MCAS.

“It most likely appears that the flightcrew were trying to find other means to relieve the force,” says the inquiry, in an explanation for the decision. MCAS subsequently commanded a fourth nose-down shift in the stabiliser, pushing the aircraft into its final fatal dive.

None of the 157 passengers and crew aboard the 737 Max (ET-AVJ) survived the impact.

The inquiry says MCAS and a lack of pilot training “did not trigger” the accident, but that it was initiated by flawed data from the AoA sensor.

157

Death toll of occupants aboard
Ethiopian Airlines flight ET302

But the NTSB believes the analysis of the pilots’ performance is “not sufficiently developed” by the inquiry which, it adds, focuses “heavily” on system design issues instead.

“Absence of flightcrew performance information limits the opportunity to address broader and equally important safety issues,” it states, pointing out that evaluation of the crew’s actions “would not have been particularly difficult” given the amount of information available.

“Design mitigation must adequately account for expected human behaviour [in order] to be successful,” the NTSB adds, while demanding a “thorough understanding” of crew performance – not only for design purposes

but also operational and training safety improvements.

The NTSB disputes a conclusion that airspeed and altitude ‘disagree’ messages were not presented to the crew, and says the inquiry should have explored the pilots’ “lack of conversation or action” in response to the messages.

Thrust reduction

According to the NTSB, the aircraft was not uncontrollable, but the inquiry neglects to state that a manual reduction of thrust and appropriate use of manual electric trim would have allowed the pilots to maintain control despite the uncommanded MCAS inputs.

“The flightcrew’s failure to reduce thrust manually and the excessive airspeed that resulted played a significant role in the accident sequence of events,” the NTSB insists.

It says the activation of the stick-shaker or the annunciation of an ‘airspeed disagree’ message should have prompted an “expected” crew response to disengage the autothrottle.

Instead the autothrottle remained active and responsive to the erroneous (AoA) data, and failed to order a thrust reduction. Despite an aural ‘overspeed’ warning as the aircraft accelerated towards 340kt, at high thrust, the NTSB says the crew did not notice the autothrottle’s unusual behaviour, or take action to manually control thrust, leaving the pilots to deal with excessive forces on the control column and manual trim-wheel.

Countering the uncommanded nose-down inputs with manual nose-up electric trim – as described in operating manual documentation – would have enabled control forces to remain in a “controllable regime”, it says.

It adds that the draft report “did not examine” the pilots’ understanding of the relationship between airspeed and necessary control forces, and says it “misses”

of 340kt (630km/h) – and also prevented the flight-management computer from detecting a threshold altitude at which thrust would have automatically reduced.

As the aircraft climbed, the crew retracted the flaps, but shortly afterwards the autopilot disconnected. The combination of manual flight, retracted flaps, and the false AoA data triggered MCAS to adjust the horizontal stabiliser and lower the nose.

Although the crew attempted to counter this nose-down tendency with manual input, the continuing high-thrust acceleration meant the pilots had to apply excessive forces in response.

MCAS triggered for a second time, and the pilots responded by activating the trim cut-out switches – a correct response, advised after the Lion Air accident – which effectively prevented MCAS from adjusting the stabiliser when it triggered for a third time.

Substantial force

At this point the aircraft was travelling at 332kt, at 9,100ft altitude, and gradually climbing – but the crew was having to counter the out-of-trim stabiliser with substantial force.

The crew advised air traffic control of the flight-control difficulties, and aimed to reach the minimum safe altitude of 14,000ft in order to start diagnosing the problems.

an opportunity” to evaluate the effectiveness of airline training on this matter.

Evidence from the inquiry, the NTSB states, shows the crew did not carry out appropriate non-normal procedures in response to annunciations relating to unreliable airspeed, stall warning and runway stabiliser.

Flight-data recorder information shows only “minimal” use of manual electric trim, which would have reduced control forces, while performing memory items for unreliable airspeed or runway stabiliser would have led the crew to disengage the autothrottle. Such actions should have been carried out before the crew activated the trim cut-out switches.

Switches disconnected

But even after activating the trim cut-out, says the NTSB, the crew subsequently disconnected the switches – a decision “contrary” to procedures that direct crews to ensure that the cut-out remained in place for the rest of the flight.

“Available evidence for this accident did not indicate why the crew performed this action,” it adds.

“By not evaluating the human factors associated with this crew action, the report provides a limited understanding of the circumstances leading to the airplane’s nose-down pitch before impact.”

The NTSB has received support from its French counterpart over its complaints regarding the report’s lack of focus on the actions of the flightcrew, an omission the BEA describes as “regrettable”.

“There was no discussion nor diagnosis [made by the captain or the first officer] with respect to the nature of the events on board”

French investigation authority BEA

The BEA investigation authority believes the 737 Max’s pilots experienced rapidly developing stress from a stick-shaker alert on take-off, even before they found themselves fighting against the MCAS.

It says the stick-shaker should have prompted the crew to apply stall-recovery procedures from memory – including applying nose-down input and disengaging the autopilot and autothrottle.

“Only the nose-down input was performed by the flightcrew,” the BEA states. “The autothrottle remained engaged and the pilot later insisted on engaging the autopilot.”

Engineering simulations, it says, show the pilots would have been presented with airspeed and altitude ‘disagree’ messages, and should have run a checklist for unreliable airspeed – which also requires autopilot and autothrottle disengagement, adopting a 10° nose-up pitch and a specific thrust setting.

But the captain did not disconnect the autothrottle and instead attempted to engage the autopilot, despite being below the autopilot height threshold set by the airline.

“This premature action, although not appropriate in stick-shaker

conditions, may be symptomatic of a state of stress that had been rapidly developing following the activation of the [stick-shaker] immediately after take-off,” says the BEA.

It says the first officer – who had just 300h experience – appears to have been “overwhelmed” by events from the point at which the stick-shaker triggered.

The authority says parts of the cockpit-recorder transcript illustrating the first officer’s difficulties have not been included in the final report into the accident.

“Co-ordination and the communication between the captain and the first officer were insufficient,” says the BEA. “There was no discussion nor diagnosis with respect to the nature of the events on board. The situational awareness, problem-solving and decision making were therefore deeply impacted.”

Aerodynamic forces

The lack of thrust reduction meant the aircraft accelerated to excessive speeds and made manual control against aerodynamic forces extremely difficult when the false AoA data, combined with other logic conditions, led MCAS to issue uncommanded pitch-down inputs.

The BEA argues that crew-performance aspects of the accident – particularly those which emerged before the MCAS activation – are “insufficiently addressed” by the Ethiopian investigation.

It says the crew’s failure to apply checklists or reduce thrust, use of autopilot contrary to procedures, and inadequate use of electric trim to relieve high control forces should have had further explanation.

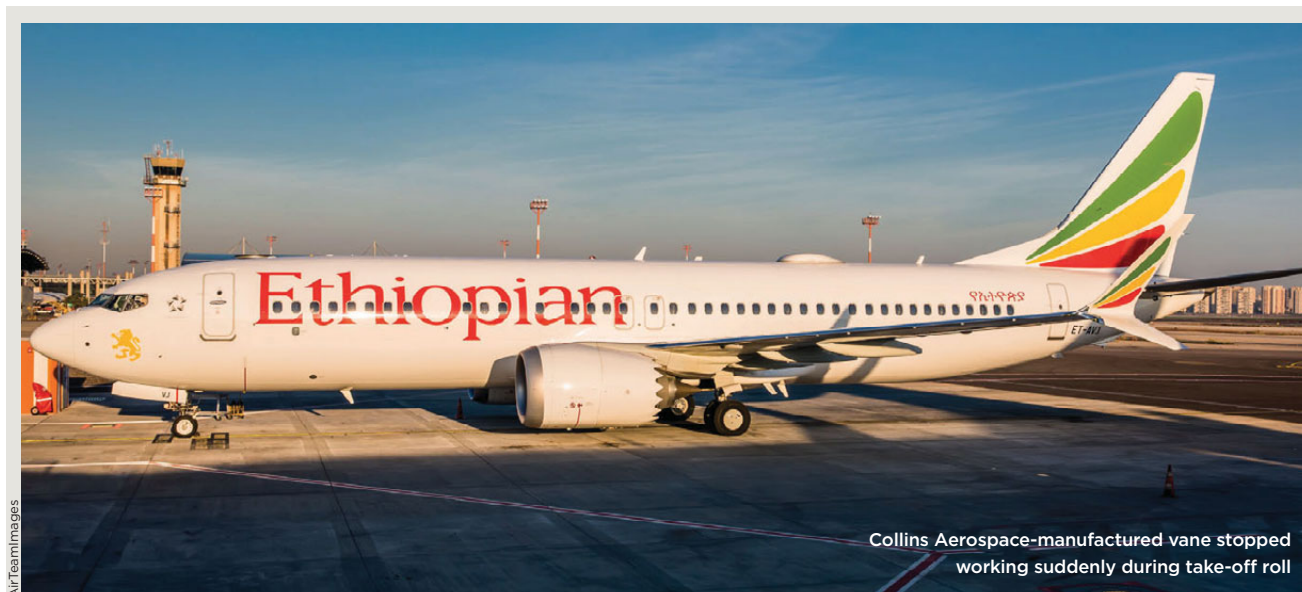
“Shortcomings relating to the crew’s actions, particularly in the first phase of the flight, is not accompanied by a thorough analysis of the reasons for the behaviours observed, in relation with their training [and] their experience,” says the BEA. ▶

See p46

Lack of thrust reduction made manual control ‘extremely difficult’



STR/EPA-EFE/Shutterstock



Probe rejects bird-strike theory for angle-of-attack sensor failure on crashed jet

One of the aspects of the Ethiopian Airlines Boeing 737 Max crash which had remained unclear during the investigation was the cause of the original angle-of-attack (AoA) sensor malfunction that initiated the accident sequence.

The sensor suddenly failed during the take-off run from Addis Ababa on 10 March 2019, transmitting flawed information to various aircraft systems including the Maneuvering Characteristics Augmentation System (MCAS) horizontal stabiliser trim function – which led the aircraft to enter a nose-down attitude and rapid descent from which its crew was unable to recover.

Ethiopia's air accident investigation bureau believes the sensor was defective and malfunctioned "most likely" as a result of a "power quality problem".

At the time of the malfunction, flight-data recorder information showed heater power to the left-hand sensor was lost.

"Evidence indicates the loss of power was likely due to a production-related intermittent electrical [or] electronic failure involving the airplane's electrical wiring interconnection system," the inquiry claims.

It points out that the aircraft had been experiencing various electronic glitches shortly after its delivery to Ethiopian Airlines in November 2018.

But the US National Transportation Safety Board (NTSB) argues that a bird-strike, which damaged the AoA vane, is a more plausible explanation for the sudden change in sensor data.

Readings from the left- and right-hand AoA sensors began to deviate sharply just as the aircraft lifted off. The left-hand figure fluctuated from 11.1° to 35.7° and then 74.5°, while the right-hand instrument remained largely constant at about 15°.

Ethiopian investigators, states the NTSB, omitted "key findings" about the sensor failure in their draft report into the accident.

Collins Aerospace manufactured the sensor and was appointed to the investigation team as a technical adviser to look into possible reasons for the malfunction, including manufacturing defects, component and heater faults, and structural failures.

The company conducted vibration, acceleration and flight-simulation testing, and modelled the sensor's performance.

While the Ethiopian inquiry refers to Collins' analysis, the NTSB says it "does not acknowledge" that the analysis of flight-data recorder information was "not consistent" with any internal failure of the sensor.

"Instead, those data were fully consistent with previous instances of partial [AoA] vane separation due to a bird-strike," it adds.

The vane appears to have broken at the hub and separated from the sensor, causing the performance deviation evident 44s after the Ethiopian aircraft commenced its take-off roll.

Separation of the vane resulted in an open circuit for the vane heater and resulted in a fail annunciation about 6s later.

According to the analysis the aircraft was travelling at about 170kt (314km/h) at the time and a 0.23kg (0.5lb) bird impact would have been sufficient to break the vane away from the jet. Large birds, such as steppe and tawny eagles, are common around Addis Ababa airport.

"Windtunnel test data and the [AoA] dynamic performance model show that the failure mode involving separation of the vane at the hub is consistent with the large and near-instantaneous initial change in the left [AoA] value and the resulting [AoA] dynamics observed," says the NTSB.

The Ethiopian inquiry states that an inspection of departure runway 07R, covering about a quarter of its 3,780m (12,400ft) length, did not locate any bird remains or debris from the vane.

But the NTSB states that the search took place eight days after the accident and did not include the area around taxiway D, where the erroneous left-hand AoA sensor readings began.

It adds that the lack of debris located during the inspection is not sufficient to rule out a foreign-object impact on the vane.

The NTSB says the inquiry "misses the opportunity" to address improvement of wildlife management at Addis Ababa.

But the Ethiopian investigators, while conceding that a bird-strike "may be" a cause, has leaned towards technical failure, insisting that a "wide range of power quality problems" can lead to erroneous AoA sensor output.

Putin the boot in: minister chided over status of aerospace contracts

Tensions emerge in discussion of Russian aircraft production strategy amid lack of firm commitments from its airlines

David Kaminski-Morrow London

Russian President Vladimir Putin has scolded industry minister Denis Manturov in an extraordinary exchange over the state of aircraft orders.

Putin hosted a meeting with several government officials, including Manturov, on 11 January.

Manturov updated the president on the planned delivery of 63 aircraft to Aeroflot Group – including 18 Irkut MC-21s, 34 updated Superjets, and 11 Tupolev Tu-214s – over the course of 2023-2025.

He also referred to separate plans for other airlines to ensure a “comprehensive programme” for development of the aviation industry.

But Putin told him that ambitions to deliver 700 aircraft and helicopters by 2030 required clear figures on the numbers of civil and military types, and other firm information – and that, in some cases, no orders had been finalised even for 2023.

Industrial organisations need to have a clear view of their prospects, Putin added.

“They have to hire labour, they have to maintain or expand production facilities,” he told Manturov.

“They need to understand how much the military department will order, how many civil aircraft will be ordered.”

Although Manturov attempted to assure Putin about the industrial preparations, Putin reiterated his concerns about an absence of firm contracts which, he said, meant the enterprises involved “do not have an understanding” of their tasks.

Putin ordered Manturov to “speed up” the work, and chided him for suggesting that the situation was in hand.

“I know there are no contracts at the enterprises [because] the directors told me,” stated Putin, adding that the discussion appeared to be turning into an argument, before asking: “What are you playing the fool for?”

He then continued pressuring Manturov, demanding to know when the contracts will emerge, and added: “These are the questions that need to be answered.”

Putin instructed him to complete the work within a month and refused to entertain Manturov’s response that the ministry would “try to do our best”.

“This should be done within a month,” Putin told him. “No later.”

Meanwhile, Russian airframer Irkut has delivered the second SSJ-New aircraft intended for strength testing, transferring it from its Komsomolsk production centre to Novosibirsk.

Structural certification tests will be carried out at the Siberian aeronautical research institute, SibNIA.

Structural modification

The shipment includes the fuselage and parts of the wing. The SSJ-New is a structurally modified version of the Superjet 100, designed to be powered by the Russian-built Aviadvigatel PD-8 engine, and features changes to its landing gear.

Irkut shipped an initial test airframe to the TsAGI Central Aerohydrodynamic Institute in Moscow in July last year.

Researchers at SibNIA aim to complete the first static tests on the second airframe in autumn of this year. These will include applying various loads to the wing, fuselage, undercarriage and pylon.

“Results obtained, along with the results of flight tests, will be used for certification of the aircraft in its new import-substituted guise,” says Irkut general director Andrei Boginsky.

He says the airframer expects to receive regulatory approval for the design changes by the end of 2023.

SibNIA director Vladimir Barsuk says the organisation has been working with the Superjet 100 since 2007, conducting life-cycle tests of the original model.

For assessing the SSJ-New, an updated and automated control system has been developed in order to carry out a wide range of tests, he adds. ■

President ordered Manturov to ‘speed up’ finalisation of orders



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Agency believes the X-59 design will eliminate issues around sonic boom

NASA confident Quesst can begin this year

Lockheed Martin-built supersonic X-plane should be ready to take to the skies in 2023 despite environmentalist concerns

Lockheed Martin

Jon Hemmerdinger Tampa

NASA expects its delayed X-59 Quiet Supersonic Technology (Quesst) demonstrator aircraft will make a first flight in 2023 once outstanding system evaluations are complete.

The programme is already significantly delayed, with NASA previously targeting a maiden sortie for the X-59 in the autumn of 2021.

Meanwhile, NASA is facing criticism over the environmental credentials of the X-59 programme, which is designed to develop technology that could help usher in a new era of supersonic air travel.

But in a sign of the increased focus on aviation's environmental performance, one advocacy group is calling on NASA to review the project on the grounds that it conflicts with the US government's goal of reducing carbon footprint from the sector.

"We anticipate that the X-59's roll-out and first flight will occur this year," NASA says. "We expect to have a more specific date after NASA and Lockheed Martin complete a series of system checkouts and ground tests in the coming months."

Lockheed confirms it is "on track for" first flight in 2023, citing supply chain and labour difficulties as issues holding up the complex development effort.

"It is a one-of-a-kind X-plane," Lockheed says. "We are expecting 2023 to be the year."

The X-59 is central to NASA's Low-Boom Flight Demonstration Mission, through which the agency is working to perfect and test designs that can lessen a supersonic aircraft's sonic boom. It believes the work "could make supersonic flight over land possible" by persuading US regulators to lift noise-linked bans on such operations.

As part of the Low-Boom project, NASA in 2018 awarded Lockheed a \$247 million contract to design, develop, manufacture and flight test the X-59. The aircraft's features – including its long, slender fuselage and unique structural elements – will result in a sonic boom of 75 perceived dB on the ground, which is comparable to distant thunder or a car door shutting, NASA hopes. Concorde's boom came in at 105 perceived dB.

Community approach

Lockheed had been assembling the single-pilot X-59, powered by a 22,000lb (98kN)-thrust GE Aerospace F414-100 engine, at its Skunk Works site in Palmdale, California. The jet is to cruise at 55,000ft and fly at speeds up to Mach 1.4.

Ultimately, NASA intends to use the X-59 to perform "community flights" – those will involve flying the aircraft over the USA while measuring the loudness of the sonic boom and its perceptibility to people on the ground. NASA intends to provide X-59 noise data to US regulators.

Critics of supersonic development projects have noted that such aircraft will be much less efficient

than subsonic aircraft, and NASA is not immune from that disapproval.

In a 12 January letter, non-profit group Public Employees for Environmental Responsibility urged NASA administrator Bill Nelson to review the X-59 programme in light of its "climate implications".

"Supersonic aircraft consume many times more fuel and produce many times the amount of pollution as current commercial flights," the letter says.

Spending tax dollars to "enable higher-polluting aircraft" is "difficult to reconcile" with NASA's broader goal of reducing emissions, it adds.

A 2022 report from the International Council on Clean Transportation found that supersonic passenger aircraft would use seven to nine times more fuel per passenger, per kilometre, than subsonic jets.

NASA tells FlightGlobal it "recognises that there are multiple challenges to making commercial supersonic flight a reality, including our long-term vision of addressing challenges such as emissions and fuel burn".

"However, the agency's focus at this time is specifically on flights of the X-59 in support of the Quesst mission," it adds.

NASA is now conducting "due diligence, as good stewards of the environment, to assess impacts during the entire Quesst mission", it says.

"The agency is conducting an analysis to identify environmental effects from the research flights of the X-59 prior to the community overflight campaign." ▶

Virgin Orbit takes heart despite failure of Start Me Up mission

Company analysing cause of ‘anomaly’ that doomed UK’s first satellite launch, ending hopes of milestone achievement

David Kaminski-Morrow London

In the end, after all the hype and excitement surrounding the UK’s first satellite launch, the event turned out to be the proverbial damp squib.

Despite a successful deployment from its carrier aircraft – a modified Boeing 747-400 (N744VG) – the LauncherOne rocket did not reach orbit, instead falling back to earth along with its satellite payload.

Investigations are now being conducted by both the launch operator, Virgin Orbit, and the UK’s newly constituted Space Accident Investigation Authority, which will probe the incident in co-operation with the US Federal Aviation Administration (FAA).

It had all started so well, however. The 747-400, named ‘Cosmic Girl’, had departed the southwest UK’s Newquay airport, which has been designated as Spaceport Cornwall for satellite launch activity, at about 22:00 on 9 January.

It flew west at around 30,000ft to a specified airspace zone southwest of Ireland for the drop, which took place about 70min after take-off.

Virgin Orbit says the vehicle’s first-stage rocket engine ignited and accelerated the craft to hypersonic speed.

“Initial data assessments indicate that the first stage of the rocket performed as expected,” it says.

The vehicle reached space altitude and underwent first-stage separation, fairing separation, and second-stage ignition. But at an altitude of around 180km the second stage “experienced an anomaly”, Virgin Orbit says, which prematurely ended its initial engine burn.

The craft failed to reach its intended orbit and the launch vehicle, along with its satellite payload, fell back to Earth.

Virgin Orbit says the launch vehicle was travelling at more than 9,500kt (17,600km/h) at the time.



Virgin Orbit

Operator is confident in future for Newquay-located Spaceport Cornwall

It was attempting to place satellites into orbit on behalf of seven customers as part of a mission dubbed ‘Start Me Up’.

“Extensive telemetry coverage for the flight allowed for the collection of an enormous quantity of data during the mission,” Virgin Orbit adds. This has enabled rapid analysis of the event.

“An extensive fault analysis and investigation of all required corrective actions identified during the investigation will be completed prior to the next flight,” it says, pointing out that, before the UK mission, each of its customer satellites had reached their required orbit.

Root cause

Chief executive Dan Hart adds that he is “confident” that the root cause will be determined in an “efficient and timely manner”, given Virgin Orbit’s previous successful launches using the vehicle and the quantity of telemetry it obtained from the UK flight.

“We are continuing to process and test our next vehicle per our plan and will implement any required modifications prior to our next launch,” he says.

Virgin Orbit is to conduct its next space launch from California’s Mojave Spaceport, but says that it expects to return to Spaceport

Cornwall and is holding discussions on potential opportunities which could emerge later this year.

But the launch failure has led to an early task for the UK’s new Space Accident Investigation Authority.

With the new launch capabilities being introduced in the UK, the Air Accidents Investigation Branch (AAIB) was designated as the Space Accident Investigation Authority in 2021.

Inspectors from the AAIB had been attending the launch from Spaceport Cornwall as observers.

While the Space Accident Investigation Authority is independent of the UK Civil Aviation Authority, the regulator will act as an adviser as investigators work with the FAA to oversee Virgin Orbit’s inquiry. “The aim will be to ensure any relevant safety lessons are learnt,” it adds.

And despite the mission not achieving its aims, many in the UK’s fledgling space industry are keen to take positives from the mishap. “While this result is disappointing, launching a spacecraft always carries significant risks,” says UK Space Agency director of commercial spaceflight Matt Archer.

But both the agency and Virgin Orbit stress that the flight demonstrated that launch capability from the UK is possible, and that Spaceport Cornwall has potential. ■

Corrupt database file led to
standstill at US airports

John Angellio/UP/ Shutterstock

FAA IT failure reignites reform calls

Collapse of crucial air traffic control system on 11 January led to 90min flight ban and has spurred demands for overhaul

Howard Hardee Sacramento

A US Federal Aviation Administration (FAA) IT breakdown that caused a 90min nationwide flight ban early on 11 January has led to renewed calls to upgrade the country's air traffic control (ATC) system.

A shutdown and reboot of the FAA's Notice to Air Missions (NOTAM) system – caused by a damaged database file, the agency says – delayed thousands of airline flights throughout the country before normal operations resumed just before 09:00 Eastern time.

"Americans awoke this morning to the largest ground stop of our national airspace system since 9/11," said Sam Graves, a Republican member of Congress who chairs the House of Representatives' Transportation and Infrastructure Committee.

"While it appears that the Notice to Air Missions – or NOTAM – system malfunction was not the result of a cybersecurity breach, it highlights a huge vulnerability in our air transportation system.

"Just as Southwest's widespread disruption a few weeks ago was inexcusable, so too is the [Department of Transport, DoT] and FAA's failure to properly maintain and operate the air traffic control system."

Southwest Airlines cancelled more than 16,700 flights between 21 December and 31 December 2022 as its decades-old software lost track of the locations of flight-crews and aircraft following a severe winter storm in the Midwest

and northeast USA. It took days for the airline to reset its network.

Southwest estimates it lost between \$725 million and \$825 million due to the operational meltdown, warning investors in a 6 January letter that it now anticipates a net loss for the fourth quarter of 2022.

US Transportation Secretary Pete Buttigieg blasted the Dallas-based airline for its disastrous holiday performance, writing in a 29 December letter to Southwest chief executive Bob Jordan that the DoT "will use the fullest extent of its investigative and enforcement powers to hold Southwest accountable if it fails to adhere to the promises made to reimburse passengers".

Scrutinising regulators

Now scrutiny is on federal regulators and Buttigieg's DoT. The FAA's recent struggles underscore the need to upgrade the NOTAM system, says Eric Blinderman, a spokesperson for aviation lobby group Aircraft Owners and Pilots Association (AOPA).

"In short, yes, the system needs modernisation," he tells Flight-Global. "That said, it's not just our opinion – everyone associated with this issue, including the FAA, knows that."

The incident also demonstrates that the NOTAM system and other ageing IT infrastructure are vulnerable to future cyberattacks, according to analysis from Moody's Investors Service.

"The outage highlights how the minute-to-minute operations of US airports and the US aviation sector rely on systems that are outside of

their control and are exposed to cyber risks," Moody's says.

Since 2007, the FAA has pursued its multi-billion-dollar Next Generation Air Transport System (NextGen) programme, seeking to implement "major new technologies and capabilities" into the US national airspace system rather than "simply making minor upgrades to ageing infrastructure", the agency says.

However, the ongoing effort has been repeatedly delayed and has resulted in little improvement to ATC capabilities.

"NextGen's actual and projected benefits have not kept pace with initial projections due to implementation challenges, optimistic assumptions, and other factors," reads a 30 March 2021 report by the DoT's Office of Inspector General.

It said benefits from the NextGen effort will be around \$100 billion lower than original estimates, and the improvements that had been achieved by that time were "minimal and difficult to measure".

The FAA said it is investigating the root cause of the 11 January shutdown. "Our preliminary work has traced the outage to a damaged database file," the agency says. "At this time, there is no evidence of a cyberattack."

Meanwhile, Graves says he expects the FAA "to provide a full briefing to members of Congress as soon as they know more".

"And just as the DoT expected Southwest to make passengers whole after their leadership failures, I expect a prompt update on [its] efforts to do right by the passengers it has wronged." ▀

Dassault resumes domestic Rafale deliveries in enhanced standard

French air force takes its first new example of combat aircraft since 2018, after pause to support multiple export customers

Craig Hoyle London

The French air force should receive 13 new Dassault Rafales during 2023, with Paris also expected to sign a production contract for its final tranche of the multirole fighter this year.

Detailing the delivery plan on 12 January, France's DGA defence procurement agency said shipments from its 40-unit, fourth tranche deal are to be completed during 2025.

A first aircraft from the order – two-seat example B359 – was handed over to the DGA at Dassault's Merignac site in late December, in the first such transfer for the French air force since B358 had been accepted in November 2018.

The agency notes that the four-year domestic delivery pause enabled Dassault to devote its assembly activities during the period to export customers, "making it possible to deliver 100 of the 224 new aircraft ordered to date by six other countries".

Fleet growth

A total of 192 Rafales will have been produced for France by the end of 2025, with this total to include aircraft for the air force (142), navy (45), four used in support of development testing by industry, and a single example which will be employed by the DGA's Essais en vol flight-test unit. Deliveries began in September 1999, with B359 as the 153rd unit.

Received in the F3R operating standard, the recently-delivered Rafale B will initially be employed in support of acceptance work for a new F4.1 standard, which the DGA says is "currently being approved... with a view to its start of deployment in 2023".

The new standard "incorporates hardware and software upgrades directly resulting from developments carried out in the context of export", plus enhanced cyber protection, "collaborative air combat capabilities" and the ability to deploy the 1,000kg (2,200lb) version of the Safran AASM air-to-surface weapon.

Meanwhile, "An order for

Dassault Aviation

Paris launches maritime patrol successor studies

Airbus and Dassault both awarded contracts to assess the viability of replacing current assets with adapted narrowbody or business jet solutions

Dominic Perry London

France has awarded contracts worth €10.9 million (\$11.8 million) each to Airbus Defence & Space and Dassault to conduct early-stage development work on a new maritime patrol aircraft (MPA) based on their respective A320neo and Falcon 10X platforms.

Set to run for 18 months, the activity will study "the architecture of

a future maritime patrol system" – named 'Patmar' – that could replace the French navy's modernised Breguet ATL-2 MPA fleet in the 2030s.

Under the terms of the contracts, awarded by France's DGA defence procurement agency, each airframer "will have to offer an economically attractive solution that meets the operational needs of the French navy in the post-2030 horizon".

Any resulting programme would launch in 2026 to support the service entry timeline, the DGA says.

Paris's move casts further uncertainty on a joint initiative with Germany to develop a future MPA through the Marine Airborne Warfare System (MAWS) programme.

Bilateral doubts

Berlin's selection in 2021 of the Boeing 737NG-based P-8A Poseidon as a replacement for its navy's Lockheed P-3C Orions had already thrown the bilateral effort into doubt. Germany signed a five-aircraft contract for the P-8A in



Dassault Aviation



B359's December transfer kicked off a fourth tranche of home shipments

42 additional Rafales is scheduled for 2023", the DGA says. This commitment will represent a fifth and final tranche of production for the French military.

Global demand

Cirium fleets data records the current global in-service Rafale inventory as totalling 240 aircraft, flown by France (94 air force and 40 navy), plus Egypt (24), Greece (10), India (36) and Qatar (36). The type is on order for Indonesia (42) and the United Arab Emirates

(80), with Croatia also to receive 12 ex-French air force examples.

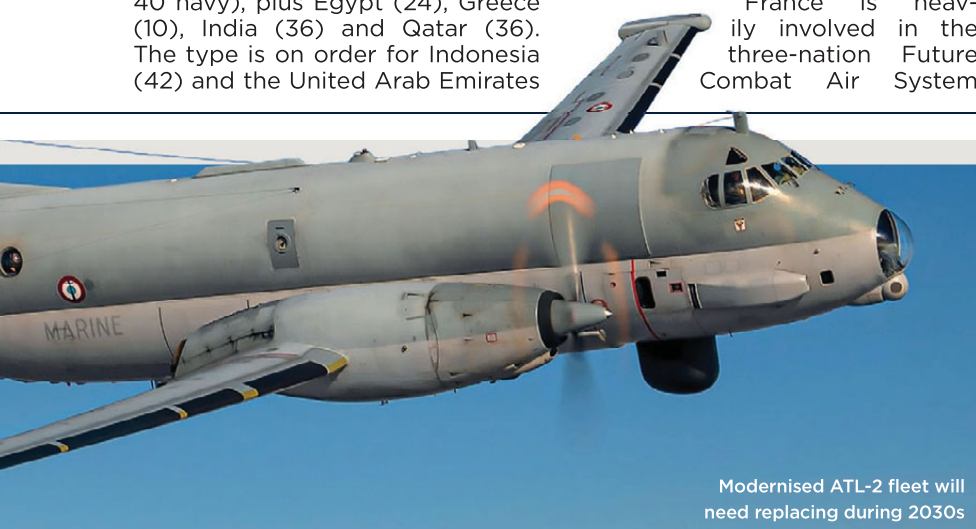
Dassault in March 2022 announced that it will boost its output of the Rafale to three aircraft per month by the middle of the decade, to match its current order commitments.

The airframer handed over 14 of the type last year; a reduction from 25 shipped in 2021.

France is heavily involved in the three-nation Future Combat Air System

(FCAS) endeavour with Germany and Spain, which seeks to deliver a manned successor for the Rafale for entry to service around 2040. Dassault is leading development work on the FCAS project's New Generation Fighter demonstrator, with flight testing expected to begin late this decade.

A €3.2 billion (\$3.4 billion) Phase 1B development deal for the FCAS programme was signed on behalf of the three partner nations last December, with this covering activities until 2025. ▶



Modernised ATL-2 fleet will need replacing during 2030s

June 2021, with the heavily adapted narrowbodies due for delivery from the fourth quarter of 2024 via a Foreign Military Sales deal with the US government.

At last June's ILA Berlin air show, a German official insisted that the P-8 acquisition represented a 10-year interim solution, and that the nation remained committed to MAWS, but it is unclear whether the joint development plan will survive the two nations apparently pulling in different directions.

While the DGA says the solutions proposed via the Patmar studies "should remain open to co-operation with other potentially interested European partners", this stops considerably short of a commitment to MAWS. Dassault confirms it is no longer working on any MAWS activity.

Technologies to be considered for the Patmar effort include new sensors, communications, data links, artificial intelligence-based computing systems and "in

particular" the integration of the future anti-ship missile that is being developed by MBDA for France and the UK through the FC/ASW programme.

Airbus has often touted the potential of its A320-family jets for military applications, with the company seeking to emulate Boeing's success with its P-8. But those efforts have so far been in vain.

Falcon variant

Dassault, meanwhile, in 2021 advanced the possibility of an MPA variant of its Falcon 10X – an ultra-long-range business jet that is set to enter service in 2025.

France currently conducts maritime patrol activities with a fleet of 22 ATL-2s, 18 of which are now being upgraded to the Standard 6 configuration.

A 10th modernised example was received at Lann-Bihoué naval air station in Brittany, northwest France last December. Upgrades include a new mission system and Thales Searchmaster radar, alongside the resolution of obsolescence issues. ▶

Type is believed to have had limited role during operations against Ukraine

Su-57 deliveries advance

Russian air force receives its latest batch of stealth fighters, but Western intelligence casts doubt on frontline contribution

Ryan Finnerty Tampa
Greg Waldron Singapore

United Aircraft (UAC) met its 2022 delivery target for the Sukhoi Su-57 stealth fighter, with the Russian air force receiving several of the aircraft shortly before the year's end.

"Our aircraft plant in Komso-molsk-on-Amur has fulfilled this year's programme for the production of fifth-generation Su-57 aviation systems and Su-35S multi-role fighters," UAC director general Yuri Slyusar said in late December.

Social media images and video showed multiple Su-57s with blurred tail numbers undergoing inspection and then taking off from a snowy runway. The footage is believed to include four aircraft.

Operational testing

Moscow will acquire 76 of the twin-engined fighters by late this decade, with the type still in operational testing. Cirium fleets data indicates that the service had previously taken a single active example, with another 10 assigned to Sukhoi.

Speaking at the Army 2022 show last August, Slyusar indicated that a further four Su-57s were being built under a defence ministry contract.

"The aircraft scheduled for delivery [in 2023] are already in production," he now says.

According to the TASS news agency, the Russian air force will

have 22 of its Su-57s in service by late 2024, with the full fleet to be fielded by 2028.

The most recent Su-57 deliveries were accomplished despite severe economic sanctions levied against Russia by Western powers in retaliation for Moscow's February 2022 invasion of Ukraine. Those trade restrictions have limited its aerospace industry's ability to access advanced, Western-sourced components and financial capital.

In a related development, it is uncertain if a planned schedule for UAC to roll out and fly its first prototype of the Su-75 Checkmate this year remains intact. The light-weight fighter programme was announced in July 2021, with work on a prototype taking place in Komso-molsk-on-Amur and deliveries previously targeted for 2026.

Meanwhile, the UK Ministry of Defence (MoD) says Moscow has "almost certainly" operated the Su-57 in combat against Ukraine since June 2022.

But according to the UK's Defence Intelligence organisation, Russia has employed the aircraft mainly for long-range, stand-off strikes. It has released an open-source satellite image showing Su-57s at Akhtubinsk air base, east of Volgograd; the site houses the 929th Flight Test Centre.

"Russia is highly likely prioritising avoiding the reputational damage, reduced export prospects, and the compromise of sensitive technolo-

gy that would come from any loss of [an Su-57] over Ukraine," it says. "This is symptomatic of Russia's continued risk-averse approach to employing its air force in the war."

Moscow's assets have been unable to secure air supremacy during the conflict, despite facing an adversary with far fewer aircraft. The Russian air force also has proven ineffective at providing close air support to its ground troops, and has largely restricted itself to attacking fixed military and civilian targets from extended ranges, in part because of Kyiv's strengthened air defence network.

Defensive weapons

Last December, Washington DC confirmed that it would for the first time supply Ukraine with a Raytheon Patriot surface-to-air missile system. Ukraine has already been provided with other defensive weapons, including NASAMS batteries using Raytheon AIM-9X and AIM-120 AMRAAM missiles.

On 6 January, the US government announced its latest, \$3 billion package of equipment support to the Ukrainian military, citing "anti-aircraft capabilities including RIM-7 [Seasparrow surface-to-air] missiles and 4,000 Zuni rockets".

By mid-January, Ukraine claimed to have downed 286 fixed-wing aircraft and 276 helicopters since Russian forces invaded, although these figures have not been verified independently. ▀



New technologies to boost A330 tanker

Trials to assess viability of automatically refuelling unmanned air vehicles from MRTT platform, as Airbus seeks fresh buyers

Craig Hoyle Madrid

Airbus Defence & Space is furthering its pursuit of new technologies for use with the A330 multirole tanker transport (MRTT), as it eyes major additional sales opportunities for the type.

Buoyed by the certification in mid-2022 of its A3R automatic boom refuelling enhancement for the adapted widebody – initially for use by the Republic of Singapore Air Force – Airbus plans to trial a further iteration of the system from later this year. The planned A4R version will bring the ability to perform the in-flight refuelling of unmanned air vehicles (UAVs).

To be performed in tandem with the company's UpNext technology accelerator unit, the pending A4R trials will involve its A310 MRTT testbed and an Airbus Do-DT25 tactical UAV.

"The demonstration will go step by step: formation flight, control, and then refuelling," says Jean-Brice Dumont, the airframer's head of military aircraft. "What is extremely critical initially is to ensure the safety of close flight, the controllability and the resilience of the control systems where you control the drone from the [tanker] aircraft."

As with the in-service A3R technology, the enhancement will be based on the use of the MRTT's fly-by-wire-controlled refuelling boom. Ground-based testing was scheduled to begin at the company's Getafe site near Madrid in January.

Expected to run over a two-year period, the activity also will involve simulated additional unmanned aircraft, to eventually represent a six-strong formation of receivers, Airbus says.

Dumont describes the development work as "a feeder for what a remote carrier may need" for use as part of the European Future Combat Air System (FCAS) capability.

Airbus also is pursuing the integration of other new capabilities for the A330 MRTT, with Dumont identifying work to enhance its self-protection equipment.

"With the tanker becoming more and more a key asset, we need to have a level of self-protection more comparable to what we have on some fighters," he notes.

Extended connectivity would enable the platform to support FCAS operations for the French-German-Spanish programme.

Sales success

Meanwhile, Airbus expects to build on its sales success with the A330 MRTT: it has so far delivered 54 examples from a total of 66 ordered by 14 nations.

"We see a very promising worldwide market, [of] around 90 aircraft in the couple of decades to come," Dumont says. That projection excludes the USA, where the A330-200-based LMXT platform is being promoted by local prime contractor Lockheed Martin for the US Air Force's expected "bridge tanker" requirement.

"We see additional orders from our [existing] customers, realising

that there is a ratio of fighters per tanker that motivates them to order more," Dumont says.

New customer Canada is expected to acquire six A330 tankers, including converted secondhand aircraft. Ottawa is currently completing a strategic planning activity ahead of confirming the deal, having announced the type's selection in April 2021.

"We see the secondhand market for the couple of years to come as quite promising," Dumont said during the company's annual Trade Media Briefing event in Getafe last December. "Many customers are considering for cost-efficiency reasons to have a cheaper 'green' aircraft. We see customers – Canada, Spain, and a few others – asking for secondhand bids."

Current conversion work in Getafe includes preparing a first ex-Iberia-operated A330 for the Spanish air force, with the MRTT modification process typically taking nine months to complete. Madrid will eventually field three examples.

Airbus also will in the first quarter of 2023 respond to a recent request for proposal from Brazil to modify two ex-Azul-operated A330s to the MRTT configuration.

"We needed time to mutually understand each other, as they are secondhand [aircraft]," Dumont says. "As we speak, we are putting our offer together," he adds.

The Brazilian air force currently operates one of the future KC-30 aircraft in a passenger configuration, following its arrival at Galáez air base last July. ▀

Mesa move shakes up US market

Regional carrier ditches loss-making contract with American in favour of expanded partnership with United Airlines

Howard Hardee Sacramento

The severing of regional US carrier Mesa Airlines' contract to operate on behalf of American Airlines in favour of a five-year deal with United Airlines represents a significant shake-up in the regional segment.

Phoenix-based Mesa will in March begin transitioning to United 38 Bombardier CRJ900 aircraft it now flies for American, with that process to be complete by 3 April. In turn, United will park the same number of Embraer 175s to avoid conflict with its pilot union.

But accounts differ on how the relationship soured between Mesa and American. In a 17 December memo to employees, Derek Kerr, American's chief financial officer and president of regional unit American Eagle, told employees that his company was concerned about "various financial and operational difficulties this year".

"As a result, we have concerns about Mesa's ability to be a reliable partner for American going forward," Kerr says. "American and Mesa agree the best way to address these concerns is to wind down our agreement."

However, Jonathan Ornstein, Mesa's long-time chief executive, bristles at the suggestion that American initiated the break-up due to Mesa's struggles.

"While the pilot shortage has created significant challenges

recently, I would suggest that our operational performance over the last 10 years has certainly been no worse than mainline American," he tells FlightGlobal.

American has not commented on Ornstein's remarks.

And in an internal memo to Mesa employees, he says the carrier's operation with American was losing about \$5 million monthly due to higher pilot pay rates and penalties for not meeting contracted block-hour requirements - meaning it was not flying enough.

\$5m

Monthly loss being incurred by Mesa due to its contract with American, according to CEO Jonathan Ornstein

"We would have been happy to maintain a relationship with American. We just couldn't afford to do it," he says.

"We can't afford to lose \$5 million a month. That's a lot of money for us. We're losing 50 to 60 pilots a month, watching our block-hour production collapse. What else could we do? We had to get out from under this."

Ornstein's warnings are borne out by Mesa Air Group's fourth-quarter financial performance: in the three months to end-September 2022, it lost \$115 million, a worsening of

the \$7.5 million loss recorded in the same period a year earlier.

For the full fiscal year, Mesa reported a \$183 million loss, compared to a profit of \$16.6 million in fiscal year 2021.

Total revenues during the three months hit \$126 million, compared with \$131 million during the same quarter of 2021.

Ornstein believes the national pilot shortage in the USA was "masked" by the downturn in demand for air travel caused by the Covid-19 pandemic and then exacerbated by early retirements.

But the root problem is the expensive, years-long process of accruing enough time in the cockpit to become a commercial pilot, he says. With airlines recovering from the pandemic and travel demand surging, US majors boosted wages, drawing captains and first officers away from the regional carriers.

American, for example, has "aggressively" recruited Mesa's pilots, Ornstein says, without helping to cover the cost of rising pilot wages. It then penalised Mesa for not flying enough under its block-hour requirements because it lacked sufficient pilots, he adds.

"You raise regional pilot pay almost 100% and then refuse to support pilot pay increases at not-wholly-owned carriers, and then you heavily recruit our pilots and then you penalise us to the brink of bankruptcy," Ornstein says.

Mesa was forced to make a change, he says.



38 Bombardier CRJ900s will be transitioned to United by 3 April

By his account, American agreed to match whatever United offered. United agreed to waive block-hour penalties, pay a block-hour rate and fund new pilot wages – and American did not. Ultimately, American did not provide what it would take for Mesa to fly out its contract, according to Ornstein.

“They offered a little more money, but a little bit wasn’t enough,” he says. “I mean, we are not going to drown in an inch of water.

“We had to plead to be let out of this contract,” he continues. “Any inference that anything other than that occurred is a fabrication. Not only did American ask us to fly out the contract, at one point they offered us an extension if we would continue.”

Equity risk

Filing for bankruptcy could have wiped out all of Mesa’s equity, Ornstein acknowledges. The airline may have been forced to sell its aircraft, though he believes the business would have survived even if it had not reached a new agreement with United. The deal gives Mesa a clear path forward, however.

Ornstein speaks glowingly of Scott Kirby, United’s chief executive, with whom he has had a personal relationship since the early 1990s, and he is “delighted” with their new deal. “We’re going to start moving our aircraft over to United, and it will be a smooth transition,” he says.

United is providing Mesa with \$41.2 million in financial assistance and \$80 million for 30 spare engines, Ornstein says.

Additionally, United has gained 10% equity in Mesa and a position on the board of Mesa Air Group.

United will also pay Mesa increased block-hour rates to cover the incremental pilot-wage increases in its new contract with union Air Line Pilots Association, International (ALPA), which will remain in effect through September 2025.

Mesa has suffered from the pilot shortage as major US airlines have recruited a large number of captains and first officers – but the carrier currently has 400 pilots in its training pipeline.

Now, its plan is to position itself as a pathway for pilots who want to fly for United.

“United has acted very decisively in this particular circumstance to ensure there’s a pilot flow that goes from Mesa into United,” Ornstein says. “United now has literally the greatest growth plan in the history of commercial aviation.

“There is a big demand for pilots and I think United views Mesa as their [feeder] team.”

United, meanwhile, has been forced into a fleet reshuffle on the back of the new partnership, parking 38 E175s to make way for the same number of CRJ900s.

“Mesa Airlines recently announced changes in its operation that mean we will replace up to 38 Embraer E175 aircraft in the United Express fleet with up to

38 of their Bombardier CRJ900 aircraft,” said Bryan Quigley, the Chicago-based carrier’s senior vice-president of flight operations, in an internal memo.

“It is important to note that there is no change to our scope provisions in the United Pilot Agreement. United will remove a corresponding number of Embraer E175 aircraft from its regional fleet.”

Market opportunity

Mesa’s CRJ900s will operate United Express services from the mainline carrier’s hubs in Houston and Denver “as capabilities allow”, Quigley says. With this move, the airline hopes to increase flights to small- and mid-sized markets across the USA that have seen a reduction in air service over the past few years.

United’s regional partners currently include Air Wisconsin, CommuteAir, GoJet, Mesa, Republic and SkyWest.

Air Wisconsin, however, said last August that it will end its relationship with United, instead partnering with American. From March 2023 it will transition up to 60 CRJ200s to operate American Eagle flights. ▶

*Additional reporting by
Pilar Wolfsteller in Las Vegas*



“We would have been happy to maintain a relationship with American. We just couldn’t afford to do it – we had to get out”

Jonathan Ornstein Chief executive, Mesa Airlines

Air New Zealand details net-zero push

Carrier reveals aircraft partners for programme that will help determine its future fleet evolution and potential successor plan for 50-seat Dash 8-300 turboprops

Dominic Perry London

Air New Zealand (Air NZ) has selected four aircraft providers – Beta Technologies, Cranfield Aerospace Solutions (CAeS), Eviation, and VoltAero – for its Mission NextGen programme, which will see the carrier perform commercial demonstration flights of low-emission aircraft from 2026.

Following the initial phase of the programme, Air NZ will then select which aircraft will form the backbone of its new regional fleet, replacing ageing De Havilland Canada Dash 8-300s on domestic routes from 2030.

The companies involved in the project are drawn from across the globe, with their aircraft employing different propulsion solutions and operational models.

Vermont-based Beta Technologies will supply its five-passenger ALIA electric vertical take-off and landing aircraft; UK firm CAeS will provide three Britten-Norman BN2 Islanders converted to run on hydrogen fuel cells; Eviation of the USA its Alice all-electric aircraft; and France's VoltAero its Cassio 330 hybrid-electric five-seater.

Demonstration phase

In each case, Air NZ has signed a "statement of intent to order", which will see the carrier take three aircraft for the demonstration phase, with options for a further 20, subject to an evaluation process.

Greg Foran, Air NZ chief executive, says: "Mission NextGen Aircraft is not about backing one innovator. It's about working with a range of leaders in zero-emission aircraft technology to help move the whole ecosystem along.

"Our goal is to confirm our commitment with one or more of these

partners in the next 12 months with the ambition of purchasing an aircraft for delivery from 2026.

"The learnings we will take from flying an aircraft with next generation propulsion technology from 2026 will then pave the way for our long-term partners to deliver an aircraft that can replace our Q300 turboprop domestic fleet."

Air NZ announced the Mission NextGen accelerator programme last November, building on a set of

23

Total order commitment, including options, placed by airline with each selected aircraft manufacturer

specifications for a future aircraft released in December 2021 which drew responses from more than 30 aircraft developers, the airline says.

In addition to the 23 50-seat Dash 8s, Air NZ's domestic turboprop fleet also includes 29 68-seat ATR 72-600s, which will come up for replacement in the mid-2030s.

Jenny Kavanagh, chief strategy officer at CAeS, says the initiative is an example of the "collaboration that is needed" to drive aviation's decarbonisation.

Selection of the converted Islander by Air NZ is also a "statement of credibility" for the programme, she adds. "The size of the airline and the fact that it has been established for a long time as one of the sustainability leaders in the airline industry is a big boon for us.

"They are currently not flying anything smaller than a Dash 8 but are really trying to embrace the opportunities that new technology brings."

Jean Botti, chief executive of VoltAero, says he is "very proud" of its selection by the carrier.

"It's the first big international company to have signed up with VoltAero; we have lots of regional airline customers up to now but [Air NZ] is an international company."

He confirms the demonstration flights will be conducted with the Cassio 330, targeted for certification in 2024.

VoltAero is developing two follow-on aircraft, the six-seat Cassio 480 and 10-12-seat Cassio 600, and Botti suggests the latter would likely be of greater interest for Air NZ in the longer term. "I think ultimately that for their needs that would be probably the most appropriate thing," he says.

VoltAero's parallel hybrid-electric powertrain could ultimately be scaled up for a 20-seat passenger aircraft, he adds, but is dependent on improved battery technology.

"Things have to happen in that domain and that's why we are focussing on the best available technology today that will allow you to have an electric aircraft."



Air New Zealand

“Mission NextGen is not about backing one innovator. It’s about working with a range of leaders in zero-emission aircraft technology”

Greg Foran Chief executive, Air New Zealand



VoltAero's Cassio 330 five-seater features a hybrid-electric powertrain

CAeS is also planning successors to its converted Islander, progressively growing in power and range, and moving from the use of existing airframes into clean-sheet designs. The first of these – a 19-50-seat regional aircraft – would arrive in the early 2030s, followed by a 75-100-seater in around 2035.

But first, CAeS needs to complete the development of the seven-seat Islander. Bench and ground tests were due in 2022, but have now

been pushed into 2023 due to supply chain constraints.

A first flight of the converted BN2 is due towards the “back end of the year”, says Kavanagh, as the company works towards its target of achieving supplemental type certification for the modification in 2025.

However, she sees no impact on the overall timeline from the delays, with work already under way on the production version of the propulsion system.

“We pretty much know now what we need to be doing for the production [version], it’s just a matter of getting a team on it.

“The flight of the demonstrator is a really exciting milestone and extremely important for testing those final things you can’t test on the bench or ground, but in terms of the design we are pretty much there.”

Botti, meanwhile, points to the more than 135 flight hours VoltAero has accumulated over two years with its 600kW powertrain aboard its Cassio 1 demonstrator – a converted Cessna 337 Skymaster. Over 175 flights have seen it travel in excess of 5,400nm (10,000km).

VoltAero’s architecture sees the Cassio aircraft use electric motors in the aft fuselage-mounted

propulsion system for all-electric power during taxi, take-off, primary flight, and landing, while the thermal engine serves as a range extender – charging the batteries in flight – or as an emergency back-up.

Eviation chief executive Gregory Davis says: “Regional flights make up a sizeable proportion of Air New Zealand’s routes. The Alice offers an effective way to decarbonise these journeys, revolutionising air travel and supporting the goals of the Mission NextGen programme.”

Alliance agreement

Air NZ has also signed a “strategic alliance agreement” with Hirling Energy, a New Zealand-based green-hydrogen supply and refuelling infrastructure company, to help the carrier better understand the requirements of the new fuel.

“While the aircraft play a pivotal role, infrastructure partners are just as important. Through this agreement we will explore the future green-hydrogen supply solutions for our commercial demonstrator ambitions with a focus on ensuring any solutions we create to meet our 2026 goal are also building a platform for a larger next generation fleet from the 2030s,” Foran says. ▀

CAeS will provide Britten-Norman BN2 Islanders converted to run on hydrogen

Crew saw headlights only after freighter had become airborne

Controller cleared 737 for take-off from occupied runway during long solo shift



Inspection vehicle was given authorisation to enter runway at Porto minutes before narrowbody began departure roll

David Kaminski-Morrow London

Portuguese investigators have found that a Boeing 737 was granted take-off clearance on an occupied runway by a controller who had worked alone and uninterrupted, in a unified approach and tower position, for 4h before the incident.

The ASL Airlines Belgium 737-400 was departing Porto on 27 April 2021, its crew unaware of a runway inspection vehicle which had started its work on runway 35 some 12min earlier.

Only after the driver of the vehicle – which had started heading south from the northern end of runway 35 – noticed a bright light, and contacted the tower, was he

told that the aircraft was approaching and to vacate the runway.

There had been no other contact between the controller and the vehicle driver since the controller's authorisation of the inspection, says Portuguese investigation authority GPIAAF.

It adds that the two were in contact over a terrestrial radio system, and the driver was not listening – and was not required to listen – to the aeronautical frequency.

The driver took evasive action after seeing the aircraft's lights, and vacated the paved surface of the runway.

GPIAAF says the vehicle was only seen by the 737's crew at lift-off, when the pilots saw headlights near the left-hand edge of the runway. It estimates the aircraft

became airborne 300m (984ft) from the vehicle, and was separated by 150m vertically as it passed.

Investigators found the controller had been working in a "tedious and low-activity environment" for an extended time, and the presence of the vehicle on the runway had "completely slipped his mind".

"Regular and frequent contact between the [vehicle] and the tower would probably have minimised the possibility of the controller to forget the occupied status of the runway," the inquiry adds.

Unreliable communications

The driver had not received formal training in operating the radio scanners in the vehicle, it says, and the radios installed were "notoriously unreliable" and "not user-friendly".

GPIAAF states that the vehicle was equipped with lights, but these would have blended into the runway lights at a distance from the 737, making its detection difficult for the aircraft's crew.

While Porto tower was equipped with a runway incursion alert system, it had been inhibited at an unknown point in time, apparently for producing several false alarms.

"This inhibition did not allow the system to generate the alert for the simultaneous presence of two targets in the critical area," the inquiry says. Neither of the occupants of the aircraft (OE-IAJ) nor the driver was injured. ▶



Airport's incursion alert system had been inhibited after false alarms

Ditching inquiry reveals pilots' uncertainty over failed engine

Flight-data recorder information highlights Transair crew's confusion as freighter departed from Honolulu in July 2021

David Kaminski-Morrow London

Investigation details from the Transair Boeing 737-200 freighter ditching off Honolulu in 2021 indicates uncertainty from the pilots over which of the aircraft's engines had initially failed shortly after the jet took off.

Flight-data recorder information released by the US National Transportation Safety Board shows a sudden drop of thrust on the right-hand engine as the aircraft climbed through 390ft.

The climb paused at 1,000ft before continuing to 2,000ft, when the thrust on the left-hand engine reduced to idle – where it stayed for the remainder of the flight.

Thrust for the right engine also reduced further at 2,000ft but then continued to fluctuate, at low level, several times while the crew were attempting to keep the jet airborne and return to the airport.

Cockpit-voice recorder transcripts from the 2 July 2021 accident show that, seconds after take-off and just after the 'gear up' call, the captain mentioned the loss of an engine.

The first officer, who was flying, replied "number two" – an apparent reference to the right-hand powerplant – and the captain also said, "number two".

After levelling at 2,000ft, the crew declared an emergency to air traffic control, informing that they had "lost an engine", but did not immediately indicate which one.

According to the transcript, the captain asked the first officer to "read the gauges" to determine which "has the EGT" – the exhaust gas temperature – to which the first officer replied: "It looks like the number one."

The captain then responded, "Number one is gone?", and the first officer responded: "[It's] gone, yep... so we have number two."

"So we have number two, OK," the captain then remarked.



But as the crew sought to run checklists and co-ordinate the return to Honolulu airport, the aircraft's airspeed declined and it lost altitude. The first officer appeared to mention that the right-hand engine had reached "red line" and the captain advised air traffic control that they could potentially be facing a dual engine failure.

The 737 (N810TA) struck the ocean surface, breaking up, but both crew members – the only occupants – survived.

Initial beliefs

In subsequent testimony to investigators, the first officer said he had heard a 'pop' from the vicinity of the left engine around the time the landing-gear retracted, and initially believed the left engine had failed.

The captain told the inquiry that he thought the left-hand engine had the problem, at first, before changing his mind – based on the aircraft's yaw and roll motion – and telling the first officer that he thought the right-hand engine was the one affected.

But during his testimony the captain referred to the first officer's having told him that the number one engine, the left-hand powerplant, had failed.

The captain told investigators that the first officer, with whom he had flown several times, "never makes a mistake", adding: "If [he] says number one is gone, then number one is gone."

The captain was asked about the position of the left-hand engine thrust lever and the left-hand engine instruments, but told the inquiry he "ignored it" because he believed the engine was not functioning.

Investigators queried the captain over his initial belief that the number two engine was the one that had malfunctioned, which he acknowledged, but said he believed the first officer, as the flying pilot, would know which engine had failed.

At one point the captain picked up on a remark from the investigator about the position of the number one thrust lever, and whether it had been moved backwards.

"Why are we talking about number one thrust lever?", he asked. He asked the investigator to confirm which engine had the problem, but the investigator could not disclose this or provide a fuller explanation.

Investigators have not reached any conclusions on the circumstances of the accident, and the reasons for the recorded losses of thrust in the 737's engines. ■

LCI drives Chaparral higher

Autonomous, hybrid-electric VTOL cargo aircraft programme lifted by lessor's latest order in advanced air mobility space

Dominic Perry London

Lessor LCI has further broadened its portfolio with an order for up to 40 Elroy Air Chaparrals – an autonomous vertical take-off and landing (VTOL) cargo aircraft that uses a hybrid-electric powertrain.

Under the deposit-backed agreement, LCI will initially acquire 20 Chaparral aircraft, with an option for up to 20 more. No details of the transaction value were revealed.

Delivery timelines depend on Elroy Air securing certification for the Chaparral, which will enter flight testing later this year, the company says.

Designed to carry a payload of up to 225kg (500lb) on routes of up to 300nm (555km), the Chaparral uses a turbine-based hybrid-electric powertrain to drive a series of distributed electric motors: eight for lift and four for forward flight.

Goods are carried in a specially-designed modular pod that fits under the fuselage.

Better known as a helicopter lessor – but with a small interest in the fixed-wing segment – LCI has already signalled its interest in the advanced air mobility (AAM) market, last year placing an order for up to 125 BETA Technologies ALIA-250 eVTOL utility aircraft.

"The AAM market forms an integral part of LCI's future growth,

and this marks our second commitment in less than 12 months for these innovative and sustainable new aviation systems," says chief executive Jaspal Jandu.

"We see their wide range of applications complementing our existing fleet of modern helicopters and fixed-wing aircraft, enabling us to offer even greater value and choice to operators across the globe."

Jandu says the deal will "strengthen LCI's position as a leading provider of leasing, financing and investing solutions for this new and exciting market."

David Merrill, chief executive and co-founder of Elroy Air, adds: "Through our agreement with LCI, the Chaparral will be available for financing – enabling much broader access to the aircraft."

Commitments secured

Elroy Air says it has now secured commitments for more than 900 Chaparral systems worth in excess of \$2 billion. Disclosed customers include AYR Logistics (up to 100 units), Bristow Group (100), FedEx, and Mesa Airlines (150). The company also holds orders where the buyer has not been revealed.

Ground testing of the Chaparral is to begin shortly at Byron airport in California, around 45 miles (73km) to the east of Elroy Air's San Francisco headquarters.

Initial tie-down testing will validate the Chaparral's software

and hardware systems before moving to flight tests later this year, Merrill confirms.

Elroy Air intends to launch operations prior to obtaining US Federal Aviation Administration (FAA) validation, in order "to serve missions and uses that do not require full FAA certification", says Merrill.

"Alongside this early roll-out phase, we are collaborating with the FAA on type certification and expect to secure type certification and operational certification within the next several years," he adds.

It sees applications for the Chaparral including disaster relief, firefighting and humanitarian missions, plus middle-mile logistics, "without risk to pilots or the need for airport infrastructure".

LCI says it is working closely with the manufacturer in order to introduce the aircraft to customers "as soon as practical".

While it does not have operators already lined up for the Chaparral, the lessor says it has "every confidence" the system will prove popular globally.

"This commitment for the pioneering Chaparral system will enable us to efficiently support mission-critical, remote logistical work and socially responsible humanitarian efforts around the world," says Jandu.

"It will do so in complement with the wide-ranging capabilities of our existing aviation fleet." ■

Goods are carried in a modular pod under the fuselage

Elroy Air/LCI

EASA outlines helicopter VRS study plan, as it awards research contract to ONERA and DGA

Airbus Helicopters

Results could influence certification and training updates

Test flights supporting potential regulatory changes set to take place from Istres air base in the south of France

Dominic Perry London

European regulators are hopeful that newly-commissioned research into vortex ring state (VRS) will deliver a significant safety boost for helicopter operators, and potentially lead to changes in certification and pilot training requirements.

In addition, the study could help with the development of similar regulations for electric vertical take-off and landing (eVTOL) aircraft.

In early December, the European Union Aviation Safety Agency (EASA) awarded French aerospace research institute ONERA a 24-month contract, worth just under €380,000 (\$403,000), to conduct a deeper examination of VRS.

ONERA, working with the flight-test arm of France's DGA defence procurement body, will conduct a series of flight tests from Istres air base near Marseille using a pair of heavily-instrumented rotorcraft – an Airbus Helicopters AS550 light-single, together with an AS365 medium-twin.

VRS – where a rotorcraft descends rapidly through its own downwash – is a serious safety risk for helicopter crews, but is not considered as part of the aircraft certification process, says EASA.

Although pilots are taught to recognise VRS and learn exit techniques as part of their basic training, EASA points out that the

“envelope and the characteristics of VRS can change” from one helicopter type to another.

But there is no requirement for a manufacturer to define those rules, or to “define specific limitations and crew instructions in the relevant aircraft flight manual”.

In addition, “the recovery manoeuvres being taught to student pilots are mostly limited to traditional ones”, the agency notes.

EASA says the study will “provide a better understanding of the VRS phenomenon on different kinds of helicopters” and also an “indication of the effectiveness of other recovery manoeuvres”, including the so-called Vuichard technique.

Agency evaluation

Results from the research will enable the agency to evaluate whether it needs “to change the current regulations” to enhance safety, it says.

“This, however, will not only include certification specification, but also regulations, like pilot training and ops regulations.

“At the same time, the study could lay down the basis for the development of relevant regulations for eVTOLs,” it adds.

EASA says the two different helicopter types were chosen for the study “in order to have more data available that would support a generalisation of the test results, both for the VRS envelope prediction and for the evaluation of the recovery manoeuvre.”

Exact details of the evaluations are still to be finalised, says EASA, but its initial phase will “include the exploration of the vortex ring envelope, including its variation with the most relevant parameters”.

A second stage will explore the Vuichard technique and assess its effectiveness against conventional recovery methods.

EASA says although the precise assessment criteria are still to be defined, it expects the evaluation will be “based on specific criteria, such as pilot workload, ease of the manoeuvre, pilot situational awareness, altitude loss, as well as monitoring relevant flight parameters for a safe recovery of aircraft control.”

At least two test pilots will perform the assessments for each condition and each type, it adds.

Named after Swiss pilot Claude Vuichard, the Vuichard technique involves increasing the collective to maximum power while maintaining heading through pedal input and applying opposite lateral cyclic to bank out of the vortex.

This technique, says EASA, is claimed to be effective at limiting altitude loss compared with the conventional escape method.

VRS has previously been blamed for a number of high-profile accidents, including the August 2013 crash of an AS332 (G-WSNB) on approach to Sumburgh airport in the Shetland Islands, in which four passengers were killed. ▀

FutPrInt50 hopes to leave mark with hybrid-electric concept

European research project details its design for a possible low-emission regional aircraft to enter service next decade

Dominic Perry London

A team of European researchers is putting the final touches on a 50-seat hybrid-electric concept aircraft that has been developed through a project funded under the EU's Horizon 2020 programme.

Co-ordinated by the University of Stuttgart, FutPrInt50 – Future Propulsion and Integration towards a hybrid-electric 50-seat regional aircraft – has involved Cranfield University in the UK and TU Delft in the Netherlands, plus contributions from airframer Embraer's operations in Portugal and Brazil.

Running since the start of 2020, the project has arrived at a concept aircraft that it believes is suitable for service entry from 2035 onwards.

Compared with many of the more radical concepts out there, the external appearance of the current design is relatively conventional: it features a pair of large electrically-boosted gas turbines on the inboard section of the wing, supplemented by a pair of smaller electric propulsors on the wingtips.

But there are significant differences. The wingtip-mounted

electric motors, for example, also double as generators, allowing “energy harvesting” during certain flight phases. Power comes from a mixture of conventional gas turbines and batteries.

Now in its final six months, the FutPrInt50 team is working to complete its analysis of the key technologies involved – evaluating component-level maturity, development roadmaps and potential integration challenges, says project co-ordinator Professor Andreas Strohmayr.

Reference point

In addition, as a reference, the team has designed a conventionally powered regional aircraft based around the engine technology that should be available in the 2040s.

“The gap [in emissions] performance will not be that big then, but we need to have an apples-with-apples comparison,” Strohmayr says.

FutPrInt50 intends to publish its findings as an open-source resource for the industry to help accelerate the transition to climate-neutral flight.

Strohmayr says a huge number of possible configurations were initially considered, based on different powertrains and energy sources,

including hydrogen combustion and fuel cells. These were then whittled down to eight options before the current architecture was settled on.

“In our view, this is the most promising [design] which can be compared against the reference aircraft,” he says. “Technology is converging into a feasible and certifiable aircraft for the 2030s.”

FutPrInt50 has also sought input from the European Union Aviation Safety Agency, which is a member of its advisory board, to advance regulatory issues around the design.

It is also seeking to connect with technology research or development projects being undertaken by other organisations such as the EU-backed Clean Aviation programme: “We need to be more or less on the same page,” Strohmayr says.

Closer ties with Clean Aviation, or FutPrInt50's existing links with Embraer, could also provide a route to seeing the aircraft – or at least key parts of it – come to life.

Other FutPrInt50 partners include the French CEA energy research commission, engineering consultancy ADSE in the Netherlands, Niccolò Cusano University in Italy, and the Belgium-based European Aeronautics Science Network. ▶



Configuration features electrically-boosted gas turbines and smaller electric propulsors

Leonardo Helicopters delivered the Austrian air force's lead AW169M, as Vienna doubled its order to 36 examples



Bundesheer



N509FZ/Wikimedia Commons

Comac named YTO Cargo Airlines and Zhongyuan Airlines as customers for a converted freighter version of the ARJ21



Markus Mainka/Shutterstock

Israir signed an agreement to sell its two ATR 72-500s to an undisclosed "foreign airline" for \$13 million

Brazilian air force



Saab's Gripen E entered frontline use, with the Brazilian air force fielding two of the locally-named F-39Es at Anapolis air base

Condor took a first of 14 Airbus A330-900s, with the 310-seat widebody (D-ANRA) sporting its "Island" colour scheme



airbus

Toronto-based Porter Airlines received its initial pair of E195-E2 regional jets, from a 50-unit order with Embraer



Embraer

Best of the rest

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

Romania announced a \$410 million acquisition of Elbit Systems/Thales Watchkeeper X unmanned air vehicles



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With annual accident rates for airliners and associated fatalities having remained roughly stable for a decade, it is time for the industry to tackle the causes of mishaps and improve further

Urgent action

David Learmount London

The safety performance of airlines in 2022 reflected the stability that has been seen over the past 10 years, with steady, relatively low accident numbers. Indeed, following the industry's previous decades of emphatic improvement, safety figures have effectively been almost flatlining since 2012.

Last year saw 12 fatal accidents globally across all airline operational categories and aircraft sizes, resulting in 229 fatalities.

These figures can be compared with an annual average of 15.4 and 302 respectively in the 10-year period from 2013, making 2022 appear rather good. However, this is statistically of little significance; in fact, fatalities climbed from a 2021 total of 134, caused by 15 deadly crashes.

Apart from the loss of a China Eastern Airlines Boeing 737-800 on 21 March – in which 123 passengers and nine crew members lost their lives – all the other fatal accidents in 2022 involved small or medium-sized turboprop aircraft. Most of the airlines involved would have been unknown outside their own regional environments.

These included the 6 November crash of a Precision Air ATR 42-500, which came down in Lake

Victoria, Tanzania, while attempting to land at Bukoba airport. Nineteen of the 43 people on board were killed in the accident.

That the China Eastern event was the only big-jet accident in 2022 was not rare: the previous year also included a single such loss.

It would be easy for the world to see this status quo as acceptable, but that would be a pity, because all sectors of the industry could become almost accident-free.

Reducing risk

To reach the impressive standard achieved by the world's safest aviation nations today, it took a concentrated effort by organisations such as the US Commercial Aviation Safety Team (CAST) and its EU and ICAO equivalents. This began in the 1990s, with their effort to lift their relatively poor safety performance to the levels that have now been achieved.

Success happened by assembling operational data that enabled the bodies to identify the causes of the accidents that they were still suffering in significant numbers. That knowledge allowed them to design strategies to reduce risk.

Controlled flight into terrain (CFIT) accidents – at that time the most deadly risk – were almost eliminated by the determined mandating of terrain awareness warning systems.

Report into China Eastern 737 crash does not explain the aircraft's steep descent



Xinhua/Shutterstock

In addition to the efforts of CAST and its multi-national partners, the IATA Operational Safety Audit (IOSA) programme – launched in 2003 – has delivered performance dividends for most of the world's larger airlines: fatal accidents have almost been eliminated among IOSA participants. But smaller carriers could also reap the safety rewards of an adapted IOSA if the strategy were to be applied with the encouragement of their aviation authorities.

Meanwhile, the interim factual report on last year's China Eastern 737 loss, released by the Civil Aviation Administration of China several months ago, is distinctly economical with the information it provides. It confirms – but does not attempt to explain – the steep, high-speed descent profile adopted suddenly from an apparently uneventful cruising phase of flight, with no radio communication of any kind from the crew (*see accident listings, p50*).

302

Average annual number of aviation fatalities in the 10-year period from 2013

Expert observers have noted the fact that the flight and its unusual descent profile was remarkably similar to that of the shocking Germanwings Airbus A320 crash in France in 2015. This has inevitably resulted in speculation that it may have had the same cause, although any apparent evidence for that so far is circumstantial. In the Germanwings case, the French inquiry found that the co-pilot, who had privately been receiving psychotherapy, had deliberately crashed the aircraft in a suicide bid. No data suggesting such a conclusion of the 2022 incident has been provided by the Chinese authorities.

To put the China Eastern event in context, China's jet fatal accident rate had been zero for the past two decades, having improved dramatically compared with its relatively poor performance in the 1990s and earlier. The crash was the first loss of a Chinese mainline jet since an Air China 767 was lost in a CFIT event in 2002.

Among the non-fatal accidents and incidents listed for 2022, the most worrying single event involved a TAP Air Portugal A320 that carried out a late go-around from the approach to Copenhagen's runway 30 on 8 April. Just as the aircraft was approaching the flare, it swung left, triggering the go-around decision. During the attempt to climb, the crew found they were dealing with un-commanded deployment of three of the four thrust reverser doors on the

“The [Sriwijaya] report is significant because loss of control in flight has caused far more deaths than any other accident category over the past 20 years”

▶ left-hand CFM International CFM56 engine, which they left at idle. The crew declared an emergency and followed air traffic control vectors to land on runway 22L. They did well to land safely.

There also were some dangerous runway incursion accidents during 2022, two of which resulted in deaths by collision. On 2 September, a TAP A320 was making a night approach to Conakry airport, Guinea. The pilots discussed a stationary light visible on the runway, questioning whether it was an exit indicator, but continued the approach. When the aircraft's landing lights finally illuminated the darkness ahead, they saw that a motorcycle was on the runway heading for its edge, but the right engine hit it, killing its two riders.

On 18 November, a LATAM Chile A320 had been cleared for a night take-off on runway 16 at Lima's Jorge Chavez airport, Peru, when – at a speed of about 125kt (230km/h) – it hit an airport fire and rescue truck; one of three vehicles that had been cleared to cross the runway as part of a rapid response exercise. The fire crew in the vehicle were killed, the aircraft's right undercarriage collapsed, and the wing caught fire. It came to rest on the runway and all occupants evacuated without injury.

In a further case of runway confusion, on 22 January, at an uncontrolled airport in Colorado, USA, a JetBlue Airways A320 took off from runway 10 when a Beechcraft Super King Air was approaching to land on the same runway from the opposite end (runway 28). A manoeuvre by the JetBlue crew to avoid the King Air resulted in a tail-scrrape and a consequent diversion.

Meanwhile, Indonesian accident investigators have issued a final report on the crash in January 2021 of a Sriwijaya Air 737-400. The crew lost control of the aircraft during its climb away from Jakarta bound for Pontianak on the island of Borneo.

The report is significant because loss of control in flight has caused far more passenger and crew deaths than any other accident category over the past 20 years. The Sriwijaya accident is further confirmation that parts of the commercial aviation world are still failing to take action to deal with this identified risk, for which there are known remedies.

The Indonesian report attributes the crew's failure to control the aircraft to “automation complacency” and “confirmation bias”, which is another way of saying that they failed to monitor the autopilot and autothrottle, on the assumption that they usually do the right thing.

Meanwhile, the report says, mechanical friction in the throttle quadrant caused the starboard power lever to remain stuck while the autothrottle was trying to retard both levers. As a result, the starboard power lever remained where it was, and the port one retarded even more, until the autopilot could no longer compensate for the increasing thrust asymmetry, and it disconnected. The aircraft rolled left into a spiral dive to the sea, with the crew disorientated because it was in thick cloud.

Another important final report has also just been published: the Ethiopian Aircraft Accident Investigation Branch (EAAIB) verdict on the Ethiopian Airlines 737 Max 8 crash near Addis Ababa in March 2019.

Many of the conclusions had been made known in advance because of their importance – since this was the second Max crash within a two-year period, and problems with the single-aisle's control software had been identified by investigators and acknowledged by Boeing.

Prescribed procedures

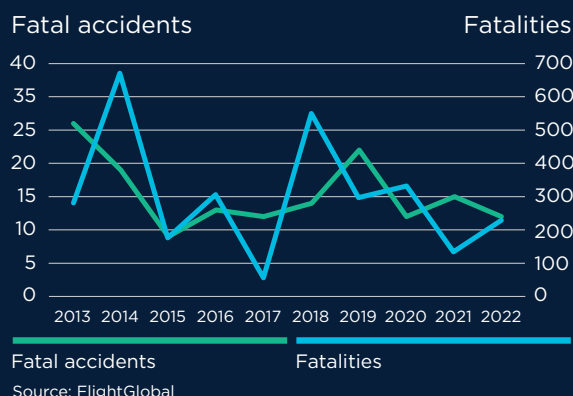
The EAAIB report is accompanied by a separately filed objection to it by the US National Transportation Safety Board (NTSB). The latter acknowledges that the Ethiopian crash report contains the truth, but maintains that it is not the whole truth.

According to the NTSB, the EAAIB did not report on the failure of the pilots to follow prescribed procedures during the developing emergency. If they had they done so, the NTSB insists, they could have prevented the crash. Also, whereas the EAAIB report has judged that erroneous signals to the aircraft's Maneuvering Characteristics Augmentation System (MCAS) from the angle-of-attack (AoA) sensor were caused by a “power supply quality problem”, the NTSB insists that the sensor malfunction was the result of a bird-strike directly on the relevant AoA vane at take-off.

The NTSB says it is not attempting to lessen the part played by the MCAS design flaws, but alleges that the accident as a whole has not been fully examined in the EAAIB report.

Meanwhile, as a result of the corporate soul-searching at Boeing over the Max issues, real change has

World airline fatal accidents and fatalities, 2013-2022





TAP Air Portugal A320 had to make an emergency landing because of problems with CFM56 engine

Markus Mankia/Shutterstock

15.4

Average annual number of fatal accidents in the 10-year period from 2013

taken place in the company. This matters, because when a manufacturer as influential as Boeing effectively admits it had lost focus and has now identified how and why that happened, other manufacturers have the opportunity to use the lessons learned for a reflection on their own practices.

In May 2022, Boeing held a briefing on its global safety update programme. Alongside the company's self-examination, the US Federal Aviation Administration (FAA) has looked at its relationship with the manufacturer and distanced itself somewhat. The FAA is also becoming more demanding about the demonstration of product and systems design, which is visible in some of its ongoing interventions regarding the 777X and 787 programmes, as well as the Max.

Boeing has restructured its corporate safety management system, a process which has included the creation of a new safety oversight post: chief aerospace safety officer. Mike Delaney, who was previously vice-president of Boeing Commercial Airplanes digital transformation, has been appointed to that office.

The company also set up an office of "product and services safety" to oversee regulatory compliance

and product safety worldwide. The objective, says Delaney, is to create greater transparency of process within the company, and to implement a "just culture" reporting system designed to encourage individuals to report anything that warrants attention – without fear of some form of retribution.

From the time that David Calhoun became Boeing's chief executive in January 2020, he has made it clear that the airframer's assumptions about pilot reactions to system faults were going to have to be completely reviewed, not least because aircraft have become so much more technically complex since existing pilot performance assumptions were drawn up, effectively in the post-war period.

Boeing also is still wrestling with certification of the Max 7 and Max 10 variants, but appears to have secured an exemption from a 31 December 2022 deadline to do so or have to equip the models with a central flightcrew alerting system. That rule was introduced in the wake of the type's two crashes, but the airframer was unable to meet the time requirement due to disruption caused by the Covid-19 pandemic.

This apparently simple issue at Boeing is a perfect metaphor for the challenges the commercial aviation world is facing. Taken as a whole, the industry has achieved impressive advances in safety performance, but it has the means to do even better.

The question remains: what actions are still required in order to achieve that final advance toward zero serious accidents? ▶

● Our annual accident listing uses data from *Flight International's* research, in association with Ascend by Cirium

ATR 42-500 came down in Lake Victoria
in November, resulting in 19 fatalities

STR/EPA-EFE/Shutterstock



Fatal accidents:

Scheduled passenger flights

Date: 21 Mar ● **Carrier:** China Eastern Airlines ● **Aircraft type/registration:** Boeing 737-800 (B-1791) ● **Location:** Tengxian, Guangxi Province, China
Fatalities (crew/pax): 9/123 ● **Total occupants (crew/pax):** 9/123 ● **Phase:** En route

En route from Kunming to Guangzhou on a domestic scheduled flight, the aircraft was cruising normally and without incident at about 29,000ft until close to the point at which it might normally have begun the descent towards its destination airport. At that point it did indeed begin a descent, but without any communication with air traffic control (ATC), and the descent profile was very steep and at high speed. During the descent there was little deviation from the heading maintained during the cruise, and questioning calls from ATC went unanswered. A winglet from the aircraft was found some 5.4nm (10km) from the main wreckage. When the flight-data recorder and cockpit-voice recorder

were recovered they were found to be damaged. They were sent to Washington DC for downloading by the US National Transportation Safety Board (NTSB), which was co-operating with the Civil Aviation Administration of China (CAAC) in the investigation process. An NTSB source has been quoted by the *Wall Street Journal* as saying the descent was initiated and maintained by inputs to the flight controls in the cockpit, but the agency has refused to confirm this and there has been no relevant comment from the CAAC. All China-registered Boeing 737-800s were grounded by the CAAC for inspection, but no faults were found and the fleet was cleared to fly again.

Fatal accidents:

Non-scheduled flights

Date: 11 May ● **Carrier:** Caverton Helicopters ● **Aircraft type/registration:** De Havilland Canada Twin Otter 400 (TJ-TIM)
Location: Near Nanga Eboko, Cameroon ● **Fatalities (crew/pax):** 2/9 ● **Total occupants (crew/pax):** 2/9 ● **Phase:** En route

The aircraft had been chartered to carry a number of oil company employees to the Domta airstrip in northeastern Cameroon. It crashed

into jungle near Nanga Eboko, about 1h into the flight, with the loss of all on board.

Fatal accidents:

Regional and commuter flights

Date: 26 Feb ● **Carrier:** AB Aviation ● **Aircraft type/registration:** Cessna 208B Grand Caravan (5H-MZA)
Location: Offshore Moheli, Comoros Islands ● **Fatalities (crew/pax):** 2/14 ● **Total occupants (crew/pax):** 2/14 ● **Phase:** Runway approach

On a domestic scheduled flight from Moroni airport to Moheli, a distance of about 50nm (92km), the aircraft crashed into the sea in daylight

while on its approach to the runway at its destination airport. There is no report of a distress call.

Date: 29 May ● **Carrier:** Tara Air ● **Aircraft type/registration:** De Havilland Canada Twin Otter (9N-AET) ● **Location:** Jomsom, Nepal
Fatalities (crew/pax): 3/19 ● **Total occupants (crew/pax):** 3/19 ● **Phase:** En route

The aircraft went missing towards the end of a flight from Pokhara to Jomsom, Nepal, and was later found to have crashed on high ground close to the Lete Pass, about 7nm (13km) south of Jomsom. The aircraft had been flying on a northwesterly heading along the Kall Gandaki River valley while climbing towards 12,800ft. It then turned right on to

a northerly heading to fly through the Lete Pass before descending into Jomsom. The accident happened in daylight (10:10 local time) and in instrument meteorological conditions. The Civil Aviation Authority of Nepal is preparing stricter guidance on operations in adverse weather following this accident.

Fatal accidents:

Regional and commuter flights

Date: 4 Sep • **Carrier:** Friday Harbor Seaplane Tours • **Aircraft type/registration:** De Havilland Canada DHC-3T Turbine Otter (N725TH) • **Location:** Mutiny Bay, Washington, USA • **Fatalities (crew/pax):** 1/9 • **Total occupants (crew/pax):** 1/9 • **Phase:** En route

The 55-year-old float-equipped aircraft took off from Friday Harbor Seaplane Base, Washington at about 14:50 local time to fly to Renton Municipal airport. Flight tracking data from Flightradar24 shows the aircraft flying for about 23min at a height varying between 650ft and 975ft above mean sea level with ground speed between 115kt and 125kt (212-231km/h). Approaching 15:09, the height and ground speed began to vary rather more, and the last tracking data capture showed a height

of 700ft and ground speed of 55kt. Witnesses say the aircraft pitched up briefly, then pitched steeply down and spiralled into the water. Most of the aircraft wreckage has been recovered, and the US National Transportation Safety Board (NTSB) has advised Otter operators to inspect a control actuator in the horizontal tail, which may have suffered mechanical failure leading to this accident. At the time of writing the NTSB was still investigating that possibility but had not confirmed it.

Date: 20 Sep • **Carrier:** SAETA Peru • **Aircraft type/registration:** BAE Systems Jetstream 31 (OB-2152) • **Location:** San Antonio del Estrecho airport, Peru • **Fatalities (crew/pax):** 0/1 • **Total occupants (crew/pax):** 2/15 • **Phase:** Take-off

The aircraft overran following an aborted take-off from the airport's runway 31. It continued through the airport perimeter fence, across a road and collided with a low embankment. The accident happened

in daylight (08:45 local time) and in visual meteorological conditions. Runway 31 is 1,200m (3,950ft) long. The aircraft was operating a flight to Iquitos.

Date: 6 Nov • **Carrier:** Precision Air • **Aircraft type/registration:** ATR 42-500 (5H-PWF) • **Location:** Near Bukoba airport, Tanzania • **Fatalities (crew/pax):** 2/17 • **Total occupants (crew/pax):** 4/39 • **Phase:** Final approach

On its final approach to runway 31 at Bukoba airport, at the end of a flight from Dar es Salaam, the aircraft came down in Lake Victoria at a distance of about 500m (1,640ft) from the runway threshold, which is

very close to the shore of the lake. The accident happened in daylight (08:45 local time) but in poor weather, with reduced visibility as a result of heavy rain.

Fatal accidents:

Non-passenger flights

Date: 13 Apr • **Carrier:** Gem Air • **Aircraft type/registration:** Cessna 208B Grand Caravan (N928JP) • **Location:** Heyburn, Idaho, USA • **Fatalities (crew/pax):** 1 • **Total occupants (crew/pax):** 2 • **Phase:** Runway approach

The Cessna Grand Caravan, on an inbound flight from Salt Lake City, began an approach to runway 20 at Burley Municipal airport, Idaho, in light snow, but abandoned the approach and set up a return for a

second attempt. During the second approach the aircraft crashed into a factory about 700m (2,300ft) from the runway 20 threshold on the extended centreline.

Date: 22 Apr • **Carrier:** Constanta Airlines • **Aircraft type/registration:** Antonov An-26-100 (UR-UZB) • **Location:** Mikhailivka, Ukraine • **Fatalities (crew/pax):** 1/3 • **Total occupants (crew/pax):** 1/3 • **Phase:** Cruise

Soon after take-off from Zaporozhye airport the aircraft hit power lines and crashed in daylight about 5.9nm (11km) northwest of Zaporozhye.

Date: 16 Jul • **Carrier:** Meridian • **Aircraft type/registration:** Antonov An-12 (UR-CIC) • **Location:** West of Kavala airport, Greece • **Fatalities:** 8 • **Total occupants:** 8 • **Phase:** En route

On a cargo flight from Nis, Serbia to Amman, Jordan cruising at 21,000ft, the aircraft began losing height just after it coasted out over the Aegean Sea at night. The crew began a left turn through 180° back toward the coast, but the descent rate was increasing. About five minutes later the crew declared a Mayday and reported a fire on their number 4 engine.

The flight diverted towards Kavala but crashed in fields about 5.4nm (10km) to the west of the airport. The accident happened at 22:47, and in visual meteorological conditions. The aircraft was transporting a cargo of munitions to Dhaka, Bangladesh via technical stops at Amman, Riyadh, Saudi Arabia and Ahmedabad, India.

Date: 9 Sep • **Carrier:** Air Kasai • **Aircraft type/registration:** Antonov An-28 (9S-GAX) • **Location:** Near Bukavu-Kavumu airport, Democratic Republic of Congo • **Fatalities:** 3 • **Total occupants:** 3 • **Phase:** Climb

The accident appears to be a classic case of controlled flight into terrain. The crew of the cargo flight took off from runway 35 and turned left, heading directly toward their destination of Kasese, which is about 108nm (200km) to the northwest. The normal procedure for departures

in that direction was to turn right and then circuit around and return overhead the airfield, gaining height to avoid high ground to the west, which that day was wreathed in cloud. The wreckage was found in the hills to the west of the airport nine days later.

Date: 3 Nov • **Carrier:** Goma Express • **Aircraft type/registration:** Aircraft Industries L410 (9S-GPK) • **Location:** Democratic Republic of Congo • **Fatalities:** 2 • **Total occupants:** 2 • **Phase:** En route

The domestic cargo flight from Kasese to Bukavu-Kavumu airport went missing and its crash site was not located for two days. The en route weather was poor, with low cloud and rain. The wreckage was found in jungle a little more than half way to its intended destination.

Significant non-fatal accidents/incidents:

All commercial airline categories

Date: 3 Jan • **Carrier:** SA Airlink • **Aircraft type/registration:** BAE Systems Jetstream 41 (ZS-NRJ) • **Location:** Venetia Mine airport, South Africa • **Injuries (crew/pax):** 0/0 • **Total occupants (crew/pax):** 3/4 • **Phase:** Landing

During the landing run on runway 08 a large bird flew into the starboard propeller that had already been selected to reverse thrust. Almost all of one blade broke off and parts penetrated the fuselage. The crew shut

down the engine and stopped on the runway. The captain checked that no-one had been hurt, then taxied to the apron, where the passengers disembarked normally. The aircraft suffered substantial damage.

Date: 4 Jan • **Carrier:** Lanhsa Airlines • **Aircraft type/registration:** BAE Systems Jetstream 31 (HR-AYY) • **Location:** Roatan airport, Honduras • **Injuries (crew/pax):** 0/0 • **Total occupants (crew/pax):** ?/? • **Phase:** Landing

The right-hand main gear leg collapsed while landing on runway 07 at Roatan's Juan Manuel Galvez airport.

Significant non-fatal accidents/incidents:

All commercial airline categories

Date: 5 Jan ● **Carrier:** Caspian Airlines ● **Aircraft type/registration:** Boeing 737-400 (EP-CAP) ● **Location:** Isfahan airport, Iran
Injuries (crew/pax): 0/2 ● **Total occupants (crew/pax):** 6/110 ● **Phase:** Landing

The aircraft, inbound from Mashhad, Iran, landed on runway 07R with its left main undercarriage malfunctioning, although it was not clear

whether it had collapsed or failed to extend/lock down. It came to a halt on the runway, which was closed until the aircraft was cleared.

Date: 8 Jan ● **Carrier:** AviaStar ● **Aircraft type/registration:** Tupolev Tu-204-100 (RA-64032) ● **Location:** Hangzhou airport, China
Injuries: 0 ● **Total occupants (crew/pax):** 8 ● **Phase:** On ground

A fire broke out in the aircraft's forward cabin/cockpit area shortly before it was due to depart from Xiaoshan International airport, in Hangzhou, Zhejiang, China. The fire and rescue service responded but were unable to prevent the fire spreading and it eventually destroyed

the aircraft. Early reports suggested that the fire may have been associated in some way with the crew oxygen system. The accident happened in darkness (04:50 local time). The aircraft was to operate a cargo flight to Novosibirsk, Russia.

Date: 22 Jan ● **Carrier:** JetBlue Airways ● **Aircraft type/registration:** Airbus A320 (N760JB) ● **Location:** Hayden-Yampa Valley airport, Colorado, USA
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 6/102 ● **Phase:** Take-off

There was very little wind at this non-towered airport when the crew elected to take off on runway 10. The crew noticed that a Beechcraft Super King Air was approaching the runway from the reciprocal end (runway 28), about 2.5nm (4.6km) from the threshold. They rotated the aircraft and banked to the right, causing a tail-strike, then climbed to 31,000ft. The crew then made a decision to divert to Denver

International airport instead of continuing on to their intended destination of Fort Lauderdale. ADS-B data suggests the two aircraft were about 800m (2,620ft) horizontally separated when they passed. Operators using Hayden communicate on a common traffic advisory frequency, and instrument approaches can be provided by Denver Center.

Date: 28 Jan ● **Carrier:** China Airlines ● **Aircraft type/registration:** Boeing 747-400F (B-18715) ● **Location:** Chicago O'Hare airport, USA
Injuries (crew/pax): 0 ● **Total occupants (crew/pax):** 2 ● **Phase:** On ground

The aircraft had arrived at Chicago O'Hare on a cargo flight from Anchorage, Alaska, and was turning into the southeast cargo ramp when

its two inboard engines hit a number of baggage trolleys, causing major damage. It was dark and the ground was snow-covered.

Date: 4 Feb ● **Carrier:** Sun Country Airlines ● **Aircraft type/registration:** Boeing 737-800 (N817SY) ● **Location:** Las Vegas airport, USA
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 6/50 ● **Phase:** Landing

Shortly after take-off from Las Vegas, when the undercarriage was selected up, there was an unsafe indication for the right main undercarriage. The crew elected to return, but the right main gear collapsed during the landing roll on runway 26R. The accident happened

at night, in visual meteorological conditions. An examination of the right undercarriage found that the outer cylinder was fractured at the upper end, between the forward and aft trunnions, and a portion of the gear had punctured the upper wing skin.

Date: 8 Feb ● **Carrier:** KLM Royal Dutch Airlines ● **Aircraft type/registration:** Airbus A330-300 (PH-AKE) ● **Location:** Calgary, Canada
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 12/216 ● **Phase:** Take-off

The aircraft suffered a tail strike during take-off from runway 29 at Calgary International airport, but despite checking the cause the crew misidentified the symptoms and elected to continue to their destination at Amsterdam, the Netherlands, where the damage was recognised. The flightcrew had detected a burning odour immediately after lift-off and suspected that the cause was the auxiliary power unit (APU); it had been a 'bleeds off' take-off and the APU had been supplying conditioned air at the time. The flightcrew had then consulted the electronic centralised aircraft monitor 'wheel page' and

'APU page' and observed no abnormalities. The crew then consulted with air traffic control, which suggested a possible tail strike as the cause of the burning odour. The flightcrew then spoke to the cabin crew, but they reported that they had not noticed anything unusual, so the flight continued to its destination and no further indications of a problem were detected. However, when the aircraft arrived at the gate in Amsterdam, ground servicing crew noticed damage to the underside of its empennage. The accident happened in daylight (15:40 local time).

Date: 14 Feb ● **Carrier:** Doren Air Congo ● **Aircraft type/registration:** Aircraft Industries L410UVP (9S-GFA) ● **Location:** Bukavu-Kavumu airport, Democratic Republic of Congo ● **Injuries:** 0 ● **Total occupants:** 2 ● **Phase:** On ground

While taxiing for take-off, a fire developed on board the aircraft, which was operating a cargo flight bound for Lulingo. The crew were able to

evacuate quickly, but the aircraft burned out before the fire services could extinguish the blaze.

Date: 15 Feb ● **Carrier:** Delta Air Lines ● **Aircraft type/registration:** Airbus A319 (N354NB) ● **Location:** Benito Juarez airport, Mexico City
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** ?/? ● **Phase:** Take-off

The crew abandoned the take-off from runway 05L at just less than 100kt (185km/h) following an engine failure. The aircraft came to rest

with its right main gear on the runway edge with one tyre deflated. The aircraft suffered substantial damage.

Date: 15 Feb ● **Carrier:** American Airlines ● **Aircraft type/registration:** Boeing 737-800 (N344PP) ● **Location:** New York John F Kennedy airport, USA
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** ?/? ● **Phase:** Take-off

During the course of the take-off roll on runway 31L at New York's John F Kennedy airport both tyres on the left main gear failed, causing some damage to the wing and fuselage underside of the

aircraft. The crew were able to bring the aircraft to a halt safely on the runway, and the crew and passengers were then disembarked using mobile steps.

Date: 28 Feb ● **Carrier:** American Eagle ● **Aircraft type/registration:** Embraer 175 (N402YX) ● **Location:** Washington Reagan airport, USA
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 4/71 ● **Phase:** Landing

At about touchdown during the landing at Washington Reagan a loud noise was heard. Subsequent examination of the airframe revealed that

there was a hole in the belly of the aircraft. The cause of the damage is currently under investigation.

Date: 8 Mar ● **Carrier:** Cebgo ● **Aircraft type/registration:** ATR 72-600 (RP-C7283) ● **Location:** Manila International airport, the Philippines
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 4/42 ● **Phase:** Landing

Following a reportedly hard, bounced landing on runway 24 at Ninoy Aquino International airport, in Manila, the Philippines, the aircraft began to veer to the right following the second touchdown. The flightcrew found that they were unable to regain directional control

and the aircraft ran off the right side of the runway and on to the grass. The accident happened in daylight (11:27 local time), in visual meteorological conditions at the end of a flight from Naga, also in the Philippines.

Significant non-fatal accidents/incidents:

All commercial airline categories

Date: 12 Mar ● **Carrier:** Bocas Air ● **Aircraft type/registration:** Beech 1900 (HP-1948BT) ● **Location:** Panama City airport, Panama
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 2/6 ● **Phase:** Cruise

The aircraft's aft entry door opened and separated some 20min into the flight. The crew elected to return to Panama. There were no injuries.

Date: 12 Mar ● **Carrier:** Alliance Air ● **Aircraft type/registration:** ATR 72-600 (VT-AIW) ● **Location:** Jabalpur, India
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 5/55 ● **Phase:** Landing

Landing on runway 24 at Jabalpur, India, the aircraft reportedly 'floated' and 'landed long', then overran the runway and eventually came to rest on gravel off the left side of the overrun area, about 60m (197ft) beyond

the end of the runway. The accident happened in daylight, and in visual meteorological conditions. Runway 24 at Jabalpur is 1,990m (6,230ft) long. The aircraft was operating a flight from Delhi.

Date: 6 Apr ● **Carrier:** Mwant Jet ● **Aircraft type/registration:** Embraer ERJ-145 (9S-AMG) ● **Location:** Kolwesi, Democratic Republic of Congo
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 5/24 ● **Phase:** Landing

Inbound from Lubumbashi, the aircraft landed on runway 11 and overran into scrub, causing minor damage.

Date: 7 Apr ● **Carrier:** DHL Aero Expreso ● **Aircraft type/registration:** Boeing 757-200SF (HP-2010DAE) ● **Location:** San Jose International airport, Costa Rica ● **Injuries:** 0 ● **Total occupants (crew/pax):** 2 ● **Phase:** Landing

Having taken off from runway 07 at San Jose and flown about 60nm (111km) north in the direction of the flight's intended destination at Guatemala City, the crew initiated a return to San Jose, reportedly with hydraulic problems. After setting up a holding pattern for multiple circuits, the crew began a straight-in approach to runway 07. The touchdown appeared to be normal, but not far into the landing run

smoke appeared to be emanating from the main wheels, and the aircraft made a turn to the right that took it off the runway in what looked like a skid, the fuselage swinging rapidly to the right through more than 180°. The 757 came to rest in a ditch with its fuselage broken just forward of its tail. The visibility was good at the time of the incident, with light wind.

Date: 8 Apr ● **Carrier:** Aerolíneas Andinas ● **Aircraft type/registration:** Douglas C-47TP (HK-5016) ● **Location:** San Felipe, Colombia
Injuries: 0 ● **Total occupants:** 3 ● **Phase:** Landing

The turbine-powered C-47TP (DC-3) swung off the runway left side on landing and ground-looped. Its right main undercarriage collapsed.

Date: 8 Apr ● **Carrier:** TAP Air Portugal ● **Aircraft type/registration:** Airbus A320 (CS-TNV) ● **Location:** Copenhagen, Denmark
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 6/103 ● **Phase:** Runway approach

Inbound from Lisbon to Copenhagen's runway 30, the crew carried out a go-around from the flare, but during the climb the aircraft veered left and they struggled to maintain the expected climb rate. The crew noticed an alert indicating the left engine thrust reverser

doors were unlocked. They declared an emergency and were provided with radar vectors to runway 22L. After landing, three of the four reverser doors on the CFM International CFM56 engine were found to be fully deployed.

Date: 11 Apr ● **Carrier:** Thunder Airlines ● **Aircraft type/registration:** Beechcraft King Air 100 (C-GYQK) ● **Location:** Timmins airport, Ontario, Canada
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 2/8 ● **Phase:** Runway approach

The aircraft took off from Moonsonsee, Ontario, for a short flight to Fort Albany, Ontario. On approach the landing gear refused to extend, so the crew lowered it manually and obtained "three greens", suggesting the gear was locked down. They decided to return to Moonsonsee, but at touchdown on runway 24 there was an unexpected noise from the left side, the left green light extinguished, and the left wing began to

drop. The captain immediately began a go-around and managed to complete it without damage. The crew decided to divert to Timmins because it was a main base for the carrier. During the landing on runway 21, the aircraft touched down on the right and nose landing gear, and finally slid to a halt supported partly on its belly baggage pod. There were no injuries.

DHL Aero Expreso 757 came to rest in a ditch at San Jose International



Jeffrey Arguedas/EPA-EFE/Shutterstock



Tibet Airlines A319 aborted take-off mishap injured 36 passengers on 12 May

Significant non-fatal accidents/incidents:

All commercial airline categories

Date: 14 Apr ● **Carrier:** Denver Air Connection ● **Aircraft type/registration:** Swearingen Metro 23 (N820DC)
Location: Denver International airport, USA ● **Injuries (crew/pax):** 0/0 ● **Total occupants (crew/pax):** 2/5 ● **Phase:** Take-off

Shortly after take-off from Denver's runway 34L the crew reported that there was a problem with hydraulic pressure on the aircraft. They returned to land on runway 16R after advising air traffic control they might have no nosewheel steering. The landing was completed safely

and the aircraft was towed to the pan. Later it was cleared for another flight to Alliance, Nebraska, but the crew abandoned the take-off on runway 34L at high speed, and when turning off the runway the nose gear collapsed.

Date: 15 Apr ● **Carrier:** South African Airways ● **Aircraft type/registration:** Airbus A330-300 (ZS-SXM) ● **Location:** En route near Gaborone, Botswana
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 25/184 ● **Phase:** En route

The aircraft was flying from Accra, Ghana, to Johannesburg, South Africa. At 41,000ft about 310nm (570km) northwest of Johannesburg the crew reported surging on both engines and requested descent to 19,000ft, and when at that level the captain decided to continue to Johannesburg despite further surges from both the Rolls-Royce Trent 772 engines, including during approach to the destination airport. The aircraft landed safely on runway 21R. The flight had originally been scheduled to depart on 14 April, but after pushback the engines failed to start, and after the

aircraft had been towed back to the stand this was found to have been caused by water contamination of the fuel. Water was drained from the tanks and the flight took place the following day. After landing at Johannesburg, the fuel tanks, fuel lines and engines were all found still to have water in them. The fuel pumps were all changed and the aircraft remained at Johannesburg until 18 May. Ghana's accident investigation unit, monitored by South Africa's Civil Aviation Authority, is investigating the event, but so far no preliminary information has been forthcoming.

Date: 3 May ● **Carrier:** Air Cargo Carriers ● **Aircraft type/registration:** Short 360 (N744LG) ● **Location:** San Juan airport, Puerto Rico
Injuries: 0 ● **Total occupants:** 2 ● **Phase:** Landing

Shortly after take-off from San Juan Luis Munoz Marin airport for Aguadilla the captain reported that there was a problem with the undercarriage and stopped the climb at 1,500ft. After several failed

attempts to get the gear to lock down - including high-g manoeuvres - the crew decided to return to the airport and landed on runway 08 with the gear retracted.

Date: 6 May ● **Carrier:** Blue Air ● **Aircraft type/registration:** Boeing 737-800 (YR-BMM) ● **Location:** Naples Capodicino airport, Italy
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** ?? ● **Phase:** Landing

Inbound from Bucharest, Romania, the aircraft suffered such a hard landing that its rear fuselage was structurally damaged.

Date: 12 May ● **Carrier:** Tibet Airlines ● **Aircraft type/registration:** Airbus A319 (B-6425) ● **Location:** Chongqing-Jianbei airport, China
Injuries (crew/pax): 0/36 ● **Total occupants (crew/pax):** 9/113 ● **Phase:** Take-off

The crew abandoned the take-off on runway 03 and swerved off the left side, causing the undercarriage to collapse and both engines to detach. A fire began in the left wing root, and caused considerable

damage to the fuselage forward of the wing, but the passengers and crew managed to evacuate safely despite some injuries. The aircraft was unreparable, however.

Date: 20 May ● **Carrier:** Sales Taxi Aereo ● **Aircraft type/registration:** Embraer EMB-110 Bandeirante (PT-SHN) ● **Location:** Near Aeroclub Eldorado do Sul, Brazil ● **Injuries:** 2 ● **Total occupants:** 2 ● **Phase:** En route

The aircraft, which was operating a short cargo flight from Porto Alegre International airport, carried out a forced landing on soft ground

close to its destination airfield. The undercarriage collapsed and the left wing separated.

Date: 5 Jun ● **Carrier:** NXT Air ● **Aircraft type/registration:** ATR 42-300F (S2-AHI) ● **Location:** Chittagong airport, Bangladesh
Injuries: 0 ● **Total occupants:** 2 ● **Phase:** Take-off

The outboard wheel on the left main gear detached during the take-off run, and Chittagong tower advised the crew of what they had seen. The

aircraft continued to its destination at Cox's Bazaar where it carried out two low passes near the tower for a visual inspection, then landed safely.

Significant non-fatal accidents/incidents:

All commercial airline categories

Date: 21 Jun ● **Carrier:** Red Air ● **Aircraft type/registration:** Boeing MD-82 (HI1064) ● **Location:** Miami International airport, USA
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 10/130 ● **Phase:** Landing

Inbound from Santo Domingo, the Dominican Republic, the aircraft suffered a left main gear collapse while landing on runway 09. It slid off

the left side of the runway and a fire broke out in the left wing. The crew and passengers managed to complete an evacuation without injuries.

Date: 22 Jun ● **Carrier:** NPP Mir ● **Aircraft type/registration:** Antonov An-30 (RA30001) ● **Location:** Near Olenyok, Russia
Injuries: 3 ● **Total occupants:** 7 ● **Phase:** En route

Having taken off from Yakutsk for Olenyok, the crew had to carry out a forced landing in woodland when the aircraft ran out of fuel about 45nm

(83km) from its destination airport. All seven crew survived the incident, but three were reported to have been injured.

Date: 26 Jun ● **Carrier:** Alaska Seaplanes ● **Aircraft type/registration:** Cessna Caravan (N265KP) ● **Location:** Elfin Cove seaplane base, Alaska, USA
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 1/7 ● **Phase:** Take-off

The float-equipped seaplane, which was attempting a take-off for a scheduled flight to Juneau, Alaska, crashed into rocks on the shore of

Elfin Cove and was substantially damaged. Neither the pilot nor the seven passengers were injured.

Date: 1 Jul ● **Carrier:** Motor Sich Airlines ● **Aircraft type/registration:** Antonov An-12 (UR-11316) ● **Location:** Uzhhorod International airport, Ukraine
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 4/2 ● **Phase:** Landing

The cargo aircraft reportedly suffered a 'hard landing' on its arrival at Uzhhorod, Ukraine, and then veered off the left side of the runway, eventually coming to rest with its left main undercarriage either dug

into the ground or collapsed. The accident happened in darkness (23:50 local time). The aircraft had been operating a flight from Istanbul, Turkey.

Date: 13 Jul ● **Carrier:** Corporate Air for FedEx ● **Aircraft type/registration:** Cessna Cargomaster (N877FE) ● **Location:** Salt Lake City, Utah, USA
Injuries: 0 ● **Total occupants:** 1 ● **Phase:** Landing

Inbound from Hailey-Friedman airport to runway 34R at Salt Lake City, the aircraft ran off the side of the runway and was badly damaged.

Date: 16 Jul ● **Carrier:** Jubba Airways ● **Aircraft type/registration:** Fokker 50 (5Y-JSN) ● **Location:** Rubkona airport, South Sudan
Injuries: 0 ● **Total occupants:** 3 ● **Phase:** Landing

The cargo aircraft, on a domestic flight from Juba carrying food items for UN staff stationed near Rubkona, burst a tyre when landing on

runway 17 according to one of the crew, and slewed off the runway causing the left main gear to fail.

Date: 18 Jul ● **Carrier:** Jubba Airways ● **Aircraft type/registration:** Fokker 50 (5Y-JXN) ● **Location:** Mogadishu Aden Adde airport, Somalia
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 3/33 ● **Phase:** Landing

The aircraft's rate of descent rapidly increased during the course of its final approach to runway 05 at Aden Adde International airport, Mogadishu, Somalia, apparently because of wind-shear, and it landed very hard. One of its wings failed and it rolled over, coming to rest

inverted off the left side of the runway. The accident happened in daylight (11:28 local time), visual meteorological conditions, and in wind from 200° and 18kt (33km/h). The aircraft was operating a flight from Baidoa, Somalia.

Date: 25 Jul ● **Carrier:** Delta Air Lines ● **Aircraft type/registration:** Airbus A321 (N332DN) ● **Location:** Denver International airport, Colorado, USA
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 6/193 ● **Phase:** Take-off

The aircraft suffered a bird-strike on its number 1 engine during the take-off roll on runway 08 at Denver International airport. The take-off was aborted at 110-120kt (203-222km/h) and the aircraft brought to a safe stop on a high-speed turn-off. Shortly after coming to a stop, leaking fuel

that had pooled under the engine caught fire but was quickly extinguished by the fire service. Passengers disembarked using mobile stairs. The accident happened in daylight (18:00 local time) and visual meteorological conditions. The aircraft was operating a flight to Atlanta, Georgia.

Date: 30 Jul ● **Carrier:** Nok Air ● **Aircraft type/registration:** Boeing 737-800 (HS-DBR) ● **Location:** Chiang Rai airport, Thailand
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 6/164 ● **Phase:** Landing

During the landing roll on runway 03 at Chiang Rai, Thailand, the crew lost directional control and the aircraft ran off the left side of the runway on to soft ground, becoming bogged down. The accident happened in

darkness (21:04 local time) and poor weather, with wind from 330° and 6kt (11km/h), visibility 5,000m (16,400ft) in rain associated with local thunderstorms. The aircraft was operating a flight from Bangkok.

Date: 6 Aug ● **Carrier:** Delta Air Lines ● **Aircraft type/registration:** Boeing 757-200 (N540US) ● **Location:** Atlanta International airport, USA
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 6/197 ● **Phase:** Landing

The aircraft suffered a tailstrike while carrying out a go-around on runway 09R, but landed safely about 10min later.

Date: 14 Aug ● **Carrier:** Asia Cargo Airlines ● **Aircraft type/registration:** Boeing 737-300 (PK-YGV) ● **Location:** Banjarmasin airport, Indonesia
Injuries: 0 ● **Total occupants:** 2 ● **Phase:** Landing

Following a practice asymmetric flap approach to Syamsudin Noor airport, Banjarmasin, Indonesia, the aircraft rolled left on or shortly

after touchdown and dragged its left engine and wing on the runway. Otherwise, the landing was completed safely.

Date: 17 Aug ● **Carrier:** Angara Airlines ● **Aircraft type/registration:** Antonov An-24 (RA-47848) ● **Location:** Ust-Kut airport, Russia
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 4/44 ● **Phase:** Landing

While landing in bad weather, the aircraft struck its left wing on the runway, pitched down and landed hard at Ust-Kut, Irkutsk Oblast, Russia. The aircraft was brought to a stop on the runway with the outer part

of its left wing broken off and its nose-wheel collapsed. The accident happened in daylight (10:00 local time) but in 'difficult' weather conditions. The aircraft was operating a flight from Irkutsk.

Date: 20 Aug ● **Carrier:** PACC Air ● **Aircraft type/registration:** Beechcraft 99 (N399TS) ● **Location:** Oshkosh field, Wisconsin, USA
Injuries: 0 ● **Total occupants:** 1 ● **Phase:** Landing

On approaching its destination at Green Bay Austin Straubel field on a cargo flight from Milwaukee General Mitchell airport, the crew reported gear problems and carried out two overflights before electing to fly

to Oshkosh. At Oshkosh the tower reported that all three gear legs appeared deployed and cleared the aircraft to land on runway 09, where the gear collapsed.

Significant non-fatal accidents/incidents:

All commercial airline categories

Date: 22 Aug ● **Carrier:** Alaska Airlines ● **Aircraft Type:** Boeing 737-900 (N293AK) ● **Location:** Seattle-Tacoma airport, Washington, USA
Injuries crew/pax: 0/0 ● **Total occupants (crew/pax):** 6/176 ● **Phase:** Take-off

After take-off, the crew reported an unusual vibration and elected to return. During the subsequent landing on runway 16L at Seattle the inboard and outboard fan cowl on the aircraft's left engine came open

and the inboard cowling was torn away. The landing was completed safely. The accident happened in daylight (08:00 local time) and visual meteorological conditions on a flight to San Diego, California.

Date: 2 Sep ● **Carrier:** TAP Air Portugal ● **Aircraft type/registration:** Airbus A320neo (CS-TVI) ● **Location:** Conakry International airport, Guinea
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 6/73 ● **Phase:** Landing

Inbound on a flight from Lisbon, Portugal, approaching midnight local time, on short final approach the pilots discussed an apparently stationary light on or near the runway, and wondered if it was an exit indicator. They landed, and when the landing lights illuminated the

object it turned out to be a motorcycle with two people on it, now moving toward the side of the runway. The pilot flying used rudder to attempt to avoid the motorcycle, but the right engine hit it, killing the two riders.

Date: 8 Sep ● **Carrier:** Air Atlanta Icelandic ● **Aircraft type/registration:** Boeing 747-400 (TF-AMC) ● **Location:** Waremme, Belgium
Injuries: 0 ● **Total occupants:** 2 ● **Phase:** Climb

The aircraft was operating a flight from Liege, Belgium, to Malta. While climbing through about 8,000ft after take-off the aircraft lost an engine cowl (suspected to be the left core cowl) which subsequently fell on

the roof of the garage of a house in Waremme, about 8nm (15km) west of the airport. The flight was continued and the aircraft landed safely at its destination. The accident happened in darkness (23:43 local time).

Date: 15 Sep ● **Carrier:** Aeronaves TSM ● **Aircraft type/registration:** Swearingen Metro III (XA-UMW) ● **Location:** Near Saltillo airport, Mexico
Injuries: 0 ● **Total occupants:** 2 ● **Phase:** Climb

The aircraft suffered a loss of power on its right engine immediately after take-off from Plan de Guadalupe airport, Saltillo, Mexico, and was substantially damaged in a forced landing on rough ground near the

Parque industrial Ramos Arizpe, about 1.6nm (3km) north of the airport. The accident happened in daylight (16:35 local time) and visual meteorological conditions. The aircraft was operating a flight to Leon, Mexico.

Date: 21 Sep ● **Carrier:** Jags Aviation ● **Aircraft type/registration:** Britten-Norman Islander (8R-GGT) ● **Location:** Eteringbang airstrip, Guyana
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 1/8 ● **Phase:** Landing

The aircraft, inbound from Georgetown airport on a chartered flight, ran off the strip on landing, sustaining substantial damage. The left main gear

and nose were damaged, as well as the left-hand wing. There were no injuries to the pilot or passengers.

Date: 24 Sep ● **Carrier:** Swiftair ● **Aircraft type/registration:** Boeing 737-400 (EC-NLS) ● **Location:** Montpellier airport, France
Injuries: 0 ● **Total occupants:** 3 ● **Phase:** Landing

Landing in darkness and poor weather conditions (heavy rain) on Montpellier's runway 12L, inbound from Paris Charles de Gaulle, the cargo flight overran the runway, then passed through the airport's

perimeter fence and eventually came to a halt with its nose dipped into the Etang de l'Or lake. Swiftair was operating the flight on behalf of West Atlantic.

Date: 25 Sep ● **Carrier:** Copa Airlines ● **Aircraft type/registration:** Boeing 737-800 (HP-1539) ● **Location:** Tocumen airport, Panama City, Panama
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 7/159 ● **Phase:** Landing

Directional control was lost during landing on runway 03R and the aircraft ran off the left side of the runway on to soft ground. It continued for some distance parallel to the runway before eventually

coming to rest with its nose undercarriage dug in. The accident happened in darkness (21:12 local time) and poor weather associated with local thunderstorms.

Date: 1 Oct ● **Carrier:** Transavia France ● **Aircraft type/registration:** Boeing 737-800 (F-GZHA) ● **Location:** Nantes Atlantique airport, France
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 6/154 ● **Phase:** Landing

Inbound from Djerba, Tunisia, the aircraft suffered substantial damage in a hard, nosewheel-first bounced landing on runway 21, including entirely shedding the nosewheel tyres. At the end of the landing run

the aircraft exited on to a taxiway where the passengers disembarked and were picked up by buses. The accident happened in daylight (13:05 local time).

Date: 3 Oct ● **Carrier:** Torres Strait Air ● **Aircraft type/registration:** Britten-Norman Islander (VH-WQA) ● **Location:** Moa Island, Torres Strait, Australia
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 1/6 ● **Phase:** En route

Operating a charter from Saibai Island to Horn Island, both in the Torres Strait between Australia and Papua New Guinea, the aircraft lost power on both engines. The pilot decided to attempt a forced landing

on Moa Island, hoping to reach the airport at Kubin. The aircraft came down in scrub well short of the runway, and the tail broke away. No-one was injured.

Date: 13 Oct ● **Carrier:** SAETA Peru ● **Aircraft type/registration:** Cessna Caravan (OB-2228) ● **Location:** Near Jeberos, Peru
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 2/10 ● **Phase:** En route

During a domestic flight from San Lorenzo in northern Peru to the commercial hub town of Tarapoto, the crew were compelled to force-

land the aircraft. It came down in a swamp and suffered major damage, but all on board survived.

Date: 17 Oct ● **Carrier:** Flamingo Air ● **Aircraft type/registration:** Beechcraft 99 (C6-OFM) ● **Location:** Black Point airport, Great Guana Cay, Bahamas ● **Injuries (crew/pax):** 0/0 ● **Total occupants (crew/pax):** 2/9 ● **Phase:** Landing

Inbound on a flight from Nassau, the aircraft overran the runway on landing and then came to rest with its left main undercarriage

collapsed. The accident happened in daylight, and in visual meteorological conditions.

Date: 23 Oct ● **Carrier:** Korean Air ● **Aircraft type/registration:** Airbus A330-300 (HL7525) ● **Location:** Mactan-Cebu airport, The Philippines
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 11/162 ● **Phase:** Landing

The crew of the aircraft, which was on an inbound flight from Seoul Incheon airport, carried out two go-arounds in difficult weather at Mactan-Cebu airport while attempting to land on runway 22. They held off for 30min before carrying out a third approach to runway 22, but after the aircraft had touched down it overran the runway end

by about 360m (1,180ft) and ploughed through the approach lights and instrument landing system localiser antenna array before coming to a halt with its nosewheel collapsed. At the time of the incident the weather was stormy, with extensive cumulonimbus cloud in the airport vicinity.

Korean Air A330 overran runway end by about 360m and went through approach lights



Juan Carlo de Vela/AP/Shutterstock

Significant non-fatal accidents/incidents:

All commercial airline categories

Date: 30 Oct ● **Carrier:** Sunrise Airways ● **Aircraft type/registration:** Embraer EMB-120 Brasilia (ZS-SOC) ● **Location:** Toussaint Louverture airport, Port au Prince, Haiti ● **Injuries:** 0 ● **Total occupants:** 2 ● **Phase:** Go-around

While the crew was carrying out a base-training exercise, during a practice single-engine go-around with the right engine shut down to simulate a failure, the left engine suffered a catastrophic failure and

uncontained fire. The crew managed to re-start the right engine and returned for a safe landing. The accident happened in daylight, visual meteorological conditions.

Date: 10 Nov ● **Carrier:** Link Airways ● **Aircraft type/registration:** Saab 340 (VH-VEQ) ● **Location:** Canberra airport, Australia ● **Injuries (crew/pax):** 0/0 ● **Total occupants (crew/pax):** 3/? ● **Phase:** En route

The aircraft started up and took off from Canberra, with a strap still attached to its left propeller. At some point, part of the strap separated from the propeller and penetrated the forward fuselage.

The aircraft returned and landed safely. The accident happened in daylight. The aircraft was operating a flight to Sydney, New South Wales, Australia.

Date: 14 Nov ● **Carrier:** Virgin Australia ● **Aircraft type/registration:** Boeing 737-800 (VH-IWQ) ● **Location:** Sydney International airport, Australia ● **Injuries (crew/pax):** 0/0 ● **Total occupants (crew/pax):** ?/? ● **Phase:** Landing

The 737 had just cleared runway 25 after landing and was continuing on the taxiway. Meanwhile, a Singapore Airlines Airbus A380 was cleared for take-off on runway 34L, which crosses 25. The 737 was then cleared

to cross runway 34L to get to the parking area, but the 737 crew questioned the clearance and it was cancelled. The 737 held well short of the 34L intersection while the A380 took off, then was re-cleared to cross.

Date: 15 Nov ● **Carrier:** Ameriflight ● **Aircraft type/registration:** Fairchild SA227 Merlin (N247DH) ● **Location:** Western Lakes Golf Club, Wisconsin, USA ● **Injuries:** 3 ● **Total occupants:** 3 ● **Phase:** Final approach

The cargo flight was carrying 56 dogs from New Orleans Lakefront airport, Louisiana, to Waukesha airport, Wisconsin, a distance of about 800nm (1,480km). The aircraft crash-landed during an instrumented landing system approach to runway 10 in snow and conditions of poor visibility, coming down on a golf course 1nm short of the runway threshold. The US National Transportation Safety Board has since reported that when the crew disconnected the autopilot during the

approach, because of anomalous indications from the flight director, the aircraft made a strong uncommanded roll to the right. The pilots increased power and managed to stop the roll, but the aircraft lost height and struck the ground in a wings-level attitude, colliding with trees that caused the wings to break away. The three crew members received minor injuries and the aircraft was damaged beyond repair. The dogs all survived.

Date: 18 Nov ● **Carrier:** LATAM Chile ● **Aircraft type/registration:** Airbus A320neo (CC-BHB) ● **Location:** Lima Jorge Chavez airport, Peru ● **Injuries (crew/pax):** 0/0 ● **Total occupants (crew/pax):** 6/102 ● **Phase:** Take-off

Setting off for a scheduled domestic passenger flight, the aircraft began its cleared take-off run on runway 16 but, when accelerating through about 125kt (230km/h), its right wing and engine hit an airport fire and rescue vehicle that had entered the runway. It appears that, just before the impact, the A320neo crew realised the vehicle was about to enter the runway and attempted to veer left to avoid it. The right landing

gear collapsed, and the aircraft slewed to a halt with its starboard wing on fire. An emergency evacuation of the aircraft was carried out successfully. Both the crew members in the fire vehicle were killed. It was the second of three fire trucks taking part in a planned exercise at the time, and one of them had already crossed the runway ahead of the aircraft.

Date: 19 Nov ● **Carrier:** Envoy Air ● **Aircraft type/registration:** Embraer 175 (N269NN) ● **Location:** Chicago O'Hare International airport, USA ● **Injuries (crew/pax):** 0/0 ● **Total occupants (crew/pax):** 5/52 ● **Phase:** Climb

Just after take-off from Chicago's runway 28R, the co-pilot declared that the captain was incapacitated and he needed to return. O'Hare provided vectors for what was basically a right-hand circuit to land back on runway 28C, climbing to a maximum altitude of 5,000ft. Weather was visual meteorological conditions and the aircraft landed safely, and turned

right on to the parallel taxiway. Air traffic control was advised that the aircraft would stop briefly for the co-pilot – a check airman – to transfer to the right-hand seat before taxiing it to the allocated stand. The airline confirmed the captain later died in hospital. The aircraft was operated by Envoy Air for American Eagle.

Significant non-fatal accidents/incidents:

All commercial airline categories

Date: 20 Nov ● **Carrier:** Blue Bird Aviation ● **Aircraft type/registration:** Boeing 737-400 (TF-BBM) ● **Location:** Paris Charles de Gaulle airport, France
Injuries: 0 ● **Total occupants:** 2 ● **Phase:** Taxi

During taxi for take-off, bound for Lisbon, Portugal, the cargo aircraft suffered serious damage as a result of a collision with fixed

equipment on the ground. The carrier was operating a flight for ASL Airlines Belgium.

Date: 30 Nov ● **Carrier:** Virgin Australia ● **Aircraft type/registration:** Boeing 737-800 (VH-YFH) ● **Location:** Brisbane airport, Australia
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** ?/? ● **Phase:** Take-off

The Australian Transport Safety Bureau is investigating a runway overrun incident at Brisbane airport's runway 19L, which had work in progress at the far end at the time, shortening the runway length

available for use. The aircraft entered the area under repair before getting airborne, but took off successfully and continued with its domestic flight as scheduled.

Date: 30 Nov ● **Carrier:** Air Canada ● **Aircraft type/registration:** Boeing 777-300ER (C-FNNU) ● **Location:** Near Buenos Aires International airport, Argentina ● **Injuries (crew/pax):** 0/0 ● **Total occupants (crew/pax):** ?/? ● **Phase:** Final approach

The aircraft was damaged by hail on final approach to runway 11 at Buenos Aires International airport. The crew carried out a go-around at about 1,200ft and the aircraft diverted to Rosario, where they made a

safe landing. The incident happened in daylight (15:05 local time) but in poor weather on a flight from Guarulhos International airport, Sao Paulo, Brazil.

Date: 1 Dec ● **Carrier:** LATAM Airlines Brazil ● **Aircraft type/registration:** Airbus A321 (CC-BEJ) ● **Location:** Santiago International airport, Chile
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** ?/? ● **Phase:** Take-off

The crew stopped the climb at 18,000ft and returned to land safely after suffering a tail strike during take-off from runway 17R.

Date: 15 Dec ● **Carrier:** Irkutsk Aircraft Plant ● **Aircraft type/registration:** Antonov An-12 (RA-11309) ● **Location:** Tolmachevo airport, Novosibirsk, Russia ● **Injuries (crew/pax):** 0/0 ● **Total occupants (crew/pax):** ?/? ● **Phase:** En route

The aircraft suffered a failure and uncontained fire on the number 4 engine while en route from Irkutsk to Ufa. The crew shut down the engine and diverted to Novosibirsk for an emergency landing. The aircraft

landed safely and taxied to the ramp, but the fire on the right wing in the vicinity of the affected engine continued to burn and was eventually put out by the fire service.

Date: 15 Dec ● **Carrier:** Key Lime Air ● **Aircraft type/registration:** Swearingen Metro (N398KL) ● **Location:** Dwight D Eisenhower airport, Wichita, Kansas, USA ● **Injuries:** 0 ● **Total occupants:** 1 ● **Phase:** Landing

During a night approach to runway 01L, the pilot forgot to extend the undercarriage. When the propellers began to impact the runway just

before touchdown, the pilot applied power and carried out a go-around. The aircraft climbed away, then returned and landed safely.

Date: 17 Dec ● **Carrier:** Blue Bird Aviation ● **Aircraft type/registration:** De Havilland Canada Dash 8-400 (5Y-VVY) ● **Location:** Abudwak airstrip, Somalia ● **Injuries:** 0 ● **Total occupants:** 6 ● **Phase:** Landing

The aircraft ran off the airstrip on to rough ground and the right main undercarriage leg failed.

Date: 31 Dec ● **Carrier:** BAR Aviation ● **Aircraft type/registration:** Cessna Caravan (5X-GBR) ● **Location:** Mweya airport, Uganda
Injuries (crew/pax): 0/0 ● **Total occupants (crew/pax):** 2/3 ● **Phase:** Landing

The aircraft, transporting passengers to the Mweya Safari Lodge, ran off the runway and struck a building, causing extensive damage to the

aircraft. Early reports suggest there were no serious injuries, because the fuselage itself escaped major damage.



An Air Canada 777 diverted after being damaged by hail

AirTeamImages

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Survival instinct

Airliner accidents are thankfully rare events, but many believe the industry's existing passenger evacuation requirements are no longer fit for purpose in helping to minimise deaths and injuries



All passengers and crew survived when an Emirates 777-300 caught fire at Dubai airport in 2016, but evacuation took 6min 40s

STR/PA/Shutterstock

David Kaminski-Morrow London

Passenger aircraft evacuation tests are a paradoxical spectacle. Certifying the seating capacity of a new model means demonstrating that a full complement of passengers can escape the cabin within 90s – a somewhat arbitrary pass mark based largely on the development of rapid evacuation slides and other safety improvements – with only half the exits available.

But replicating a life-threatening situation without actually jeopardising the participants' health and safety means evacuation tests tend to be idealistic and theoretical, as well as expensive.

Almost 30 years ago, a US Office of Technology Assessment paper said such demonstrations were “only a benchmark” and the requirement to show complete evacuation within 90s was “not an adequate performance standard” for actual evacuation capabilities.

“I have long doubted that the 90s evacuation standard can be met in most instances,” says Tennessee congressman Steve Cohen, who sits on the Transportation and Infrastructure Subcommittee on Aviation.

Cohen has introduced a bill – the Emergency Vacating of Aircraft Cabin Act – which is aimed at directing the US Federal Aviation Administration (FAA) to rethink evacuation standards to take into account “real-life conditions”.

These would include not only a broad range of passenger ages, heights and weights, but also passengers

with reduced mobility, and those who cannot speak English, or have limited communication abilities.

The revision also would take into account the presence of carry-on baggage, plus the effect of seat configuration, size and pitch.

“We must act to make flying as safe as we know it can be,” says Illinois senator Tammy Duckworth, a former Sikorsky UH-60 Black Hawk helicopter pilot who suffered the loss of both legs during combat in Iraq.

Duckworth and Wisconsin senator Tammy Baldwin are putting the same FAA revision to the Senate. Baldwin says the FAA needs to ensure the requirements take “all passengers into account”, including senior citizens and youngsters, and are met under “realistic conditions”.

Passenger sizes, and obesity trends, have led to reviews of average weights for aircraft balance calculations, while airlines have shifted towards



“We must act to make flying as safe as we know it can be”

Tammy Duckworth
Illinois senator

higher-density seating. Cohen had previously introduced a bill aimed at establishing minimum dimensions for passenger seat width, length and pitch, in order to ensure safe evacuation.

But while physical constraints can be modelled in evacuation tests, accurately replicating the complexity of human behaviour under stress, and accounting for unexpected problems, becomes almost impossible for a one-off demonstration.

The evacuation of an Emirates Boeing 777-300 – which caught fire after coming down on its fuselage during a failed go-around at Dubai in 2016 – was successful, in that all on board survived.

But although the aircraft was only 77% full, it took the passengers 6min 40s to exit the jet. Nearly half of those who responded to a survey admitted to having retrieved carry-on baggage, despite being instructed not to, according to the United Arab Emirates' General Civil Aviation Authority.

Several passenger escape slides became unusable during the evacuation, stated the inquiry, forcing the redirection of those trying to escape, and the process was further complicated by smoke in the centre cabin forming a “barrier” between the forward and aft fuselage sections. Some passengers also chose to film the chaos on board with mobile phones, rather than prioritise their disembarkation.

UK investigators highlighted the “compulsion” to retrieve baggage – particularly high-value items

30

Average annual evacuation events in 2010-2020, according to US Federal Aviation Administration

– even in the face of danger, after a Lauda Airbus A320 incident in 2019, and recommended adapting procedures for simulating evacuation for certification.

A European Union Aviation Safety Agency (EASA) review of passenger weights, conducted in 2022, found that carry-on baggage has increased, while hold baggage has fallen. The Lauda inquiry suggested that checked-baggage fees were partly responsible for the rise in cabin luggage.

EASA guidance published in 2017 put stronger emphasis on telling passengers to leave baggage behind in the event of an emergency. But the authority has resisted looking into automatically locking overhead bins. “This option might lead to even [greater] delay time due to passengers trying to force [open] the overhead storage,” it says.

An audit of the FAA process for updating evacuation standards, performed by the Office of the Inspector General in 2020, found the last update was based on a USAir 737-300 landing collision at Los Angeles in 1991. That incident saw a combined 35 people killed aboard the jet and a SkyWest Airlines Swearingen Metroliner twin-turboprop in the crash and post-impact fire, which hindered evacuation from the 737.

The audit said the absence of updates was based on reduced cabin flammability and safer seat design.

But it pointed out that the FAA had conducted “insufficient research” on passenger behaviour, and the effects of baggage retrieval and presence of emotional support animals, and did not take into account “real world” risks such as cabin smoke and passengers’ use of electronic devices.

The regulator, it added, did not collect comprehensive data from evacuations, including information on factors influencing evacuation times.

The FAA accepted the audit’s recommendations that it should implement a systematic process to collect and analyse evacuation data to determine whether standards should be revised, and develop policies to maintain aircraft manufacturers’ own evacuation demonstration data to identify risks and ensure information is accurate.

Design improvements

But the FAA also argued that the audit overstated the importance of the 90s evacuation demonstration, given the improvements in cabin safety, lighting, dynamic seat testing, and escape equipment. The auditors, however, remarked that – while cabin design might aid safe exit – the 90s threshold was the “only standard that is purportedly meant to demonstrate” the maximum number of passengers that can safely evacuate.

The FAA submitted a report to Congress in 2022 which described a rulemaking committee’s review, in 2019-2020, of 290 evacuation events over the previous decade. This review found that only about 30 evacuation events occurred worldwide annually, with no fatalities in the USA during the period, and the “overall level of safety” was “very high”.

But it acknowledged “continually evolving” factors, and made a dozen recommendations, including better markings for overwing evacuations, reinforcement of passenger briefings on leaving baggage behind, and the periodic review of evacuation standards “based on demographics and anthropometry” to adapt requirements as characteristics change.

The FAA’s report also referred to a series of 2019-2020 evacuation simulations to gather data on minimum seat sizes. While size and spacing “did not adversely affect” the success of evacuations, the FAA recognised that the tests relied on able-bodied adult participants under 60 years of age.

Passengers often try to collect cabin luggage in an emergency





There were 35 fatalities when USAir 737 collided with a SkyWest commuter plane on landing at Los Angeles in 1991

AP/Shutterstock

"They provide useful, but not definitive information, regarding the effects of seat dimensions on safe evacuations for all populations," the regulator admits.

Computer modelling has the potential to address the weaknesses of real-life simulations, incorporating more realistic behaviour without the risk of injury to test subjects, says the Inspector General audit.

But it stresses that such models require "validated" evacuation data, which the FAA "does not have", and this "inhibits" the use of modelling for certification testing. The US National Transportation Safety Board had made a similar remark in a 2000 paper, stating that models were "heavily dependent" on real data.

"We have been ready to apply evacuation modelling to aircraft certification for at least the past 15 years – at least for derivative aircraft configurations," says University of Greenwich Fire Safety Engineering Group director Ed Galea.

Outdated approach

"The US regulatory community has really dragged their feet on this and have not kept pace with the development of modelling technology," he says.

Galea, a professor of mathematical modelling, says the reliance on full-scale demonstrations is "outdated", and that evacuation scenario simulation "can do a much better job".

"Nevertheless, I am very pleased that the FAA is moving towards a performance-based environment. I think it is definitely the right move and long overdue," he says. The maritime industry has already moved towards such methods for passenger ships and is "significantly" further ahead than aviation, he notes.

"While there is still reluctance to accept some modelling concepts, the maritime industry has made important advances with each evolution," Galea adds.

Various modelling concepts and programs have emerged – with 'airEXODUS', 'Steps' and 'Pathfinder' among the more high-profile – and a number of academic papers have used them to explore application to aircraft evacuation.

A 2020 paper from the Polish military technology university WAT, using Pathfinder and the 787 wide-body as a base, showed that increasing passengers' maximum speed "paradoxically" increased evacuation time, as it led to more passenger collisions.

"It was found that one of the key issues affecting the timing of an evacuation is the proper organisation of the evacuation by on-board personnel," it adds.

Pathfinder was also used on another 2020 study, from Berlin's Technische Universität, to examine evacuation of a 180-seat single-aisle jet and assess the suitability of simulation software to reproduce passenger behaviour. It looked at such parameters as body dimension, conflict behaviour, and walking speed, the influence of body size on overwing hatch use, and the effect of escape-slide angle on evacuation time.

It concluded that evacuation within the 90s threshold prescribed by EASA and the FAA becomes "more difficult" as demographics and the physical characteristics of passengers change.

"Passenger composition specified for the certification test must be adapted... or the legal requirement of 90s must be reconsidered," it stated. "Certification tests to be performed by the manufacturer do not represent a real emergency evacuation situation, due to the failure to trigger a survival instinct.

"Since such a situation must not occur [given the need to protect passenger safety], the results of the certification tests have limited significance. It is questionable to what extent an evacuation, carried out under real conditions within 90s, is possible." ■

Australia is strengthening its defences by ensuring doctrinal and equipment commonality with the USA, with both nations increasingly alarmed by China's expanding territorial ambitions

Lock step

Greg Waldron Singapore

Amid a darkening geopolitical outlook, Australia faces important questions about its future airpower capabilities, as it draws ever closer to the USA.

When the gates open for the Avalon air show near Melbourne, Victoria on 28 February things will appear much the same as in years past.

The Royal Australian Air Force (RAAF) will practise flying displays on the trade days along with aircraft from other air forces. Food, drink, and conversation will flow in the well-stocked chalets adjacent to the runway, as an army of amateur photographers snaps images of fighters and other aircraft.

Because of the coronavirus pandemic the show has not been held since 2019, so overseas visitors will have much to catch up on with their Australian friends.

Increased deterrent

But the festive atmosphere will belie a starkly changed geopolitical environment: one characterised by strategic rivalry between an increasingly aggressive China and Australia's great ally, the USA.

The years since the last Avalon saw the rise of AUKUS, a security pact between Australia, the UK, and the USA. AUKUS's key objective is providing Australia with nuclear submarines in order to increase deterrence against China. Some defence observers feel that AUKUS should be broadened to include airpower, specifically an Australian acquisition of the Northrop Grumman B-21 Raider strategic bomber.

China's behaviour has also boosted the importance of the Quadrilateral Security Dialogue, or 'QUAD',

between Australia, India, Japan and the USA. As never before, Australian interoperability with key allies in the air remains essential.

Malcolm Davis, senior analyst, defence strategy and capability at the Australian Strategic Policy Institute, feels that interoperability with allies is "vital" for the country.

"There needs to be commonality in terms of information sharing via common data links and networks... common platforms and force architectures, commonality and compatibility of weapons systems," he says.

"We need to be able to support US and allied air combat capabilities operating from Australian bases in wartime, with maintenance, and force sustainment."

An RAAF F/A-18F Super Hornet alongside a US Air Force B-1B bomber during Exercise Diamond Storm



Commonwealth of Australia



Australia already has a significant fleet of F-35A combat aircraft

Commonwealth of Australia

“We need to be able to support US and allied air combat capabilities operating from Australian bases in wartime, with maintenance, and force sustainment”

Malcolm Davis Senior analyst, defence strategy and capability, Australian Strategic Policy Institute

Interoperability with the USA and other allies is already a pillar of Australian airpower thinking, and it is one that is likely to be further strengthened later in the 2020s.

A December 2022 joint statement from the US state and defense secretaries, Anthony Blinken and Lloyd Austin, and Australia's ministers of foreign affairs and defence, Penny Wong and Richard Marles, underlined the importance of the Australian/US relationship.

The statement appeared to reference the US Air Force's (USAF's) Agile Combat Employment doctrine, whereby American aircraft are envisaged operating from dispersed, austere bases. This complicates the targeting strategy of potential foes, namely China.

“To support enhanced air co-operation, Australia and the USA committed to co-develop agile logistics at nominated airfields – including at bare bases in northern Australia – to support more responsive and resilient rotations of US aircraft.”

They also disclosed that crews for the USAF's planned future airborne early warning and control aircraft, the Boeing E-7 Wedgetail, will undergo training in Australia. Canberra has extensive experience with the 737NG-based type, having operated it for more than a decade.

A notable demonstration of Australia's commitment to working with partners was the Pitch Black air-power exercise in Queensland that ran in August and September of 2022. The event brought 100 aircraft and 2,500 personnel from around the world to North Australia, where they simulated high-end air combat.

In addition to traditional Pitch Black participants such as the USA, New Zealand, and other regional neighbours, for the first time Germany, Japan and South Korea participated.

Close ties

In November, RAAF and USAF assets conducted Exercise Global Dexterity from RAAF Amberley in Queensland. This saw Boeing C-17s from the two countries conduct tactical airlift and airdrop missions. For the first time, USAF C-17s received fuel from RAAF Airbus Defence & Space KC-30As – the Australian designation for the A330 multirole tanker transport (MRTT).

Underlining the close ties between the two air forces, Global Dexterity saw integrated aircrews manoeuvring at low levels in Papua New Guinea. RAAF and USAF maintenance personnel also worked together on the ground.



Australia and South Korea – both A330 MRTT operators – have pledged to align their air-to-air refuelling procedures

November also saw Australia and South Korea enter an agreement to co-operate on air-to-air refuelling – the Republic of Korea Air Force is also an operator of the A330 MRTT. The two nations will align their air-to-air refuelling procedures to improve interoperability, according to Australia's Department of Defence (DoD).

"This helps further ensure that our two air forces can support one another in the skies, during exercises and training activities and on any future operations," says RAAF Air Vice-Marshal Darren Goldie. "The transfer of fuel when required to sustain and prolong our presence in the air is critical to our aircraft being able to successfully project air power."

Combined capabilities

Yet the greatest symbol of Canberra's alignment with Washington DC's global alliance network is its commitment to the Lockheed Martin F-35, which has replaced its Boeing F/A-18A/B "Classic" Hornets. Cirium fleets data indicates that the RAAF has received 53 F-35As – in July 2022, the DoD said that 50 examples were based in Australia.

Again highlighting interoperability, before the RAAF's 49th and 50th F-35As flew to Australia from Nellis AFB in Nevada in mid-2022, they participated in Exercise Black Flag 22-1 and integration work with the USAF's 422nd Test and Evaluation Squadron.

Black Flag explored ways for the RAAF and USAF to combine their capabilities against a "peer adversary", with a focus on an "advanced air-to-air threat".

Canberra has committed to acquiring 72 F-35As, but faces a key question as to whether to take its fleet beyond this, possibly to 100 aircraft.

The RAAF also operates 24 F/A-18F Block II Super Hornets and 11 EA-18G Growlers. The Super Hornets appear set to stay in RAAF service into the 2030s, but the DoD is coy about whether they will be upgraded to the advanced Block III standard now being rolled out for the US Navy (USN).

In response to a query from FlightGlobal about a potential Block III upgrade, the DoD says: "The RAAF will continue to undertake a spiral upgrade of our Super Hornet fleet through life of type. The spiral upgrade programme provides ongoing capability

50

Number of F-35As based in Australia, according to Canberra in July 2022

assurance including maintaining interoperability with the USA and allies, as well as service life assurance."

The Super Hornet's electronic warfare variant, the EA-18G, will continue to provide a key enabling capability for the RAAF, the only other operator of the type apart from the USN.

Work has also continued on the Boeing Australia MQ-28A Ghost Bat, an unmanned aircraft developed in conjunction with the RAAF. The unveiling of the MQ-28A, formerly named the "Airpower Teaming System", was the big news at the 2019 Avalon show.

Without detailing specifics, Boeing says that work is still under way on the programme, and that production of the MQ-28A continues in the company's Fishermans Bend, Melbourne facility alongside system and payload development. Testing is also informing the type's electronic "digital twin".

"Boeing will continue to manufacture and test aircraft, as well as the supporting capabilities, with support from our Australian industry team throughout 2023 as we expand production capacity and deliver to RAAF commitments. These requirements continue to expand as we move towards our aim of developing an operational capability for Defence," says the airframer.

"Boeing will continue to manufacture and test [Ghost Bat] aircraft, as well as the supporting capabilities, with support from our Australian industry team"

Boeing

In March 2022, Australia's then defence minister, Peter Dutton, said the aircraft would be key in adding mass to the RAAF's capabilities, although a formal order for the type has yet to emerge. The MQ-28A – or a more capable evolution of the type – is envisaged as accompanying RAAF fighters on combat missions, and also performing support roles, such as escorting E-7s and KC-30As.

Davis feels that the MQ-28A could have a bearing on the degree and flavour of Australia's possible participation in the USAF's Next Generation Air Dominance (NGAD) programme, a secretive effort to develop a sixth-generation fighter.

In addition to a potential B-21 buy, he believes that "the other issue on the horizon is NGAD and whether Australia, having already developed Ghost Bat, could enter into the NGAD programme in the same way it did with the [F-35] many years back, with the view to perhaps acquiring NGAD-type capability – or co-developing the NGAD system of crewed and autonomous systems using Ghost Bat – in the mid-2030s, to initially complement, but ultimately replace the F-35A down the track."

Davis adds that these decisions are being made against the background of China's increasing military power, as well as its development of fifth-generation capabilities in the form of the Chengdu J-20 and AVIC J-31/35 fighters, not to mention long-range bombers such as the Xian H-6N, the developmental H-20 stealth bomber, and the mysterious J/H-XX bomber.



The Avalon show is being held for the first time since 2019

Alex Cimbala/Shutterstock

“Add to this their long-range conventional missile capabilities, investment in autonomous systems, and their advanced counterspace capabilities, and China’s ability to project airpower is rapidly growing,” Davis says. “Most of it is still focused on the Taiwan contingency, but it’s clear that China is also extending its reach. Our northern bases are now under threat with Chinese missiles able to range Tindal and other bases. If the Chinese were to establish forward air bases – perhaps in the Solomon Islands – that would dramatically increase the threat to Australia.”

While Davis and others believe the B-21 is the ideal platform to extend Australia’s long-range strike capability, Canberra has been low key about expressing interest. It is still early days, however: the B-21 was only rolled out on 2 December 2022, and faces years of testing before entering USAF service.

Nonetheless, RAAF chief Air Marshal Robert Chipman attended the B-21’s roll-out at Northrop’s Palmdale, California factory, as did UK Royal Air Force chief of staff Air Chief Marshal Sir Mike Wigston. This invited speculation in Australian media about Canberra’s interest in the stealthy type.

New bomber

At an 8 December doorstep interview in Washington DC after the AUKUS joint statement, Marles was asked point blank about Australia’s interest in the B-21.

“The B-21 is a cool-looking aircraft but... we should remember that the Americans have just announced it themselves and are getting it operational, so there are no conversations about B-21s,” Marles says.

Nevertheless, an Australian B-21 acquisition would help reduce the unit cost of the type for the USAF, in addition to shoring up the airpower of a key US ally.

Any conflict in the Asia-Pacific region involving Australia and the USA is going to involve plenty of airlift. To this end, Australia has decided to replace its 12 Lockheed C-130Js with up to 24 brand-new C-130Js.

“Defence has identified that the new C-130J aircraft represents the only option that meets all of Australia’s capability requirements and assures Defence’s medium air mobility capability without introducing substantial cost, schedule and capability risk,” the DoD said in November 2022, when it announced the tactical airlift update.



Nation is replacing and expanding its fleet of C-130J tactical transports

The DoD states that the decision to obtain new C-130Js reflects experience with previous defence acquisitions as well as the RAAF’s experience with the type. Obtaining new Hercules, it contends, reduces risk and is affordable, while meeting requirements. Two days after the DoD’s announcement, the US government stated that it had cleared a potential Australian buy of 24 new C-130Js for a total cost of \$6.35 billion.

Australian Army airlift will also be brought into line with the US Army. In late 2021 Canberra said that it would retire its 47 NH Industries NH90s (designated the MRH90 Taipan in Australia) early, and replace them with Sikorsky UH-60M Black Hawks. The decision followed years of problems with the European type since it first entered service in 2014. Canberra also plans to replace its legacy Sikorsky S-70s with the UH-60M.

The Black Hawk acquisition was confirmed on 18 January. The US government last August valued a 40-aircraft Foreign Military Sales deal at a potential \$1.95 billion.

Rapid delivery

“Delivery of the Black Hawk helicopters will commence this year,” the DoD says.

To be operated from Holsworthy, New South Wales and Oakey, Queensland, the rotorcraft will “be a crucial element for us to protect Australia’s sovereignty, and deliver foreign policy objectives, including providing humanitarian assistance and disaster relief”, says Major General Jeremy King, the army’s land capability head.

“The Black Hawk will support the deployment of our troops and their equipment where they are needed in times of crisis,” says King, who describes the UH-60M as “a reliable, proven and mature platform supported by a robust global supply chain.”

The Royal Australian Navy will also receive 12 additional MH-60R helicopters from mid-2025, adding to 23 in-service examples. These will replace Taipans that now serve in a naval logistics role. The army is also replacing its Airbus Helicopters Tigers with 29 Boeing AH-64E Apache attack helicopters.

Over the past decade Australia has drawn ever closer to the USA on the airpower front, as shown by Canberra’s acquisition decisions. Common interests and common security concerns suggest that US and Australian airpower will become even more entwined over the coming years. ■



In-development MQ-28A ‘loyal wingman’ will add combat mass to the RAAF’s inventory

Boeing

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Falling short



With its combat fleet size in decline, the Indian air force is counting on domestic programmes to recapitalise its fighter inventory from the end of this decade

Atul Chandra Bengaluru

The Indian air force – which is one of the largest and most capable in its region – is now championing the case for the indigenous procurement of defence equipment, even as it seeks to reorient its power to cater for an increasingly belligerent Chinese military on the nation's eastern borders.

The air force has become a vocal proponent of Indian Prime Minister Narendra Modi's government slogan of 'Atmanirbhar Bharat' (Self-Sufficient India) – and appears to have abandoned its previous position that, as a technology-intensive service, it requires cutting-edge equipment in order to match the capabilities of its adversaries.

Air Marshal Manavendra Singh, who headed the air force's training command until 31 December 2022, tells FlightGlobal that the procurement of indigenously-designed defence equipment is now inevitable and inescapable, and that the service is factoring this into its acquisition plans.

India's armed forces, however, are faced with the reality of a still-nascent domestic aerospace and defence industry that is struggling to deliver top-shelf equipment. Meanwhile, onerous transfer of technology requirements and local manufacturing

demands associated with foreign aircraft and weapon purchases have often increased procurement costs without delivering any long term benefits.

According to retired Lieutenant General DS Hooda – who was general officer commander-in-chief of the Indian army's Northern Command and is the co-founder of the New Delhi-based think tank Council for Strategic and Defence Research – the challenge for the government and the Indian armed forces is balancing the need to grow the nation's indigenous defence industry while at the same time procuring equipment that is fit for purpose.

"The armed forces must be allowed to acquire what is operationally essential and not kept waiting for indigenous alternatives that will require time to mature," he says.

Foreign imports

It would also appear that despite India's fervent desire to not be held hostage to foreign arms imports, close to half of the key equipment used in its indigenously-developed aircraft and helicopters – including engines, line replaceable units, sensors and weapons – are imported.

According to figures released by India's Ministry of Defence (MoD) in July 2022, indigenous content levels bettered this on the Hindustan Aeronautics (HAL) Tejas Mk1/Mk1A fighter (slightly more than



Service's current strike assets include Su-30MKI and locally-designed Tejas Mk1

AirTeamImages

53%), and the airframer's Dhruv utility helicopter (almost 56%), Light Combat Helicopter (54%) and Light Utility Helicopter (52%).

For the Sukhoi Su-30MKI fighter and Dornier 228 light transport, both built under licence in India, the MoD cites figures of 51% and 44%, respectively.

"The great pitfall with relying on indigenous platforms is that most of the value goes to foreign contractors, who then have total control over exports and production," says AeroDynamic Advisory managing director Richard Aboulafia. "If you're a strong Western ally like South Korea or Sweden, there's no problem with this. If you're India, and want to be friends with both sides, that means you're vulnerable to cut-offs by any supplier nation you've offended.

"The alternative is to create vertically-integrated national systems, which guarantee systems mediocrity and final result mediocrity. There's a

reason Tejas isn't powered by the [indigenous] Kaveri engine," Aboulafia notes.

India's air force is now slated to acquire nearly 20 squadrons, with 18 aircraft in each, of three indigenously-developed fighter types: the Tejas Mk1A, Tejas Mk2 and the Advanced Medium Combat Aircraft (AMCA). All told, this will see more than 350 of the aircraft manufactured by 2045.

Air force chief Air Marshal VR Chaudhari has said the service will procure enough aircraft to equip seven AMCA squadrons and six with Tejas Mk2s.

India's Aeronautical Development Agency started work on the AMCA programme in 2010, when a feasibility study was undertaken, and the formal sanction for the programme was obtained in December 2018. The first prototype was to have been ready this year, with a maiden flight planned in 2026. In reality, HAL commenced production of the programme's lead prototype in July 2022.

Retired Air Commodore KA Muthanna, who was Chief of Test Flying (Fixed-Wing) at the airframer until March 2020, cautions that dilution of the AMCA effort with the Tejas Mk2 programme will definitely impact the timelines for both aircraft.

Considering the advanced technologies that need to be mastered for the AMCA programme and its importance to the air force, Muthanna says it is important to enter into expert partnerships.

13

Squadrons to be acquired by the Indian air force – with 18 aircraft in each – of Tejas Mk2 and AMCA fighters



Indian air force

The Indian air force is looking to replace its HAL-produced Jaguars

» The air force issued its preliminary staff qualitative requirements for the Tejas Mk2 in July 2019. “The key design requirements are improved range, endurance, lethality and increased payload carrying capacity that will provide the IAF with an ideal platform to replace [Dassault] Mirage 2000, [Sepecat] Jaguar and the [RAC] MiG-29,” a HAL official tells FlightGlobal.

The Mk2 version was conceived in 2009 as a re-engining effort for the Tejas, with the fitment of the GE Aerospace F414 engine. However, the air force later insisted on developing a larger and more capable aircraft with more fuel and greater endurance and weapons carrying capability. While the Tejas Mk1A carries 2,400kg (5,300lb) of fuel, the Mk2 will carry 3,300kg.

Enhanced systems

The roll-out of the Tejas Mk2 was originally to have taken place last August, with a first flight planned by December 2023. It will feature the Defence Research & Development Organisation’s (DRDO’s) Uttam active electronically scanned array (AESA) radar, an internal electronic warfare (EW) suite with jamming capability, a nose-mounted infrared search and track (IRST) sensor and an onboard oxygen generating system, among other enhancements.

According to a senior DRDO official, once all the changes requested by the air force were incorporated on the Tejas Mk2, simulations found that the aircraft was too stable, limiting manoeuvrability. An initial proposed solution was to add a wing strake (such as that used on the Boeing F/A-18E/F Super Hornet), but the designers later settled on the use of canards.

The Tejas Mk2 design features a unique layout, with the canards in a close-coupled configuration positioned slightly ahead and above the wing plane,

for optimal interaction. HAL says this will allow a low wing loading to be maintained by generating additional lift, provide better aerodynamic stability, reduce transonic and supersonic wave drag and improve longitudinal control.

The air force has placed orders for 83 Tejas Mk1As (73 single- and 10 twin-seat examples), with deliveries to commence next year. A first prototype made its flight debut in May 2022, and Muthanna says that delays, if any occur, are not expected to last more than one year.

Speaking at the last Aero India show in Bengaluru in February 2021, HAL’s then chairman, R Madhavan, stated that the cost of a single-seat Tejas Mk1A was approximately \$42 million, with the trainer version coming in at \$38 million. The aircraft has a total technical life of 30 years, or 3,000 flying hours, with major servicing due after every 1,000h.

“The requirements [for the Tejas Mk2] are improved range, endurance, lethality and payload, to replace the [Dassault] Mirage 2000, [Sepecat] Jaguar and the [RAC] MiG-29”

Hindustan Aeronautics

HAL is also aggressively pursuing a Royal Malaysian Air Force requirement for 18 fighter lead-in trainer – light combat aircraft, and responded to an October 2021 request for proposals with an offer of the Tejas Mk1A.

The Indian air force is now down to 31 fighter squadrons (a reduction from 34 in 2015), which includes two each of the Dassault Rafale and baseline Tejas Mk1. It has 12 squadrons of Su-30MKIs and six flying the venerable Jaguar, both of which were produced under licence by HAL, along with three squadrons each with MiG-29UPGs and Mirage 2000T/TIs. Its three remaining squadrons of MiG-21s, meanwhile, are due to be retired by 2025.

The service also continues to pursue a deal for 114 Multi-Role Fighter Aircraft (MRFA), with a contract anticipated in the latter half of this decade. Speaking in Bengaluru last August, Chaudhari said responses for the MRFA tender had been obtained from eight major global players, and that an assessment of their capabilities had been made.

Local production

The procurement will be made under the Defence Acquisition Procedure 2020's Buy (Global – Manufacture in India) category. This will see a few aircraft; likely enough to equip two squadrons, acquired in 'fly-away' condition from a foreign manufacturer, and the rest manufactured in India under licence. The new type will be supported by the establishment of local maintenance, repair and overhaul facilities.

An earlier example of this approach can be found in the air force's ongoing acquisition of 56 Airbus Defence & Space C295 tactical transports. The programme's first of 16 Spanish-completed aircraft is currently in assembly at the company's San Pablo site near Seville, while Indian partner Tata Advanced Systems will be responsible for producing the remaining 40.

The service's procurement situation is also clearly unsatisfactory when it comes to the induction of airborne enablers, such as new airborne early warning and control (AEW&C) platforms and in-flight refuelling tankers. The air force continues to soldier on with its fleet of Ilyushin Il-76-based Beriev A-50s and indigenously-developed Embraer ERJ-145-derived 'Netra' AEW&C aircraft, while its Il-78 tankers have been in service for nearly 20 years and are becoming increasingly difficult to sustain.

The air force has received approval to acquire a single tanker on wet-lease, which it expects to retain in service for three to four years, while an ongoing

\$42m

Cost of a single-seat Tejas Mk1A, of which the air force has ordered 73 examples together with 10 twin-seat variants

procurement process for six aircraft concludes. It has also chosen to proceed with an indigenously-developed AEW&C solution based on adapting six ex-Air India Airbus A321s, after abandoning the earlier AWACS India programme, for which Airbus was selected in March 2015 to provide two A330s.

More aircraft also need to be inducted into the service's training fleet, with it currently operating fewer than 260 trainers, against a sanctioned strength of 388. This includes 75 Pilatus PC-7 MkII basic trainers, 82 obsolescent HAL Kiran MkI/IA intermediate jet trainers and 99 BAE Systems Hawk 132 advanced jet trainers. Some 43 Kiran MkII aircraft, which are now



Developmental Tejas Mk2 has gained canards behind cockpit

Atul Chandra

used during the training of flight instructors, also could soon be pressed into service.

Transport aircraft crews now receive instruction using the Do 228, replacing the Antonov An-32 in the role, while following the retirement of the Mil Mi-8 fleet in 2018, helicopter pilots now train on Mi-17s.

In the latter half of this decade, the air force will begin operating a second basic trainer type, with the current PC-7 MKIIs to be joined by the Hindustan Turbo Trainer 40 (HTT-40). HAL received an \$850 million contract for 70 HTT-40s in October 2022, and is slated to deliver the first example next year. An additional 38 HTT-40s are to be ordered after the type has become operational.

Improved support

Meanwhile, a follow-on buy of 29 Hawk 132s has been reduced to 20 due to cost and engine life issues. The air force also recently extended a support contract with Pilatus to maintain its PC-7 MKIIs, and is looking to indigenise 83 different types of spares parts on the turboprop to ensure that its fleet remains serviceable.

A Parliamentary Standing Committee report on Defence, released last August, quoted an air force official as saying the air force ended up spending a large amount of its funds in 2021 on spare parts.

"There is an interesting aspect that a very large number of Su-30 and other fighters are on ground, and we are hopeful that when those spares start coming from this year [2022] onwards, we will be able to actually add some squadrons," the official said. With a large number of legacy platforms in service, fleetwide serviceability of the air force will continue to pose a challenge, at least until its new assets start to come online around the end of this decade.

The air force has approximately 260 Su-30MKIs in use, from a total procurement of 272, and is seeking to upgrade 84 of the aircraft. This will install an upgraded fly-by-wire control system, with other proposed modifications including a larger version of the Uttam AESA radar, an indigenousIRST sensor to replace the current OLS-30, a new laser designation pod and an updated EW suite.

Avionics improvements will provide a new mission computer, larger multi-functional displays, a voice command system, software-defined radio, digital head-up display, helmet-mounted display system and artificial intelligence-based support systems.

An important weapons upgrade to the modernised Su-30MKI will be the integration of the new BrahMos-NG supersonic cruise missile. Unlike the original BrahMos – just one of which can be carried on the aircraft's centreline stores station – three of the smaller and lighter BrahMos-NGs can be deployed by the fighter, and without the need to perform expensive and time-consuming structural modifications.

Multiple of India's ambitious fighter projects, including the Tejas Mk2, AMCA and MRFA procurement, will be high on the agenda at the Aero India show, taking place from 13-17 February. ▶

\$850m

Value of contract received by HAL to produce 70 HTT-40 trainers; 38 more are to be ordered after service entry

Extensive upgrade will boost capability of roughly one-third of the nation's Su-30MKIs



Indian air force



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Return of the spinning machine

We read a lot about innovations in advanced air mobility, but what if the future of aviation is a 100-year-old technology?

Highland Aviation believes it might be. The Inverness-based training organisation is offering courses in flying gyroplanes, 100 years after the first such aircraft took to the skies.

Spaniard Juan de la Cierva, a glider enthusiast and self-taught aeronautical engineer, developed the first autogyros in the early 1920s in a quest to produce an aircraft that could fly safely at low speeds.

An autogyro uses autorotation – where airflow acts on a set of unpowered rotor blades to keep them spinning and provide lift. A conventional engine-driven propeller allows forward motion, but if it fails, an aircraft in autorotation will perform a controlled glide to the ground.

De la Cierva's fourth and first successful prototype took off on 9 January 1923 in Getafe, Spain, covering a distance of 180m. During a subsequent flight, the engine failed but the aircraft landed safely in a state of autorotation, exactly as intended.

After successfully demonstrating his invention in Farnborough in 1925, he set up the Cierva Autogiro Company in the UK.

Although he died in 1936 – ironically in an airliner crash – his work paved the way for the development of helicopters, whose ability to hover gave them an advantage over autogyros.

Highland Aviation claims to be the first company to become a UK Civil Aviation Authority approved gyroplane-training organisation.

"We are passionate about gyroplanes for safe, fun and affordable flying. We are excited about the potential for them to be used for short-range commercial flights," it says.

Karolis Kavolelis/Shutterstock



Spin doctor: de la Cierva's autogyro



Wikimedia Commons

From the archive

100

1923 An intolerable burden

The Secretary of State for Air pointed out the two very considerable obstacles to the progress of civil aviation – shortage of money, and the after-War confusion of the world. "Personally," Sir Samuel Hoare said, "I regard the huge expenditure of the world upon soldiers and ships, and armies and fleets, and air squadrons as an intolerable burden upon trade and industry, and indeed as an outrage upon Christian civilisation. But until there is a new spirit in the world, and until we have got out of this atmosphere of wars and rumours of wars, we cannot afford to let our air defences fall below the Empire's needs. This being so, it is inevitable that the greater part of the national expenditure upon air must, for the present, go to our military commitments of home and Imperial defence."

75

1948 Orville Wright dies

Aviation the world over mourns the death, on January 30th, of the first man to make a controlled flight in a power-driven, heavier-than-air aircraft. On that day Orville Wright passed away at the age of 76, only 45 years after he made his historic flight lasting 12 seconds. That was on December 17th, 1903. Yet what strides have been made in the art and science of flying during that short period. Wilbur and Orville Wright laid a sound foundation for further work. They built a wind tunnel to obtain reliable data. They realised that when their wings were warped for lateral control there would be a yawing moment which had to be countered by the rudder. They were clear that large-diameter airscrews were needed for efficiency. Even assisted take-off was practised by the Wright brothers.



Pies fighter?

Not such a nimble ninja

During a recent visit to a partner company involved in building a current multinational European fighter aircraft, we picked up some interesting insight into the challenges involved with designing a true air superiority platform.

"If you listen to pilots around the world, and ask them [which combat aircraft] is best at dogfighting, they probably will come up with the Eurofighter," an official says.

"If you ask them: 'is the [Lockheed Martin] F-35 a really good dogfighter', they will tell you probably not.

"I have heard one pilot say that the F-35 is a 'really fat ninja'."

Joking aside, the source stresses that the Eurofighter and F-35 are in fact a potent mix when flown as complementary platforms: hence the latter's acquisition by Italy and the UK and recent selection confirmation by Germany.



Air pets

For a bit of shameless feel-good seasonal PR, not much beats a fluffy-animal story, and US carriers – or at least some of them – managed to bask in just such a glow over the holiday period.

One of United Airlines' captains gave a home to an adopted dog – named 'Polaris' – in mid-December, after it was abandoned at San Francisco airport, according to the city's animal-rescue charity SF SPCA.

It says the dog arrived from an international location with a person who "chose to continue travelling on without his animal", whereupon United and the SPCA took on the responsibility for ensuring the dog could stay in the USA and be rehomed in time for Christmas.

Frontier Airlines also associated itself with animal adoption, offering tickets to those prepared to look after three kittens offered by The Animal Foundation of Las Vegas – all named after US airlines.

Quite why the shelter called them 'Delta', 'Frontier' and 'Spirit' isn't entirely clear, although a clue might lie in chief executive Hilarie Grey's former roles leading communications and public affairs at budget carrier Allegiant and Las Vegas airport.

This experience in putting air transport brands in a positive light might also explain why young 'Spirit' underwent a hasty renaming after the holiday-travel fiasco affecting one of the largest US operators.

"Spirit's name used to be Southwest," says The Animal Foundation. "But due to recent events, our marketing requested we change it."

1973 Ceasefire in Vietnam

After more than a decade of American military involvement in a struggle that had lasted for nearly 30 years, an agreement has been reached to end the Vietnam war. It was initialled in Paris on January 24 by M Le Due Tho of North Vietnam and Dr Henry Kissinger, the American President's special adviser. The terms of the settlement were included in 23 articles and four protocols. The ceasefire was due to begin at midnight GMT on January 27. The war resulted in many military developments, including that of the armed helicopter. The bombing of Hanoi and Haiphong by B-52s during the final weeks of the war and the loss of a significant number to surface-to-air missiles has resulted in widespread modifications to the type's electronic countermeasures.

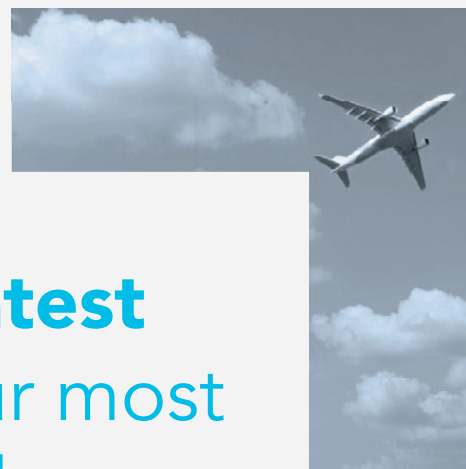
1998 Better beat the bug

Aviation insurers have challenged airlines to prove that their fleet avionics are free of the "millennium bug" which threatens to disrupt computer software, or lose their cover for any incidents which result from it. The issue, says a major underwriter, is what may happen to embedded computer microprocessors at midnight on 31 December, 1999. Some, programmed with dates which recognise years only as two digits, will see the "00" as a reversion to the year 1900, which could affect the system software. British Aviation Insurance Group chief underwriter Tony Medniuk says that airlines have been sent a checklist of actions, and any carriers which cannot demonstrate compliance will lose cover. Some airlines have decided to ground their fleets for a short time on 1 January.



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Max reports expose fundamental divide

Regarding your online coverage of the Ethiopian Airlines Boeing 737 Max 8 crash report (FlightGlobal.com, 28 December 2022 and 4 January 2023), it is notable that the comments from the BEA and US National Transportation Safety Board (NTSB) do not match.

The BEA's comments – which are much fairer – concentrate on the failure to run the approach to stall and/or indicated airspeed/altitude (IAS/ALT) disagree procedures before the flaps were retracted.

The NTSB concentrates on the failure to run the trim stabiliser runaway procedure as stated in the Federal Aviation Administration (FAA) emergency airworthiness directive after flap retraction, which activated the Maneuvering Characteristics Augmentation System (MCAS).

The unreliable airspeed procedure would have saved everybody's lives, provided it was run with the flaps down, avoiding MCAS activation. But it cannot be run immediately after take-off, because of the need to gain height: in this case, 14,000ft.

We will never know whether the pilots intended to run the unreliable airspeed procedure with the flaps up, but it would not have worked. The reason is that MCAS was activated on flap retraction, and within 9s the pilot flying was pulling 90lb on the control column to keep control of the airplane. FAA regulations say the limit should be 70lb with both hands.

The BEA's comments are telling: "During this phase, the physical efforts applied by the crew on the column probably impacted their situational awareness and their cognitive resources and did not allow them to undertake the proper actions."

The Ethiopian Aircraft Accident Investigation Branch has not accepted that there was an IAS/ALT annunciation, as it was not recorded. My belief is that it did appear, but as the flightdeck was in meltdown perhaps it didn't register with the pilots.

The NTSB's comments are simply unfair. The stabiliser runaway procedure as stated in the FAA

emergency directive is wrong, as it does not mention the need for speed management, or to disconnect the autothrottle and apply the speed manually.

The directive does say that the electric manual trim should be used to unload the aerodynamics/stabiliser – but how do you do that when, within 9s, you are hanging onto the airplane for dear life?

The BEA's comments are instructive, asking 'can it be done?', and its comments suggest not.

Once the flaps had been retracted and MCAS activated it was game over. The NTSB simply does not address reality – could anyone do what it suggests?

I don't think so.

If the regulators cannot agree on the procedures to use, even with 20/20 hindsight, then how can pilots be expected to?

I am not surprised that the Ethiopian investigators have simply refused to blame the pilots.

Philip Mason

Via email

Markus Mainka/Shutterstock

Taking a Liberty

I suspect the artist's impression of DARPA's massive new 'Liberty Lifter' flying-boat project (FlightGlobal.com, 29 November 2022) is just a naughty teaser.

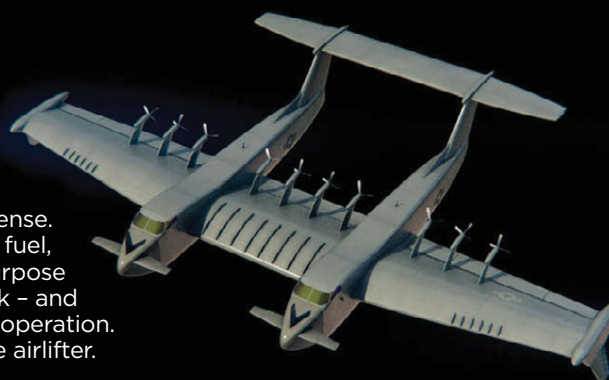
Instead of using twin hulls – never convenient – a blended body configuration would make much more sense.

There would be ample room for cargo and hydrogen fuel, engines at the back (out of spray's way), and a dual-purpose undercarriage of light and compact foils for water-work – and multiple wheels with ground-effect assistance for land operation.

This challenged world urgently needs such a versatile airlifter.

David Stevens

Woking, Surrey, UK



DARPA

Is artist's impression
a twin-hull tease?

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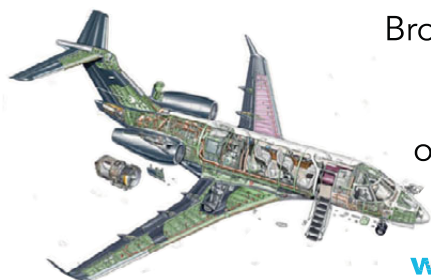
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Susan Ying has transformed a series of unfortunate events – including losing all her possessions in a flood and a cancer diagnosis – into a stellar career that now finds her at electrification innovator Ampaire

Engineering change

Dominic Perry London

Engineers don't hold much truck with concepts like luck, preferring instead to trust in hard empirical data. But even Susan Ying – whose CV includes stints at hard-data places like Boeing and NASA – occasionally wonders if her four-decade journey hasn't been helped by the stars aligning.

She is too modest to say, but the reality is that talent and sheer hard work put her in the right place at the right time to make her career arc possible.

Ying is now senior vice-president of global partnerships at electric aircraft developer Ampaire, her second job since nominal retirement.

Born in Taiwan but raised in Indonesia, travelling throughout Southeast Asia as a child sparked an early passion for aviation. "We did lots of flying in big jets. It was really exciting because it was so different from everything else," she says.

Despite her interest, barriers were already obvious. "A couple of times as little kids my brother would be able to go to the cockpit and visit the pilots but I was never invited because I was the little girl."

Perhaps because of that exclusion, her curiosity was piqued: "I thought there must be some magic going on up there for them to make the airplane fly; it fascinated me. But when I went to college my first choice originally wasn't aerospace or engineering because I didn't know there were such options."

A lacklustre attempt to tackle her first subject choice coincided with Ying stumbling into flying lessons and the discovery that "flying isn't just a boy's thing". She found from other female aviators that a path into engineering was available.

Initially graduating from Cornell University in Ithaca, New York, Ying found the eastern USA "too cold", and quickly left for the warmer climes of Stanford in California. There she met a professor, Dick Shevell, who was a chief engineer for Douglas Aircraft on the DC-8, -9, and -10 programmes. "I was able to study

under him, which was fantastic. By that time, I knew what I wanted to do with the rest of my life – be a designer of airplanes."

But aircraft design was not the first role she took post-Stanford. Instead, NASA beckoned.

Ying's thesis was on 3D computational fluid dynamics and she joined NASA to "push this state-of-the-art technology". That led her down a supercomputing path – first joining Florida State University and helping to establish its new engineering school, then to the Department of Energy's Scalable Computing Lab in Iowa State University in Ames.

However, torrential rain on her very first night in the Midwest flooded Ying out of her apartment. Most of her possessions were ruined, she was rendered homeless, and her car left running only intermittently. "I basically lost everything," she says.

"Life goes on but after that I was bound and determined to leave Iowa and go somewhere else; I said to myself, I have to get my act together and get out."

Space race

Ying began applying for jobs and among the adverts for more regular aerospace positions there was one from NASA that caught her eye: the space agency was seeking astronauts for its Shuttle programme.

But Ying did not think she had the 'right stuff'.

"Before I never would have dreamt of applying to NASA for the astronaut programme," she says.

"Why? Because I knew astronauts were super-smart; some of these people had three PhDs, or one medical doctorate and a PhD, or they were a fighter pilot with 1,000 hours of jet time – things like that. I didn't think I would qualify."

But it transpires a degree of desperation can help you overcome your reservations: "When you are homeless and have nothing then you have nothing to lose. So I applied – and I became a finalist."

Then fate – or the fallibility of the human body – intervened: NASA's stringent medical examination process threw up a cancer diagnosis, removing Ying from the astronaut pool.

Susan Ying



“Life is so precious – you really have to make the most of it. And that’s what I’m doing working in sustainable aviation”

Ying is attracted to Ampaire’s focus on regional air mobility

Putting the disappointment behind her – and having overcome the disease – Ying landed a job at McDonnell Douglas working on high-lift aerodynamics.

There was a twist, however: on a commercial flight, Ying bumped into Kalpana Chawla, who she knew from her time in Ames and the NASA selection process. By then, Chawla had been picked as an astronaut, making her first spaceflight in 1997. Ying invited her to speak at one of McDonnell Douglas’s regular Amelia Earhart Society meetings, and Chawla promised to set a date once she was back from her next mission.

Sadly, that next flight was aboard the shuttle *Columbia* in January 2003, for the STS-107 mission, which ended in the loss of all seven astronauts as the spacecraft disintegrated on re-entry.

As it turns out, the cancer diagnosis may have saved Ying’s life. “Thinking back, if it hadn’t been for my cancer it could have been me on that flight.

“Life is so precious – you really have to make the most of it. I think she [Chawla] made the most out of her life doing what she loved, and I think that’s what I’m doing right now working in sustainable aviation.”

After McDonnell Douglas was acquired by Boeing, Ying stayed on, helping to drive numerous projects, including advocating for the more-electric architecture eventually adopted on the 787. Post-Boeing, she retired, only to be tempted back by Chinese airframer Comac, where in 2014 she became chief integration officer, taking charge of the systems engineering function at the fledgling manufacturer.

Returning from China, Ying retired for a second time, before one of those coincidences that have defined her career again intervened. Back in her Boeing days, she had helped with recruitment activities at Stanford University – her alma mater. There in 2009 her team spoke with a “young man we all thought was brilliant” but who, to her surprise, turned down a job offer.

“When I retired from China, I came back to the US, my former Boeing colleague told me to go and meet this same young man again,” she says.

Revolutionary vision

Although no longer working for the US airframer, she reluctantly agreed. And the young man turned out to be Ampaire co-founder Cory Combs. “He was just so impressive and visionary... to cut a long story short, he recruited me,” she says.

Ampaire’s initial focus on aircraft for short-haul or island-hopping missions – so-called regional air mobility – offers the potential to improve people’s lives, in a sustainable way, by enhancing connections across many regions. But perhaps closest to heart is her childhood home of Southeast Asia. The inhabitants of a country like Indonesia – an archipelago of more than 17,000 islands with often limited links between them – stand to gain hugely from aviation’s third revolution, Ying argues.

But it is a revolution that could be closer than people think: “Cory convinced me the future of aviation would be electrification, and it is possible with today’s technology!” ▶

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