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INTERNATIONAL

SURVEY

TOP 100

Who's been making the money and trading places in our annual ranking of aerospace's most powerful players?

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Mighty Moscow

Russian industry showcases growing strength at MAKS **14**

After Bombardier

Dash 8's new owner details ambitious update plan **18**

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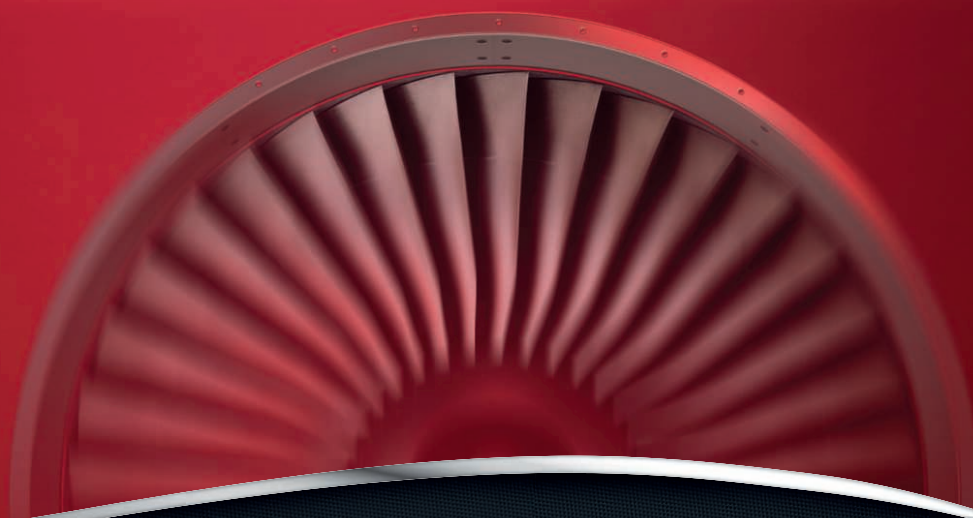
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Extraordinary together





Saab flies first Gripen E in Brazilian livery **P23**

BEHIND THE HEADLINES

Garrett Reim was at the MAKS event in Moscow, and produced our show report (P14). In Bedford, Murdo Morrison got an update on HAV's ambition for Airlander sales (P27)



BAE Systems

NEXT WEEK TYPHOON

We look at BAE Systems' production plans beyond Eurofighter. Plus, our latest environment special report

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Chris Gardner/FlightGlobal



Garrett Reim/FlightGlobal

Scheduled helicopter flights for MAKS show **P16**

Download the 2019 Commercial Engines Report
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Image of the week

A rainbow provided a colourful backdrop as this Luftwaffe A400M arrived at the Royal Air Force's base in Waddington, Lincolnshire. The German air force Atlas will be among 50 aircraft taking part in exercise Cobra Warrior, along with assets from Israel, Italy, the UK and the US Air Force

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The week in numbers

↑ **17%**

Cirium Dashboard

Half-year growth in Kenya Airways' available seat kilometres. But operating losses trebled to \$28m – pre-tax loss was \$83m

\$93m

Cirium Dashboard

Loss-making SAS Group's cost-saving target for its year to end-October is part of a bid to axe \$310m in costs by 2020

↓ **750**

Cirium Dashboard

Jobs cut at Virgin Australia; the carrier is slashing costs in the face of an underlying loss of \$50.7m for the year to 30 June

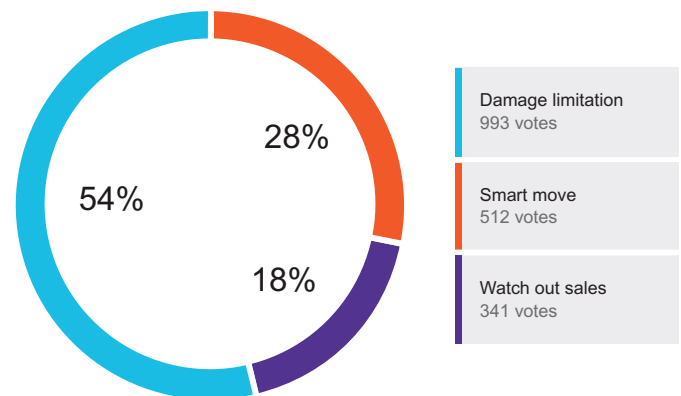
Question of the week

Last week, we asked:

What does it mean that Boeing delayed the 777-8?

You said:

Total votes: 1,846



This week, we ask: **Taiwan's F-16V purchase?**

☐ China-baiting ☐ Needless expense ☐ Valid deterrent

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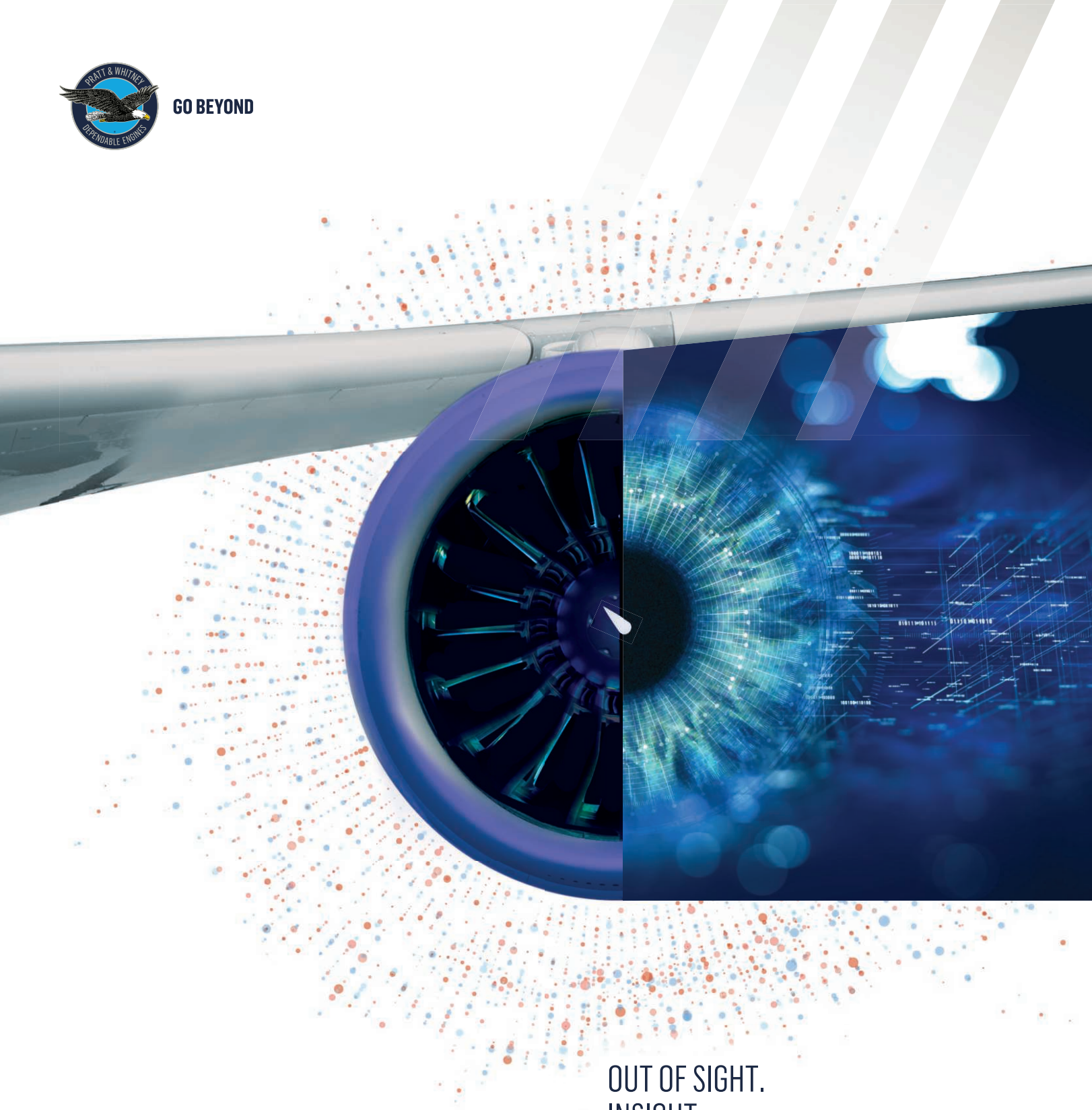


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On the defensive

Closer to war?

Washington's approval for a Taiwanese buy of advanced F-16s has drawn Chinese ire and likely industrial consequences, but deterrence is essential

Beijing's reaction to the US government's plan to sell 66 Lockheed Martin F-16Vs to Taiwan was as rapid as it was predictable.

While the deal still requires congressional approval and Taipei's acceptance, China's defence ministry attacked the transaction as a "complete mistake" and "very dangerous".

One Chinese general claimed that the F-16V has "no significant advantage" over Chinese types such as the Chengdu J-15 and J-16. He also contends that Taiwan's ruling Democratic Progressive Party (DPP) is no more than a pawn to the USA, and that the fighter deal is part of a protection racket.

"Taiwan people must wake up and be highly alert to this fact," he says. "The DPP is gambling with the future of Taiwan by attaching [itself] to US war machines, pushing the island and its people ever closer to the abyss of war."

Deterrence theory suggests otherwise. China's military build-up under Xi Jinping has coincided with increasingly common – not to mention alarming – calls for Taiwan to be unified with the mainland.

Though much is made of China's rising air and naval power, its military is entirely untested. An attempt to invade Taiwan would amount to one of the largest and most complex operations in history – and the USA and Japan would almost certainly be drawn in.

The human and economic costs of such a war defy imagination. This is precisely why bolstering Taiwan's defences is so imperative: anything that increases Beijing's uncertainty

about its ability to prevail in a war for Taiwan is to be welcomed. And it is hard to find a weapons transaction that has more potency than a major fighter deal.

Yet there will be fallout. Beijing has made it clear that the companies involved in arms sales to Taiwan will be punished. Lockheed can shrug off such threats, but a list of other firms with exposure to the Taiwanese defence market would read like a who's who of the US aerospace industry.

Anything that increases Beijing's uncertainty about its ability to prevail in a war for Taiwan is to be welcomed

The situation is especially awkward because the global aerospace industry has banked its future on China's seemingly limitless commercial market. In addition to direct sales, US suppliers see big opportunities in Chinese programmes such as the Comac C919.

Given Beijing's obsession with Taiwan, it may be willing to accept some industrial pain to snub Washington. It will almost certainly redouble efforts to develop its own aerospace sector, so as to one day cut ties with the West.

Long term, the F-16V deal is probably bad news for US industry – but good for peace. ■

See Defence P22

Bigger is better

Our latest report on the biggest companies in aerospace underscores a powerful reality about the industry: the big are getting bigger. In revenue terms, number-one-ranked Boeing has broken through the \$100 billion ceiling, and billion-dollar-plus firms now make up two-thirds of our Top 100. Organic growth is broadly real, but only part of the story, because what is really driving this up-sizing are mergers and acquisitions.

M&A is nothing new in aerospace – an industry that has gone through many waves of consolidation. Airbus as we know it is an amalgamation of European national champions, as is Leonardo. And Boeing became boss by absorbing rivals like McDonnell Douglas; there is a reason for double-barrelled names like Lockheed Martin and Northrop Grumman.

What these OEMs have always been after is scale, and the same logic applies in consolidating a supply chain. Big companies have the financial clout to remain reasonably stable while managing the huge investment demands inherent in aerospace. Big companies can also cope better with the financial turbulence that comes of competing over long time periods for winner-takes-all defence contracts.

For sure, government and central bank responses to the 2008 financial crisis are driving a recent wave of consolidation. Tax cuts and near-zero interest rates have left companies and private equity investors awash with cash and scratching for profits in a financial environment where risks are high yet returns, paradoxically, are low.

But there is another reason for a new-found eagerness to do deals. Investors have long been expecting a downturn – possibly global and severe – and all indicators suggest that a crunch time is imminent. More than ever, getting bigger looks like a sound survival strategy. ■

See Top 100 P28



Back in the day, it was just Douglas

BRIEFING

BEA HUNTS FOR LOST PW1500G PARTS

INCIDENT France's BEA investigation authority is seeking help to locate titanium parts believed to have fallen from a Swiss-operated Airbus A220-300 around 102nm (190km) southeast of Paris on 25 July. The aircraft (HB-JCM) suffered a failure to the stage one rotor of its left-hand engine's low-pressure compressor while climbing through 32,000ft on a service from Geneva to London Heathrow. The crew shut down the Pratt & Whitney PW1500G and diverted to Paris Charles de Gaulle airport.

GATWICK ADVANCES RUNWAY PLAN

CAPACITY London Gatwick airport has notified the UK's Planning Inspectorate that it intends to file a full application seeking permission for its standby northern runway to be used from the mid-2020s. In July, Gatwick said it wanted to bring its inactive second runway into routine use for smaller departing aircraft, to "balance operational resilience and sustainable growth". A public consultation will be held next year.

QANTAS COMMITS TO FIRST A321P2F

FREIGHTER Qantas is securing its first Airbus A321 for cargo conversion through Luxembourg-based asset specialist Vallair. The International Aero Engines V2500-powered twinjet (MSN835) was originally delivered to UK carrier BMI in 1998, before being flown by Turkey's Onur Air, Cirium fleets data shows. Vallair will deliver the converted A321P2F in 2020, with Qantas Freight to use it on routes for Australia Post. Meanwhile it has taken the first of two Boeing 747-8Fs wet-leased from Atlas Air.

REPUBLIC CALLS TIME ON A220 PURCHASE

CANCELLATION US operator Republic Airways Holdings appears to have cancelled an order for 40 Airbus A220-300s, placed in 2010 when the type was offered as the Bombardier CS300. Republic does not feature as a customer in Airbus's latest backlog figures, with the deletion trimming its net order total for the first seven months of the year to just 79 aircraft.

IMPROVED PROTECTION BOOSTS F-35 FLEET

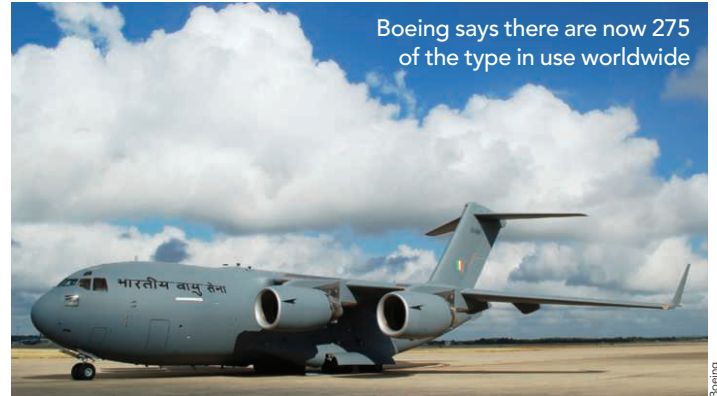
CONTRACT BAE Systems is to upgrade the electronic warfare suite it provides for Lockheed Martin's F-35 fighter, adding 11 undisclosed "new capabilities". The work involves updating the ASQ-239 countermeasures system for the Lightning II's Block 4 configuration, BAE says.

LEAD A350 FLIES FOR AIR FRANCE

DEBUT The first of 28 Airbus A350-900s for Air France has completed its debut flight from Toulouse. The Rolls-Royce Trent XWB-powered twinjet is being prepared for delivery to the French flag carrier in the coming weeks. The airline will boost operational efficiency and reduce costs by adopting a common type-rating with its in-service A330s.

BELL BEATS US NAVY IFR DEADLINE

APPROVAL Bell narrowly met a US Navy deadline to secure instrument flight rules (IFR) certification for its 407GX light-single helicopter. The model is being pitched against the Airbus Helicopters H135 and Leonardo TH-119 for the 130-aircraft Advanced Helicopter Training System deal to replace the navy's Bell TH-57 Sea Rangers. A decision is expected later this year.



Boeing says there are now 275 of the type in use worldwide

DELIVERY GREG WALDRON SINGAPORE

Final C-17 goes on a passage to India

Last example of strategic airlifter received by New Delhi, ending era that was begun by McDonnell Douglas in 1991

The Indian air force has received its 11th and last Boeing C-17, marking the company's final formal delivery of the strategic airlifter.

The delivery of this last aircraft (MSN IAF-11) means that there are now 275 C-17s in service around the world, the airframer says.

The final C-17 manufactured by Boeing departed its Long Beach, California site in November 2015, with the company having ended production by building several "white tail" examples without confirmed customers. All these aircraft have since been sold.

In June 2017, the US Defense Security Cooperation Agency outlined the last unit's proposed sale to existing C-17 operator New Delhi, valuing the transaction at \$366 million.

Cirium fleets data shows that the Indian air force is the second-largest operator of the type, with 11 examples. The US Air Force (USAF) operates the bulk of the global fleet, with 222 in service.

Australia, Qatar, the UK and the United Arab Emirates have eight each, Canada five and Kuwait two, while a consortium of NATO and Partnership for Peace nations have three.

"The C-17 fleet has been a vital part of the Indian air force's

strategic and combat airlift capability," says Boeing, noting that it has "performed a wide range of operations in military missions, and provided peacekeeping support, humanitarian assistance and disaster relief in India and internationally, since induction in 2013."

Boeing is responsible for the Indian fleet's maintenance, field support, modifications, upgrades, technical manuals and logistics. In addition, it has a simulator centre in the country that has completed over 5,100h of training for aircrew and loadmasters.

McDonnell Douglas, the original manufacturer of the airlifter, delivered the first C-17 (MSN T-1) to the USAF on 15 September 1991. This aircraft was retired in 2011. The in-service fleet has an average age of 14.4 years, Cirium data shows, with the oldest examples over 27 years old.

In September 2013 Boeing announced that it would shut down C-17 production owing to insufficient orders to keep its Long Beach line going beyond 2015.

Defence pundits in India have suggested that while the nation's air force would have liked to buy more C-17s, New Delhi's slow acquisition process was unable to produce orders in time to help sustain Boeing's production of the type. ■



DRA sets Dornier
328 back in motion
This Week P12

FLEET JON HEMMERDINGER LAS VEGAS

Southwest keeps faith with Max brand

Carrier rules out changing name of 737, saying it will give customers confidence in safety when grounding is lifted

US carrier Southwest Airlines has taken a potential renaming of the Boeing 737 Max off the table, according to its chief revenue officer, Andrew Watterson.

In what he describes as an effort to be transparent with its customers, the Dallas-based airline has chosen to retain the “Max” title when the type returns to the skies.

“We will not change the name of the aircraft. That would be disingenuous,” Watterson said during the Boyd Group International Forecast Summit in Las Vegas, Nevada. “It will still be called the Max for us.”

Speculation has abounded that airlines may feel compelled to drop the “Max” moniker so as to avoid reminding customers of the type’s troubled past. But after conducting customer surveys, Southwest believes its passengers trust it to thoroughly vet the aircraft’s safety.

“Essentially the customers told us ‘We trust you’,” says Watterson. “Our job will be to provide credible evidence that we have validated that the aircraft is safe to fly.”

The Max’s return to service timeline remains fluid, although Boeing expects to submit certi-



Airline currently has 34 narrowbodies stored at Victorville, California

fication requirements to the US Federal Aviation Administration (FAA) in September, and for regulators to clear the aircraft in the fourth quarter.

Southwest has removed the Max from its flight schedules through 6 January 2020, although that could change.

SOFTWARE CHANGE

“When Boeing delivers the software to the FAA – that’s a significant milestone,” says Watterson, who estimates that regulators could lift the grounding four to six weeks later. “That will be our cue to ramp up our plans,” he adds.

Those plans call for Southwest to revise flight manuals to include new details required by the

FAA, and to implement a training programme to teach pilots about those changes. The carrier estimates needing 30 days to train all of its crews.

Southwest also would at that point publish a new schedule containing Max flights and begin preparing its 34 737 Max jets – currently in storage at Victorville, California – for a return to the skies. Those aircraft will need Boeing’s updated flight control software, and also must undergo maintenance related to coming out of storage, which Watterson expects could be completed in relatively short order.

But the most significant hold-up will likely be Boeing’s ability to deliver to airlines the hundreds of

737 Max jets it has manufactured but not delivered since the grounding took effect in March.

Delivering new aircraft under ideal circumstances can take several days, requiring thorough inspections, test flights and correction by the manufacturer of any issues uncovered, Watterson says.

“The ones that are grounded in some parking lot somewhere – that will be the bottleneck for Boeing,” Watterson says. “How long will it be before we get all our aircraft? We are not sure.”

Separately, United Airlines has received regulatory approval to ferry its fleet of 14 grounded 737 Max aircraft to Goodyear airport near Phoenix, Arizona, where they will be placed in “short-term storage”. The carrier had nine examples at Houston’s Hobby airport, three at Houston Intercontinental, and two at Los Angeles International airport.

“Arizona is a much better place to store aircraft, due to lack of humidity and other more-favourable weather conditions,” says United.

United’s flight schedules still show the 737 Max as returning to revenue service after 3 November – the same month that American Airlines hopes to bring the type back into use. ■

ORDERS DAVID KAMINSKI-MORROW LONDON

Sukhoi secures Superjet sales at Moscow air show

Russian carriers Azimuth and Yakutia are to take a dozen more Sukhoi Superjet 100s, with the commitments announced at the MAKS Moscow air show.

Azimuth, which commenced operations two years ago and has a fleet exclusively comprising nine Superjet 100s, will take another two via Russian state lessor GTLK. Its next example will arrive in October, for service introduction the following month. The carrier also announced at the

show an intention to take between five and 10 Irkut MC-21 narrowbodies.

Yakutia, meanwhile, will lease 10 Superjets over the period of 2020-2021, in order to develop a base at Khabarovsk airport and a network to destinations in China, Japan and Korea, says the regional Sakha government. The carrier already operates Superjets as part of a fleet also including Boeing 737s and Bombardier turboprops. ■

See Show Report P14



Russian carriers Azimuth and Yakutia made commitments

DEVELOPMENT DOMINIC PERRY LONDON

DRA sets Dornier 328 back in motion

New German OEM promises 'more efficient, economic and environmentally friendly' update of twin-turboprop design

Germany has a new aircraft OEM – DRA – which intends to revive production of the Dornier 328 twin-turboprop at a new facility in Leipzig.

DRA has been set up by 328 Support Services, the aircraft's type certificate holder, and is being supported by the German federal government and the authorities in the state of Saxony.

The three parties signed a memorandum of understanding on 21 August to establish the new final assembly line in the east German city. Up to 250 jobs will be created in Leipzig, with a further 100 at 328 Support Service's site in Oberpfaffenhofen, Bavaria.

However, few details on the aircraft have been released. DRA describes the proposed development as a "derivative of the

Dornier 328", which it has termed the D328NEU.

The original product could carry up to 33 passengers, and it is thought the revived design will accommodate a similar number. Images on DRA's website indicate that it will be turboprop-powered, but the company has released no details of proposed powerplant or systems suppliers.

Under a now-abandoned plan to establish production in Turkey under the TRJet brand, Pratt & Whitney Canada had agreed to provide PW127 engines for the platform. Other suppliers included Collins Aerospace, which was to provide its Pro Line Fusion avionics suite, while Liebherr was to supply air management and flight control systems, and Heggemann the landing gear.



Original aircraft could carry up to 33 passengers

AirTeamImages

DRA says it will "exploit future technologies and capabilities to produce a more efficient, economic and environmentally friendly aircraft". It also promises to "lead the way in clean and renewable energy with a smaller carbon footprint, getting more power from less to benefit operators and passengers alike".

DRA promises an improved cabin, new landing gear, redesigned propellers for quieter operation and the "latest in avionics". More information on the aircraft's specification will be released in early 2020, the company says.

US firm Sierra Nevada has owned 328 Support Services since 2015. ■

REQUIREMENT GARRETT REIM LOS ANGELES

US Navy seeks a lock on EO/IR targeting pods

The US Navy is soliciting options to improve or replace the electro-optical/infrared (EO/IR) targeting pods on its Boeing F/A-18E/F Super Hornets and EA-18G Growlers, amid concern about its current hardware's readiness and sustainment cost. The service currently uses Raytheon's Advanced Targeting Forward Looking Infrared pod.

In a request for information, the service says it is looking at systems currently fielded on US tactical strike or fighter aircraft. Potential bidders must have capacity to deliver 250 pods between fiscal years 2022 and 2029.

"The government wants to assess the feasibility of a replacement EO/IR targeting pod to support an initial fielding of [calendar year] 2023," the US Naval Air Systems Command says. ■

ORDER DAVID KAMINSKI-MORROW LONDON

Revived Il-114 is hottest prospect for Polar Airlines' fleet replacement plan

Siberian operator Polar Airlines used the MAKS Moscow air show to provisionally sign for three Ilyushin Il-114-300 turboprops, for delivery from 2023.

General director Semen Vinokurov says the carrier is prepared to serve as the launch operator of the twin-turboprop, certification of which is scheduled during the same year.

The airline has proposed taking a 52-seat version, rather than the standard 68-seat layout. This will enable it to employ a larger baggage compartment to address what it describes as "climatic conditions and restrictions" in its operating region.

Vinokurov says delivery of the regional type in the scheduled timeframe is "very important",

adding: "With the introduction of the aircraft we expect the efficiency of flights to improve."

The Il-114-300 will be used to replace foreign-built types, as well as the "obsolete" Antonov An-24 and An-26, says the Yakutsk-based carrier.

Polar Airlines operates Let Aircraft Industries L-410s as well as 15 of the Antonov turboprops.

Regional governing authorities for the Sakha republic are supporting the fleet upgrade.

"Stable inter-regional communication in the extreme climatic conditions of the Arctic, the far north and the regions of the far east is extremely important for the population, as aviation is often the only available year-round mode of transport," says Sakha republic first deputy prime minister Andrei Fedotov. ■

See Show Report P14



United Aircraft

Siberian carrier says it is prepared to serve as type's launch operator



Putin touts defence pact with Turkey
[Show Report P14](#)

MILESTONE

First EgyptAir A220 nears delivery

EgyptAir's first Airbus A220 conducted its maiden flight from the airframer's Montreal Mirabel facility on 23 August, with delivery due "in the coming weeks". The Pratt & Whitney PW1500G-powered twinjet – SU-GEX – performed a sortie of around 2h 30min. The Egyptian flag carrier is taking 12 A220-300s under a 2017 agreement, made before Airbus acquired the then-Bombardier CSeries programme. Each will be configured with 134 seats, and deployed by the carrier's EgyptAir Express regional operation, which currently uses Embraer 170s. Cirium fleets data records 81 A220s in service, with Air Baltic, Air Tanzania, Delta Air Lines, Korean Air and Swiss.



Airbus

RETROFIT GARRETT REIM LOS ANGELES

Boeing to extend A-10 wing upgrades

Airframer awarded long-term contract to provide replacement structures for remainder of USAF's ground-attack fleet

The US Air Force (USAF) has given Boeing an 11-year contract worth up to \$999 million to provide replacement wing sets for the rest of its Fairchild Republic A-10 ground-attack fleet.

Boeing on 21 August confirmed that it "will be responsible for managing the production of a maximum of 112 wing sets and spare kits". The USAF has so far confirmed orders for 27

wing sets, with an option for up to 85 more.

"Work will be performed at multiple subcontractor locations in the US and one in South Korea," the US Department of Defence (DoD) says, with the latter activity to be performed by Korea Aerospace Industries.

The majority of retrofit duties will be performed at Hill AFB in Utah, and the project is expected to conclude by August 2030.

The USAF in early August announced that it had finished installing Boeing-supplied wings on 173 of its A-10s, marking the completion of a \$1.1 billion Enhanced Wing Assembly programme which started in 2011.

The new arrangement covers the remainder of its fleet.

Introduced in 1976 as a close air support asset, and armed with a 30mm GAU-8/A seven-barrel Gatling gun and up to 7,200kg (16,000lb) of mixed ordnance, the A-10 completed its production run in 1984. The USAF's wing replacement programme has been designed to extend the lifespan of the type into the late 2030s, with the new structure supposed to last for 10,000 flight hours before needing depot-level inspection.

"This award is the result of a competitive acquisition and two offers were received," the DoD says, without identifying the unsuccessful candidate. ■



US Air Force

New deal will cover modifications for maximum of 112 strike aircraft

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MAKS 2019



Paol Golovin/AP/Shutterstock

Russia's biennial MAKS event was staged near Moscow from 27 August-1 September, with a debut appearance by the Irkut MC-21 one of its most notable attractions. President Vladimir Putin also welcomed an important ally – his Turkish counterpart Recep Tayyip Erdogan – and offered Ankara products including the Sukhoi Su-57 fighter. Visitors could even beat the traffic, with seats offered on a commercial Ansat helicopter service touted for use around the capital. Report by Garrett Reim

MODEL

Design update shrouds exhaust for Hunter UAV

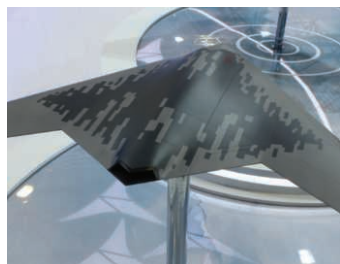
Sukhoi displayed a scale-model of its S-70 Okhotnik "Hunter" unmanned air vehicle (UAV) with a concealed exhaust at the show.

The updated design, which better matches the flying-wing type's shape than the unshrouded nozzle fitted to its initial prototype when it took to the air on 7 August, would reduce the aircraft's radar cross section and infrared signature.

The model looks similar to Western flying wing UAVs with stealth characteristics, such as the BAE Systems Taranis, Dassault Neuron and Northrop Grumman X-47B.

Russia's defence ministry claims the UAV already uses "special materials and coatings that make it practically invisible to radar detection equipment".

Sukhoi has not disclosed its schedule for integrating the updated exhaust configuration. ■



Garrett Reim/FlightGlobal

Radar and infrared signature will be reduced by the enhancement

RESTRICTION

Moscow decries US pressure on potential military exports

Threat of sanctions amount to "unfair competition" in international market, officials claim

The USA's Countering America's Adversaries Through Sanctions Act (CAATSA) is making air forces wary of buying aircraft and other weapons from Russia, according to officials from the nation's Rostec defence holding company and Rosoboronexport arms export agency.

Enacted in retaliation for Russia's invasion and occupation of Ukraine's eastern regions and Crimean Peninsula, CAATSA has already slowed New Delhi's first payments for Almaz-Antey S-400 Triumph air-defence system equipment, as no Indian banks want to facilitate the transaction and be subject to US sanctions.

"There were initial difficulties due to banking restrictions," says Victor Kladov, director of international co-operation and regional policy for Rostec. "But then we talked on a [government-to-government] level and we used different currencies. In the case of India we rely on rupees. The system is adapted to new reality."

New Delhi is expected to imminently pay 20% of the \$5.2 billion cost of its S-400 acquisition, with Russia's Sberbank facilitating the exchange.

While Kladov downplays the need to circumvent US sanctions in the case of India, he acknowl-



Indonesia's concerns may affect its acquisition of more Sukhoi fighters

Commonwealth of Australia

edges that some countries have grown cautious of arms deals with Russia. For instance, Indonesia's interest in buying 11 Sukhoi Su-35s for \$1.14 billion

"[The USA] wants to push Russia away from traditional markets, and create unbearable conditions"

Dmitry Shugaev

Director general military-technical co-operation, Rosoboronexport

appears to have been dampened by worries about US measures. Jakarta already operates Su-27-series fighters.

"I talked to the Indonesian chief of the air force and he mentioned CAATSA," says Kladov.

"I understand they receive threats. They are dependent not just on Russian equipment – they are dependent on a large part on US-made equipment.

"If as a punishment measure American manufacturers stop supplying spares, stop supporting American-made equipment, then there will be a breach in security in national defence in Indonesia. So they are very cautious."

Dmitry Shugaev, director general of the federal service of military-technical co-operation with Rosoboronexport, says the CAATSA sanctions amount to "unfair competition".

"They want to push Russia away from traditional markets, and create unbearable conditions, and not to give us a way into new markets," he says. "The pressure is going up every day [on potential customers]. It is not a secret for anyone." ■



Helicopter service
appears on
schedule
Show Report P16

PRODUCTION

MC-21 debut brings new commitments

Russian carriers place provisional orders as Irkut uses show to emphasise programme's progress towards certification

Irkut's MC-21 narrowbody made a high-profile debut appearance at the show, with the manufacturer having all three of its flying examples present at the event.

Lead aircraft FTV-1 performed a flying display in front of Russian President Vladimir Putin and the show's guest of honour, Turkish President Recep Tayyip Erdogan, on its opening. Its other aircraft were in the static display, with one example fitted with a two-class passenger cabin.

During the show, Russian operator Yakutia signed a tentative agreement to acquire five MC-21-300s, while two other carriers announced preliminary deals. Kazakhstan's Bek Air is looking to take 10 aircraft, while another five will provisionally go to an unidentified customer.

The agreements – with no

details given on engine type or delivery dates – keep Irkut's firm order total for the MC-21 at 175 aircraft, with letters of intent or memoranda of understanding covering 160 more.

State corporation Rostec's financing arm Novikombank has arranged Rb10 billion (\$1.5 billion) in finance to support certification and serial production of the MC-21-300, under an agreement also signed at MAKS.

"Supporting Russia's advanced industry is Novikombank's top priority," says chairman Elena Georgieva. "This [MC-21] programme gives powerful impetus to development of the entire domestic aircraft industry."

Irkut president Ravil Khakimov says the manufacturer's "most important" task is to complete certification of the twinjet and start



Aircraft FTV-1 made flying display on opening day

United Aircraft

initial deliveries to customers. It is pursuing an airworthiness certificate from Russian authorities first, and later plans to submit the aircraft for approval by the European Union Aviation Safety Agency.

The programme's first three aircraft use Pratt and Whitney PW1400G engines. Irkut's next

example, which is currently being assembled, will use Russian-made Aviadvigatel PD-14 turbofans.

Irkut believes it can boost the production capacity of its Irkutsk plant to eventually deliver 72 MC-21s per year. ■

Additional reporting by David Kaminski-Morrow in London

CO-OPERATION

Putin touts defence pact with Turkey

A little over a month after the USA ejected Ankara from the Lockheed Martin F-35 programme over its decision to buy the Almaz-Antey S-400 Triumph air-defence system from Russia, Turkish President Recep Tayyip Erdogan visited the show looking for a new defence partner.

Russian President Vladimir Putin courted the leader of the NATO member country with a strong display of air power, including an aerobatic demonstration by four Sukhoi Su-57 stealth fighters and a debut appearance by Irkut's MC-21 twinjet.

After giving speeches at the event's opening ceremony, the pair toured the site examining various products, with Putin even buying Erdogan an ice cream.

The Turkish delegation included military personnel and business executives, with Moscow offering joint involvement in



Russian leader and Turkish president were shown cockpit of Su-57

aviation projects. "We talked about co-operation on the Su-35 and even on the Su-57," Putin told state-owned news agency TASS.

United Aircraft, the parent company of Sukhoi, unveiled the Su-57E export version of its new fighter at the show, with Erdogan and Putin shown the cockpit of an example in the static display.

While Erdogan did not commit to any joint development projects

with Moscow, or the purchase of Russian aircraft, he says the countries' recent agreement to jointly produce part of the S-400 system has strengthened their co-operation, describing it as "a major step in relations with Russia".

Moscow is hoping to use Washington's reaction to the Turkish S-400 buy as a means of driving the USA away from what it views as weaker allies and partners. ■

MISSILE

BrahMos races toward second air-launch test

BrahMos Aerospace may conduct a second air-launched test of its Mach 2.8 cruise missile as soon as November.

While the Indian/Russian-developed weapon has already met New Delhi's requirements, BrahMos chief general manager of market promotion Praveen Pathak says: "We might do one more test against a sea target."

Two of a planned 40 Indian air force Sukhoi Su-30MKI fighters have already been adapted to carry the 2.5t, 8.5m (28ft)-long, scramjet-powered missile.

Pathak says the company may also demonstrate striking a target from a 90° angle in the future.

"The top-attack mode gives it the maximum capability to destroy a vulnerable aircraft carrier," he says. ■

DEMONSTRATION

Helicopter service appears on schedule

Moscow-based operator performed 40 flights to show site in effort to gain government approval for regular services

As part of a bid to win approval for scheduled flights in and out of Moscow, Russian Helicopter Systems performed 40 such movements from a helipad on the outskirts of the Russian capital to the show site at Zhukovsky International airport during MAKS.

With each seat costing about Rb19,000 (\$288), the roughly 20min flights were available on a light, twin-engined Kazan Ansat. The company claims that its transfers to and from the show were the first scheduled helicopter flights in Moscow in the past 30 years.

Russian Helicopter Systems has 14 Ansats in its fleet: 12 used as emergency medical service transports, one for VIP duties and another for utility applications. It plans to receive three more examples by the end of 2019.

Founded in 2006, the firm also operates five leased Mil Mi-8s and

single examples of the Leonardo AW109, AW139 and Robinson R44. A further six Mi-8s should be received before year-end, bringing its fleet total to 31.

The company has constructed a helicopter pad at the Moscow International Business Center and a floating pad on the Moskva River, and hopes to start operations in months. First, however, the operator needs government approval to fly in the highly-restricted airspace around Moscow, and hopes that the MAKS demonstrations will help it gain support from Russian President Vladimir Putin.

Russian Helicopter Systems sees the whole Moscow Oblast region as able to sustain 10 to 20 helicopters making regular scheduled flights. It says the Ansat can carry up to seven passengers to destinations within a 216nm (400km) radius of the capital.



Nine-passenger Ansat provided 20min transfers to Zhukovsky site

However, scheduled flights could prove difficult during winter months, due to extreme cold and whiteout conditions. The Ansat currently lacks a de-icing system, although the operator says it is working with Kazan's parent company, Russian Helicopters, to add the technology.

The helicopter also is not instrument flight rules certificated, but the operator says it expects to gain this approval "in the near future".

First flown in 1999, the Ansat also serves as a trainer with the Russian air force, which operates 50 examples. ■

DEMAND

Growing market keeps appeal for Western firms

Western suppliers are optimistic of accessing what they see as a growing market for air travel in Russia, despite Moscow's current struggling economy and the difficulties faced by its domestic manufacturing sector.

GE Aviation/Safran joint venture CFM International expects the number of airline passengers

in Russia to grow at a rate of about 5% annually, to reach 160 million during 2024. This is slightly better than a forecast 4.5% annual growth rate worldwide, it notes.

The engine supplier used the show to promote its Leap engine to a number of Russian airlines. The turbofan made its debut in the country in October 2018 aboard a

Boeing 737 Max received by S7 Airlines; this is currently out of operation, due to a global grounding of the narrowbody type.

Other carriers due to receive the Leap-powered aircraft in Russia include Belavia Belarusian Airlines, NordStar, Pobeda Airlines and Utair, CFM says.

Russia and the Commonwealth of Independent States already represent an important market for CFM, with the company reporting a 90% market share in those regions with its earlier CFM56.

Collins Aerospace-owned Ratier-Figeac is also making moves in the Russian market. The company supplies parts for Irkut's MC-21 twinjet, including a cockpit control suite with two active sidestick units, along with cabin equipment for the aircraft's doors. Its parent company also provides primary and sec-

ondary flight control actuation equipment, electric power generation and distribution systems.

"The MC-21 is definitely a great airplane, born from an advanced design," says Ratier-Figeac president Jean-Francois Chanut. "We have received very good feedback from the flight test team and are confident that the aircraft will perform very well in operations."

Ratier-Figeac is also eyeing supplying parts for the Chinese-Russian CRAIC CR929 widebody, and sees synergy in supporting other development projects for the nations, including Beijing's Comac C919 narrowbody.

"Building a family of platforms, re-using the most recent technologies developed successfully on the MC-21 or C919 is a good opportunity to offer a wider fleet to airlines at a reduced development cost and low risk," says Chanut. ■



CFM's Leap engine made its debut in Russia with S7 Airlines 737 Max



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ACQUISITION JON HEMMERDINGER BOSTON

De Havilland focuses on Dash 8 revival

New owners of former Bombardier turboprop programme gear up to launch upgrades and ambitious sales campaign

Recently released by Bombardier, the now De Havilland Aircraft of Canada Dash 8 may have received the adrenaline injection it has needed for a decade.

De Havilland, a unit of Longview Aviation Capital, has only run the twin-turboprop programme for three months, but is already planning product upgrades and a North American sales push.

Such updates are likely to include new cockpit technologies and efficiency improvements, and De Havilland is also considering additional variants including a 50-seater, the Toronto-based company's chief operating officer Todd Young tells FlightGlobal.

"The question coming back is, are you going to do something to replace the existing 50-seat turboprops," says Young. "The Dash 8-400 is capable of being stretched, and of being shrunk. We are looking at all options."

With the Dash 8 as its only product, Young says De Havilland will give it its undivided attention. "We now have a company that's totally focused on the Dash 8. I think that's going to pay dividends," he says. "We are looking at what we can do to bring the Dash 8 product line to the worldwide market and build these airplanes for many years to come."

Addison Schonland, partner at consultancy AirInsight Group, agrees that the Dash 8 is better off at De Havilland than with its previous owner. "Bombardier was the wrong place," he says. "The CSeries sucked all the air out of the room and all the money out of the bank. It took everything."

The narrowbody programme was ultimately taken over by Airbus as the A220, and Bombardier has since shifted its aerospace focus to business aviation.

De Havilland has established its headquarters at the Downsview site in Toronto where Dash 8s are produced. "Our sales team wakes up every morning thinking



Company holds orders with carriers including Ethiopian, and is targeting North American growth

about how they can sell Dash 8s," says Young.

The company already has several Dash 8 improvements in mind. It first plans upgrades to the in-production, 76-seat -400, potentially beginning after the start of the next fiscal year in November. Avionics improvements, fuel efficiency tweaks, LED cabin lights and aircraft health management products are among changes being evaluated, Young says.

"We are going to put a big effort into seeing if we can penetrate the US market"

Todd Young
Chief operating officer,
De Havilland Aircraft of Canada

De Havilland will also study potential demand, particularly in North America, for stretched or shortened variants, he says. North American airlines operate about 870 aircraft in the 50-seat category, the majority being ageing Bombardier CRJs and Embraer ERJs, according to Cirium fleets data.

Few other replacement options currently exist beyond the ATR 42-600 twin-turboprop. As a result, United Airlines is removing seats from 70-seat CRJ700s to create 50-seat CRJ550s.

Other manufacturers have eyed similar opportunities, with ATR dismissing the development

of a 90-seat product, and Embraer also considering a potential turboprop development prior to its planned tie-up with Boeing.

"We spent a lot of time knowing that under Bombardier we would never do a 50-seat programme," says Young.

A \$300 million payment on 1 June from Longview to Bombardier for the Dash 8 programme included type certificates for four variants and product support. Some 1,200 former Bombardier staff – about 98% of those eligible – also transferred to De Havilland.

The new company holds about 50 unfilled Dash 8-400 orders from carriers including Air Tanzania, Biman Bangladesh Airlines, Ethiopian Airlines, SpiceJet and TAAG Angola Airlines, Cirium data shows. The worldwide Dash 8 in-service fleet stands at about 550 aircraft.

The company can continue production at the Downsview site until at least 2023, when a lease expires, but Young hopes to negotiate an extension. "Of course, our first choice would be to stay even longer," he says.

An engineer by education, Young joined the original de Havilland Canada in 1986, and had been Bombardier's vice-president of commercial aircraft programmes and planning, and vice-president of customer support.

"Our first step is to go out and get in touch and connect with all of our customers," Young says.

"They envision an improved focus on the product."

De Havilland's sales team now stands at 80% of its planned strength, headed by vice-president of sales and marketing Philippe Poutissou; another former Bombardier executive.

While ATR has proved a formidable competitor, Bombardier had landed notable Dash 8 sales recently with customers in India, Africa and parts of Asia, and invested in the certification of a high-density, 90-seat variant.

Young sees additional sales prospects with customers in Africa and Asia, and demand for special-mission applications, such as fire-fighting.

PRIME CUSTOMERS

But De Havilland has bigger ambitions: to focus sales efforts on its "fortress markets" in North America, where many of its prime customers operate, says Young.

Airlines like Horizon Air, Jazz Aviation and WestJet Encore operate some 340 Dash 8s combined, according to Cirium. De Havilland sees an opportunity to sell replacements to such carriers, and to otherwise tap North America's regional segment, which has suffered severe cutbacks amid consolidation and pilot shortages.

"We are going to put a big effort into seeing if we can penetrate the US market much better than we had in the past," says Young, while noting: "we do recognise it's not going to be an easy win." ■



Cobham mines opportunity with Q400
Air Transport P20

INVESTIGATION DAVID KAMINSKI-MORROW LONDON

Late pitch-up led to tail strike for Korean Air 737 in Osaka

Narrowbody's fuselage damaged by runway impact as captain attempted go-around

Investigators believe a Korean Air Boeing 737-900 suffered a tail-strike at Osaka's Kansai airport on 9 April last year as it pitched down during a go-around, after bouncing on landing.

The aircraft (HL7725) had conducted its approach to runway 06L in a tailwind and the captain, who was flying, opted to reduce thrust to idle earlier than usual in order to avoid a long touchdown.

But as the aircraft entered the flare at 30ft, with a 2° nose-up attitude, the first officer felt the rate of descent was excessive. He intervened – without making

any call-out – by pulling the control column aft.

The aircraft's pitch increased to 3.5° as it touched down with an impact of 1.87g. Its main landing-gear weight-on-wheels switches activated and the spoilers began to deploy. But the captain, unable to ascertain the extent of the hard landing, expected the aircraft to bounce and opted to execute a go-around.

The aircraft made runway contact a second time with a 1.66g impact, and flight data shows its pitch then increased from about 7° to 10°; above the 8.2° threshold for a tail-strike.

"It is highly probable that the lower aft fuselage of the aircraft was damaged [by] contacting the runway because its pitch angle became too high," says the Japan Transport Safety Board, in its report into the event. It states that the excessive pitch was probably the result of the captain's attempt to avoid the second runway contact by pulling the nose up.

None of the 91 passengers or eight crew members were injured, but the narrowbody sustained cracks and scratch marks to its aft fuselage underside over a length of 2m (6.5ft), and its tail-skid was broken. ■



None of the 91 passengers or eight crew aboard were injured in April 2018 incident involving HL7725

INSPECTION DAVID KAMINSKI-MORROW LONDON

FAA mandates GP7200 checks on superjumbo

Operators of Airbus A380s with Engine Alliance powerplants are being instructed to conduct independent inspections for damage during disassembly of the engine fan hub blade lock.

The inspections are an evolution of the regime implemented after an Air France A380 (F-HPJE) suffered an uncontained GP7200 engine failure over Greenland in September 2017.

This incident resulted in the detachment of the fan hub, leading to an extensive search to find crucial engine components that had been buried by heavy seasonal snowfall – an effort which proved successful earlier this year.

The US Federal Aviation Administration (FAA) states that the powerplant manufacturer has determined a need for inspection of the fan hub assembly for damage before reassembly of the fan hub blade lock.

"The manufacturer has also developed a new design of the assembly that decreases potential for damage," adds the FAA.

Cirium fleets data shows 129 operational A380s are powered by GP7200s, with these used by Air France, Emirates, Etihad Airways, Korean Air and Qatar Airways. ■



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CHARTER CIRIUM PERTH

Cobham mines opportunity with Q400

Operator set to exploit Australian resources sector recovery as first of two De Havilland Canada types enters service

Cobham Aviation Services Australia is eyeing new opportunities in the mid-tier mining sector after inducting the first of two De Havilland Canada Dash 8 Q400 twin-turboprops into its fleet – even as it prepares for a likely sale.

The first aircraft (VH-IYJ) arrived at the company's Perth base in late July, and entered service on 14 August when it operated a charter flight to Jundee.

Chief executive of Cobham Australia Ryan Both is upbeat about how the new turboprop in its fleet will help to solidify its presence in the fly-in, fly-out (FIFO) charter market.

"This is a story about growth. For us, we want the Q400 to be the growth platform, and so the flights that we will be doing with this primarily serves both existing and new customers," says Both.

Cobham Australia's focus has been on serving mid-tier mining companies that have operations in the remote parts of Western Australia. In addition, it has a long-term contract to fly staff to energy giant Chevron's operations on Barrow Island, which is the base for the Gorgon gas project.

But the FIFO industry has been increasingly competitive, with Brisbane-headquartered Alliance Airlines taking a large stake of the market thanks to major contracts with miners such as Rio Tinto and BHP. Qantas and Virgin Australia also have their own charter units that, like Alliance, largely fly Fokker 100 jets.

As with their clients, the operators have had to weather the ups and downs of the mining industry in Western Australia, the fortunes of which have largely been tied to iron ore prices and demand from China. Having been through a lull, activity in the resources sector is beginning to pick up again, which Both expects will drive new business.

"The industry is recovering, we are seeing all the signs of the



Gravel kit-equipped BAe 146s, which can operate from rough airfields, form important part of fleet

industry beginning to accelerate again," he says, pointing to increased exploration in the Goldfields region as a sign that mid-tier miners are once again looking to expand to take advantage of stronger commodity prices.

Both adds that while others chase contracts with the larger mining houses, Cobham is best equipped to serve the second-tier operators, especially with the 76-seat capacity of its newest aircraft.

"The launch of the Q400 is about giving up-and-coming miners a high-reliability service"

Ryan Both
Chief executive, Cobham Australia

"We really pride ourselves in serving the mid-tier of the mining industry, and the launch of the Q400 is about providing that mid-tier mining segment, really the up-and-coming miners, with a high-reliability service," he says.

Both is also adamant that the operating economics of the Q400 will make it compelling against the out-of-production jets that dominate the Australian FIFO market. "It gives us a lot of options, because economics wins at the end of the day," he says.

"This airplane is not just competitive against a Fokker 70 – it is competitive against a Fokker 100."

Cobham will take its second Q400 in September; both aircraft were formerly operated by Air Berlin, and have been leased from GECAS.

Both says that Cobham evaluated a wide range of aircraft before choosing the Q400, including the rival ATR 72, but the latter's relatively modest fuel capacity and lack of an auxiliary power unit to run the aircraft's air conditioning system while on the ground largely ruled it out. These are important considerations as it flies into hot areas where refuelling infrastructure is not always available.

Another factor is the type's ability to operate from rough airstrips – something Cobham Australia has long done with its gravel kit-equipped BAe 146s and Avro RJs.

The Q400 comes into the fleet only a few months after Cobham welcomed a single Embraer 190 back into its operations, having previously flown a single example between 2015 and March 2018 on a contract for Chevron.

Both says that while the two parties benefited from its first experience with the E-Jet, "it wasn't an accessible product for everybody at the time".

"It was an expensive thing to do. You need to fly at a very high utilisation and have a lot of staff to justify that sort of an aeroplane."

Both is non-committal about adding more of the type, and expects that instead more Q400s will join the fleet in the near term, given the customer interest.

"Based on the market reaction, which is already quite strong, we'll start a pipeline of deliveries next year for whatever the customer demand is."

STRATEGIC REVIEW

As it adds new aircraft to its fleet, Cobham Australia is the subject of a strategic review by its UK-based parent company, which is being bought by a US private equity firm. This is likely to see it divested.

"There has been a lot of interest from potential buyers of the business," says Both. "We're very confident in the story we've got to tell. We're the largest aviation group in Australia after Qantas and Virgin, a diversified group with special mission, government, defence and fly-in, fly-out – it's a very interesting story."

FIFO aside, the company also operates four BAe 146 freighters for Qantas, while also flying 20 Boeing 717s under the Qantas-Link brand. Cobham's other operations in Australia include a special missions unit that operates surveillance and search-and-rescue aircraft on behalf of government agencies.

Both says the sale is in its "advanced stages" and an announcement is planned by year-end. ■



Taiwan F-16 approval draws China's ire
Defence P22

TECHNOLOGY DAVID KAMINSKI-MORROW LONDON

Nordic carriers give Heart to electric aircraft development

Swedish battery-powered regional project receives interest from BRA, SAS and Wideroe

Scandinavian operators BRA, SAS and Wideroe have shown tentative interest in an electric regional aircraft project being undertaken by a Swedish start-up.

Gothenburg-based Heart Aerospace is aiming to produce and certify an initial 19-seat aircraft, the ES-19, by 2025. It says the battery-powered aircraft's range of around 216nm (400km) means it could be deployed on a third of Swedish domestic routes.

But Heart has greater ambitions, with preliminary plans to develop a 48-seat regional aircraft based on the same technology.

"We are currently flying a number of routes that are shorter than 400km and that can potentially be replaced by electric aircraft of the appropriate size," says SAS sustainability manager Lars Andersen Resare. "Therefore, this is an interesting project that we obviously support."

Heart Aerospace's prospects have been lifted by its acceptance to an accelerator programme, as the company seeks the necessary funding to develop the proposed aircraft.

The California-based innovation funding specialist Y Combinator,

which oversees the programme, lists Heart Aerospace among publicly-launched companies with which it is associated.

It claims support and grants from the Swedish government, as well as holding letters of intent from the three Scandinavian operators, covering 86 aircraft worth \$1.6 billion.

"Wideroe wants to be an early adopter of the new technology as part of the company's long-term strategy to be emission-free," says the carrier's strategy director Terje Skram.

Heart Aerospace chief Anders Forslund says the collaboration with Y Combinator will enable it to "accelerate the work" of developing electric aircraft in Sweden.

Scandinavian governments, he

states, are providing "strong incentives" to electrify air transport.

"By electrifying the aircraft, we can completely remove the emissions, and thereby create a new type of sustainable travel," he adds.

Heart Aerospace's project has emerged from a government programme known as Elise, a collaboration between various academic and industrial partners.

"We have built up a fantastic consortium in the Elise project, where we gathered the best expertise in Sweden around both aerospace technology and battery technology," says Forslund.

"But in order to build an aircraft, we need large private investments, and therefore I applied to Y Combinator." ■



Start-up aims to produce and certify an initial ES-19 design by 2025

PROGRAMME
TOM ZAITSEV MOSCOW

VASO produces first wingbox for upgraded Il-114

Russian airframer VASO has completed the first wingbox for a prototype Ilyushin Il-114-300 twin-turboprop.

Director of production Nikolai Lysakov says that, under a co-operation agreement with RAC MiG, the structure will be shipped to an assembly facility in Lkhovitsy, near Moscow, during September.

Along with Aviastar, Voronezh-based VASO is a key participant in the revived Il-114 turboprop programme.

"We're responsible for around 40% of the aerostructures going into the Il-114 modernised variant," says Lysakov. "Apart from centre fuselage sections, these include wing panels as well as nacelle and tail-unit components."

The amended project schedule, adopted by United Aircraft – which owns Aviastar, Ilyushin, RAC MiG and VASO – targets mid-2020 for the roll-out of an upgraded Il-114-300 fitted with new Klimov TB7-117C engines instead of the Pratt & Whitney Canada PW127s that equipped the initial -100 version.

The upgraded turboprop should also have domestically-produced auxiliary power units, hushkits and avionics. ■



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CAPABILITY GREG WALDRON SINGAPORE

Taiwan F-16 approval draws China's ire

Beijing condemns Washington's clearance of long-anticipated fighter deal, as US firms brace for retaliatory sanctions

The US government's formal clearance of the potential sale of 66 new Lockheed Martin F-16C/D Block 70 fighters – also known as the F-16V – to Taiwan provides a much-needed boost for the island, but the move has already drawn protests from Beijing.

A US Defense Security Cooperation Agency (DSCA) statement on the pivotal transaction has been expected for some months, with confirmation finally coming in early August from the House Foreign Affairs Committee.

In the DSCA's standard dry language, the approval lists the full scope of the deal: 66 fighters, 75 GE Aviation F110 engines, data links, 75 Northrop Grumman APG-83 active electronically scanned array radars, 75 electronic warfare suites, and other equipment, training, and services related to the purchase.

"The President approved the notice that went up to Capitol Hill so that we could move forward with these F-16 sales," says secretary of state Mike Pompeo.

"These are deeply consistent with the arrangements, the historical relationship between the United States and China, the three communiques that layer on top of that. Our actions are consistent with past US policy. We are simply following through on the commitments we've made to all of the parties."

Beijing may beg to differ. It protests all American arms sales to Taiwan, which it considers a breakaway province. For years, US administrations have balked at selling new fighters to Taiwan, fearful of China's reaction.

A story in the official *China Daily* on 19 August quoted Ma Xiaoguang, a spokesperson for the State Council Taiwan Affairs Office, vehemently protesting against the proposed deal.

"We resolutely oppose, and the US should immediately stop all planned arms deals to Taiwan,



Lockheed Martin

Along with 66 Block 70 aircraft, acquisition includes engines, electronic warfare equipment and training

and stop sending seriously erroneous signals to Taiwan secessionists," he said. "Nobody should underestimate our will and ability to safeguard national sovereignty and territorial integrity."

US arms sales are a "protection fee" and make Taiwan a "pawn" of Washington DC, he says.

STRAINED RELATIONS

While China has routinely protested against arms sales to Taiwan for years, the latest comes against a backdrop of particularly strained US-China relations.

Although the acrimonious trade row between the two has so far largely spared the aerospace industry, Beijing has said it will punish firms involved with arms sales to Taiwan.

Such a threat is largely irrelevant to companies such as Lockheed and Northrop, which actually benefit from the rise of a peer competitor like China.

On the other hand, GE Aviation – and General Electric more broadly – has significant exposure to China. Cirium fleets data shows there are 440 aircraft in service in China that use GE engines. There are also 2,278 Airbus and Boeing narrowbodies powered by engines produced by CFM International – a 50/50 joint venture between GE and Safran.

Aviatic Systems, which sup-

plies avionics and other systems for the Comac C919, is a joint venture between AVIC and GE.

US companies such as Honeywell and Collins Aerospace also have substantial involvement in mainland China, including work on Comac's airliner programmes. United Technologies, the parent company of Collins and Pratt & Whitney, which also have vast interests in China, is on the verge of merging with Raytheon, which supplies weaponry to Taiwan.

Moreover, there are 102 Gulfstream business jets in service in China. While Gulfstream itself has no involvement in the F-16 sale, it is owned by General Dynamics, a division of which produces the M1A1 Abrams tank. In July, the state department cleared the possible sale of 108 M1A1s to Taiwan, another deal that infuriated Beijing.

But in a late-July earnings call, General Dynamics chief executive Phebe Novakovic downplayed concerns of Chinese sanctions against Gulfstream, noting that it was the US government, rather than the company, which was selling the tanks to Taiwan.

Boeing, which produces the AH-64E Apache attack helicopter used by Taiwan's army, will also be watching closely. The Civil Aviation Administration of China (CAAC) was the first regulator to

ground the 737 Max narrowbody after the type's second crash in early March, part of a global cascade of groundings that remain in place.

While it is to be hoped that the 737 Max's global return to service will be based entirely on technical considerations, Beijing could play hardball on lifting its grounding. Chinese carriers have 97 737 Max aircraft in storage, with a further 214 on order.

In addition, the region's other airlines require the flexibility to operate their Max aircraft to Chinese destinations.

AEROSPACE MARKET

Nonetheless, it remains to be seen if Beijing uses its importance as an aerospace market to retaliate against the Taiwan F-16 deal, which still requires Taipei's (all but certain) acceptance.

The one certainty is that Beijing will continue to develop airpower and other military capabilities, with the Taiwan contingency foremost in planners' minds.

While the F-16 sale could have costly implications in the broader aerospace sector and for US-China ties, it must be viewed as an investment in that most valuable of military outcomes: deterrence. ■

Additional reporting by
Garrett Reim in Los Angeles



Plain sailing as Japan approves F-35B acquisition
Defence P24

PROGRAMME CRAIG HOYLE LONDON

Gripen E testing accelerates as Saab flies flag with lead Brazilian example

The first Gripen E fighter produced for Brazil completed a 65min flight debut from Saab's Linköping site in Sweden on 26 August.

Performed by company test pilot Richard Ljungberg, the milestone sortie "included test points to verify basic handling and flying qualities at different altitudes and speeds", the airframer says.

Test aircraft 39-6001 also is the first Gripen to be flown with a new cockpit layout, featuring a wide area display, two small head-down displays and a new head-up display. The asset also has been equipped with updated flight control laws, Saab says.

Already sporting air force markings, a Brazilian flag tail liv-

ery and with the customer number 4100, the aircraft "will now join the test programme for further envelope expansion, as well as testing of tactical system and sensors", Saab says. The company has previously flown three test examples of the Gripen E.



Milestone sortie lasted 65min and verified basic handling qualities

Brazil will receive 28 single-seat Gripen Es and eight two-seat F-model examples, and operate the type under the local designation F-39. It will join the Swedish air force in fielding the type, with Stockholm having ordered 60. ■

CONTRACT GREG WALDRON SINGAPORE

Lisbon suite on Elbit protection for KC-390 fleet

Portugal has selected Elbit Systems to provide the electronic warfare suite for its future fleet of five Embraer KC-390 tactical transports.

Subject to final approval by Lisbon, the deal includes laser and radar warning receivers, infrared missile warning systems, directional infrared countermeasures equipment, dispensers and an active electronic countermeasures system, the Israeli supplier says.

Lisbon on 22 August signed for the Brazilian-built twinjets, which will replace its Lockheed Martin C-130Hs.

KC-390 deliveries to the NATO nation are expected to run at a rate of one aircraft per year from February 2023. ■

INVESTMENT GARRETT REIM PALMDALE

Production of Global Hawk set to soar

Airframer expands manufacturing facility for unmanned RQ-4 and MQ-4C Triton, as export programmes gather pace

Northrop Grumman plans to more than double production capacity for its RQ-4 Global Hawk and MQ-4C Triton unmanned air vehicles (UAVs) to 12 per year, in anticipation of growing demand for the intelligence, surveillance and reconnaissance aircraft.

The manufacturer in late August began using a remodelled building at its Site 7 facilities in Palmdale, California. Located within the grounds of US Air

Force (USAF) Plant 42, this was previously a manufacturing facility for the Northrop F-5 fighter.

The additional building is part of a larger revamp of production facilities for the RQ-4 and MQ-4C at Site 7. Northrop says all of its buildings on the site – more than 32,500sq m (350,000sq ft) – have been modified to improve production capacity and efficiency.

"This is probably one of the largest single investments I've

seen in 20 years," says Doug Shaffer, the company's vice-president and programme manager for the MQ-4C Triton.

Northrop has so far secured six customers for variants of its high-altitude, long-endurance UAV: the USAF and the US Navy (USN), plus NATO and export buyers Australia, Japan and South Korea. It declines to identify other prospective customers in its sales pipeline.

The USAF received the last of its fleet of 45 Global Hawks in March, says Northrop. The USN programme of record is for 70 MQ-4C Tritons, including two test aircraft.

Northrop plans to retrofit some of the navy's already-delivered UAVs with signals intelligence payloads: an enhancement that will allow them to take over electronic eavesdropping missions from its aged Lockheed EP-3Es.

First deliveries for NATO's Alliance Ground Surveillance fleet and South Korea are scheduled before the end of 2019.

Northrop has previously produced between three and five RQ-4s or MQ-4Cs per year, with final assembly work typically taking 12 to 14 months.

Several other large buildings have been built at Site 7 in recent years to support programmes including the USAF's B-21 Raider stealth bomber.

Joint-Global Strike Operations Center commander Major General James Dawkins, who was visiting Palmdale for a B-2 bomber first flight 30th anniversary event on 20 August, said the service is pleased with Northrop's work on the new type, which is due to fly by December 2021.

"Everything I hear is that cost, schedule and performance is right on expectations," he says. ■



US Air Force

Output of high-altitude, long-endurance type will rise to 12 per year

REQUIREMENT MIKE RAJKUMAR BENGALURU

ASRAAM on target for Indian air force

Jaguar's short-range missile could be integrated with additional types following MBDA campaign success in New Delhi

MBDA's ASRAAM appears set for integration on several Indian combat aircraft types, having won a competitive evaluation for the air force's New Generation Close Combat Missile programme.

The European manufacturer was in July 2014 awarded a £250 million (\$428 million) contract to supply its short-range missile for integration with the Indian air force's Sepecat/Hindustan Aeronautics (HAL) Jaguar fleet.

It will also now be a candidate for the service's HAL-built Tejas Mk 1As and Sukhoi Su-30MKIs, along with a combat-capable version of the BAE Systems Hawk 132, the Hawk-i.

MBDA says it is "committed to setting up an ASRAAM live build facility in India", adding:

"we have opened up our supply chains to Indian businesses".

HAL says work to integrate the weapon on two Jaguars will be completed this year. "Firing trials will be taken up by the air force post integration," it adds. "On successful completion of trials and demonstrations, HAL will take up series modification of Jaguar aircraft for integration of ASRAAM, based on the requirement of the air force."

New Delhi operates approximately 110 Jaguars of different variants, and HAL was contracted in 2009 to upgrade 61 of these to a so-called DARIN-III standard.

HAL is in discussions with the air force to integrate ASRAAM on the Tejas Mk 1A, even as it awaits an order for 83 aircraft. MBDA says that performing such work



Su-30MKI and Tejas platforms could also gain European weapon

Ajaz Rahi/AP/Shutterstock

"would be consistent with the Indian air force's aspiration for ASRAAM to be its fleet-wide short-range air-to-air missile".

More than 200 Su-30MKIs have been manufactured under licence in India, and HAL confirms that it is "keen to carry out the modification" with regard to ASRAAM.

MBDA's Brimstone air-to-surface missile is also being considered for the HAL-funded Hawk-i development.

"We believe that arming Hawk is a logical step for India, and that ASRAAM and Brimstone together offer a high-performance weapon suite that could be decisive in a major conflict," MBDA says. ■

ORDER GREG WALDRON SINGAPORE

Plain sailing as Japan approves F-35B acquisition

Tokyo has confirmed that it will obtain 42 Lockheed Martin F-35Bs for use aboard its pair of Izumo-class helicopter

destroyers, which will be modified to accommodate the short take-off and vertical landing (STOVL) strike aircraft.

Japan's defence ministry announced the development on its website on 16 August, noting: "The F-35B satisfied all the requirements for the Air Self-Defence Force's short take-off and vertical landing fighter".

The ship-based F-35Bs will be acquired in addition to around 105 conventional take-off and landing F-35As that the Japan Air Self-Defence Force will operate under current plans. Cirium fleets data shows Tokyo has so far received around a dozen examples.

South Korea is also reportedly looking at a new class of landing

platform helicopter vessel that could accommodate the F-35B. The proposed 30,000t ship could be launched in the late 2020s, local reports suggest.

Seoul is set to receive its next four F-35As, doubling its fleet of the type. A report by official news agency Yonhap indicates the Republic of Korea Air Force will have taken 10 examples by the end of 2019, from an order for 40 to be delivered through 2021.

South Korea's first pair of F-35As arrived in the country in March 2019, followed by another two in July. ■



US Navy

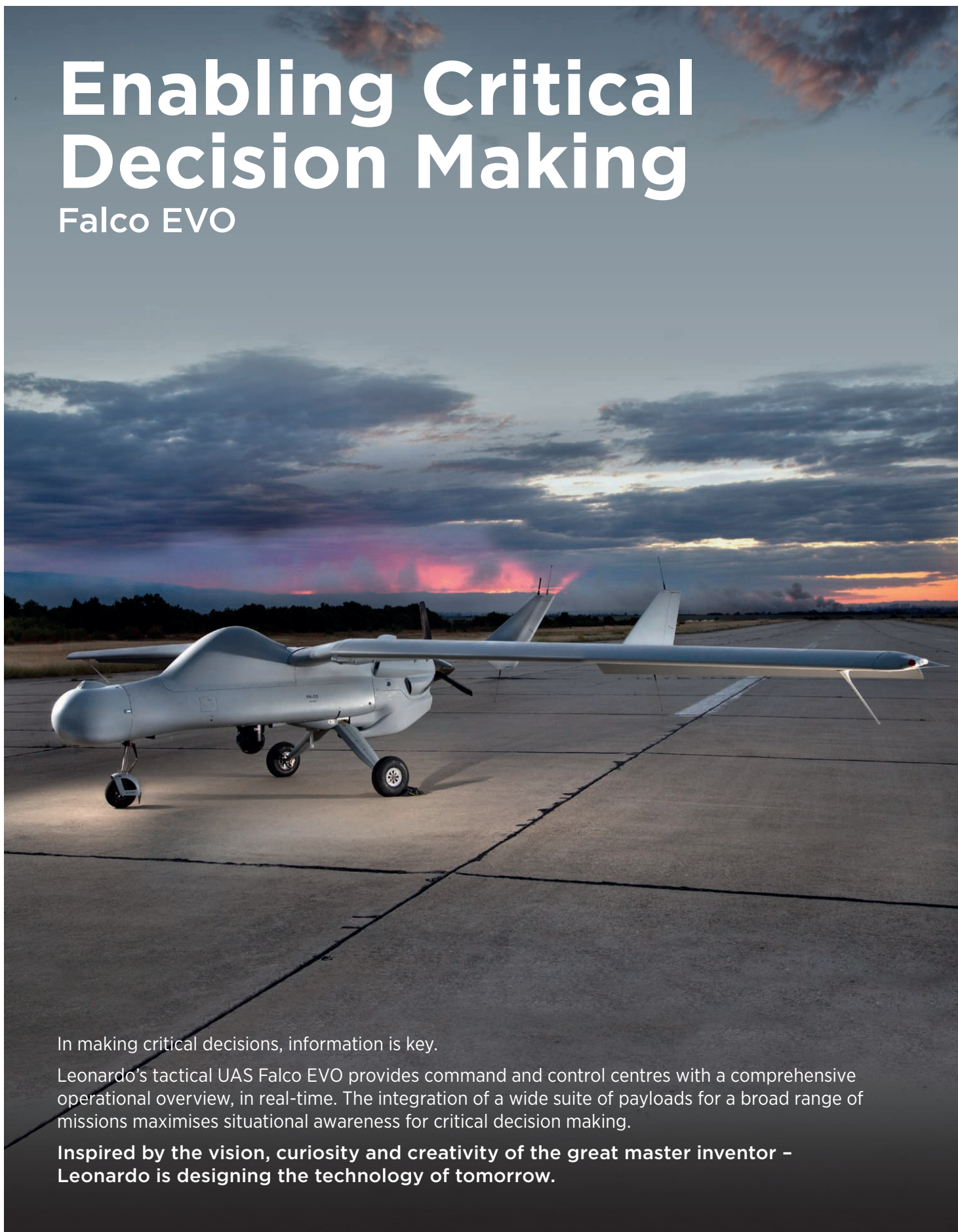
Nation will modify its Izumo-class destroyers to carry STOVL variant

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CONTRACT
KATE SARSFIELD LONDON

Quantum leaps for Bye's eFlyer electric air taxis

Bye Aerospace has secured a purchase agreement from US start-up air taxi operator Quantum Air for 22 four-seat eFlyer 4 electric aircraft, and two examples of its two-seat eFlyer 2. Quantum will also acquire two of its "future advanced aircraft", details of which have not yet been released.

"The future has arrived," says Quantum's vice-president, Scott Akina. "By electrifying aviation, Quantum will ignite urban and regional mobility."

Bye has secured more than 600 commitments to date for the eFlyer pair – the first of a family of European and US CS/Part 23-certified all-electric aircraft targeted at the air taxi, owner-flyer and training segments.

The eFlyer 2 will be first to market. Launched in May 2016, the all-composite type made its maiden sortie two years later, and flight testing continues at Denver, Colorado. Certification and service entry are scheduled for 2021.

Powered by a 120shp (90kW) Siemens SP70D motor, the eFlyer2 can better 135kt (250 km/h) and has a 3h 30min endurance. ■

UNVEILING KATE SARSFIELD LONDON

VoloCopter steps up the pace of eVTOL development effort

VoloCity multicopter ready for production as start-up prepares to unveil ground stations

German urban air mobility (UAM) developer Volocopter has unveiled its first electric vertical take-off and landing (eVTOL) aircraft to be put into series production.

The two-seat air taxi, dubbed VoloCity, is the fourth generation of the all-electric multicopter, and is scheduled to make its first flight within 18 months.

Describing the VoloCity as "the most powerful Volocopter yet", the start-up says it is planning to certificate the battery-powered aircraft under the European Union Aviation Safety Agency's new special condition for VTOL (SC-VTOL) airworthiness regulations, which were announced in July.

"It is rigorously designed to meet the demands of urban air mobility," says Volocopter chief executive Florian Reuter.

The VoloCity incorporates changes and improvements identified following more than 1,000 flights with earlier generation prototypes, the company says.



Designed to seat two people, the aircraft will have a range of 19nm

The design retains the multicopter configuration of the current test aircraft, known as the 2X, but the company has refined the aerodynamics of the beams that house the aircraft's 18 rotors. A new stabiliser has also been added to increase lift and stability in flight.

Designed for inter-city transport, the eVTOL is expected to have a range of 19nm (35km), a top speed of 60kt (110 km/h) and

be able to carry two people and hand luggage. A piloted version will be first to market, with an autonomous VoloCity expected to follow later.

The VoloCity will be operated from ground stations – dubbed VoloPorts – which the Bruchsal-based firm is developing in partnership with UK company Skyports. The first example will be unveiled in the fourth quarter in Singapore. ■

ACQUISITION KATE SARSFIELD LONDON

PC-24 order aids Swedish air ambulance initiative



KSA plans to start operating nationwide medevac service from 2021

Pilatus has clinched an order from the Swedish air ambulance organisation, KSA, for six PC-24s to be delivered in 2021. The superlight business jets will be used by the Luleå-headquartered operator to provide aeromedical services across the country.

The acquisition follows "an extremely intensive selection process", says Pilatus. KSA operates across Sweden and is mutually owned and financed by all 21 of its regions.

"The highly professional selection process has confirmed

that the PC-24 is indeed the perfect aircraft for medevac missions," says Pilatus chairman Oscar Schwenk.

KSA is the second air ambulance services provider to buy the PC-24. Australia's Royal Flying Doctor Service placed an order for six of the Williams International FJ44-4A-powered type in 2014, and has taken delivery of three examples so far.

Andreas Eriksson, KSA chief executive, says the deal marks "a major milestone" in establishing a national air ambulance service, with operations to start in 2021. ■



Golden weddings
Special Report P24

ANALYSIS MURDO MORRISON BEDFORD

Airlander lifted by commercial interest

Hybrid Air Vehicles secures first commitments for 'optimised' airship design as it works towards certification campaign

Hybrid Air Vehicles (HAV) has gained its first two letters of intent for its Airlander 10 hybrid airship, as it works to secure a launch order and start a certification campaign.

The commitments, from "commercial" operators, with others "in train", come as the UK business steps up its efforts to market the world's largest aircraft to the high-end leisure market. HAV installed a luxury cabin mock-up at its Bedford premises earlier this year, and has been exhibiting it to potential customers.

The 15m (49ft)-long walk-in demonstrator – built by Design Q – includes a large U-shaped bar, and is intended to illustrate what the full 47m-long interior might look like in VIP configuration. This includes eight double bedrooms, seating areas and features such as panoramic windows and windows in the floor. HAV and Design Q showed a virtual reality version at last year's Farnborough air show.

In an effort to offer what it describes as the first zero-carbon aircraft, HAV is also working with Collins Aerospace Systems on an electrical-powered system that will eventually replace the current four Thielert diesel engines, says new chief executive Tom Grundy.

The former BAE Systems engineer says HAV is ready to open a production line – he will not reveal where – and build three flight-test aircraft as soon as the company secures its first firm customer or customers.

The company plans to begin flight testing "by the early 2020s", with deliveries from 2024. Initial output is likely to be three aircraft per year, but will "ramp-up fairly rapidly" to 12, says Grundy.

He says HAV is "well placed" to secure the institutional funding it needs to build flight-test aircraft and a final assembly facility. Until now, small, enthusiast shareholders – including Iron Maiden frontman Bruce Dickinson – have provided most of the start-up's finances.

Damage sustained in a ground incident in November 2017 – six brief sorties into an earlier test-flight programme, and 15 months after an earlier crash – put paid to the 92m-long Airlander 10 prototype. HAV has spent the 21 months since refining the design of the 10t-payload aircraft, Grundy says.

"We offer an aircraft that can go places where the leisure industry cannot"

Tom Grundy
Chief executive, Hybrid Air Vehicles

One of the changes has involved moving some of the equipment from an aft service bay to above the gondola – which hangs underneath the helium-filled hull – creating more space for passengers, freight or surveillance systems.



Demonstrator illustrates how interior could look in VIP configuration

"We've been taking everything we learned from flying the prototype to come up with the most compelling proposition possible," says Grundy. "We've really been able to look at the design, and we've optimised it for commonality for the different markets we've identified."

As well as the luxury cruise sector, these markets include organisations carrying cargo to remote mines or conducting aerial surveys, and defence. HAV's predecessor company designed the original Airlander for a US Army surveillance contract, but the project was scrapped before the aircraft entered service.

Grundy anticipates defence organisations making up about half of HAV's customers. The company will showcase the Airlander 10 to this market when it exhibits at September's DSEI defence and security expo in London.

However, Grundy says HAV is now also seeing "real momentum" in the leisure market, with the Airlander 10 pitched as a longer-endurance, luxury competitor to the small number of Zeppelin airships offering sightseeing excursions.

"We are able to offer an aircraft that can go places where the leisure industry cannot operate," says Grundy. These range from cruises over the Alps to transport between remote luxury resorts. "There is a growing

interest in new day and overnight experiences that people are prepared to pay for, as well as in sustainable travel, and we can deliver both," he says.

Grundy says that for both the commercial and defence markets, HAV will likely team with specialist partners or prime contractors. "Our business model is to deliver cost effective capability, which can be tailored to individual needs by a third party," he says.

APPROVAL PROCESS

Although he will not reveal details, Grundy says HAV is aware of what regulators' requirements are for flight-test and certification. "We have had a lot of detailed conversations with EASA [the European Union Aviation Safety Agency] and have opened that same conversation with the FAA [US Federal Aviation Administration], and we know what the process will involve," he says.

Six years after a group of visionaries formed HAV to certify a new version of the abandoned US Army Airlander design, putting together a team of engineers and test pilots, as well as a supply chain, Grundy says "we are now in a position where we are really happy" with the aircraft.

"We are finally transitioning from a design and flight test organisation to being a production organisation able to make 12 aircraft a year." ■



Earlier prototype completed six test sorties before ground incident



Robust commercial deliveries helped Boeing break through \$100 billion revenues in 2018, but the Max crisis will have effect in 2019

Golden weddings

With the 12 months since our last survey characterised by a wave of mergers, what has the impact of this consolidation been on our ranking of the global industry's biggest players?

MURDO MORRISON LONDON

Rarely since the turn of the century has there been such a flurry of merger and acquisition activity in the aerospace industry as in the past 18 months, involving companies in and outside our Top 100 ranking. Major aerospace groups have driven much of the consolidation with the coming together of United Technologies and Rockwell Collins, L3 and Harris, Northrop Grumman and Orbital, TransDigm and Esterline, and Parker Hannifin and Lord. Parker also said in July that it is to acquire privately-owned Exotic Metals for \$1.56 billion.

Meanwhile, with interest rates low and aerospace continuing to provide attractive margins, private equity concerns have also been active, leading to a change in ownership of some Top 100 companies, if not in name. Turnaround specialist Melrose Capital, for in-

stance, became the new owner of listed GKN in early 2018 after a hostile takeover in a deal worth almost \$10 billion. Fellow UK firm Cobham is also to exit the London Stock Exchange after a buyout by US private equity group Advent International.

Since the start of the year, there has also been major change in a commercial aircraft sector dominated for the past two decades by the foursome of Airbus and Boeing in 120-plus seats, and Bombardier and Embraer in regional jets. Since divesting the CSeries to Airbus in 2017, Bombardier has been steadily exiting the segment, this year offloading its Q400 turbo-prop programme to fellow Canadian firm Longview Capital, and its CRJ family to Mitsubishi, while also putting its aerostructures division on the market. At the same time, Boeing is taking a majority stake in Embraer's civil aircraft business, which is due to be spun off into a standalone entity by the end of the year.

While some of these deals have caused movement in the middle and lower reaches of this year's Top 100, the completion of some of the more significant transactions came too late in the 2018-19 financial year to create major shifts at the upper end. The eight largest aerospace businesses by revenue in the 2018/19 financial year remain the same as they were the previous survey, with some jostling for position among the next four. Such is the gap between third placed Lockheed Martin and United Technologies in fourth that the latter's takeover of 15th-placed Rockwell Collins – signed off in late 2018 – should not lead to a change in next year's top order.

However, an even bigger proposed merger – that of Raytheon and the enlarged United Technologies, news of which emerged just before the Paris air show in June – could see the combined business overtake Lockheed with potential combined revenues of well over \$60

billion. (For the purposes of this listing, we do not include the revenues of clear non-aerospace or defence divisions – in United Technologies' case, this includes its soon-to-be spun off Otis and Carrier buildings equipment arms.) In July, United Technologies chief executive Greg Hayes said the Raytheon deal would give the new company "the scale to compete anywhere" in aerospace.

COMBINED MUSCLE

The other mega-merger of the past 12 months, L3 and Harris, completed in June and created a business spanning defence equipment to pilot training services. However, their combined muscle may not be enough to push L3Harris into the top 10 next time. This year, L3 is 13th, with revenues of just over \$10 billion, while Harris, at 35, notched up \$3.3 billion in 2018. Italian aerospace and defence concern Leonardo, in 10th, recorded revenues of \$14.4 billion. Meanwhile, sixth-placed Northrop Grumman's 2018 purchase of Orbital, which boosted revenues from half way through the financial year, helped it close the gap with GE Aviation to half a billion dollars.

The move out of commercial for Bombardier and Embraer will also affect their future standing. The Canadian company is 19th this year, with \$7.3 billion revenues from its combined corporate aircraft, commercial aircraft and aerostructures units (we exclude rail). However, the loss of commercial aircraft and the possible divestment of its Belfast-based aerostructures unit will result in a smaller business next time. Likewise, the creation of Boeing Brazil – the new name for the divested entity responsible for the E-Jet family – will see Embraer, in 28th with revenues of \$5 billion, roughly halve in size, although we will probably not see the effect of this until the next but one Top 100.

As has been the case since we started compiling the Top 100 in the 1990s, Boeing remains number one, and in this year's analysis – by consultancy Counterpoint Market Intelligence – the Chicago-headquartered group's revenues have topped \$100 billion for the first time. This growth of 7.6% is largely down to



Bombardier's business has continued to shrink after it divested the CSeries programme

8.2%

Top 100 revenue growth

healthy commercial aircraft deliveries, with airlines' appetite for its models showing few signs of slacking off in 2018. Boeing's profit also grew by almost 16% to \$12 billion (more than the revenues of 13th placed L3). However, it remains to be seen what impact the grounding of the 737 Max will have on the 2019 figures. Boeing shareholders are bracing for the worst.

ROBUST DEMAND

Airbus's sales in 2018 were almost exactly three-quarters that of its US rival, at just over \$75 billion. Again, ongoing problems in its defence and space business – particularly with the A400M airlifter – and sluggish sales in the offshore helicopter market meant the Toulouse-based company was reliant on strong commercial sales. Despite the cancellation of its A380 programme in January, com-

20.6%

Top 100 profit growth

mercial aircraft demand continued to be robust in 2018 – in particular for the A320neo family. The airliner segment made up three-quarters of revenues and well over four-fifths of profits, which leapt by almost 90% in the last financial year.

Every other business in the top 10 recorded revenue increases in 2018, with most achieving double-digit margins. Lockheed Martin notched a 13.6% margin on its \$53.8 billion sales, and United Technologies just under 10% on its \$36 billion. GE Aviation's margin stood at over 21% on \$30.6 billion revenue, and next-placed Northrop Grumman made a 12.6% return on its revenues of £30.1 billion. While Rolls-Royce's margin of 2.9% – on revenues of \$15 billion – was the lowest in the top 10, its \$443 million profits represented an almost 89% rebound on the previous year. Leonardo had the second-lowest margin in the top 10 at 4.1% and saw its profitability fall.

Two companies have disappeared from the survey this year as a result of consolidation. We have mentioned Orbital and Northrop Grumman already. Safran's takeover of fellow French company Zodiac towards the end of 2018 – which added cabin interiors to a portfolio that includes engines, landing gear, nacelles and defence electronics – helped lift its 2018 revenues from \$17.9 billion to \$25.2 billion. However, other mergers announced in 2018, including L3 with Harris, TransDigm with Esterline, and Spirit AeroSystems with Belgium's Asco did not conclude in time to affect the 2018 ranking, and all six firms are



QinetiQ, the diversified UK defence services organisation, is ranked at 95



» listed separately. Spirit's Asco purchase still had not concluded at time of writing.

There are a number of arrivals and departures in the lower reaches of the Top 100. This is either because of financial performance, or we have decided that certain businesses are sufficiently aerospace-focused to be considered. This year we have put Rostec at number 18. The state corporation's assets include Russian Helicopters, which last year we included separately at 32, along with United Engine. Also making its Top 100 debut – at 51 – is Sierra Nevada, a private company whose interests span cybersecurity and spaceflight.

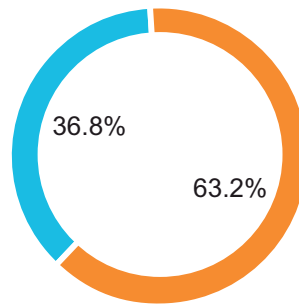
67

Number of Top 100 companies posting revenues in excess of \$1 billion

While we exclude from the Top 100 businesses that make the majority of their revenues from maintenance, repair and overhaul or other services, we have judged that engine parts specialist Chromalloy is a manufacturer, and listed the US company at 73. Likewise, Qinetiq, the UK research and development house, which has diversified its business since being spun out of the Ministry of Defence in the early 2000s, comes in at 95. Martin-Baker, famous for its ejection seats, returns to the Top 100 at number 100, with revenues of just over \$300 million, but Marshall and Chemring, two other UK companies, now fall outside the survey.

The point in the survey at which companies break through the \$1 billion turnover

Top 20 share of top 100 sales



Source: FlightGlobal

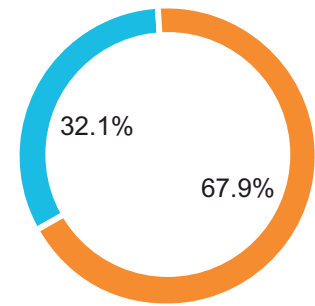
Top 20	The rest

mark is getting lower. Last time, 64th placed Belgian chemicals and speciality materials provider Cytec Solvay was the lowest-placed member of the billion-dollar club. This time, UK engineering firm Senior, ranked 67, squeezes into ten figures with revenues of \$1,010 million. While that might be a mere hundredth of Boeing's sales, it does mean that more than two-thirds of the companies in the Top 100 are now billion-dollar-turnover businesses.

WANING INFLUENCE

One interesting aspect of this year's survey is that, while there is only one change among the 20 biggest companies – Rostec replacing fellow Russian group United Aircraft – their influence has waned slightly. Last time, the top 20 accounted for around 76% of overall Top 100 revenues and 82% of profits. This year those ratios are around 63% and 68% respectively. It is difficult to determine a single reason for this, but consolidation activity in the supply chain may have been a factor. Isra-

Top 20 share of top 100 profits



Source: FlightGlobal

Top 20	The rest

el's Elbit Systems was among many companies boosting its turnover in 2018 with an acquisition outside the Top 100 – in its case Tucson-based avionics provider Universal.

Overall, the Top 100 companies have become substantially bigger – and more profitable. With the world's GDP rising by 3.6% during 2018, average revenue growth for the biggest 100 aerospace businesses was 8.2%, compared with just 3% the previous year. The average operating profit increase was 20.6% against 14.1% in 2017, while operating margins increased from 10.6% in the last survey to 11.3% this time. Barriers to entry in aerospace remain high, and there are consolidation pressures as OEMs increasingly look to deal with fewer suppliers, but the Top 100 suggests that the top end of aerospace compares favourably with many other industries when it comes to making a return for shareholders.

Michael Richter, managing director of aerospace and defence at investment banking group Lazard, which has been an advisor on a number of aerospace mergers and acquisitions in the past 12 months, says an availability of finance, and OEMs anxious to deal with a less-fragmented supply chain, have helped drive consolidation. He says the priority for airframers has been to ensure "fewer potential points of failure" among vendors as they ramp up. "If they have to choose between the two evils of stronger suppliers with more pricing power and a vulnerable supply chain, they would rather have the former," he says.

He admits that the grounding of the 737 Max remains a risk for Boeing and its suppliers. However, he points to the fact that merger and acquisition activity has continued among key suppliers to the programme in recent months. "It is testament to the strength of the market that it is looking beyond short to medium term issues" to the longer-term potential of aerospace businesses, he says. "If we can get past the headwinds [of the 737 Max], I can't see anything in terms of the evolving trend that is going to change." ■



Airbus's revenues in 2018 were almost exactly three-quarters of rival airframer Boeing



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Top 100 aerospace companies by revenue 2018 (\$ millions)

Rank	Company name	Movement in ranking from 2017	Sales (revenue) 2018	Sales (revenue) 2017	Operating profit 2018	Operating profit 2017	Operating margin 2018	Operating margin 2017
1	Boeing	0	\$101,000	\$94,000	\$12,000	\$10,300	11.9%	11.0%
2	Airbus	0	\$75,100	\$63,900	\$5,950	\$2,890	7.9%	4.5%
3	Lockheed Martin	0	\$53,800	\$50,000	\$7,330	\$6,740	13.6%	13.5%
4	United Technologies	0	\$36,030	\$30,900	\$3,570	\$3,490	9.9%	11.3%
5	General Electric (GE Aviation)	0	\$30,600	\$27,000	\$6,470	\$5,370	21.2%	19.9%
6	Northrop Grumman	0	\$30,100	\$26,000	\$3,780	\$3,220	12.6%	12.4%
7	Raytheon	0	\$27,100	\$25,300	\$4,540	\$4,230	16.8%	16.7%
8	Safran	0	\$25,200	\$17,600	\$3,430	\$2,280	13.6%	12.9%
9	Rolls-Royce	1	\$15,000	\$13,000	\$443	\$218	2.9%	1.7%
10	Leonardo	1	\$14,400	\$12,700	\$588	\$637	4.1%	5.0%
11	Honeywell	1	\$12,900	\$11,600	n/a	n/a	n/a	n/a
12	BAE Systems	-3	\$12,800	\$13,400	n/a	n/a	n/a	n/a
13	L-3 Technologies	1	\$10,200	\$9,570	\$1,110	\$1,030	10.8%	10.8%
14	Textron	-1	\$9,620	\$9,840	\$1,030	\$857	10.7%	8.7%
15	Rockwell Collins	5	\$8,670	\$6,820	\$1,110	\$931	12.8%	13.6%
16	General Dynamics (Aerospace)	-1	\$8,460	\$8,130	\$1,490	\$1,580	17.6%	19.4%
17	Precision Castparts	0	\$7,770	\$7,160	n/a	n/a	n/a	n/a
18	Rostec State Corporation		\$7,390	\$7,660	\$818	\$847	11.1%	11.1%
19	Bombardier	-3	\$7,320	\$7,650	\$227	-\$144	3.1%	-1.9%
20	Spirit AeroSystems	-2	\$7,220	\$6,980	\$843	\$532	11.7%	7.6%
21	United Aircraft	-2	\$7,190	\$7,440	\$344	\$356	4.8%	4.8%
22	Thales	-1	\$6,820	\$6,220	\$683	\$614	10.0%	9.9%
23	Mitsubishi	-1	\$6,140	\$6,160	-\$339	-\$544	-5.5%	-8.8%
24	Dassault Aviation	3	\$5,990	\$5,280	\$789	\$387	13.2%	7.3%
25	Arconic	1	\$5,890	\$5,440	n/a	n/a	n/a	n/a
26	AVIC	4	\$5,420	\$4,770	\$91.7	\$259	1.7%	5.4%
27	MTU Aero Engines	-2	\$5,390	\$4,220	\$731	\$565	13.6%	13.4%
28	Embraer	-5	\$5,070	\$5,860	\$35.3	\$342	0.7%	5.8%
29	GKN Aerospace	0	\$4,710	\$4,500	\$387	\$219	8.2%	4.9%
30	IHI	1	\$4,460	\$3,980	\$420	\$515	9.4%	13.0%
31	Kawasaki	7	\$4,290	\$4,470	\$294	\$290	6.9%	6.5%
32	TransDigm	2	\$3,810	\$3,500	\$1,660	\$1,480	43.4%	42.2%
33	Israel Aerospace Industries	0	\$3,680	\$3,520	\$12.0	\$121.0	0.3%	3.4%
34	Triumph Group	2	\$3,370	\$3,200	-\$275	-\$466	-8.2%	-14.6%
35	Harris	0	\$3,330	\$3,200	n/a	n/a	n/a	n/a
36	Hindustan Aeronautics	1	\$2,960	\$2,860	\$530	\$478	17.9%	16.7%
37	Korea Aerospace Industries	10	\$2,530	\$1,760	\$133	-\$177	5.3%	-10.1%
38	Meggitt	3	\$2,470	\$2,170	n/a	n/a	n/a	n/a
39	CAE	4	\$2,450	\$2,000	\$367	\$336	15.0%	16.8%
40	Saab	2	\$2,410	\$2,210	\$230	\$203	9.5%	9.2%
41	Panasonic Avionics	-2	\$2,360	\$2,330	n/a	n/a	n/a	n/a
42	Parker Hannifin	-2	\$2,320	\$2,290	\$398	\$337	17.2%	14.7%
43	ATI (Allegheny Technologies)	8	\$1,970	\$1,720	n/a	n/a	n/a	n/a
44	ST Engineering	2	\$1,960	\$1,760	\$181	\$170	9.2%	9.7%
45	Hexcel	3	\$1,910	\$1,760	n/a	n/a	n/a	n/a
46	Eaton	3	\$1,900	\$1,740	\$398	\$332	21.0%	19.0%
47	Aerojet Rocketdyne	-3	\$1,890	\$1,870	\$264	\$178	14.0%	9.5%
48	Moog	2	\$1,780	\$1,650	\$196	\$163	11.0%	9.9%
49	Diehl Aviation	3	\$1,740	\$1,480	n/a	n/a	n/a	n/a
50	Cobham	-5	\$1,690	\$1,860	\$190	\$182	11.3%	9.8%



Top 100 aerospace companies by revenue 2018 (\$ millions)

Rank	Company name	Movement in ranking from 2017	Sales (revenue) 2017	Sales (revenue) 2016	Operating profit 2017	Operating profit 2016	Operating margin 2017	Operating margin 2016
51	Sierra Nevada Corporation		\$1,690	\$1,600	n/a	n/a	n/a	n/a
52	Turkish Aerospace Industries	2	\$1,670	\$1,420	n/a	n/a	n/a	n/a
53	Liebherr	0	\$1,630	\$1,480	n/a	n/a	n/a	n/a
54	Heico	2	\$1,560	\$1,330	n/a	n/a	n/a	n/a
55	Woodward	2	\$1,560	\$1,340	\$301	\$258	19.4%	19.2%
56	Esterline	-1	\$1,530	\$1,400	n/a	n/a	n/a	n/a
57	Elbit Systems	2	\$1,470	\$1,270	n/a	n/a	n/a	n/a
58	Ball Aerospace	7	\$1,200	\$991	\$113	\$98	9.4%	9.9%
59	Subaru	1	\$1,190	\$1,230	\$54.8	\$105	4.6%	8.6%
60	RUAG	2	\$1,160	\$1,100	\$59.2	\$79.1	5.1%	7.2%
61	Amphenol	5	\$1,150	\$982	n/a	n/a	n/a	n/a
62	Daher	-1	\$1,130	\$953	n/a	n/a	n/a	n/a
63	Maxar Technologies Space Systems	-5	\$1,130	\$1,270	\$5	\$151	0.4%	11.9%
64	Pilatus	3	\$1,120	\$963	\$160	\$132	14.4%	13.7%
65	LISI	-2	\$1,100	\$1,080	\$114	\$139	10.4%	12.8%
66	Solvay Group	-2	\$1,030	\$947	n/a	n/a	n/a	n/a
67	Senior	2	\$1,010	\$898	\$107	\$94.8	10.6%	10.6%
68	Teledyne Technologies	0	\$994	\$932	\$168	\$148	16.9%	15.9%
69	AIDC	1	\$935	\$869	\$77.8	\$87.4	8.3%	10.1%
70	FACC	2	\$922	\$810	\$51.4	\$65.1	5.6%	8.0%
71	Constellium	0	\$911	\$823	n/a	n/a	n/a	n/a
72	Sonaca	1	\$890	\$619	n/a	\$38.6	n/a	6.2%
73	Chromalloy		\$850	\$850	n/a	n/a	n/a	n/a
74	Curtiss-Wright	0	\$800	\$787	n/a	n/a	n/a	n/a
75	Latecoere	4	\$777	\$712	\$5.8	\$45.4	0.7%	6.4%
76	JAMCO	7	\$761	\$667	\$39.1	\$38.3	5.1%	5.7%
77	Kongsberg	-1	\$751	\$735	\$76.4	\$47.4	10.2%	6.5%
78	Magellan Aerospace	0	\$745	\$708	\$91.2	\$97.7	12.2%	13.8%
79	Crane Aerospace and Electronics	1	\$744	\$691	\$164.0	\$160	22.0%	23.2%
80	Kaman Aerospace	-3	\$736	\$725	\$94.4	\$118	12.8%	16.2%
81	Astronics Corporation	3	\$719	\$593	n/a	n/a	n/a	n/a
82	Aernnova	-7	\$705	\$654	n/a	n/a	n/a	n/a
83	Recaro Aircraft Seating	5	\$700	\$527	n/a	n/a	n/a	n/a
84	Kaiser Aluminum	1	\$665	\$588	n/a	n/a	n/a	n/a
85	Hutchinson	1	\$637	\$569	n/a	n/a	n/a	n/a
86	Garmin	4	\$604	\$501	\$205	\$154	33.9%	30.7%
87	Korean Air Aerospace Division	-6	\$582	\$651	\$12.9	-\$29	2.2%	-4.5%
88	Ducommun	1	\$579	\$502	n/a	n/a	n/a	n/a
89	Nordam group	-7	\$575	\$625	n/a	n/a	n/a	n/a
90	SKF	2	\$557	\$483	n/a	n/a	n/a	n/a
91	Figeac Aero	3	\$505	\$401	\$35.8	\$25.3	7.1%	6.3%
92	Barnes Aerospace	-1	\$501	\$463	\$101	\$83.6	20.2%	18.1%
93	ASCO Industries	0	\$428	\$412	n/a	n/a	n/a	n/a
94	ShinMaywa	2	\$395	\$349	\$5.9	\$11.7	1.5%	3.4%
95	Qinetiq		\$387	\$340	n/a	n/a	n/a	n/a
96	ITT Corporation	-1	\$378	\$358	n/a	n/a	n/a	n/a
97	Heroux-Devtek	3	\$373	\$286	\$28.7	\$17.3	7.7%	6.1%
98	Lord Corporation	0	\$333	\$310	n/a	n/a	n/a	n/a
99	Linde (Praxair)	-2	\$307	\$271	n/a	n/a	n/a	n/a
100	Martin-Baker	1	\$301	\$279	\$75.3	\$59.7	25.0%	21.4%



The South Korean aerospace champion's range of products includes the T-50 trainer

SALES GROWTH

Fast-climbing KAI targets spot among top five OEMs

Top placed Korea Aerospace Industries saw its sales soar by more than 34% in 2018, largely as a result of revenues from key export deals. The South Korean champion's portfolio includes aerostructures work for Airbus, Boeing and other airframers, as well as an extensive MRO offering and a series of its own military programmes. These include the FA-50 and its T-50 trainer sibling, the KT-1 light trainer, and the Surion transport helicopter. With several programmes coming to fruition and a strategy that foresees expansion in unmanned systems and avionics, KAI is nothing but ambitious, targeting a place among the world's top five aircraft manufacturers by 2030 with projected revenues of Won20tn (\$16.4 billion).

ANCHORED

KAI is followed by Sonaca, a business that has expanded rapidly of late mainly as a result of acquisition, "firmly anchoring" it among the industry's top 10 aerostructures suppliers, it says. In mid-2017 it took over similarly sized US player LMI Aerospace, whose \$346 million turnover led to the Belgian company more than doubling in size. This year, growth continued strongly at 32%, helped by the demand for programmes it is a supplier to, although the company admits that "concomitant ramp-ups of major platforms" in the USA

Top 20 by sales growth

Rank by margin	Rank by sales	Company	Sales growth
1	37	KAI	34%
2	72	Sonaca	32%
3	8	Safran	32%
4	15	Rockwell Collins	27%
5	97	Heroux-Devtek	25.2%
6	83	Recaro	22%
7	81	Astronics	21.4%
8	58	Ball	20.7%
9	86	Garmin	20.4%
10	54	Heico	17.9%
11	39	CAE	17.5%
12	26	MTU	17.2%
13	52	Turkish Aerospace	17.1%
14	61	Amphenol	17%
15	4	UTC	16.8%
16	55	Woodward	16%
17	6	Northrop Grumman	15.7%
18	57	Elbit	15.6%
19	91	Figeac Aero	15.5%
20	88	Ducommun	15.2%

caused "operational problems" and "associated pressure on margins" (the state-owned company does not release profit figures).

Third place Safran has had a knockback this year with Textron Aviation axing the Citation Hemisphere, the sole application for its

Silvercrest business aviation engine, and the grounding of the Boeing 737 Max. The narrow-body is powered by the CFM International Leap, which Safran builds in partnership with GE Aviation. However, strong demand for the Leap and CFM56, together with many of Safran's other



7%

Growth in revenue
for bottom 20

9.5%

Growth in revenue for top 20

aerospace products, ranging from nacelles to landing gear, gearboxes to cabin equipment, led to an almost 32% sales growth in 2018.

Other companies that saw 20%-plus sales growth include:

- Rockwell Collins, in its last reporting year as a company in its own right;
- Canadian landing gear manufacturer Heroux-Devtek, which on top of its milestone deal to supply the Boeing 777X, also benefited from the acquisitions of Beaver in the USA and Spain's CESA;
- Recaro Aircraft Seating. The company is enjoying a spike in demand as more narrowbodies enter service;
- Astronics, which supplies a range of cabin products such as lighting and connectivity technology. ■

COMMERCIAL

Boom times for the big two, but regional manufacturers take a hit

Our table for commercial sales presents a mixed picture, with half of the businesses we assessed seeing sales slump in 2018. With almost \$61 billion in commercial sales, Boeing tops the list, edging Airbus in terms of revenues, but the European company trumps its rival for sales growth, at 10.3% compared with 4.7%.

Meanwhile, the three biggest business aviation manufacturers, Gulfstream, Bombardier Business Aircraft and Textron Aviation (including its military aircraft sales – Textron does not split out revenue for its flagship Cessna brand) also enjoyed a sales boost last year.

However, the three main regional aircraft players – Bombardier, Embraer and ATR – saw revenue growth go into reverse, while the other two of the big five business aviation brands, Dassault and Embraer, also experienced tumbling sales.

With the 737 Max crisis still ahead of it, 2018 was a good year for Boeing as well as Airbus, with revenues starting to come in

strongly for their re-engined narrowbody families. Boeing also benefited from a total of 145 787 deliveries in 2018, while Airbus was shipping A350s and A330neos – if not too many A330neos or A380s.

Bombardier's regional aircraft sales declined by almost a quarter as it became clearer that the Canadian manufacturer planned to exit the segment – it has since divested both its QSeries and its CRJ ranges. Embraer's revenues fell by almost 15% as deliveries of its first-generation E-Jets slumped ahead of the introduction of the E2 range. ATR, which has come to dominate the turbo-prop sub-segment, saw its sales fall 6.4%.

With their premium ranges, Gulfstream and Bombardier Business Aircraft are now the third and fourth biggest revenue-earners in the commercial market – their sales for 2018 stood at \$8.5 billion and \$5 billion respectively. Textron and Dassault both sell more in dollar terms than the three main regional aircraft players. ■

Top 10 by commercial revenues

	Company name	Commercial sales \$ millions	Commercial sales growth
1	Boeing	60,700	4.7%
2	Airbus	56,600	10.3%
3	Bombardier (regional)	1,760	-24.2%
4	Embraer (regional)	2,360	-14.9%
5	ATR	1,770	-6.4%
6	Gulfstream	8,460	4%
7	Bombardier (business aviation)	5,000	1.2%
8	Textron (including military)	4,970	6.1%
9	Dassault Falcon	3,060	-13.4%
10	Embraer (business aviation)	1,100	-13.8%



A350 deliveries contributed to a healthy increase in commercial revenues for Airbus



OPERATING MARGIN

TransDigm keeps profiting from acquisitive strategy

As was the case last year and in our 2017 listing, aerospace and defence holding company TransDigm and avionics firm Garmin head our ranking of top 20 operating margins, with returns of 43.4% and 33.9%, respectively.

Cleveland, Ohio-headquartered TransDigm is one of the most acquisitive firms in the business, and by some degree remains the most profitable among those for whom we are able to make a calculation of operating margins. Established in 1993 as TD Holding and incorporated on the New York Stock Exchange in 2006, TransDigm has become a grouping of about 35 subsidiaries, all of them trading under their original brand and overseen with a light touch by a head office that behaves almost like a private equity owner. It supplies products from actuators and controls to pumps, batteries, cockpit displays, seatbelts and cargo loading systems.

Its latest big acquisition, earlier this year, was Esterline (still listed separately for the purposes of our Top 100 ranking), a company that specialises in advanced materials, avionics, and sensors and systems. Additions to its portfolio in 2018 included Extant and Skandia.

Earlier this year, TransDigm stood accused of making excess profits on a number of US Department of Defense contracts, because several of its subsidiaries were sole-source suppliers of a particular component on certain programmes.

Aviation makes up 18% of Garmin's revenues – the company is also a major player in the fitness, outdoor and automotive markets – but 26% of its operating income. The company says that 2018 was "another remarkable year of revenue and operating income growth driven by strong performance" in the aviation and other segments.

Family-owned Martin-Baker, making a return to the Top 100, is in third place, and has previously featured among the most profitable companies. Its ejection seats may have competitors, but the strength of the UK manufacturer's brand and reputation mean they are a specialised product that commands a premium.

Fourth placed Crane Aerospace is another grouping of legacy brands, including Eldec, Lear Romec, Signal Technology, Keltec, and Interpoint, that compete in the sensing, power, fuel and braking systems markets. Part of the industrial group Crane, the aerospace business recorded operating margins of 22% in 2018. ■

Up and away: ejection seat specialist Martin-Baker recorded margins of 25%

Top 20 by operating margin

Rank by margin	Rank by sales	Company	Operating margin
1	32	TransDigm	43.4%
2	86	Garmin	33.9%
3	100	Martin-Baker	25%
4	79	Crane	22%
5	5	GE Aviation	21.2%
6	46	Eaton	21%
7	92	Barnes	20.2%
8	55	Woodward	19.4%
9	36	Hindustan Aeronautics	17.9%
10	16	General Dynamics	17.6%
11	42	Parker	17.2%
12	68	Teledyne	16.9%
13	7	Raytheon	16.8%
14	39	CAE	15%
15	64	Pilatus	14.4%
16	47	Aerojet Rocketdyne	14%
17	3	Lockheed Martin	13.6%
18	8	Safran	13.6%
19	26	MTU	13.6%
20	24	Dassault	13.2%

11.3% 12.8%

Average Top 100 operating margin

Increase in top 10 operating profits to a total of \$48.1 billion



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DEFENCE

Military suppliers make significant advances in 2018

It has been a good year for the world's biggest aerospace defence contractors, with nine of the top 10 recording sales growth for their defence activities and three increasing their revenues by more than 15%. United Technologies saw its defence sales rise by more than a quarter in 2018 – with the completion of the acquisition of Rockwell Collins late in the year making little impact.

Total sales of the 10 largest defence businesses was just under \$187 billion in 2018, up \$15.4 billion on the previous survey.

SPLIT REVENUES

For the purposes of this sub-ranking we have split – as far as is possible – sales from the defence sector from revenues derived from commercial and other markets. Lockheed Martin, a company almost entirely devoted to defence, continues to top the list with defence sales of \$53.8 billion, followed by Northrop Grumman and Raytheon – two other suppliers with essentially defence-only portfolios. Of the two,

Top 10 by defence aerospace sales

	Company name	Defence sales \$ millions	Defence sales growth
1	Lockheed Martin	53,800	7.6%
2	Northrop Grumman	30,100	15.7%
3	Raytheon	27,100	6.7%
4	Boeing	23,200	12.8%
5	Airbus	11,100	4.4%
6	BAE Systems	8,710	-9.3%
7	Leonardo	8,320	4.3%
8	L3	8,250	6.5%
9	UTC	5,000	25.8%
10	Honeywell	4,670	15.1%

Northrop had the strongest bounce in 2018.

Boeing, number one in the main ranking, comes in at three with defence revenues of \$23 billion – just under a quarter of its entire business – followed by commercial aircraft rival Airbus, which is less of a direct competitor in Boeing's key defence markets. Boeing, largely dependent on a resurgent domestic customer base, enjoyed a 12.8% rise in defence revenues, while Airbus's sales had a

4.4% uplift, despite problems with the A400M programme.

The two other European companies in the top 10 – BAE Systems and Leonardo – had less than impressive years. The Italian company did manage a 4.3% uplift in revenues – the second lowest in the top 10 – but its UK counterpart suffered a 9.3% drop in defence sales, alongside an even larger, 11.3% decline, in its overall turnover. ■

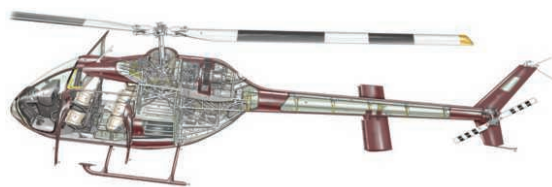


Lockheed Martin, behind the F-35 and a host of other defence products, led the field

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Top 100 by company name

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



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Boeing is taking a majority stake in Embraer's civil aircraft business

Embraer

DATA SOURCE

METHODOLOGY

Companies have been ranked for their financial year 2018 or 2018-19. As far as possible, we have sought to obtain representative figures for aerospace turnover. Companies involved predominantly in aviation services, maintenance, repair and overhaul and finance been excluded.

Sectors involved with aircraft, aero engines, avionics, missiles, space and aerostructures are relatively straightforward, but telecommunications, network-centric and C4I systems and some overhaul operations have been included only where these are largely concerned with aerospace activities. Where a business's divisional structure clearly separates its aerospace activities, we have taken that figure. In other instances, we have excluded elements of the business that are not involved in aerospace, but in some cases, where the company's revenues primarily derive from aerospace manufacturing, we have included the top-line revenue total.

Satellite services have been excluded whenever possible, as have companies and divisions that derive more than half their revenues from services such as

leasing. Joint ventures have been included in the financial data.

Inter-segment sales have been excluded from operating results and profits for divisions where possible. Where that is not possible, divisional results have been presented inclusive of divisional sales, which may result in aerospace revenues greater than group sales.

When looking at all companies, we have revisited our assumptions on what should be included as aerospace sales, and in some cases we have changed our assumptions. Where we have done this, we have used the same assumptions for 2017 and 2018.

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

Five companies in this year's survey do not produce any estimates for aerospace sales, which are in the public domain. We have included them because they are sizeable and

important companies, and we have used our industry knowledge and best estimates to arrive at estimated sales figures.

■ Chromalloy is part of Sequa Corporation, which is owned by Carlyle.

■ Hutchinson is a subsidiary of French oil company Total. In the aerospace sector, it is a significant supplier of equipment across airframes, engines and cabin systems.

■ Nordam, a private US company, is a major supplier of nacelles, transparencies and business jet interiors.

■ Precision Castparts, a US company that is owned by Berkshire Hathaway.

■ Sierra Nevada, a private US corporation that has a range of businesses in space systems, avionics and cybersecurity.

Two Russian companies, United Aircraft and Rostec, had not released their 2018 results at time of going to press so we have assumed the same results in 2017 in the local currency. However, due to currency movement these companies are showing sales increases in dollar terms.

The numbers for AVIC are different from last year's. This year we have used the sum of

the figures for AVIC Aircraft and Jiangxi Hongdu Aviation Industry, rather than AVIC International. We believe that this combination gives a better representation of AVIC's aerospace sales.

OPERATING RESULTS

Generally the profit (or loss) is before interest, tax and exceptional items, and after deduction of depreciation.

Discontinued or discontinuing operations have been included where they fall in fiscal year 2018 for that business.

EXCHANGE RATES

An average exchange rate for the period 1 January to 31 December 2018 as been used for all non-US companies, regardless of fiscal year definitions. The source for the exchange rate information was the US Internal Revenue Service. The percentage annual changes in the financial figures have been given in local currency terms in order to avoid unnecessary distortions. To eliminate exchange rates effects, we have calculated percentage increase in revenues and profits for companies in local currencies.

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Flight at its best: celebrating JMR

Luminaries of the UK aviation industry joined family, friends and former *Flight International* colleagues to celebrate the life of our former editor Mike Ramsden, who died on 28 July, aged 90.

No fewer than 18 *Flight* staff past and present attended the celebration to bid farewell to the popular and hugely respected editor. Appropriately, given Ramsden's lifelong love of all things de Havilland, a DH89 Dragon Rapide buzzed the attendees after the ceremony.

The *Flight* group photo (below) includes JMR's wife Angela (front left) – an honorary staff member, as she was the inspiration behind Straight & Level's "Angela Obvious" character, created by Ramsden in the guise of diary columnist Roger Bacon. Daughter Annabel (front right) also briefly worked for the magazine when her father was editor.

During the celebration we heard about JMR's other love – painting watercolours – and how he would sell his creations from a market stall in St Albans to fund his flying.

Former colleagues recalled JMR as a charming boss, although no one escaped his dreaded "greenies" – the handwritten corrections to their copy. Particularly worrisome was the inscription WIIH – "What in hell is happening?" – which inevitably signalled the need for a re-write.



Flight farewell: family and former colleagues remember editor JMR



Surely, declares Bob Millichap, the RAF's 18 Sqn that so deftly dropped giant sandbags from Boeing Chinooks to save the town of Whaley Bridge from flooding in early August will forever be known as the Dam Boosters

Meanwhile, a JMR stamp of approval was marked simply FAIB – "Flight at its best".

Donations in JMR's memory can be sent to Mark Miller, de Havilland Support Ltd, Duxford Airfield, CB22 4QR.

Heaven can wait

Martin-Baker has paid tribute to its first ejectee, Jo Lancaster, who has passed away at the fine old age of 100 after enjoying 70 extra years of life thanks to the UK company's invention.

Lancaster was a young test pilot when, on 30 May 1949, he binged out of his Armstrong Whitworth AW.52 on a Martin-Baker Mk 1 prototype.

Seventy years on and the Martin-Baker saved-lives counter has reached 7,605.



"Good news: it works"

Lancaster was going strong until the end, visiting the Farnborough air show in 2018 as a guest of Martin-Baker.

Prepone moan

"Somebody is inventing new words out there," worries Doug Brown, referring to an aviation newswire report that states TAP Air Portugal is planning to "prepone" the retirement of its Airbus A340-300s.

It seems not, although it is not a term likely to evade our copy-editing guard dogs.

According to the Merriam-Webster dictionary, just as Indian words such as bungalow, dungaree and shampoo have transferred into English, postpone (meaning "to move to an earlier time", the opposite of postpone) is an English word common among India's English speakers, although "largely unheard outside the subcontinent".

Until now, perhaps.

C'est magnifique!

To say that we congratulate the promoters of the

100 YEARS AGO

recently-opened London-Paris air service on the start they have

made would be too mild.

There are so many things upon which we should have to congratulate the firms concerned, that the task would be beyond us.

Great admiration

General Montgomery gave a special message to the

75 YEARS AGO

airmen. "I doubt if ever in the history of war, air forces have had

such opportunities or have taken such good advantage of them. The brilliant work of the pilots has aroused our greatest admiration."

Set for supersonic

There is an air of relaxed confidence at Concorde's

50 YEARS AGO

flight test headquarters at RAF Fairford, and Brian

Trubshaw, chief test pilot of the Filton and Weybridge divisions of BAC, admits to satisfaction at the way things have gone so far.

Becoming aware

Computers which can be programmed to emulate

25 YEARS AGO

the human thought-process are becoming increasingly

common in ground-based roles, even in aviation.

Suitably programmed, they can rapidly apply human logic to problems which are too numerous for prompt human digestion.

100-YEAR ARCHIVE

Every issue of *Flight* from 1909 onwards can be viewed online at flightglobal.com/archive

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MCAS assertion in question

Peter Gray is mistaken in some of the assertions he makes in his letter "Is safety Boeing's top priority?" (*Flight International*, 30 July-5 August) – but understandably so, considering the volume of misinformation that has been published.

Actually, it is impossible for the Maneuvering Characteristics Augmentation System (MCAS) to overpower the elevator and stick, because the movable horizontal stabiliser under MCAS control has but a very small range of physical movement, and only sufficient control power to trim the airplane throughout its allowable CG [centre of gravity] range.

The elevator and stick have sufficient control power to both trim and to manoeuvre the aircraft through the same CG range.

A trimmer runaway can interfere with the pilot's control and require some stick force to counter it but, as US 737 Max pilots have publicly stated, the instructions from Boeing are clear that the system is to be shut down.

RESOLUTION Scepticism of disabled travellers

At its annual general meeting in June, IATA members signed a resolution to make air travel more accessible to passengers with disabilities.

The resolution, with its admission that the airline industry has a problem with its capacity to transport disabled people – and wheelchair users in particular – is to be welcomed.



Photo: Shutterstock

Accessibility needs to be addressed

Unfortunately, examining the core principles of the document in detail – and their calls for disability rights laws to conform with international treaties – leads one to the conclusion that IATA is most interested in preserving the Montreal Convention's limits on compensation to less than half the cost of a bottom-end manual wheelchair.

And that is a major part of the reason why many disabled people distrust airlines.

David Gillon
Medway, UK

That may well mean that the aircraft cannot be readily trimmed – and this may necessitate some old-fashioned flying with stick forces.

It would appear that the Ethiopian Airlines pilots first obeyed the instructions from Boeing – but then unfortunately became so obsessed with trimming to zero stick force that they subsequently reconnected MCAS, and lost control when their airspeed had built up well in excess of the statutory flight envelope limits.

Perhaps they thought the fault might be a transient one.

Malcolm Bowden
McDonald, Tennessee, USA

Will Muilenburg now step down?

In my opinion, Boeing chief executive Dennis Muilenburg should fall on his sword.

He seems to have blamed uninformed pilots, and avoided answering questions directly about the 737 Max's problems.

I suspect certain strategies – such as the alleged prioritising of cost control on the programme – have come from the top of the company. If so, he should do the decent thing and go.

John Wallinger
Upton Grey,
Hampshire, UK

Firmly coupled

In your article "The future calls" (*Flight International*, 21-27 May) you say: "The GTF's [geared turbofan's] gear decouples the fan and turbine so each rotates at optimal speeds..."

This is not the first time that *Flight International* has made this assertion. Of course the gearbox does not decouple the fan and turbine. They remain firmly coupled – but the speed relationship changes, allowing the turbine to run at a multiple of the fan speed. This allows for better optimisation of the turbine design and a reduction in the number of stages, which offsets the gearbox weight.

The geared fan arrangement was run as a demonstrator based on the Rolls-Royce/Snecma M45H; the variable-pitch fan variant being the M45SD – and, of course, most turboprops are a form of geared fan.

Ralph Devereux
via email

NASA support

I was surprised by Richard Chandless's letter "Exploring space brings benefits" (*Flight International*, 30 July-5 August).

He is totally wrong to suggest that NASA has failed to publicise the benefits to humanity from space exploration.

During the 1970s and 1980s NASA frequently sent out releases related to the benefits from space exploration, and in some years published an annual compendium of these.

Also, in any public meeting at which questions on the benefits were asked, NASA officials were extremely open to explaining what benefits were available, and how they had come about.

John Davis
Wichita, Kansas, USA



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WORK EXPERIENCE STEPHEN ELLIS

A charter for simplicity by design

Stephen Ellis is user experience and interface manager at flight operations software company Schedaero, where he leads a development team dedicated to making the system intuitive in every possible way

What sparked your interest in aviation?

I caught the travel bug early. My father was in the military, so we spent a lot of time travelling and living abroad. I've always loved the experience of going to the airport and the anticipation it builds around exploring new places. Aviation is a shortcut to discovering new countries, people and cultures – I find that an exciting space in which to work, and it means I get to engage with folks from all over the world.

What are the highlights?

The big highlights have been getting out to meet people using our software. The relationships you build working in this space are fantastic. People are excited about this industry, and we're excited to bring them a solution that makes their lives easier.

What is Schedaero?

It is a flight operations software solution that enables companies to quote and schedule trips, track maintenance on their aircraft, stay up to date on crew training, expensing, invoicing and more. Part of the Avinode group of digital charter market platforms, Schedaero is a flexible tool that makes managing day-to-day operations as seamless, efficient and enjoyable as possible, so charter companies can spend more time focused on their clients. It's the most scalable flight scheduling software on the market, making it ideal for larger Part 135 operators. In addition to Schedaero.com, we've developed several application programming interfaces so operators can get their



Testing early prototypes of features is time consuming, says Ellis

data out of Schedaero to integrate with other systems – creating their own custom ecosystem.

How is this type of software evolving?

Like all software, changes happen every day. We're always trying to improve our system performance, so users spend less time waiting on page loads and more time solving the complex problems that arise around charter operations. We're committed to ensuring our products remain intuitive to use, so customers can jump straight into making the most of every feature. This means reading up on the latest cloud storage technology, testing and updating our features, and researching new tools to make the process smarter. Plus, as we develop our use of artificial intelligence, we will be able to

better foresee users' needs before they arise.

What are your responsibilities?

From our developer centre in Portland, Oregon, I oversee the usability of Schedaero, making sure it's easy to use and looks and feels right. In addition to helping shape Schedaero, I oversee the team of researchers and designers working on the digital charter market platform of our sister company, Avinode Marketplace. Across the Avinode group, our priority is engaging with our users and incorporating their feedback into our design and decision-making processes. A lot of my time is spent testing out early sketches or prototypes of features prior to development, in order to build the right solution for our users' needs.

What is your biggest challenge?

Time. There are so many amazing ideas we have kicking around the office, but it takes time to build and design them well. However, it means we get better, more stable solutions as a result, and can be more strategic about the features we develop.

What do you enjoy most about your job?

The best part of my job is the team of people I get to work with and the excitement and innovation they bring to the product development process. It's a rare pleasure to work with people as engaged and invested as the Schedaero team. Besides, our members are an amazing group of people. Aviation is such a close-knit community and it really is a joy to have such a connected and enthusiastic user base.

What do you enjoy the least?

Aviation is 24/7 and a truly global industry. Even within our company we have three offices spread across a 9h time difference. Trying to stay in sync across that wide a span can be challenging at times, although getting a few trips to beautiful Sweden each year certainly helps to offset that! ■

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