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COMMERCIAL ENGINES

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2019

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COMMERCIAL ENGINES 2019

ENGINE EVENTS

May 2018

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July 2018
Airbus secures extended twin-engined operations clearance beyond 3h for the A350-1000. The -1000 is the larger of the two A350 family variants, and is powered by the Rolls-Royce Trent XWB-97 engine

August 2018
Russian developers commence a third stage of flight testing with the Aviadvigatel PD-14 engine on an Ilyushin Il-76 testbed aircraft. The PD-14 is set to be installed on the Irkut MC-21

October 2018
Australian Transport Safety Bureau states that an in-flight engine shutdown involving a Qantas Airbus A380 on 20 May 2017 has been traced back to cracking caused by corrosion resulting from cleaning chemical residues in one of its Rolls-Royce Trent 900 engines

December 2018
GE Aviation does second round of GE9X flight testing on Boeing 747-400 testbed. The GE9X-105B variant of the engine will power the 777-9, which Boeing expects will achieve first flight in 2019 and enter service in 2020

December 2018
The Trent 7000-powered A330neo makes its first commercial flight with TAP Air Portugal

Airbus

January 2019
Rolls-Royce starts installing a redesigned intermediate pressure compressor blade design on certain Trent 1000 engines, following approval from European and US regulators

February 2019
Rolls-Royce starts ground tests of a composite fan system for its UltraFan future engine programme. R-R previously said that it will use a Trent 1000 – an option for the Boeing 787 – as a donor engine for the trial

April 2019
GTF-powered ACJ319neo sets new distance record, with the mission lasting 16h 10min. The re-engined VIP narrowbody (MSN8612) flew from Airbus headquarters in Toulouse to northern Greenland and back on 26 April. The previous record was set in 1999, when an Airbus-crewed ACJ319 made a 15h 15min flight from Santiago to Paris

FUTURE ENTRY INTO SERVICE

AIRCRAFT	ENGINE	YEAR
Embraer E-Jet E195-E2	Pratt & Whitney PW1900G	2019
Irkut MC-21	Pratt & Whitney PW1400G	2020
Mitsubishi MRJ	Pratt & Whitney PW1200G	2020
Boeing 777X	GE Aviation GE9X	2020
Embraer E-Jet E175-E2	Pratt & Whitney PW1700G	2021
Comac C919	CFM International Leap-1C	2020-21
Comac C919	ACAE CJ-1000AX	2022

Powering ahead

Last year saw engine deliveries speed past the 3,000 mark as the backlog topped 27,000 units. CFM International continues to dominate, accounting for 58% of the deliveries in unit terms alongside more than half of the global powerplant backlog. With narrowbody arrivals outpacing those of widebodies, Pratt & Whitney overtook Rolls-Royce, GE and IAE in the 12-month manufacturer delivery rankings, jumping from fifth to second place

A330 engine manufacturer share

	2018 deliveries		Backlog*	
Engine Manufacturer	Aircraft	Share	Aircraft	Share
General Electric	4	9%	7	3%
Rolls-Royce	40	91%	252	91%
Undecided	-	-	19	7%
Total	**44**		**278**	

Notes: *At 31 December 2018. Excludes corporate and military operators. Includes A330neo Source: Cirium's Fleets Analyzer

A380 engine manufacturer share

	2018 deliveries		Backlog*	
Engine Manufacturer	Aircraft	Share	Aircraft	Share
Engine Alliance	1	8%	3	3%
Rolls-Royce	11	92%	46	53%
Undecided	-	-	38	44%
Total	**12**		**87**	

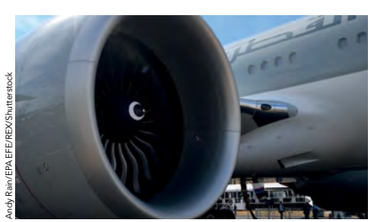
Notes: *At 31 December 2018. Excludes corporate and military operators Source: Cirium's Fleets Analyzer

767 engine manufacturer share

	2018 deliveries		Backlog*	
Engine Manufacturer	Aircraft	Share	Aircraft	Share
General Electric	17		63	100%
Pratt & Whitney	-	-	-	-
Total	**17**		**63**	

Notes: *At 31 December 2018. Excludes corporate and military operators Source: Cirium's Fleets Analyzer

GE



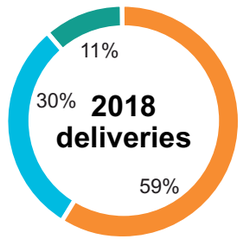
Andy Rain/EPA EFE/REX/Shutterstock

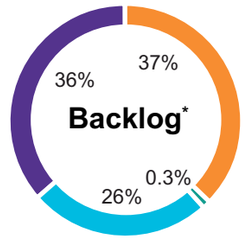
Engine manufacturer rankings 2018

		2018 deliveries		Backlog*	
Rank	Manufacturer	Engines	Share	Engines	Share
1	CFM International	1,860	58%	13,936	52%
2	Pratt & Whitney	436	14%	4,116	15%
3	Rolls-Royce	424	13%	2,302	9%
4	General Electric	332	10%	1,792	7%
5	International Aero Engines	138	4%	32	0.1%
6	Engine Alliance	4	0.1%	12	0.1%
	Undecided	-	-	4,834	18%
Total		**3,194**		**27,024**	

Notes: *At 31 December 2018. Data for installed engines based on Airbus/Boeing types. Excludes corporate and military operators
Source: Cirium's Fleets Analyzer

A320 family engine manufacturer share

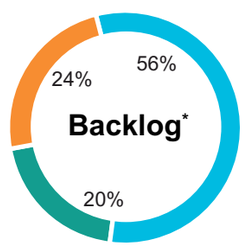




Notes: *At 31 December 2018. Excludes corporate and military operators. Source: Cirium's Fleets Analyzer

CFM International	Pratt & Whitney	International Aero Engines	Undecided	Total deliveries: 625 Total backlog: 6,047

787 engine manufacturer share

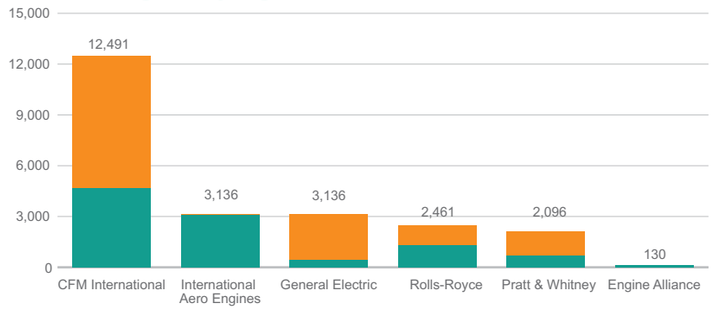


Notes: *At 31 December 2018. Excludes corporate and military operators. Source: Cirium's Fleets Analyzer

Rolls-Royce	General Electric	Undecided	Total deliveries: 144 Total backlog: 620

Rolls-Royce

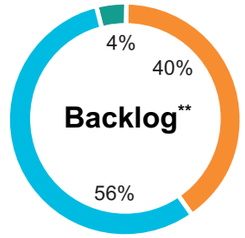
Airbus/Boeing fleet by engine manufacturer



Notes: In-service and parked fleet at 31 December 2018. Boeing data includes former MDC types. Excludes corporate and military operators
Source: Cirium's Fleets Analyzer

Airbus total: 10,276	Boeing total: 13,174	Grand total: 23,450

Regional aircraft engine manufacturer market share



Notes: *Airframe. **At 31 December 2018. Excludes corporate and military operators. ***Including P&W Canada. Data for firm orders for ATR, Bombardier, Comac, Embraer, Mitsubishi, Sukhoi and Viking Air.
Source: Cirium's Fleets Analyzer

General Electric	Pratt & Whitney***	Powerjet	Total deliveries: 238 Total backlog: 1,226

ATR

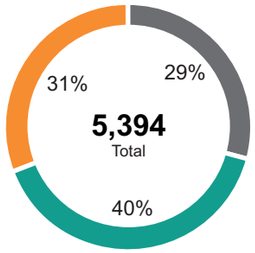
Delta Air Lines

Alastair Philip Wiper/ViewPix/REX/Shutterstock

Data talks

The modern turbofan generates thrust – along with vast quantities of information on its performance and condition. But any one powerplant says nothing about its position in the market – so we consult Cirium's Fleets Analyzer to check on the relative health of the engine producers

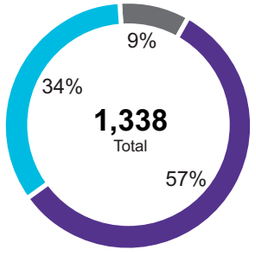
Airbus A320neo family orders by engine manufacturer



Notes: In-service fleet and order backlog at 1 May 2019
Source: Cirium's Fleets Analyzer (May 2019)

CFM International	Pratt & Whitney	Unannounced
2,150	1,689	1,555

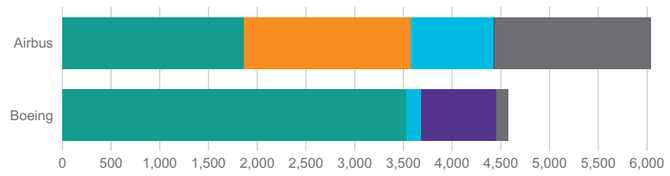
Boeing 787 orders by engine manufacturer



Notes: In-service fleet and order backlog at 1 May 2019
Source: Cirium's Fleets Analyzer (May 2019)

GE Aviation	Rolls-Royce	Unannounced
763	449	126

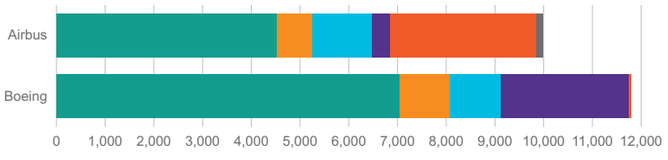
Airbus/Boeing order backlog by engine manufacturer



Source: Cirium's Fleets Analyzer (May 2019)

CFM International	Pratt & Whitney	Rolls-Royce
GE Aviation	International Aero Engines	Unannounced

Airbus/Boeing in-service fleet by engine manufacturer



Notes: In-service fleet at 1 May 2019. Boeing data includes former MDC types. A total of 383 CFM Leap-powered 737 Max aircraft were stored on 1 May 2019 and do not appear here. Source: Cirium's Fleets Analyzer (May 2019)

CFM International	Pratt & Whitney	Rolls-Royce
GE Aviation	International Aero Engines	Engine Alliance

CFM dominates the Boeing backlog, but Max grounding will hit deliveries

Matt Hartman/AP/Shutterstock

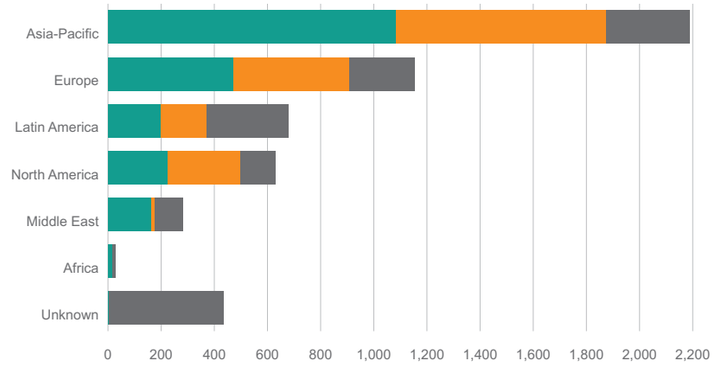
P&W trails in A320neo stakes, but unannounced orders could tip balance

Anthony Pecchi/Airbus

In Europe, 787 customers have chosen Rolls-Royce over GE by nearly two to one

Stanislaw Kowalczuk/Shutterstock

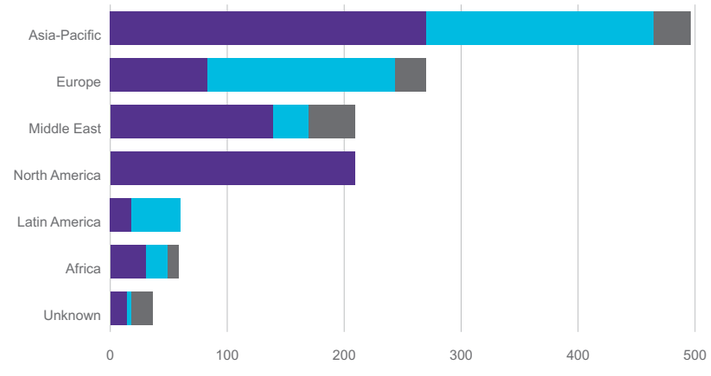
Airbus A320neo family orders by engine manufacturer and region



Notes: In-service fleet and order backlog at 1 May 2019
Source: Cirium's Fleets Analyzer (May 2019)

CFM International	Pratt & Whitney	Unannounced

Boeing 787 orders by engine manufacturer and region



Notes: In-service fleet and order backlog at 1 May 2019
Source: Cirium's Fleets Analyzer (May 2019)

GE Aviation	Rolls-Royce	Unannounced

GEnx genius: US supplier is dominant on the Dreamliner

Air Team Images

AT A GLANCE

Commercial engines: manufacturer market share

NORTH AMERICA		
MANUFACTURER	AIRCRAFT	ENGINES
CFM International	2,687	5,374
GE Aviation	2,438	5,138
Rolls-Royce	824	1,648
Pratt & Whitney	750	1,594
International Aero Engines	762	1,524
Other	8	28
TOTAL	**7,469**	**15,306**

EUROPE		
MANUFACTURER	AIRCRAFT	ENGINES
CFM International	3,337	6,782
GE Aviation	1,155	2,548
Rolls-Royce	624	1,486
International Aero Engines	698	1,396
Pratt & Whitney	265	577
Other	201	521
TOTAL	**6,280**	**13,310**

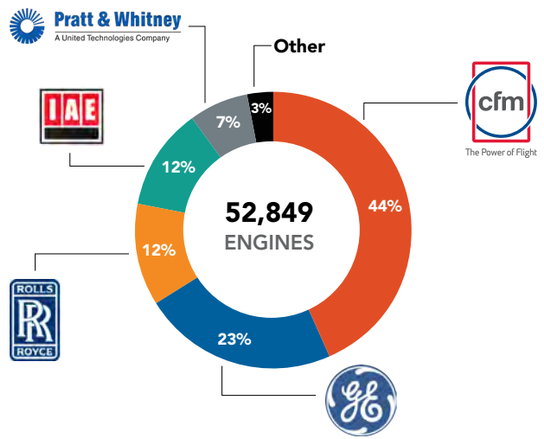
MIDDLE EAST		
MANUFACTURER	AIRCRAFT	ENGINES
GE Aviation	496	1,026
CFM International	373	758
Rolls-Royce	197	446
Engine Alliance	110	440
International Aero Engines	118	236
Other	55	199
TOTAL	**1,372**	**3,114**

SOUTH AMERICA		
MANUFACTURER	AIRCRAFT	ENGINES
CFM International	713	1,438
GE Aviation	295	591
International Aero Engines	244	488
Pratt & Whitney	131	278
Rolls-Royce	98	196
Other	22	74
TOTAL	**1,503**	**3,065**

AFRICA		
MANUFACTURER	AIRCRAFT	ENGINES
CFM International	416	860
Rolls-Royce	158	336
GE Aviation	161	325
Pratt & Whitney	44	107
International Aero Engines	39	78
Other	16	64
TOTAL	**834**	**1,770**

ASIA-PACIFIC		
MANUFACTURER	AIRCRAFT	ENGINES
CFM International	4,028	8,068
GE Aviation	1,103	2,414
International Aero Engines	1,183	2,366
Rolls-Royce	1,014	2,142
Pratt & Whitney	513	1,095
Other	63	232
TOTAL	**7,896**	**16,284**

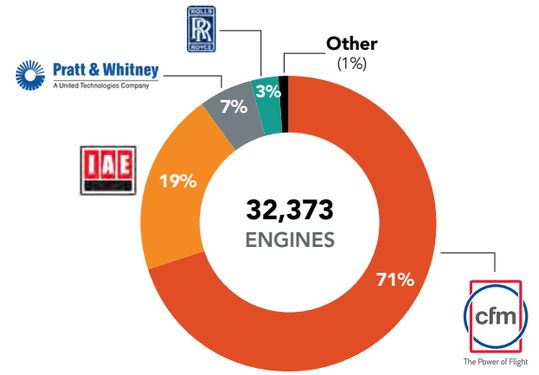
WORLD COMMERCIAL JET AIRCRAFT		
MANUFACTURER	AIRCRAFT	ENGINES
CFM International	11,554	23,280
GE Aviation	5,648	12,042
Rolls-Royce	2,915	6,254
International Aero Engines	3,044	6,088
Pratt & Whitney	1,762	3,789
Other	431	1,396
TOTAL	**25,354**	**52,849**



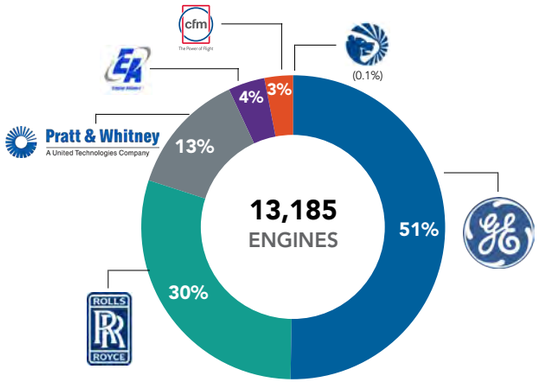
NOTE: Information for in-service commercial jets. Information includes narrowbody, widebody and regional jets in passenger, freighter, combi and quick change roles SOURCE: Cirium's Fleets Analyzer (May 2019)

Engine market share by market group

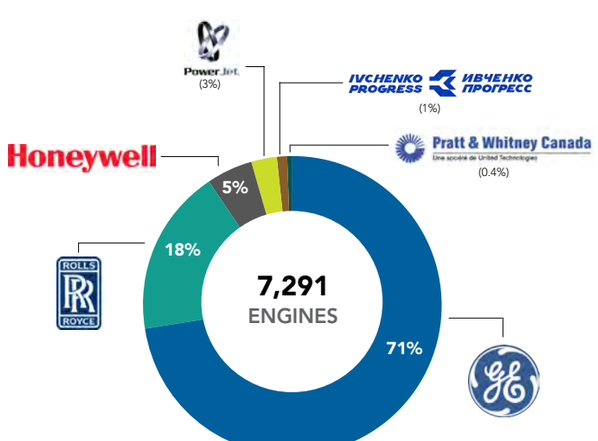
COMMERCIAL NARROWBODY AIRCRAFT		
MANUFACTURER	AIRCRAFT	ENGINES
CFM International	11,470	22,944
International Aero Engines	3,044	6,088
Pratt & Whitney	1,037	2,116
Rolls-Royce	538	1,076
Other	53	149
TOTAL	**16,142**	**32,373**



COMMERCIAL WIDEBODY AIRCRAFT		
MANUFACTURER	AIRCRAFT	ENGINES
GE Aviation	3,002	6,750
Rolls-Royce	1,738	3,900
Pratt & Whitney	720	1,663
Engine Alliance	130	520
CFM International	84	336
Aviadvigatel	4	16
TOTAL	**5,678**	**13,185**



COMMERCIAL REGIONAL JET		
MANUFACTURER	AIRCRAFT	ENGINES
GE Aviation	2,646	5,292
Rolls-Royce	639	1,278
Honeywell	100	400
Powerjet	101	202
Ivchenko-Progress	30	83
Other	18	36
TOTAL	**3,534**	**7,291**



NOTE: Information for active commercial jets. Information includes narrowbody, widebody and regional jets in passenger, freighter, combi and quick change roles SOURCE: Cirium's Fleets Analyzer (May 2019)

Single source or multiple choice?

If Boeing launches its NMA, the airframer may well follow a trend and tie the aircraft to an exclusive powerplant deal – a concept with more appeal for manufacturers than customers

MAX KINGSLEY-JONES LONDON

A key talking point around Boeing's planned New Mid-market Airplane (NMA) – and there are several – is about whether a choice of engines will be offered. And as the trend for sole-sourcing powerplants grows, could the results of Boeing's NMA strategy encourage more consolidation in the engine OEM sector?

The three-horse race to power Boeing's all-new twinjet became two (officially) in February when Rolls-Royce declared defeat around the proposed development timetable. The R-R announcement, confirming a decision taken late last year, leaves CFM International and Pratt & Whitney vying to provide that crucial component of the NMA's design – its super-efficient advanced powerplant.

But will the competition be a fight to secure a sole-source deal, or will Boeing break with recent tradition and go for a choice?

The reality is that offering a choice of engines – regardless of the projected market size for the airframe – has gone rapidly out of fashion. The last all-new airliner to be launched by a western OEM with a choice of power was the Boeing 787 – GE Aviation and R-R in that case. Even derivatives of airframes that previously had a choice of engines – the 747-8 and Airbus A330neo – now have just one option.

Gone are the days of programmes like the 747 Classic/-400, 767 and original A330, where all three engine makers had a slice of the action. It was Boeing that probably started the trend, surprising the industry in 1993 with how it structured the 737NG programme to rival the A320.

Rather than adopting the format Airbus was successfully pursuing with the A320 and offering a powerplant alternative from International Aero Engines, Boeing struck a sole-source deal with CFM. Similarly, it opted against a choice on the 777-200LR/300ER family, choosing GE power exclusively, despite having a three-way fight on the earlier versions.

POTENTIAL RISK

While the OEMs dislike the complexity to engineering development and potential after-sales scenarios that multi-engine options can create, such arrangements have traditionally provided a key negotiating point for airlines by playing one engine OEM off against another. There is also a potential risk with choosing just one powerplant – imagine impact scenarios around the A320neo or 787 engine issues if there were not two engines in the marketplace.

"If NMA is sole source, lessors will like it, but some airlines may object initially," says Rob Morris, global head of consultancy at Ascend by Cirium. "However, I've not heard anyone complain that the 737 Max or A350 do not give them a choice."


Engine options reduce risk for manufacturers if operational issues emerge

Max Kingsley-Jones/FlightGlobal

Richard Aboulafia, vice-president for analysis at Teal Group, says he is not convinced that the 787 will be the last dual-engine source platform and wonders how a possible move by Airbus to counter the 777X with its R-R Trent XWB-powered A350 family could be structured: "If Airbus really does follow through on an A350 re-engining, that platform's sole-source status might change."

Aboulafia says that the appeal to the airframe OEMs of single-source engine solutions is the prospect of up-front "contributions" – and possibly aftermarket ones as well – from the chosen engine partner.

"Engine OEMs like them too, since these concessions to the airframers are made good by a drastic reduction in the discounts necessary with multiple engine options," he says. "But the third party, the customers, really do prefer a choice both because this mitigates risk, and because of the tremendous discounts [that can be negotiated]."

Bert van Leeuwen, managing director of aviation research at DVB Bank, believes that the era of engine choices on twin-aisles has passed. "Development cost and relatively low production volumes probably won't justify splitting a fleet of twin-aisles into different sub-fleets," he says.

"I also expect the engine OEMs would demand exclusivity, to recoup the high development cost and achieve more pricing power."

MARGINAL MARKET

Calling the market size correctly is clearly vital for the engine OEMs when evaluating whether to bid as an alternative supplier on an airframe programme. When airframe sales do not match expectations, it does not make for a pretty picture for engine suppliers that have been fighting tooth and nail for share of a marginal market, Morris says.

"Having an engine choice, and competition, was good for airlines in terms of incredibly low net engine prices. On a low-volume programme like the A380, this has led to both engine OEMs struggling to recover their investments," he says.

This explains why both R-R and Engine Alliance seemed reluctant to spend more money to secure a contract from Emirates to supply engines for a follow-on A380 order. The bulk of these aircraft were cancelled in February, leading to Airbus's decision to terminate the programme. By the time production ends with around 251 aircraft delivered, the engine market will be split slightly in favour of Engine Alliance – 130 versus 121 – although R-R will have the larger share of customers.

"The NMA outcome will depend on how much Boeing pushes for low engine initial price and a share of the aftermarket," says Morris. "It does appear that Boeing will force the competition into just being sole source, due to the low returns and high risk for engine makers."

Van Leeuwen describes the NMA as "a bit of an in-between" design as it bridges the single- and twin-aisle segments. "Here I would expect a single-source situation with GE/CFM International in the lead," he says. "I believe GE/CFM have made exclusivity part of their offering."

Morris believes that "logically" the aero-engine market will consolidate around two major OEM groupings: GE/CFM versus R-R/Pratt & Whitney. "The NMA decision [should it go to CFM] will likely see P&W finally exiting the high-thrust market, just as R-R has exited narrowbodies."

Aboulafia concurs about possible consolidation: "The idea of an engine merger makes enormous sense. There's an airframer duopoly, so why not an engine OEM duopoly?" he says.

"The problem, however, is that GE is too big to merge with anyone. That leaves a Pratt/Rolls tie-up, which is enormously complicated by transatlantic politics, and has been for decades. Hopefully, that will change one day, but not just yet."

JUSTIFIED CHOICE

Van Leeuwen believes that the rules are different in the single-aisle sector, where market volume and production numbers would enable and justify an engine choice.

"For the next-generation single-aisle a lot will depend on technology. I expect a further integration between engine and airframe design, especially if open-rotor propulsion is adopted," he says.

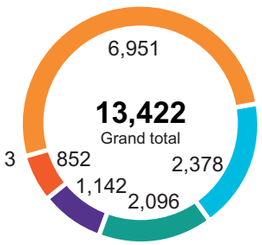
"The most interesting scenario is when there is an 'outsider' in the market, similar to Pratt's situation a few years ago," van Leeuwen says. He believes that like P&W and its geared turbofan, such an outsider could "rock the boat", triggering new technology developments across the board.

"In the single-aisle market Rolls is in this position of an outsider, but with a position in the large engine market and limited financial resources, I doubt it will follow a similar 'all or nothing' strategy with, for example, its proposed UltraFan design," says van Leeuwen. "Clearly GE and Pratt have an interest in stabilising the single-aisle [engine-supply] situation so as to maximise their benefit from the aftermarket parts and services business, where most of the profit comes from."

Of the current crop of Airbus and Boeing programmes, just two types – the A320 and 787 – remain with a choice of engines (excluding A330ceo and civil 767 "sunset" programmes). The firm backlog for all mainline jets, according to Cirium's Fleets Analyzer, stands at some 13,400 orders. Of these, just under 2,400 aircraft (18%) have no engine selection announced (including 22 A330ceos).

So, whatever happens with NMA and the like, there is still a big open market for the engine OEMs to play for. ■

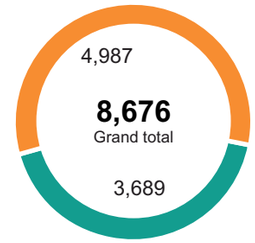
Airbus/Boeing backlog



Source: Cirium's Fleets Analyzer (March 2019)

CFM International 51.8%	Undisclosed 17.7%	P&W/IAE 15.6%
Rolls-Royce 8.5%	GE Aviation 6.3%	Engine Alliance <0.1%

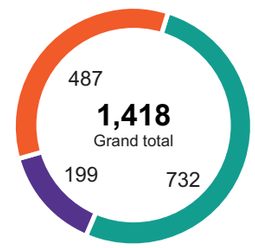
A320 family engine share*



*Total deliveries (aircraft units)
Source: Cirium's Fleets Analyzer (March 2019)

CFM International 57.5%	P&W/IAE 42.5%

747 Classic/-400 engine share*



*Total deliveries (aircraft units). Excludes 747-8 (GE - 131 deliveries)
Source: Cirium's Fleets Analyzer (March 2019)

GE Aviation 34.4%	Pratt & Whitney 51.6%	Rolls-Royce 14.0%

Aviation Images/REX/Shutterstock

Emirates increasingly became the programme's dominant operator

REPORT
LEWIS HARPER
LONDON

Turning point

Fragile operator interest in the A380 means that despite the superjumbo's popularity with passengers, it is already on track to become a rarer sight in the skies this year

The cancellation of the Airbus A380 programme comes in a year that could see the first drop in scheduled passenger flights made by the type.

Current Cirium schedules data for the whole of 2019 shows a small year-on-year fall in A380 operations versus 2018. Looking at closer-in schedules data, there was a year-on-year drop in A380 flights in the 12 months to end-April 2019.

The decline reflects waning operator appetite for the aircraft, which contributed to Airbus's decision to end production in 2021.

Given that Airbus states it has just 17 A380s left to deliver before the programme's termination in two year's time, it remains in the balance whether commercial aviation will ever see a rise in flights from the type again. Much will hinge on what has so far proven to be an extremely limited second-hand market as carriers begin to retire older examples.

A growing number of units are set to become available to that market in the coming years. For example, in mid-March Lufthansa became the latest carrier to announce it will be paring down its A380 fleet, revealing that six of its 14 units would be sold back to Airbus in 2022-23.

Nevertheless, the projected fall in total scheduled flights this year comes despite there being more of the type in service; Cirium's Fleets Analyzer shows there were 230 A380s in service on 31 December 2018, versus a projection of 237 on the same date of 2019.

The projected drop in flights this year – one

Scheduled A380 flights operating in 2019 versus 2018, by airline

	Flights		
Airline	2019	2018	Change
Air France	5,125	4,831	294
British Airways	5,115	5,288	-173
China Southern Airlines	2,486	2,324	162
Emirates	60,622	61,400	-778
Etihad Airways	5,594	5,531	63
Korean Air Lines	4,469	4,609	-140
Lufthansa	6,341	6,724	-383
Malaysia Airlines	504	1,108	-604
ANA	558	0	558
Asiana Airlines	3,587	3,361	226
Qantas	4,479	4,781	-302
Qatar Airways	6,076	5,968	108
Singapore Airlines	10,338	9,882	456
Thai Airways International	2,874	3,064	-190
Total	**118,168**	**118,871**	**-703**

Source: Cirium schedules data, 13 March 2019

Notes: One flight defined as outbound and return journey. Excludes Hi Fly wet-lease flights

A380 snapshot

Flights for 12 months to 30 April			Seats for 12 months to 30 April			ASKs for 12 months to 30 April		
2019	2018	Difference	2019	2018	Difference	2019	2018	Difference
117,761	118,019	-258	57,051,559	57,077,195	-25,636	402,804,419,320	402,437,139,315	367,280,005

Source: Cirium schedules data, 5 March 2019 Notes: One flight defined as outbound and return journey

DAVID KAMINSKI-MORROW LONDON

Risky business: how Airbus failed to hit the jackpot with its jumbo gamble

Airbus

Virgin Atlantic kept an order in place for years, but ultimately cancelled its commitment

Chroniclers might argue that the Airbus A380's fate was foretold a decade before the aircraft's maiden flight in April 2005.

Airbus's partners and Boeing had been engaged in a joint large commercial transport study to examine design options for an 800-seat jet.

This study had indicated a requirement for up to 1,000 aircraft by 2020. But the effort was frozen in July 1995 as evidence emerged that twin-engined aircraft were fragmenting this market, and true demand for a high-capacity jet was far lower.

Boeing initially adopted a conservative strategy based on stretching its 747-400 into the proposed 747-500X and -600X, before turning to the potential of a long-range 777 derivative that would become the 777-300ER.

Airbus gambled that an all-new "A3XX" would appeal to hub airlines, particularly 747 operators. "Everybody was clear that it was risky," said Airbus chief executive Tom Enders on 14 February. "Because it was clear, right from the start, this would not be a high-volume market."

The A3XX became the A380 in late 2000 – a designation reflecting the two-deck cabin, and intended to appeal to Asian cultures – as combined agreements from Air France, Emirates, ILFC, Qantas, Singapore Airlines (SIA) and Virgin Atlantic took it over the launch threshold.

DELAY CRISIS

Its complexity, however, hampered early production. Airbus celebrated the maiden flight in 2005, but parent EADS's co-chief Noel Forgeard was forced to quit over a delay crisis a year later.

Six months before Airbus handed over the first aircraft to SIA in 2007, the programme suffered further setback as the last customer for the A380F cargo variant dropped out, illustrating its weakness as a competitor to the 747 Freighter.

As the A380 entered service, the global economy faltered, and an extraordinary spike in fuel prices focused airlines' attention on efficiency. The environment was hardly ideal for a four-engined giant whose customers were tempted to configure it for passenger space rather than maximum density, even if none had been over-ambitious in their layouts.

"Little did we know in the year 2000, when we launched the A380, how the world would look in 2010, 2020," says Enders. "It's easy to say 'Well, you guys should have known that'."

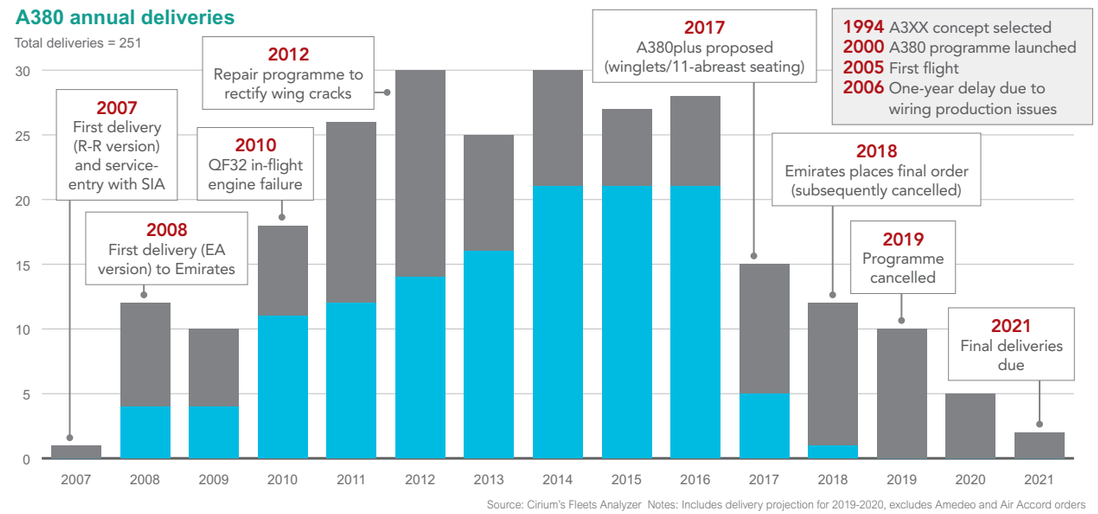
While Emirates and key 747 operator British Airways managed to slot the A380 into their business model, Airbus's arguments that the A380 would inevitably be needed to overcome airport congestion failed to convince other customers.

Orders stagnated, with major carriers including Air France and Lufthansa cutting their commitments. Although Airbus achieved production break-even in 2015, outside of the colossal investment cost, output never reached the four-per-month planned.

The A380's last order flurry came in 2011. In the subsequent seven years Emirates almost single-handedly propped up the backlog, accounting for 72 of the 80 realistic orders, while several other customers cancelled 36 A380s. When SIA retired A380s early, after just 11 years, the decision to part-out two of them emphasised the difficulty in finding buyers.

Proposals to stretch the A380, take advantage of its wing, or offer new engines failed to halt the demise. "We cannot get out of this trap by modifying the aircraft, stretching it, or putting new engines on it," says Enders. "Because these decisions made no economical sense."

A380 annual deliveries



Source: Cirium's Fleets Analyzer Notes: Includes delivery projection for 2019-2020, excludes Amedeo and Air Accord orders

Engine Alliance (EA)
Total = 130

Rolls-Royce (R-R)
Total = 121

Singapore Airlines continues to take new A380s, but has also retired its oldest units

Guillaume Horcajuelo/EPA-EFE/REX/Shutterstock

» flight is defined as an outbound and return journey – is partly explained by a temporary runway closure at Dubai International airport, where maintenance is planned to run from 16 April to 30 May. Emirates said in mid-January that this closure would see it ground up to 48 aircraft – without specifying how many of these would be A380s – and cut its schedule by 25%.

But Cirium data also shows Emirates' A380 flights are down year on year in January, February and March. The carrier did not respond when asked for comment, only pointing FlightGlobal towards an earlier statement regarding its 2019 network plans. Press reports last year claimed the carrier had parked some A380s.

Emirates' A380 flights will grow again from June onwards, the data shows, but it will end the year having operated 778 fewer flights with the type than it did in 2018, based on current schedules – a drop that exceeds the global total decline. Indeed, the Dubai-based carrier is operating more than half the total A380 flights in 2019, meaning tweaks in its deployment plans can have a significant impact on the global total.

Emirates is not alone, however, in cutting scheduled A380 flights, and the transition to a drop in total flights of the type between 2018 and 2019 is arguably on trend.

PEAK PERFORMANCE

After the first commercial A380 flight in 2007, the number of operations rose each year, peaking in 2015 with a rise of 18,111 versus 2014. Growth slowed for the first time in 2016, however, and eventually reached an increase of just 1,943 flights between 2017 and 2018.

Overall, Cirium schedules data shows there will be 118,168 scheduled A380 flights in 2019, down 703 from 118,871 in 2018.

In absolute terms, Malaysia Airlines is second to Emirates when it comes to year-on-year falls in A380 operations, dropping 604 scheduled flights to reach 504 as it continues to transfer its six aircraft to special pilgrimage operations. That charter unit – named Amal – was formally launched in February this year, having begun services in late 2018.

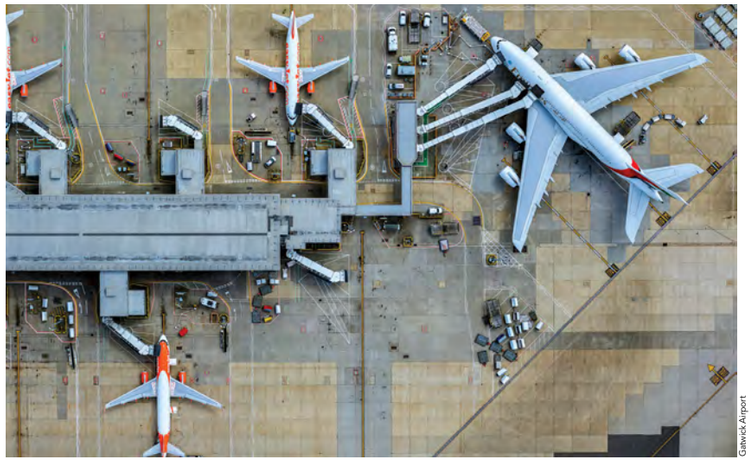
Lufthansa is meanwhile cutting more than one flight a day with a total of 6,341 scheduled for this year – 383 fewer than in 2018. The carrier moved five of its 14 A380s from Frankfurt to Munich in April 2018 and adjusted its schedule as a result.

This transition contributes to a year-on-year drop in flights in January-March 2019, before figures settle down. They drop again,

A380 in-service fleet, 31 December 2018

Airline	Units
Emirates Airline	109
Singapore Airlines	19
Lufthansa	14
British Airways	12
Qantas	12
Air France	10
Etihad Airways	10
Korean Air	10
Qatar Airways	10
Asiana Airlines	6
Malaysia Airlines	6
Thai Airways International	6
China Southern Airlines	5
Hi Fly	1
Total	**230**

Source: Cirium's Fleets Analyzer


Gatwick Airport

A380s are serving 60 airports in 2019, including Emirates flights to London Gatwick

A380 flights in 2019 by airline share

Airline	Proportion
Emirates	51%
Singapore Airlines	9%
Etihad Airways	5%
Lufthansa	5%
Qatar Airways	5%
Air France	4%
British Airways	4%
Korean Air	4%
Qantas	4%
Asiana Airlines	3%
China Southern	2%
Thai Airways	2%
ANA	0.5%
Malaysia Airlines	0.4%

Source: Cirium schedules data
Notes: Excludes Hi Fly wet-lease flights

»

» however, in November and December 2019 as Lufthansa takes A380s off its Frankfurt-Houston and Munich-Hong Kong routes, replacing them with Boeing 747s and A350s respectively. Asked to comment on what would happen to its A380 capacity during this period, Lufthansa did not comment.

Qantas's 4,479 flights leave it trailing 2018's figure by 302. The Australian flag carrier made significant adjustments to its A380 network in the first few months of 2018 as its London "kangaroo" route shifted from a stop in Dubai to one in Singapore. Reductions in A380 flights during this period combine with drops later in 2019 on its Sydney-Hong Kong route to explain the decline.

Meanwhile, deployment tweaks from British Airways, Korean Air and Thai Airways International mean they are on course to operate 503 fewer A380 flights between them in 2019.

Offsetting those falls, ANA will begin A380 services in the coming months and is scheduled to account for 558 flights this year as it launches on Hawaii routes, while single-digit percentage upticks in flights will be seen in 2019 from Air France, Asiana, China Southern, Qatar Airways and Singapore Airlines.

MORE ARRIVALS

In the case of Singapore Airlines, the increase of 456 in A380 flights is explained by continuing deliveries of new A380s during 2018, despite it being the first carrier to retire examples of the type. Cirium fleet data shows the carrier had 16 A380s in service on 31 December 2017, then 19 on the same date in 2018.

At Air France, the increase of 294 flights is partly explained by the temporary loss of one of its 10 A380s towards the end of 2017, which spilled into the first month of 2018 and affected year-on-year comparisons. The A380 suffered an uncontained failure of its starboard outboard engine during a flight to Los Angeles. Cirium fleets data shows it returned to service in January 2018.

The Skyteam carrier is also boosting A380 flights in 2019 as it shifts the type from African routes to US services.

Air France revealed in February that three of its 10 A380s will leave its fleet as they come to the end of their leases in 2020-2021.

One unknown regarding 2019 schedules is whether as-yet-unannounced wet-lease operations from Hi Fly could boost the annual total.

"Our A380 has generated a significant interest in the wet-lease market since we introduced it in the summer," Hi Fly tells FlightGlobal when asked about interest from carriers in 2019. "It had a busy start and it is expected to be a busy season ahead."

FAZRY ISMAIL/EPA-EFE/REX/Shutterstock

Malaysia Airlines is shifting significant A380 capacity to its dedicated pilgrimage unit Amal

Number of scheduled A380 flights, all airlines

Year	Flights
2007	129
2008	2,350
2009	8,109
2010	16,193
2011	28,117
2012	42,137
2013	55,631
2014	70,897
2015	89,008
2016	106,223
2017	116,950
2018	118,871
2019	118,168

Source: Cirium schedules data
Notes: Excludes Hi Fly wet-lease flights

A380 flights by region of destination airport, April 2019

Region	Proportion
Asia-Pacific	31%
Middle East	30%
Europe	26%
North America	11%
Africa	1%
Latin America	1%

Source: Cirium schedules data

Passenger flights by select widebody aircraft – 2019 versus 2018

Aircraft type	Flights 2019	Flights 2018	Change
A330	976,211	998,223	-22,012
777	841,716	855,994	-14,278
787	533,370	453,146	80,224
767	284,060	326,294	-42,234
A350	179,558	125,631	53,927
A380	118,168	118,871	-703
747	74,800	81,632	-6,832
A340	56,113	64,644	-8,531
Total	**3,063,996**	**3,024,435**	**39,561**

Source: Cirium schedules data, 13 March 2019
Notes: One flight defined as outbound and return journey. A380 excludes Hi Fly operations

Overall, in 2019 Emirates will account for 51% of A380 flights. The remaining 49% are split between 13 operators, led by Singapore Airlines at around 9%, in figures that are broadly flat with those from 2018.

Meanwhile, A380s are due to regularly serve 60 airports this year, down by just one from 2018. That is explained by Emirates no longer serving Kuwait with the type, instead operating 777s on the service. That route was the world's shortest A380 flight, at just 853km.

The shortest A380 route operated in April 2019 will be Asiana's Seoul-Tokyo service, at 1,232km, Cirium schedules data shows.

Meanwhile, figures for April 2019 show North American airports handling just 11% of global A380 flights, reflecting the type's struggles to make a mark in that region. Asia-Pacific airports lead with 31% of flights, with the Middle East close behind at 29%. European airports account for 26%.

By way of comparison, the A380 is not alone among widebody aircraft programmes in seeing a drop in flights this year.

A330 and 777 flights will fall in 2019 for the first time since Cirium schedules records began in 2004, although both have shown significantly more longevity than the A380 in sustaining year-on-year increases.

A350-family flights are meanwhile already well ahead of those from their larger stablemate. The Airbus type and Boeing's 787 are the only two commonplace widebodies projected to see an increase in flights during 2019. ■

Boeing's NMA would do a job like this 767, filling gap between the Max and Dreamliner

AirTeamImages

The future calls

The prospect of a first all-new airliner in years has been a focal point of engine technology debate, but both CFM and Pratt & Whitney are looking far beyond just one programme

JON HEMMERDINGER BOSTON

One of the more animated discussions in civil aviation recently has surrounded the choice of engine – or engine options – to power Boeing's proposed New Mid-market Airplane (NMA). But with that programme's launch now downgraded from "anticipated" to "prospective", the engine question has perhaps become academic.

However, while both CFM International and Pratt & Whitney (P&W) – the only apparent contenders for an NMA engine contract – decline to discuss the NMA specifically, both have already done a great deal of work developing their next engines for narrowbody types.

Both companies want their next models to deliver double-digit efficiency gains – but they must also remain flexible while there is uncertainty about the future aircraft programme specifications or development timelines.

P&W is studying various engine technology advances, but views its geared-turbofan (GTF) architecture as the foundation of its future powerplants. "For the commercial aviation industry, the geared-turbofan architecture holds extraordinary promise for the future," P&W senior vice-president of engineering Geoff Hunt says. "The Pratt & Whitney GTF engine technology is scalable to aircraft platforms beyond the five we power today."

BROADER APPROACH

Bill Brown, director of commercial engines marketing at GE Aviation – half of the 50/50 joint venture with Safran that forms CFM – describes a broader approach: studying multiple engine architectures simultaneously, to ensure readiness when an airframer comes calling. Should an airframer move forward with plans that would stretch the state of technology, CFM will be ready, Brown says.

"Architecture is almost the last thing we determine because it's so reliant on integration with the airplane," he says. "Don't pick your architecture before the airframer has determined the requirements."

CFM's Leap, which powers the Boeing 737 Max and is an option for Airbus A320neo-family aircraft and the in-development Comac C919, evolved from study of some 18 different engine architectures, Brown says. Those included geared fans, counter-rotating and unducted fans, and a "simple, direct-drive single-stage design" such as the CFM56's.

The advancing state of technology enables a roughly 1% gain in aircraft fuel efficiency annually, with engines driving about 75% of efficiency gains and airframes accounting for the rest, says Brown. In other words, the NMA's engine, assuming Boeing launches the aircraft and delivers it around the middle of next decade, could be 10-15% more efficient than a powerplant like the Leap. A 20% gain might be possible by the 2030s, he adds.

Earlier this year signs suggested Boeing was leaning towards launching the NMA, with a "decision to offer" the aircraft coming this year followed by a firm launch decision in 2020. Boeing has pitched the NMA as a 200-270-seat aircraft with 4,000-5,000nm (7,410-9,260km) range and powered by twin turbofans in the 50,000lb (222kN)-thrust class. The concept bridges the space between the single-aisle 737 Max and twin-aisle 787, ground roughly covered by the out-of-production 757 and the outgoing 767. It has targeted a 2025 service entry.

Boeing executives have suggested the NMA will not drive a technological leap but, rather, incorporate existing technology. The project, they have said, could help Boeing transform its manufacturing process in preparation for the next project, which some analysts suggest might be a 737 replacement.

But the already-uncertain NMA programme became doubly uncertain in March, when a second 737 Max crash prompted a grounding that has thrown Boeing into crisis and stifled nearly all public discussion by company officials about in-development aircraft programmes. Asked about the NMA during an April earnings call, chief executive Dennis Muilenburg said Boeing had "prioritised" resources to focus on returning the Max to service. But, he added, NMA work continues nonetheless, with a 2025 service entry still on the cards.

CFM, P&W and Rolls-Royce (R-R) were initially competing to power the NMA, but R-R stepped aside in February, saying it was uncertain it would be able to meet Boeing's timetable. However, R-R has expressed interest in partnering with another engine maker to power the aircraft.

David Chang/EPA-EFE/Shutterstock

Where 787 pushed new technologies, NMA may drive a manufacturing transformation

> "Thermodynamic efficiency is all about how hot you can run the engine"
>
> **Geoff Hunt**
> Senior vice-president of engineering, Pratt & Whitney

GE has suggested its proposed NMA engine would be a larger, more advanced derivative of the Leap. That engine is 15% more fuel efficient than the CFM56s preceding it, and, the simplicity of the Leap's architecture ensures reliability through the demanding schedule of a narrowbody aircraft, which might operate five or six cycles daily, says Brown.

Likewise, P&W has been studying new versions of its GTF. Aircraft with GTF power include the A220, A320neo, Embraer's E-Jet E2 and the in-development Irkut MC-21 and Mitsubishi Aircraft MRJ.

The GTF's gear decouples the fan and turbine so each rotates at optimal speeds, with the fan turning about one-third the speed of the turbine. The design is 16% more efficient than previous-generation engines, P&W says. While the GTF's gear improves the engine's propulsive efficiency (a measure of how well it converts mechanical energy into thrust), P&W is now focusing on thermodynamic efficiency (how well an engine converts chemical energy in fuel into mechanical energy).

"Thermodynamic efficiency is all about how hot you can run the engine," says Hunt. To accommodate higher temperatures, P&W is studying better cooling, improved coatings and increased use of advanced materials like ceramic-matrix composites (CMCs).

GE also thinks it can squeeze more thermodynamic efficiency from its designs, partly through expanded use of CMCs, which let engineers reduce the amount of air diverted from the compressor to cool the turbine, Brown says. Additionally, GE intends to use more additive-manufactured parts, and more carbon-fibre composites in cold sections of engines, helping reduce weight, he says.

"Until we get to hybrid electrics, ceramics are the biggest development, right behind carbon fibre," Brown says.

Engine makers are also looking further ahead, eyeing architectures that promise even greater efficiency gains. One of these – unducted fans, also known as open-rotors – is not a new concept. Several manufacturers, including GE and Boeing, developed unducted technology decades ago, and Safran ground-tested an open-rotor demonstrator in 2017.

Unducted designs address a conundrum that hampers traditional turbofan efficiency. Engineers know they can improve efficiency by increasing the size of an engine's fan. But as fan diameter increases, the weight and drag of the nacelle jumps exponentially, negating the gains. The under-wing design of current aircraft also limits fan size.

The unducted design eliminates nacelles altogether, allowing fans to spin freely in air, which enables a higher bypass ratio. "The unducted fan is kind of like hitting the jackpot," Brown says. "The open rotor takes all that drag and leaves it on the ground."

Unducted designs require a high level of co-ordination and integration between airframers and engine makers, and engineers must find ways to reduce the design's inherent noisiness. But, says Brown: "It's not a hurdle that we couldn't overcome."

EFFICIENCY JACKPOT

But no aircraft engine efficiency jackpot compares to the promise of electric propulsion. While fully-electric systems for large aircraft still seem locked in the realm of science fiction, hybrid-electric systems appear increasingly feasible, even for modest-size aircraft. "We may not see fully-electric large commercial flight in our lifetime," says Hunt, "but we're betting we will see supplemental or hybrid-electric flights."

He notes that Pratt & Whitney Canada, Collins Aerospace and United Technologies Advanced Projects (UTAP) (all sister companies in the United Technologies group) are jointly developing hybrid-electric aircraft systems.

Collins recently unveiled plans to open an electric aircraft system "laboratory" in Illinois and is working with Pratt & Whitney Canada and UTAP to develop a hybrid-electric propulsion system for a Bombardier Dash 8-100 turboprop.

Brown envisions hybrid-electric systems in which a single turbine provides electrical power to multiple, small and low-drag motors embedded in an aircraft's wings. "This is where hybrid starts to shine," he says. ■

MANUFACTURING

Production ramp-up continues as Max grounding brings financial consequences

Production of PW1900Gs for Embraer E190-E2s escaped the delays that hit PW1100Gs used for Airbus A320neos

Pratt & Whitney

The two major narrowbody aircraft engine makers have successfully accelerated production in recent months, though they are still battling with supply-chain stress. CFM International and competitor Pratt & Whitney (P&W) more than doubled output of their latest-generation turbofans – CFM's Leap and P&W's PW1000G – in the first quarter of 2019 versus the same period a year ago.

CFM shipped 424 Leap engines in the first quarter, up from 186 in the corresponding period of 2018. The engine maker, jointly owned by GE Aviation and Safran, expects to hand over more than 1,800 of the powerplants in 2019, up from 1,118 in 2018.

CFM makes the Leap-1B, the only engine available for the Boeing 737 Max, and the Leap-1A, one of two options for the Airbus A320neo family of aircraft.

One effect of the 737 Max grounding has been to provide CFM with an opportunity to catch up on delayed deliveries. The episode, however, threatens financial consequences – and not just for Boeing. Both GE and Safran executives are warning investors that the 737 Max grounding, which took effect in mid-March, will begin pinching profits in the second quarter.

Safran disclosed the potential effect on 28 April, with executives saying during an earnings call that the grounding, should it continue, could cost the company €200 million ($224 million) in lost revenue during the second quarter.

Airbus

CFM has maintained Leap-1B output despite 737 problems

That figure reflects money Safran would have collected if Boeing were still delivering 737 Max narrowbodies to customers; Safran collects about 50% of revenue from new aircraft engines prior to aircraft delivery, and 50% upon delivery.

FINANCIAL HEADWIND

Two days later, GE chief executive Lawrence Culp acknowledged his company was facing the same risk: "We probably have something in that same range as a headwind with respect… to our own side of the [CFM joint venture] in the second quarter."

Though Boeing responded to the 737 Max grounding by trimming 737 production by 19%, from 52 to 42 aircraft per month, CFM has kept Leap-1B output at previous levels. Executives say doing so will give the supply chain breathing room, helping CFM to recover from Leap delivery delays.

As of late April, Leap deliveries to Airbus were on time, but deliveries to Boeing were two weeks late, Culp said, adding: "We expect to be back on schedule in the second quarter."

P&W has likewise accelerated production of its PW1000G line of geared turbofans (GTFs) despite high-profile engine issues last year and supply-chain pressures.

GTFs power A220s, A320neo-family aircraft and Embraer E-Jet E2s, along with the in-development Irkut MC-21 and Mitsubishi Aircraft MRJ.

In the first quarter of 2019, P&W delivered 189 large commercial aircraft engines, including GTFs and International Aero Engines (IAE) V2500s, a previous-generation engine option powering A320ceos. P&W partly owns IAE.

Executives speaking during P&W parent United Technologies' first-quarter earnings call in April said shipments of GTFs, including spare engines, more than doubled year on year in the first quarter. The company does not disclose shipments by engine type, but Cirium's Fleets Analyzer shows Airbus to have delivered fewer than 10 V2500-powered A320s in the first quarter – suggesting P&W delivered about 170 GTFs in the first three months of 2019.

Like CFM, P&W has been working feverishly to meet airframers' aggressive narrowbody output goals. Airbus produced an average of 46 A320-family aircraft per month in the first four months of 2019, but plans to increase that rate to 60 per month by the middle of the year and 63 per month in 2021.

P&W has suffered PW1100G production and operational problems, including four in-flight failures that prompted the company to halt deliveries for several weeks in early 2018. That issue stemmed from modifications P&W made to the knife-edge seals on the PW1100G's high-pressure compressor.

P&W has since been working to recover, and United Technologies chief executive Greg Hayes says the company is "confident we're going to meet the customer requirements this year and next year with the capacity that we've added".

Regardless, Hayes made clear that P&W's production lines are running at full capacity, leaving the company unable – at least in the short term – to meet any new demand that might arise.

He specifically cited bottlenecks in the casting and forging of engine components; new capacity from a recently-opened fifth forging line in Georgia is already spoken for. "Trying to get additional capacity into the supply chain on the casting front is very, very difficult," Hayes says. "That fifth press is almost fully utilised in terms of the volume we see today." ■

The news listed in this section are FlightGlobal stories originally published in Cirium's premium news service available at www.cirium.com

GULF AIR FINALISES LEAP-1A AND OTHER PACTS WITH FRENCH FIRMS

Published on 30 April 2019

Middle Eastern carrier Gulf Air has finalised an agreement for CFM International Leap-1A engines for its 39 Airbus A320neo-family jets, during an official visit to France by the king of Bahrain.

The engine deal, for 65 powerplants worth $1 billion, was one of five agreements between the carrier and French companies signed during the visit of the Bahraini ruler Hamad bin Isa Al Khalifa.

Gulf Air is acquiring 17 A320neo and 12 A321neo jets and had previously disclosed the engine order in November 2017.

The airline is already an operator of CFM56 engines and has already taken delivery of two of the Leap-powered A320neos.

"This state-of-the art combo will be definitely a key asset of our sustainable growth in the near future," says Gulf Air chief Kresimir Kucko.

Gulf Air has indicated that it will take the longer-range A321LR version after signing with Thales for Ka-band connectivity on the variant, as well as its Boeing 787-9s.

Three other aerospace agreements focus on Michelin tyres and Safran Landing Systems for the Boeing and Airbus jets, as well as 787 auxiliary power unit maintenance with Air France-KLM Group.

CFM MAINTAINS LEAP PRODUCTION FOR NOW

Published on 26 April 2019

CFM International is maintaining output of Leap-1B engines for the 737 Max, despite Boeing's decision to trim production of the narrowbody.

Boeing has cut monthly production of the single-aisle from 52 to 42 units as a result of the 737 Max grounding and efforts to return the type to service.

Safran – which jointly owns CFM with GE Aviation – says Leap-1B production is being maintained "at this point", but notes that it might implement "temporary adjustments if necessary".

In February, Safran said CFM had overcome a delivery delay for Leap-1A engines – an option on the Airbus A320neo family – which had developed in 2018 as a result of supply-chain bottlenecks relating to forgings and castings. However, at that point, Leap-1B production was still three weeks behind schedule, it said.

During the first quarter, CFM's deliveries grew to 577 engines, from 498 during the same period in 2018.

Leap production rose to 424 units – from 186 – while CFM56 deliveries decreased from 312 to 153 as part of a planned ramp-down for the legacy powerplant.

First-quarter revenue for Safran's aerospace propulsion business grew by 19.6% year on year to €2.74 billion ($3.07 billion).

Group chief executive Philippe Petitcolin states: "We stand behind our customers and follow very closely the announcements regarding the 737 Max in order to adapt if necessary."

SAFRAN NACELLES CONTRACTS WITH AZUL AND AVIANCA

Published on 10 April 2019

Safran Nacelles will provide nacelle-related MRO services and replacement parts to Azul and Avianca Holdings following long-term contracts signed with those companies.

Brazil-based Azul will be able to send its Rolls-Royce Trent 700 nacelles to Safran's facility in Indianapolis for MRO services and will have access to Safran's global stock of thrust reversers for those engines, which power the low-cost carrier's Airbus A330s. Olivier Savin, executive vice-president of Safran Nacelles, and Leonardo Zerbone, supply chain general manager Azul, signed this contract on 9 April.

Safran on 10 April announced a contract with Avianca Holdings to provide MRO services and replacement parts for CFM International LEAP-1A nacelles. Those engines power the airline's A320neo-family aircraft. CFM International is a joint venture between Safran and GE Aviation.

Avianca has two A321neos and three A320neos in service, plus 54 A320ceo-family aircraft, according to Cirium's Fleets Analyzer. The Bogota-based airline also has orders for 84 A320neos and 26 A321neos.

Azul has seven A330-200 aircraft in service and has orders for five A330-900neos, data shows.

Safran

Safran Nacelles executive vice-president Olivier Savin (second from left) and Azul supply chain general manager Leonardo Zerbone (second from right) at a signing ceremony during MRO Americas

SAFRAN TO BUILD ADDITIONAL LEAP MRO SHOPS

Published on 1 March 2019

Safran is planning to establish two additional engine overhaul facilities by 2023 to handle shop visits for the Leap engines built by CFM International, its joint venture with GE Aviation.

The French aerospace group's chief executive Philippe Petitcolin said during a financial results briefing on 27 February that evaluations of the investment were under way and that management would make decisions later this year. He says that the facilities will be built at locations providing both favourable costs and access to Leap operators.

Noting that many Leap engines have been sold with long-term aftermarket support agreements, he says Safran will require more overhaul capacity for a first wave of scheduled shop visits between 2022 and 2025.

Safran handles around 10% of shop visits for its products, which span commercial, military, business jet and helicopter engines and auxiliary power units.

"You cannot run these [MRO] businesses with long-term agreements if you can only do 10% of the fleet yourself," Petitcolin says.

Cirium's Fleets Analyzer shows that a total 722 Leap-powered narrowbodies from the Airbus A320neo and Boeing 737 Max families are in service today, and that the two airframers together have a further 5,920 orders for the aircraft. The Max is exclusively powered by Leap-1B engines, while the Leap-1A is an option on the A320neo.

Petitcolin notes that engine test cells represent the highest expenditure – in the region of €10-20 million ($11-23 million) – in establishing overhaul shops.

"The rest of the shop is not that capital-intensive," he says, adding that the two planned facilities are "already in our books".

SAFRAN HOPEFUL OF REDUCED PRESSURE TO RAISE LEAP OUTPUT

Published on 27 February 2019

Safran expects an easing of the pressure from Airbus and Boeing to increase production of CFM International Leap engines for the airframers' respective A320neo and 737 Max assembly lines.

Speaking during a financial results briefing today, Safran chief executive Philippe Petitcolin acknowledged "a lot of demand" for Leap engines and that "some" pressure exists from the airframers to raise engine output.

But he says: "I don't see the high pressure [we had] in the middle of last year from our customers for a huge additional rate increase in production."

Earlier this month, Airbus said that it was on track to raise monthly A320neo-family production to 60 aircraft later this year, and that it was targeting a rate of 63 per month from 2021.

Previously, the European airframer studied increases to rate 70 and beyond.
Petitcolin says he sees "no problem" with a rate increase in 2021.

"When we have a sustained production, we have no problem to even increase rates," he says.

But he notes: "Maybe if there is less pressure, it means there is less pressure on the final customer's side."

In 2018, Boeing increased monthly 737 production to 52 aircraft – from 47 – and plans to raise the rate to 57 later this year.

Safran jointly owns CFM International with GE Aviation.

CFM STILL BATTLING LEAP-1B PRODUCTION DELAYS

Published on 27 February 2019

GE Aviation-Safran joint venture CFM International has overcome a delay in deliveries of Leap-1A engines to Airbus's A320neo-family production line, the result of supply-chain bottlenecks relating to forgings and castings – but is still battling a three-week lag in deliveries of the Boeing 737 Max-powering Leap-1B.

Speaking at a full-year financial results briefing today, Safran chief executive Philippe Petitcolin said that last year CFM reached a weekly delivery rate of 15-16 Leap-1A engines, in line with Airbus's requirement. The -1A is an option on A320neo-family aircraft.

He says Leap-1A deliveries are now on schedule and that production is on a stable "plateau" as Airbus has no plans for any huge rate increase over the coming months.

That contrasts with the 737 Max, however. "It is a different story, because Boeing is still in a huge ramp-up and increase of production," says Petitcolin.

In 2018, CFM reached a rate of 16-18 Leap-1B deliveries per week, while the US airframer's plan required shipments of "at least 20" engines per week by year-end.

"We are now at a bit more than 20 engines a week, but we have to grow to 30 engines a week by mid-year 2019," says Petitcolin.

He concedes that, in addition to the rate increase, "we have some difficulties to get rid of the delays which we have accumulated at the beginning of the [Leap] programme".
The delay translates to around 70 engines, and the manufacturer intends to get back on schedule with Boeing during the second quarter, he says.

CFM produced a total of 2,162 engines last year across the CFM56 and Leap-series programmes, an increase of 13.6% over 2017.

Leap output rose to 1,118 engines in 2018, up from 459 in 2017. This year, the manufacturer is to increase production to more than 1,800.

CFM56 production declined to 1,044 engines last year, against 1,444 in 2017, and will be further reduced over the next 12 months.

Safran says CFM last year received 3,211 commitments for Leap engines, which brought the powerplant family's total backlog to 15,620.

CFM'S LEAP DELIVERIES DOUBLED IN 2018 AMID SUPPLY CHAIN RECOVERY

Published on 1 February 2019

CFM International more than doubled the number of Leap engines it delivered in 2018, handing over 1,118 of the engines and coming closer to recovering from a supply chain slowdown.

The company, co-owned by General Electric and Safran Aircraft Engines, is "on track to deliver" at least 1,800 Leap engines this year and more than 2,000 annually by 2020, it says. It expects the Leap programme to break even in 2021.

"We're still behind on deliveries by about four weeks, but the business expects to be back on schedule by mid-2019," GE chief financial officer Jamie Miller says of Leap engine deliveries during GE's 2018 earnings call on 31 January.

In addition to the 1,118 Leap deliveries in 2018, CFM delivered 1,044 CFM56 engines for 2,162 total engine deliveries, up 14% year-on-year. By comparison, CFM delivered 1,444 CFM56 and 459 Leaps in 2017.

In the fourth quarter alone, CFM delivered 379 Leap engines, up from 202 in the fourth quarter of 2017, GE Aviation says.

CFM continues to build its backlog, logging orders for 3,337 engines in 2018, including 126 CFM56 and 3,211 Leaps. The company now holds 17,275 orders and commitments for Leaps, which power Airbus A320neo family aircraft, Boeing 737 Max and Comac C919s.

"2018 LEAP engine orders were near a record high," CFM chief executive Gael Meheust says in a media release. "We had some challenges on the production front, but in the end we were able to deliver what we promised."

CFM has struggled to ramp up engine deliveries to meet increasing 737 and A320neo-family aircraft production rates. In recent days, Boeing chief executive Dennis Muilenburg said his company is sending staff to CFM facilities to help the engine maker recover.

"As the ramp-up continues over the next couple of years, we will certainly work closely with Airbus and Boeing to keep disruptions to a minimum," CFM's Meheust adds.

As Leap production has ramped up, production costs have declined.

"Over the last two years, we've taken out more than 40% of the cost of the engine," says GE's Miller. "The overall program will break even around 2021."

He notes that 58% of A320neo family aircraft customers have chosen Leap engines. The Leap is the only engine offered on Boeing's 737 Max.

GE AVIATION'S 2018 PROFIT JUMPS 20% AS LEAP PRODUCTION LIFTS

Published on 1 February 2019

Profits of General Electric's aviation unit shot up 20% year-over-year in 2018 to $6.5 billion amid increasing deliveries of aircraft engines.

"Aviation had another outstanding quarter," GE chief financial officer Jamie Miller said during the company's earnings call on 31 January.

In 2018, GE Aviation generated $30.6 billion in revenue, up 13% from the previous year and resulting in a 21% profit margin.

GE Aviation logged $35.5 billion in new orders last year, up 22% from 2017, "driven by continued strong momentum of the Leap engine programme," says Miller.

GE affiliate CFM International manufacturers Leap engines, which power Boeing 737 Max, Airbus A320neo-family aircraft and Comac C919s. GE co-owns CFM with Safran Aircraft Engines.

CFM delivered 1,118 Leap engines last year, up from 459 in 2017. CFM's total 2018 deliveries increased 14% year-over-year to 2,162, CFM says.

GE Aviation's results outshined GE's other divisions and marked an area of particular strength in a year during which GE posted a net loss of $22.4 billion.

WILL GE REVEAL FATE OF GECAS?

Published on 28 January 2019

Many are waiting with bated breath for an announcement from General Electric about GECAS as the company reports its fourth quarter earnings on 31 January.

Larry Culp, who took over as GE's chief executive in September, said "GE needs to change" as part of his prepared remarks during a third quarter earnings call on 30 October. But after only one month in the job, he was reluctant to unveil his plan.

Now, along with the disclosure of its results, it is expected that GE will reveal what it is going to do with GE Capital's GECAS, one of the top aircraft leasing companies in the world.

It has been rumoured for years that GECAS is up for sale.

In April 2015, GE announced the GE Capital Exit Plan. Since that point, GE Capital has shrunk by nearly 75% over the past three years, from $500 billion in 2014 to $128.5 billion in the third quarter 2018, as assets were sold off.

GECAS itself has shrunk by about a fifth since 2012, with the company's assets worth about $40 billion, according to GE's 2017 annual report.

More recently, FlightGlobal reported in September that Goldman Sachs had been retained to carry out a strategic review of GECAS.

It is nearly certain that GE will announce that it is selling GECAS at some point, and many expect that disclosure to come on 31 January. But the question on everyone's mind is how will GE sell GECAS? As one entity? Or will it be parcelled off?

GECAS comprises four major parts; an aircraft leasing company, consisting of 1,232 aircraft valued at $24.7 billion, according to FlightGlobal data; an engine leasing arm; a lending business PK Airfinance; and, Milestone Aviation, a helicopter lessor.

Whether the company decides to sell the four parts together or separate them remains unknown, particularly as a sale has not formally been announced.

Some parts of the business seem better aligned with each other than others. For instance, keeping the engine leasing

business makes sense because the GECAS would have some insight into future orders/campaigns giving the company a leg up in RFP processes.

PK Airfinance, GECAS's lending business, has over 390 aircraft in its portfolio, according to its website. The company is known for lending to tougher credits, competing with the likes of DVB Bank, which itself is up for sale. The fact that DVB had several bidders for its aircraft lending business suggests that PK Airfinance could attract separate bidders for its loan portfolio.

Helicopter leasing subsidiary Milestone, however, has the "world's largest civilian helicopter fleet" according to its website, at a time when the helicopter leasing is unfashionable. One source refers to Milestone as a "big poison pill".

In a 26 November report, GE said Milestone's fleet utilisation was at 90%. It added that GECAS was anticipating returns of $50 million for 2018 and for the subsidiary to remain profitable in 2019, "despite headwinds facing the offshore oil and gas industry". Helicopter leasing has had a tough run the past few years with the downturn in the oil and gas industry which resulted in an overcapacity of helicopters bound for the space.

Milestone's peers struggled in 2018, with Babcock International writing down the value of some of its helicopters in November and Waypoint Leasing filing for Chapter 11 in December.

Moreover, the recent sale of Waypoint to Macquarie Airfinance has created an unfavorable mark for Milestone's valuation. Macquarie purchased Waypoint for $650 million - about 40% of its book value.

DEEP POCKETS

For years, GECAS benefited from its parent's investment-grade credit rating and funded itself using its parent's huge balance sheet. The lack of third-party debt makes the transaction tough, forcing any buyer to raise the debt in order to finance the transaction.

Earlier in January, reports surfaced that Apollo Global Management was eyeing the business, even though no formal announcement has been made that GE is selling the unit.

In addition to the about $7.5 billion equity check necessary, at a 70% debt to equity ratio, a buyer of GECAS would have to raise about $17 billion worth of debt at once. This creates a lot of risk for the buyer, which some lessors that FlightGlobal has spoken with have suggested would demand a discount. Two sources tell FlightGlobal that a buyer would likely require an investment grade balance sheet, which private equity firms do not have. Furthermore, private equity firms typically demand higher returns than those generated from a conservatively leveraged company funded with investment grade debt.

This could knock out a certain type of bidder like private equity at the initial stages, leaving only a few suitors, like sovereign wealth funds, which can write the required $8 billion equity check and are prepared to raise over $17 billion of debt.

GE BEGINS SECOND ROUND OF GE9X FLIGHT TESTING

Published on 11 December 2018

GE Aviation's GE9X turbofan returned to the skies on 10 December, kicking off a second round of airborne testing during which the engine maker will evaluate the powerplant's software and performance in hot-and-high conditions.

The latest round of testing will involve roughly 18 flights on GE's flying Boeing 747-400 testbed, which will carry the massive GE9X turbofan under its wing, GE says.

The 105,000lb-thrust (467kN) GE9X will power Boeing's 777X.

GE9X flight tests will stretch into the first quarter of next year, bringing GE closer to achieving its goal of receiving in 2019 certification of the engine by the Federal Aviation Administration, according to the Ohio-based engine maker.

"During the second round of testing, GE will continue software development testing that began in the first round, perform hot-and-high starts and fill in remaining gaps from the first round of testing," says GE.

The company's first round of GE9X airborne testing was delayed more than two months earlier this year after engineers discovered unexpected wear on "lever arms" that alter the pitch of vanes inside the engine's compressor.

The engine finally got airborne in March when GE began an initial round of airborne tests that lasted until early May. That round involved 18 flights and 105h of flight time, allowing GE to study high-altitude performance and to compare performance during cruise to ground-test data, GE has told FlightGlobal.

With the initial round complete, the company transported the test engine to Ohio, where it was modified into the final configuration expected for production, GE says.

"The engine is more than halfway through the certification testing programme and [has] completed various tests during the last few months," GE says.

Those tests have included evaluation of performance during water ingestion, overheating and crosswinds, it says.

"Tests that remain include blade out, hailstone, bird ingestion and block or endurance testing," GE says.

The GE9X-105B variant of the engine will power the 777-9, which Boeing expects will achieve first flight in 2019 and enter service in 2020.

GE also plans to develop versions of the turbofan with 102,000lb-thrust and 93,000lb-thrust, according to regulatory filings with the FAA. Those engines could power other 777X variants.

GE operates a flight test center in Victorville, California, but also performs airborne testing from Colorado Springs in Colorado, Seattle, Fairbanks in Alaska and Yuma in Arizona, it says.

The company acquired its 747-400 flying testbed from Japan Air Lines, then modified and strengthened the aircraft's wing and strut to accommodate test engines, it says.

FAA REQUIRES AIRLINES TO REPLACE GENX-2B FUEL MANIFOLDS

Published on 3 December 2018

The Federal Aviation Administration is ordering airlines to replace fuel manifolds on some GE Aviation GEnx-2B67 engines, which power Boeing 747-8s, due to the risk of an engine fire.

An airworthiness directive that takes effect on 4 January comes in response to an engine fire caused by "low-cycle fatigue cracking of the fuel manifold".

The order requires airlines to replace the manifolds during the next shop visit.

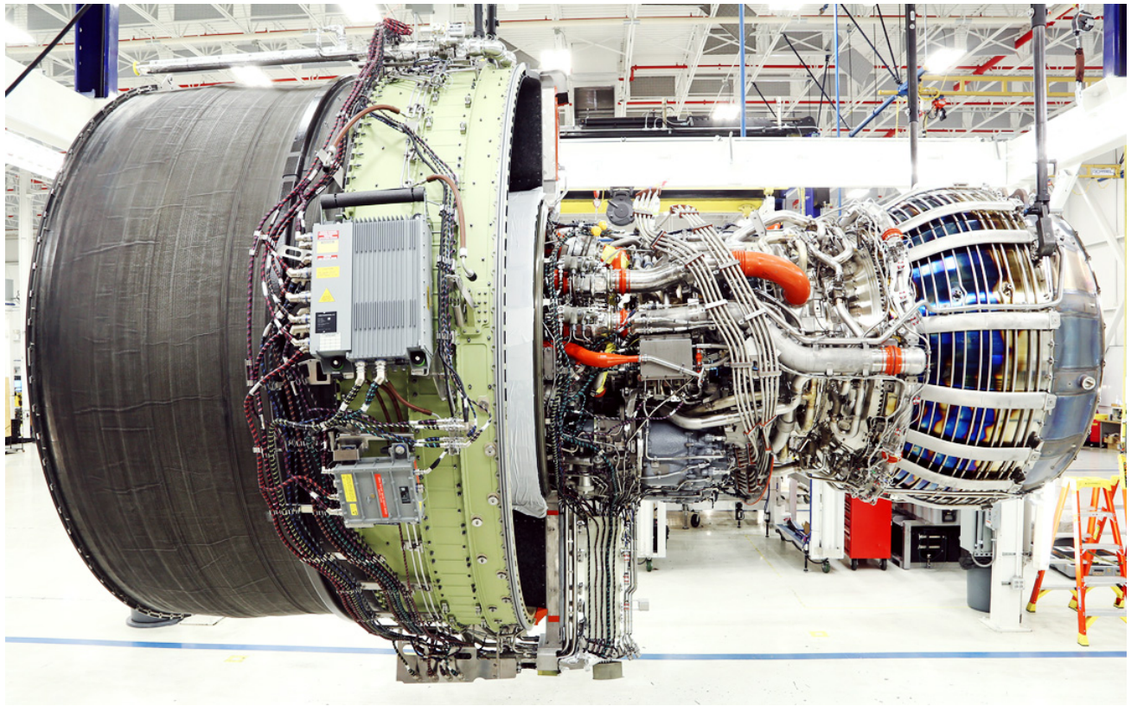
The issue affected 424 GEnx-2B engines worldwide, but GE already issued a service bulletin and only 140 engines still require fixes, the company says.

Those 424 engines compose the bulk of engines on the worldwide in-service fleet of 123 747-8s and 747-8Fs, according to Flight Fleets Analyzer.

US airlines operate only two affected engines, the directive says.

The US aviation regulator has previously issued airworthiness directives addressing problems with fuel manifolds on GEnx-1A engines, which power 787s.

In 2017, the FAA required airlines to replace some GEnx-1A fuel manifolds in response to an in-flight engine shutdown caused by a fuel manifold fracture.



GE Aviation

AIRBUS STARTS FLIGHT TESTS OF GTF-POWERED A319NEO

Published on 25 April 2019

Airbus today completed the first flight of the Pratt & Whitney PW1100G-powered version of the A319neo.

The aircraft took off from Airbus's Toulouse facility at 12:30 and landed back there at 15:20, says the airframer.

Of its re-engined narrowbody family – which also includes the A320neo and A321neo – the A319neo is the last member to enter flight testing.

All of the models are available with either PW1100G geared turbofan or CFM International Leap-1A engines.

Airbus foresees that the GTF-powered A319neo will gain certification by fourth quarter this year.

Previously, the airframer used the same A319neo airframe, MSN 6464, to certificate the Leap-1A-powered variant.

The European Union Aviation Safety Agency and US Federal Aviation Administration issued a joint approval for that version in December 2018, following a flight-test programme that had begun in March 2017 and spanned more than 500h

ACJ319NEO SETS NEW DISTANCE RECORD

Published on 29 April 2019

Two days after conducting its maiden sortie, the first ACJ319neo set a new record for the longest flight made by an Airbus-crewed A320-series aircraft.

The re-engined VIP narrowbody (MSN8612) flew from Airbus headquarters in Toulouse to northern Greenland and back on 26 April, with the mission lasting 16h 10min.

Airbus describes the sortie as an "endurance flight that included a simulated diversion under 180min [extended twin-engine operations]", for which the A320 family is already certificated.

The previous record was set in 1999, when an Airbus-crewed ACJ319 made a 15h 15min flight from Santiago to Paris.

On the latest trip, the crew were accompanied by Erik Scheidt, chief executive and chief pilot of charter and management firm K5 Aviation, which will take delivery of the CFM Leap-1A-powered aircraft in the coming weeks on behalf of its unnamed owner.

K5 has appointed Dutch maintenance firm Fokker Techniek to outfit the aircraft, which has five extra fuel tanks installed to deliver a range of more than 6,750nm (12,500km); redelivery to K5 is planned for 2020.

"We want to fly customers to their destination using the quickest routes, as well as delivering unsurpassed comfort and service, and it's impressive to see such long-range capability at first hand," says Scheidt.

Airbus says it has orders and commitments for 14 ACJ320neo-family aircraft, which are available with a choice of Leap-1A or Pratt & Whitney PW1100G engines.

The first ACJ320neo, powered by the Leap-1A, was handed over in January to Swiss completion house AMAC Aerospace. Service entry with its UK owner, Acropolis Aviation, is due by the end of the year.

Around 200 Airbus corporate jets are in service worldwide.

P&W'S Q1 DELIVERIES FALL SEQUENTIALLY BUT PROFITS CREEP HIGHER

Published on 23 April 2019

Pratt & Whitney delivered fewer commercial aircraft engines in the first quarter than in any of the last three quarters, but the company's profits inched up amid continued strong demand.

The Connecticut-based engine maker delivered 189 large commercial aircraft engines in the first quarter of 2019, up 52% from the same period last year, P&W parent United Technologies reports on 23 April.

But that is still a low compared to the last three quarters of 2018. For instance, P&W delivered 247 large commercial engines in the fourth quarter of 2018.

UTC does not break out deliveries by engine type, but UTC chief financial officer Akhil Johri says P&W shipped twice as many geared turbofans in the first quarter of 2019 than in the first quarter of 2018.

P&W also continues to reduce its per-engine GTF costs, with the figure expected to decline 15% in 2019, roughly the same as in 2018.

"Costs continue to come down and we are on the right trajectory," says UTC chief executive Greg Hayes during UTC's first quarter earnings call.

"Negative engine margin peaked last year," he adds, noting that P&W is not yet close to breaking even on GTF deliveries.

P&W's GTF engines power new-generation aircraft such as Airbus A320neos and A220s, the Embraer E-Jet E2 and the in-development Mitsubishi MRJ and Irkut MC-21.

P&W also delivered 39 military engines in the first quarter, up 56% year-on-year, and Pratt & Whitney Canada delivered 524 engines, up 4% in one year.

P&W's first quarter operating profit increased 5% year-on-year to $433 million, while sales jumped 11% to $4.8 billion. Sales of products to commercial OEMs jumped 35% year-on-year, while military sales increased 16%.

But P&W's commercial aftermarket sales inched up only 1% year-on-year in the first quarter – less than expected.

Johri attributes aftermarket weakness partly to "engine reinspection requirements at two V2500 MRO providers".

He does not elaborate on those inspections, and P&W did not immediately respond to a request for more information.

Still, UTC expects P&W's full-year 2019 commercial aftermarket sales will increase in the "mid-single digit" range.

"In the second quarter, we expect available capacity in the overall MRO network to mitigate the impact of these temporary delays," Johri says.

HOW MTU ASSEMBLES THE GTF IN MUNICH

Published on 27 February 2019

When MTU established an assembly line for the Pratt & Whitney PW1100G at its Munich headquarters, the German engine manufacturer opted to develop a bespoke production system rather than to copy the US firm's process for building the geared turbofan.

MTU installed the production line for the PW1100G – an option on the Airbus A320neo – within its existing assembly hall, on the second floor of an industrial building previously used to manufacture engines for the Panavia Tornado, Eurofighter Typhoon, Airbus Helicopters Tiger attack rotorcraft and Airbus Defence & Space A400M military airlifter.

Production of the Eurofighter-powering Eurojet EJ200 and MTR390 turboshaft for the Tiger has been transferred to a different site, in Erding, outside Munich. But the A400M's Europrop International TP400 turboprop is still assembled on a line adjacent to that for the PW1100G.

For the geared turbofan, MTU developed a floor-based transport system with remote-controlled carriers to move engines through the different assembly stations.

The engine cores are horizontally assembled on top of the carriers and can be adjusted in height and fully rotated (around the engine's main shaft) for ease of access.

Each carrier consists of two motorised units – supporting the core's fore and aft ends – which are connected by a removable, rigid link.

When the fan module is installed, the front-end carrier will be removed – the core is temporarily supported by a separate stand – and replaced with another carrier fitted with the fan section, in a laser-guided alignment procedure.

The entire engine assembly process is designed to last eight working days, with a target of producing one completed engine every 24h.

MTU says it needed to demonstrate to P&W that the floor-based production system works as reliably as processes employed at the US company's own GTF assembly facilities in Middletown, near Hartford in Connecticut, and West Palm Beach, Florida.

The PW1500G variant for the A220 – the former Bombardier CSeries – is assembled at a Pratt & Whitney Canada facility in Mirabel, near Montreal, while Mitsubishi Heavy Industries Aero Engines produces PW1200Gs in Nagoya for Mitsubishi Aircraft's in-development MRJ.

The series also includes the PW1700G and PW1900G for Embraer's E-Jet E2 family, and the PW1400G as the initial engine on Russia's in-development Irkut MC-21.

MTU's assembly line is focused solely on the PW1100G and represents about a third of GTF output, the company says.

Having delivered about 125 PW1100Gs in 2018, MTU plans to assemble around 200 of the engines this year, and further raise production to 250 in 2020.

TESTING TIMES

Engine-testing capacity is a limiting factor for MTU's production plan: there is only a single test cell at the Munich site capable of handling the PW1100G and each engine must undergo 20-24h of evaluations, according to P&W's specifications.

In comparison, an International Aero Engines V2500, an option on the A320ceo, needs 8-10h of testing, MTU says. Two additional test cells are located at MTU's overhaul shop in Hannover, though availability is dependent on the MRO operation.

P&W's endurance requirements mean that there is little opportunity to trim test-times in the near term, but MTU expects these will become less stringent over time as the engine matures. The manufacturer has no plans to build additional test cell capacity in Munich.

Elsewhere at the Munich plant, a few minutes walk from the assembly hall, MTU is working on new production processes for GTF components and has established an additive manufacturing centre.

The main purpose of the site – comprising nine 3D-printing machines – is to further develop and industrialise the technology for application in the production of engines.

MTU began experimenting with 3D printing in 2010 and today routinely produces borescope eyepieces for PW1100G engines alongside a number of other, non-critical parts as a first step in the industrialisation process.

The eyepieces are being printed through an automated laser-melting process and require about 30h of processing time per 16-unit batch.

MTU acknowledges that relatively high production costs compared with traditional manufacturing techniques have been an obstacle for the adoption of 3D printing.

But the company says it has achieved double-digit savings on the borescope eyepiece and that its current production costs are "very close" to target.

Traditional subtractive production techniques – in this case milling borescope eyepieces from solid nickel-chromium alloy – involve cost penalties due to tool wear and material waste, and MTU is confident that any remaining cost premium for 3D printing will be eradicated in the foreseeable future.

The manufacturer is now in the process of certificating 3D printing for the production of more complex parts, such as compressor seals featuring honeycomb structures.

MTU RAISING PW1100G ENGINE OUTPUT TO 200 THIS YEAR

Published on 21 February 2019

MTU plans to increase output of Pratt & Whitney PW1100G geared turbofans from its Munich plant to around 200 engines over the full course of 2019, and to 250 in 2020.

The manufacturer assembles the PW1100G – an option on the Airbus A320neo family – in the German city and is responsible for around one-third of deliveries.

Speaking at a results briefing on 20 February, MTU chief executive Reiner Winkler acknowledged that GTF production was interrupted in early 2018, which led to an eight-week suspension of deliveries of PW1100G-powered A320neo-family jets. MTU delivered 125 PW1100Gs in 2018.

But Winkler says that despite the delays, P&W met "all milestones" against Airbus's 2018 delivery plan.

Meanwhile, P&W's total output of PW1000G-series engines last year, including those for the A220 and Embraer E190-E2, "nearly doubled" versus 2017, he notes.

MTU as a routine assembles PW1100G engines five days per week, across two shifts per day.

However, the company has arrangements to extend regular 7h shifts to 10h and add a sixth working day, which together will increase capacity by 72%.

That option was used in 2018 to mitigate the delivery delays earlier that year.

P&W has two assembly lines for the PW1100G, both in the USA: one in Middletown, near Hartford in Connecticut; and the other in West Palm Beach, Florida.

Each facility accounts for 35% of the output, while MTU's Munich site is responsible for the remainder.

Winkler says MTU is ready to "support" Airbus's target of raising production of A320neo-family jets to 63 aircraft per month in 2021.

This article has been updated to clarify that there are two P&W assembly lines of the PW1100G, rather than the PW1000G series

INDIGO'S PW1100G ENGINES 'WELL WITHIN SAFETY LIMITS': AIRLINE

Published on 23 January 2019

Modifications to the Pratt & Whitney PW1100G geared turbofan engines that power IndiGo's Airbus A320neo aircraft are under way, the Indian low-cost carrier has confirmed.

In an earnings call, chief operating officer Wolfgang Prock-Schauer said the airline had received safety clearance from the US Federal Aviation Administration to continue operating the engines and that they were "well within the [safety] limits".

He reveals that for IndiGo's PW1100Gs, in-flight engine shutdowns were occurring at a rate of 0.02, as compared with the FAA's limit of 0.05.

"The situation is completely under control," says Prock-Schauer.

His comments follow a directive issued by India's Directorate General of Civil Aviation on 17 January to IndiGo and GoAir, instructing them to conduct a series of inspections on the engines to identify and correct potential low-pressure turbine (LPT) and dry face seal failures.

The airlines have also been mandated to carry out weekly inspections of third-stage LPT blades and to conduct borescope inspections on the Number 3 bearing front and aft carbon seal.

Prock-Schauer meanwhile adds that IndiGo only has one A320neo grounded as of 23 January.

As part of the DGCA's directive, IndiGo and GoAir have been barred from operating flights to Port Blair, but Prock-Schauer does not expect any more restrictions. IndiGo will rely on its ETOPS-certificated aircraft for longer-range flights, in particular its A321neos.

IndiGo expects to induct "a large number" of A321neos in fiscal 2020. They will be used on domestic trunk routes as well as for international services.

The carrier expects the A321neo to bring a 10% decrease in seat-mile costs on key routes such as between Delhi and Mumbai.

Flight Fleets Analyzer shows that IndiGo operates 67 A320neo-family aircraft. It has 364 of the re-engined narrowbodies on order, of which 150 are A321neos.

EASA DETAILS TRENT 1000 TEN BLADE INSPECTION REGIME

Published on 10 April 2019

Operators of Boeing 787s with Rolls-Royce Trent 1000 TEN engines will be instructed to de-pair powerplants with a certain number of combined cycles, and conduct repetitive inspections of the engines to check for cracks in high-pressure turbine blades.

The European Union Aviation Safety Agency has detailed an inspection regime for the engines, the latest variant of the Trent 1000.

Affected parts, it says, could deteriorate despite being subject to the manufacturer's published recommendations and life limits.

EASA has warned that this could result in blade failure and in-flight shutdown.

Rolls-Royce has developed instructions to de-pair specific engine combinations and has determined flight-cycle limits for a single affected engine.

EASA's directive states that engines with fewer than 625 cycles must be inspected before reaching 650 cycles, while engines with more than 625 cycles must be inspected within 25 cycles.

Repetitive inspections must then take place at intervals of no more than 50 cycles. This interval must be trimmed to 25 cycles once the engine reaches 725 cycles.

Engines which have reached 1,000 cycles must not be used, says EASA, nor must pairs of engines be used if they have more than 1,400 cycles combined.

EASA is inviting comments on the proposed directive until 24 April.

Rolls-Royce

EASA TO ORDER TRENT 1000 TEN CHECKS OVER BLADE DETERIORATION

Published on 10 April 2019

Rolls-Royce is to advise Boeing 787 customers of an accelerated inspection regime for Trent 1000 TEN engines, after the discovery of premature blade deterioration on some powerplants.

The Trent 1000 TEN is the latest version of the powerplant – with around 180 in service – and had not been affected by durability concerns on earlier variants of the engine.

But Singapore Airlines recently withdrew some of its TEN-powered Boeing 787-10s from service for checks on high-pressure turbine blades.

Rolls-Royce says it is responding to the "earlier than anticipated" deterioration of high-pressure turbine blades in a "small population" of the TEN engine, and has agreed an inspection regime with airworthiness authorities.

It has already advised airlines that the blades would have a limited life cycle, and the company is testing an enhanced version of the blade which will be introduced to the fleet in early 2020.

The European Union Aviation Safety Agency is to detail the agreed inspection programme, based on a service bulletin, in an airworthiness directive.

"This new accelerated inspection regime is designed to allow us to confirm the health of the Trent 1000 TEN fleet over the next few months," says Rolls-Royce.

The manufacturer states that it has examined a number of TEN engines which have logged a higher frequency of flights at the "upper end" of the powerplant's operating range.

"A small number of these engines have needed to have their [high-pressure turbine] blades replaced earlier than scheduled," the company acknowledges.

It adds that the inspections will "improve our understanding" of the deterioration phenomenon, pointing out that it is a "known issue" but is "occurring faster than we expected in some engines".

"We sincerely regret the disruption this accelerated inspection regime will cause and we are doing everything we can to support our customers," says Rolls-Royce civil aerospace president Chris Cholerton.

The company's financial guidance on the in-service cash costs of the Trent 1000 for 2019 and 2020 is unchanged.

Rolls-Royce stresses that the inspections for the TEN are not related to the durability issues which have affected its earlier Package B and C versions of the Trent 1000, which the company is already working to address.

Monitoring of the Package B and C engines has turned up a number of durability issues, including sulphidation on intermediate-pressure turbine blades caused by air pollutants.

This led Rolls-Royce to develop a new blade design with an improved protective coating.

But the company also found durability issues with high-pressure turbine blades, and a new design emerged in October last year to rectify the problem.

Improvements were also necessary for intermediate-pressure compressor rotor blades which were vulnerable to possible cracking under certain vibration conditions. Rolls-Royce says a redesigned compressor blade is starting to be installed following approval.

Rolls-Royce says it expects the number of aircraft affected by the Package B and C inspection and maintenance programmes to reduce gradually over the course of this year.

TWO SIA 787S GROUNDED OWING TO TRENT 1000 TEN HPT ISSUE

Published on 2 April 2019

Singapore Airlines has grounded a pair of Boeing 787-10s owing to premature deterioration of the high pressure turbine (HPT) blades in their Rolls-Royce Trent 1000 TEN engines.

"During recent routine inspections of Rolls-Royce Trent 1000 TEN engines on Singapore Airlines' Boeing 787-10 fleet, premature blade deterioration was found on some engines," the airline states.

The blades that suffered deterioration were in the engine's HPT section.

The carrier, working with R-R, identified other aircraft for precautionary inspections.

"All of these engine inspections on SIA's 787-10 fleet have now been completed, and a remaining check will be completed on a Scoot 787-9 by 3 April," it says. "Pending engine replacements, two SIA 787-10 aircraft have been removed from service."

Cirium's Fleets Analyzer shows that SIA operates nine 787-10s with an average age of just one year. The only other Trent-powered 787-10 is a single example delivered recently to All Nippon Airways. The other 12 787-10s in service - including one operated by Boeing - are powered by General Electric GEnx-1Bs.

SIA confirms that the two grounded aircraft bear the registration numbers 9V-SCB and 9V-SCF. Both were delivered last year: 9V-SCB was delivered on 2 April 2018 and 9V-SCF on 26 June 2018.

Previous iterations of the Trent 1000 suffered durability issues with their intermediate pressure compressor blades, requiring redesign work.

In response to an query from FlightGlobal, the engine maker said that it has told operators that HPT blades in Trent 1000 TEN engines would have a limited life cycle, and that it has sampled a "small population" of the engine fleet that has "flown in more arduous conditions."

R-R adds that it is working on a fix for the wear issue.

"This work has shown that a small number of these engines need to have their blades replaced earlier than scheduled. In anticipation of limited turbine blade life, our engineers have already developed and are testing an enhanced version of this blade," it adds.

Globally, 295 787s of all variants are powered by Trent 1000s. Of these, 70 have Trent 1000 TEN engines.

ROLLS-ROYCE WILL NOT 'WASTE' MORE TIME ON BREXIT: CHIEF

Published on 1 March 2019

UK engine maker Rolls-Royce has "wasted" enough resources on Brexit preparations in drawing up contingencies for a potential no-deal departure from the EU, in the view of chief executive Warren East.

"Brexit has wasted a huge amount of a lot of people's time over the last several months. And it is not going to waste any more of our time," East said during a financial results briefing on 28 February.

He says R-R spent a "long time" making no-deal preparations and that the company is now as "ready as we can be" for such a scenario.

"Obviously, we have to operate our business on 30 March [the day after the UK's scheduled departure date] whatever happens," he says.

R-R has built up "necessary" buffer inventories to ensure material supplies in the event of customs-related hold-ups, and transferred job functions – albeit no actual jobs – relating to regulatory approvals over to its German site at Dahlewitz, near Berlin.

In 2018, R-R disclosed that it was considering a move of its design approval processes for large engines from its Derby headquarters to Dahlewitz in order to keep regulatory activities within the jurisdiction of the European Aviation Safety Agency.

East notes, however, that there remain risks arising from the Brexit preparations of R-R's suppliers.

"We have spent a lot of time making sure that we have asked our suppliers and challenged their answers. But at the end of the day, one of those engines takes an awful lot of parts, and it takes one of those parts not to be there for the engine not to [be delivered]," he says.

Meanwhile, East expresses confidence that flight disruptions between the UK and EU as a result of Brexit would not materially affect R-R's business.

Since the manufacturer produces engines for long-haul aircraft, and intra-European air traffic is typically operated with narrowbody types, R-R is "not exposed to that risk", he says.

International Aero Engines V2500s – which power a proportion of the Airbus A320ceo fleet – generate a "relatively small part" of R-R's aftermarket support business, East says.

ROLLS-ROYCE PULLS OUT OF BOEING NMA ENGINE CONTEST

Published on 28 February 2019

Rolls-Royce has pulled out of the competition to develop an engine for Boeing's proposed New Mid-market Airplane.

The UK engine manufacturer says it is "unable to commit" to the required timetable and ensure that it has a "sufficiently mature" powerplant for the aircraft.

Rolls-Royce points out that it believes the NMA "complements" the Boeing product range.

But the manufacturer says it would want to have a mature product at entry into service, one which satisfies its own technical maturity criteria.

"This is the right decision for Rolls-Royce and the best approach for Boeing," insists civil aerospace president Chris Cholerton.

"Delivering on our promises to customers is vital to us and we do not want to promise to support Boeing's new platform if we do not have every confidence that we can deliver to their schedule."

Rolls-Royce adds that it has made a "clear commitment" to its customers to deliver on the company's current engine programmes, among them the Trent XWB, Trent 7000 and Trent 1000-TEN.

"We remain committed to the development of new technologies and will continue to mature and de-risk our next generation UltraFan engine architecture in preparation for future applications," says Cholerton.

"UltraFan is the foundation of our future large civil aero engine programmes and we must ensure that it has as smooth an entry into service as possible.

"We had begun its development before the Boeing opportunity emerged and it must undergo a rigorous testing regime before we offer it to customers, which we do not believe can be achieved within the NMA timeframe."

He adds that withdrawing from the NMA competition will enable Boeing to structure the final phase of the contest in a way which "best suits" the US airframer's needs.

"We hope and expect to work with Boeing on other new opportunities in the future," says Cholerton.

ROLLS-ROYCE 'OPEN' TO POTENTIAL PARTNERSHIP ON NMA ENGINE: CHIEF

Published on 28 February 2019

Rolls-Royce is not ruling out the possibility that it might partner with another engine manufacturer to power Boeing's New Mid-market Airplane.

The UK manufacturer disclosed today that it had withdrawn from the competition to develop a version of its UltraFan future engine for the proposed aircraft.

Alluding to in-service issues with the Trent 1000 engine, chief executive Warren East said during a financial results briefing that the manufacturer had learned from "bitter experience" that a newly developed engine needed "a certain level of maturity" before employment on an aircraft programme.

As there is "not sufficient overlap" between R-R's existing UltraFan programme and Boeing's NMA specifications, it would not be feasible to develop a new engine with sufficient maturity within the US airframer's timeframe, East says.

However, he says that R-R could become interested in a co-operation with another manufacturer to supply an NMA powerplant, if such an opportunity arose.

This would depend on which manufacturer was selected and whether that company and R-R then saw any merit in a potential partnership.

"We have see what happens," East cautions. But he says: "Of course, we are open."

Boeing has previously said it received NMA engine proposals from GE Aviation, Pratt & Whitney and R-R.

ROLLS-ROYCE FORESEES BROAD APPLICATIONS FOR ULTRAFAN

Published on 1 March 2019

Rolls-Royce sees a range of potential applications for its UltraFan future engine programme, despite the UK manufacturer's withdrawal of its bid to power Boeing's proposed New Mid-market Airplane.

Speaking during a financial results briefing on 28 February, R-R chief executive Warren East acknowledged that GE Aviation had become a dominant engine supplier to Boeing, while R-R had moved into a similar position on Airbus long-haul aircraft.

He says, however, that R-R has no intention to further "accentuate" that situation.

GE is the sole engine supplier for the Boeing 777, 747-8 and in-development 777X, and currently provides the majority of engines for the 787 – the only in-production Boeing type on which an engine manufactured by R-R is offered as an option.

All 737s since the Classic generation have been powered by engines from CFM International, a manufacturer jointly owned by GE and Safran.

R-R, for its part, is Airbus's sole engine supplier for the A350 and A330neo, and will provide its Trent 900 engine for remaining A380 orders.

East says the UltraFan programme – which involves a new engine core and geared fan architecture – is scalable to provide 25,000-100,000lb-plus (111kN-446kN) of thrust, making it suitable to power single-aisle and long-haul aircraft.

The first opportunity to provide an UltraFan variant will probably be on a long-haul aircraft, with the A350 being a likely candidate for a potential re-engining effort, East says.

But he asserts that R-R has a "very rich and very healthy" relationship with Boeing, and that he is "quite optimistic" that UltraFan will find application with both the US airframer and Airbus.

East says that while participation in the NMA programme would have been "very good" for R-R, the UK manufacturer considered it unfeasible to develop an UltraFan derivative with sufficient maturity within Boeing's timeframe.

ROLLS-ROYCE SETS TARGET FOR REDUCTION IN TRENT 1000-RELATED AOGS

Published on 28 February 2019

Rolls-Royce chief executive Warren East is hopeful that the number of Boeing 787s grounded as a result of Trent 1000 issues can be cut from 35 today to 10 by year-end.

He notes that a number of Package C engines are now flying with a redesigned intermediate-pressure compressor blade certificated by the US Federal Aviation Administration and European Aviation Safety Agency in December 2018.

While most of the engines affected by the Trent 1000 durability issues are of the Package C variant, East says redesigned IPC blades for the Trent 1000-TEN and Package B are now in the approval process and should be certificated in the third and fourth quarter, respectively. Meanwhile, a hard-life limit for affected -TEN parts has been removed in favour of an inspection regime.

East acknowledges that R-R's share of in-service and on-order 787s has declined in the wake of the Trent 1000 issues. Dreamliner operators have a choice between the Trent 1000 and GE Aviation's GEnx engine, and while R-R had hoped that the 787 orderbook would develop toward an equal split between the two engine suppliers, the UK manufacturer's share now stands at 35%, East says.

He acknowledges that several sales campaigns during the first half of 2018 "didn't go our way", and says GE Aviation "utilised" the situation in a "very aggressive" manner. But he is sanguine about this: "Wouldn't you?"

Despite the operational disruptions for affected airlines, East describes the Trent 1000 as a "very reliable" engine and says operators are able to "partition in their mind" between the powerplant's in-service performance and maintenance issues.

He expresses confidence that R-R can secure further Trent 1000 orders in future, and that the blade durability issues have been resolved.

The situation with the engine type was, East says, "very unusual" in that it involved multiple issues in the compressor and turbine sections, and several versions had entered service. In reference to the latest version, the -TEN, he says: "We are confident that we have solved the fundamental turbomachinery issues that caused all the hiatus in 2018."

Rolls-Royce has "thoroughly" tested its redesigned blades in a process "cross-examined" by Boeing, East points out. Meanwhile, airworthiness authorities were convinced "not only in terms of certification of the redesigned part, but very thorough analysis of the failure mechanism", he stresses.

"The best brains in the world on this [matter] have spent the last six months on this," says East. "That is confident as we can be."

ROLLS-ROYCE TAKES NEAR-$250M CHARGE AFTER AIRBUS'S A380 DECISION

Published on 28 February 2019

Rolls-Royce has in its full-year results for 2018 recorded an exceptional item of £186 million ($247 million) relating to Airbus's decision to end production of the A380, for which the Trent 900 was a power option.

The charge reflects "onerous contracts, tooling write-offs and the acceleration of depreciation and amortisation on associated Trent 900 programme assets", says the engine maker.

Its civil aerospace division incurred a £162 million loss last year, halving 2017's £343 million reverse, on revenue up 12% at £7.38 billion, driven by improved widebody engine pricing and higher sales volumes of spare engines.

Deliveries of 686 engines last year represent an increase of three units from 2017. Rolls-Royce says it invoiced for 469 large engines in 2018, and that an additional 11 were shipped to OEMs. It cites "good progress" in reducing large-engine losses, noting that these have fallen to £1.4 million per engine.

The same phrase, "good progress", is used in reference to technical fixes for the Trent 1000. The Rolls-Royce highlights the certification gained for a newly designed Package C compressor blade and the commencement of its roll-out, and the shift of the Trent 1000-TEN from a hard-life to a "less onerous" inspection regime.

Still, the Trent 1000 exceptional charge has increased from £544 million at the half-year stage to £790 million. Rolls-Royce says this reflects a greater-than-anticipated contribution to customer disruption costs.

AOGs "remained at a high level" in 2018's second half, the engine maker admits, citing 34 aircraft on the ground at year-end, up from 18 at the same point in 2017.

Cash costs of £431 million were incurred by the civil aerospace division in 2018. Rolls-Royce expects the Trent 1000's cash impact to be around £450 million in 2019, before declining by at least £100 million in 2020 and "materially thereafter".

The civil aerospace division's negative contract accounting adjustments last year rose by £127 million to £276 million, of which £234 million reflects "the latest information around future aircraft utilisation patterns and the resultant effects on shop-visit cost". Here, there is "a particular impact from mature programmes" on which small changes can have a significant impact on a contract's already-recognised profitability, says Rolls-Royce.

It acknowledges that 2018 was, overall, a "relatively quiet year for orders", but adds: "We expect this to pick up in the next few years driven by replacement cycles of both medium and large widebody aircraft."

ROLLS-ROYCE TESTS COMPOSITE FAN IN DERBY

Published on 25 February 2019

Rolls-Royce has started ground tests of a composite fan system for its UltraFan future engine programme.

The UK manufacturer says that the trial began earlier this month in Derby and is scheduled to continue through March.

Tests will include fan blade tip clearance measurements, engine trials with damaged blades to assess performance after a potential bird strike, and fan flutter behaviour.

While R-R tested carbon-titanium (CTi) fan blades on its Boeing 747 flying testbed in 2014 and during cold-weather rig trials in Canada, the current ground tests for the first time cover an entire composite fan assembly – dubbed "Advanced Low-Pressure System (ALPS) – comprising blades, a fan case and annulus fillers.

R-R previously said that it will use a Trent 1000 – an option for the Boeing 787 – as a donor engine for the trial.

The fan components were manufactured using fully automated construction methods at the manufacturer's dedicated composites technology centre.

Each fan blade consists of around 500 carbon-fibre layers and is fitted with a titanium leading edge to provide "extreme protection" against bird strikes or other foreign object damage.

R-R says that it is producing for each blade a digital twin with data from the tests and that the virtual model will enable engineers to predict in-service performance of individual blades in future.

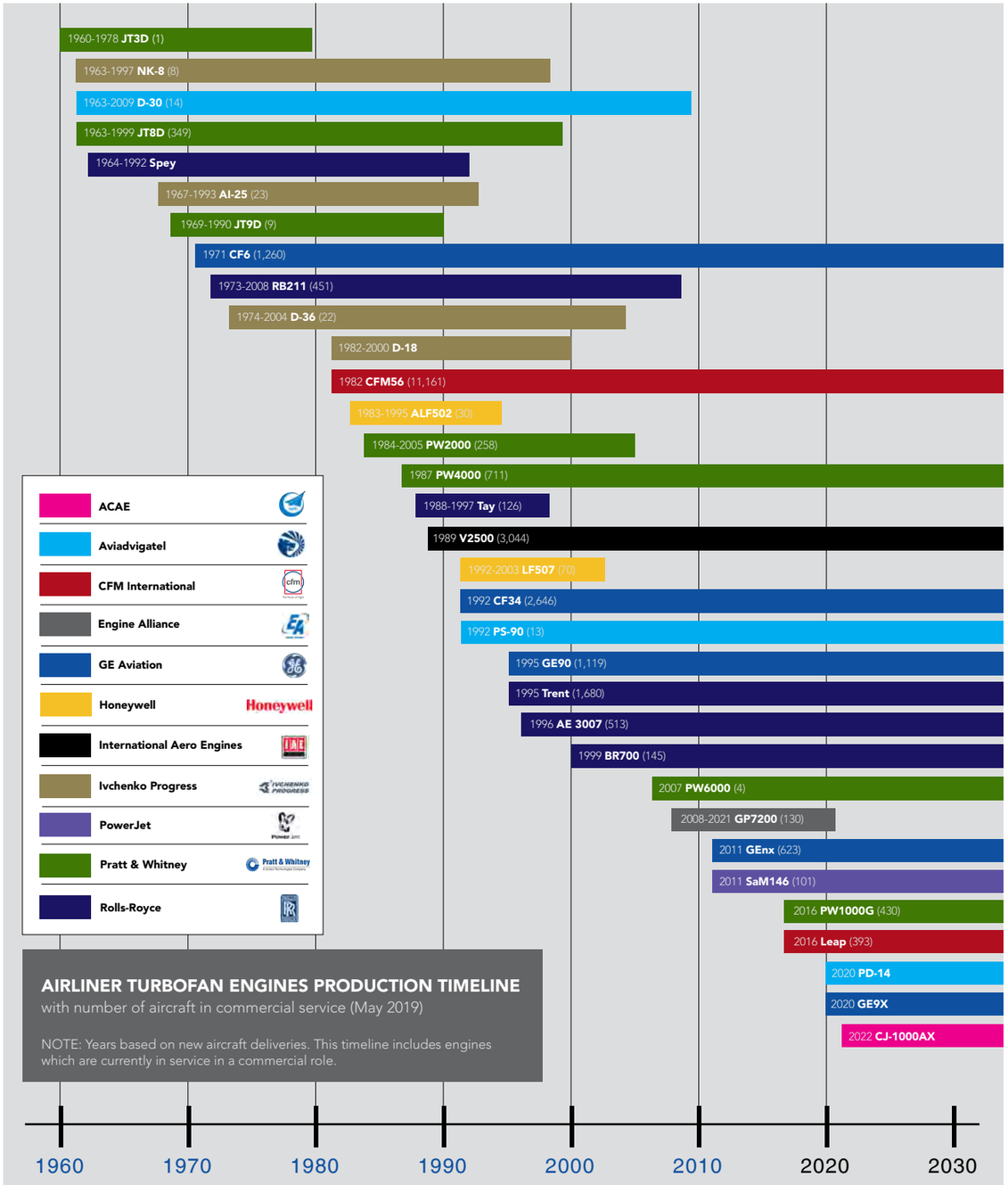
The manufacturer's chief engineer civil aerospace demonstrator programmes, Ash Owen, states that more than a decade of research and development has been invested in the ALPS technology and that the ground trial will bring the team "one step closer" to testing a complete UltraFan demonstrator engine.

R-R previously said that ground trials of the fully integrated demonstrator engine are set to begin in 2021.

The manufacturer had planned to start the ALPS ground tests in 2018. But the trial was delayed as a result of limited test cell capacity in Derby.

Rolls-Royce

TURBOFAN ENGINES: PRODUCTION TIMELINE



ENGINE OPTIONS BY COMMERCIAL AIRCRAFT

Aircraft type	No of engines	Engine option 1	Engine option 2	Engine option 3
AIRBUS				
A220	2	PW1000G		
A300*	2	CF6	PW4000	JT9D
A330neo	2	Trent 7000		
A310*	2	CF6	PW4000	JT9D
A318	2	CFM56-5B	PW6000	
A319/A320/A321	2	CFM56-5B	V2500	
A319neo/A320neo/A321neo	2	Leap	PW1100G	
A330	2	CF6	PW4000	Trent 700
A330neo	2	Trent 7000		
A340-200/300*	4	CFM56-5B		
A340-500/600*	4	Trent 500		
A350	2	Trent XWB		
A380	4	GP7200	Trent 900	
ANTONOV				
An-72	2	D-36		
An-74	2	D-36		
An-124	4	D-18		
An-148	2	D-436		
An-158	2	D-436		
An-225	6	D-18		
BAR SYSTEMS				
BAe 146*	4	ALF502	LF507	
Avro RJ*	4	LF507		
BOEING				
717*	2	BR700		
727*	3	JT8D	Tay	
737-200*	2	JT8D		
737-300/400/500*	2	CFM56-3B		
737NG (-600/700/800/900)	2	CFM56-7B		
737 Max (-7/8/9)	2	Leap		
747-100/SP*	4	JT9D	RB211	
747-200/300*	4	CF6	JT9D	RB211
747-400*	4	CF6	PW4000	RB211
747-8	4	GEnx-2B		
757*	2	RB211	PW2000	
767-200/300*	2	CF6	PW4000	JT9D
767-200ER/400ER*	2	CF6	PW4000	
767-300ER/300F	2	CF6	PW4000	RB211
777-200/200ER/300	2	GE90	PW4000	Trent 800
777-200LR/300ER/F	2	GE90		
777-8X/9X	2	GE9X		
787 Dreamliner	2	GEnx-1B	Trent 1000	
DC-8*	4	JT3D	JT4A	
DC-9*	2	JT8D		
DC-10*	3	CF6	JT9D	
MD-11*	3	CF6	PW4000	
MD-80*	2	JT8D		
MD-90*	2	V2500		

Aircraft type	No of engines	Engine option 1	Engine option 2	Engine option 3
BOMBARDIER				
CRJ (all variants)	2	CF34-8		
COMAC				
C919	2	Leap-1C	CJ-1000AX	
ARJ21	2	CF34-10		
EMBRAER				
E-170/175/190/195	2	CF34		
ERJ 145 family	2	AE 3007		
E-Jet E2 family	2	PW1700G/PW1900G		
FAIRCHILD DORNIER				
328JET*	2	PW300		
FOKKER				
F28*	2	Spey		
Fokker 70/100*	2	Tay		
ILYUSHIN				
Il-62*	4	D-30		
Il-76*	4	D-30	PS-90	
Il-96*	4	PS-90	PW2000	
IRKUT				
MC-21	2	PW1400G	PD-14	
LOCKHEED				
L-1011*	3	RB211		
MITSUBISHI				
MRJ70/90	2	PW1200G		
SUKHOI				
Superjet 100	2	SaM146		
TUPOLEV				
Tu-134*	2	D-30		
Tu-154*	3	D-30	NK-8	
Tu-204	2	PS-90	RB211	
YAKOVLEV				
Yak-40*	3	AI-25		
Yak-42*	3	D-36		

NOTE: Aircraft listed are narrowbody, widebody and regional jets currently in service and/or in development, in a commercial role. * Aircraft no longer in production

COMMERCIAL AIRCRAFT BY ENGINE TYPE

Engine type	Aircraft type
Aviadvigatel	
D-30	Il-62*, Il-76*, Tu-134*, Tu-154*
PS-90	Il-76*, Il-96*, Tu-204
PD-14	MC-21
CFM International	
CFM56	A320 family, A340*, 737 family, DC-8*
Leap	A320neo family, 737 Max, C919
Engine Alliance	
GP7200	A380
GE Aviation	
CF6	A300*, A310*, A330, 747, 767, DC-10*, MD-11*
CF34	ARJ21, CRJ, E-Jet
GE90	777
GEnx	747-8, 787
GE9X	777-8X/9X
Honeywell	
ALF502	BAe 146*
LF507	Avro RJ*, BAe 146*
International Aero Engines	
V2500	A319, A320, A321, MD-90*
Ivchenko Progress	
NK-8	Tu-154*
AI-25	Yak-40*
D-36	An-72, An-74, Yak-42*
D-18	An-124, An-225*
D-436	An-148, An-158

Engine type	Aircraft type
PowerJet	
SaM146	Superjet 100
Pratt & Whitney	
JT3D	DC-8*
JT8D	727*, 737-100/200*, DC-9*, MD-80*
JT9D	A310*, 747, 767
PW2000	757*
PW4000	A300*, A310*, A330, 747, 767, 777, MD-11*
PW6000	A318
PW1000G	A220, A320neo family, MRJ, MC-21, E-Jet E2
Pratt & Whitney Canada	
PW300	328JET*
Rolls-Royce	
Spey	F28*
RB211	747, 757*, 767, Tu-204
Tay	Fokker 70/100*
BR700	717*
Trent	A330, A330neo, A340*, A350, A380, 777, 787
AE3007	ERJ-145 family

NOTE: Aircraft listed are narrowbody, widebody and regional jets currently in service and/or in development, in a commercial role. * Aircraft no longer in production

ENGINE CENSUS

Operator listing by commercial engine type

EXPLANATORY NOTES

This census data covers all engines powering commercial jet aircraft in service or on firm order with commercial operations worldwide.

The information has been compiled using Flight Fleets Analyzer.

The information is correct up to 1 May 2019 and excludes non-commercial companies, such as business and military operators.

Engines are listed in alphabetical order, first by manufacturer and then type. The figures are for fitted engines only and don't include spares.

Operators are listed by region. Fleet data comprises the number of installed engines on the in-service fleet and, where applicable, the number of installed engines for the outstanding firm aircraft orders in parentheses in the right-hand column. The census does not include any parked aircraft/engines at the time of the data extraction.

The region is listed by operator base and does not necessarily indicate the area of operation. Options and letters of intent (where a firm contract has not been signed) are not included. Orders by leasing companies have been included where end-user is unknown.

Operators' fleets include leased aircraft/engines. Aircraft/engines being operated on wet-lease are generally listed with the company for which they are being operated, and not the airline flying the aircraft on their behalf.

The outstanding firm orders information also includes airline holding companies.

AVIADVIGATEL D-30	TOTAL 41
Asia-Pacific	**Total 16**
Air Koryo	12
Manas Airways	4
Europe	**Total 23**
223rd State Airline Flight Unit	8
ALROSA Air Company	5
Kosmos Airlines	6
Rada Airlines	4
Middle East	**Total 2**
Syrianair	2

AVIADVIGATEL PD-14	TOTAL (28)
Europe	**Total (28)**
IrAero	(20)
Red Wings Airlines	(8)

AVIADVIGATEL PS-90	TOTAL 34
Asia-Pacific	**Total 4**
Air Koryo	4
Europe	**Total 22**
Aviastar-TU	8
Rossiya Special Flight Detachment	14
Latin America	**Total 8**
Cubana	8

CFM INTERNATIONAL CFM56	TOTAL 22,494 (266)
Africa	**Total 860**
Aero Contractors	8
Africa Charter Airline	6
Afriqiyah Airways	12
Air Algerie	64
Air Arabia Egypt	6
Air Arabia Maroc	20
Air Austral	4
Air Cairo	14
Air Cote D'Ivoire	10
Air Ghana	4
Air Madagascar	10
Air Mauritius	16
Air Namibia	6
Air Peace	26
Air Senegal	4
Alexandria Airlines	2
Allied Air Cargo	6
Almasria Universal Airlines	2
AMC Airlines	8
Arik Air	12
ASKY	12
Azman Air	6
BADR Airlines	6
Buraq Air	6
CAA - Compagnie Africaine d'Aviation	2
Camair-Co	4
CEIBA Intercontinental	6
Comair (South Africa)	32
Congo Airways	4
Egyptair	58
Eritrean Airlines	2
Ethiopian Airlines	42
Express Air Cargo	6
Fly Mid Africa	2
flyEgypt	14
Gomair	4
Green Flag Aviation	2
Kenya Airways	24
Kulula	20
Libyan Airlines	6
Libyan Wings	4
Linhas Aereas de Mocambique	6
Malawian Airlines	2
Mango	30
Mauritania Airlines	8
MaxAir	6
Med View Airlines	2
Nile Air	2
Nouvelair	16
Nova Airways	2
Rahila Air	2
Royal Air Maroc	80
RwandAir	12
Safair	34
Serve Air	2
SkyAir corp	2
SonAir	4
South African Airways	38
Star Air	10
Sudan Airways	4
TAAG Angola Airlines	10
Tarco Aviation	10
Tassili Airlines	14
Trans Air Cargo Services	4
Trans Air Congo	10
Tsaradia	2
Tunisair	46
Asia Pacific	**Total 7,714 (42)**
9 Air	34
Aero K	(6)
Air Changan	22
Air China	418
Air China Inner Mongolia	12
Air Do	18
Air Guilin	10
Air Incheon	2
Air India	96
Air India Express	50
Air Kyrgyzstan	2
Air Manas	2
Air Niugini	4
Air Tahiti Nui	12
Air Travel	18
Air Vanuatu	2
AirAsia	138 (4)
AirAsia (India)	40
AirAsia Japan	6
Airblue	14
Airwork (NZ)	18
ANA Wings	14
ANA-All Nippon Airways	110
Ariana Afghan Airlines	6
Asia Cargo Express	6
Avia Traffic Company	8
Bamboo Airways	6
Bassaka Air	4
Batik Air	114
Beijing Airlines	6
Bhutan Airlines	4
Biman Bangladesh Airlines	8
Cambodia Airways	6
Capital Airlines	36
Cardig Air	2
Cebu Pacific Air	80
Chengdu Airlines	64 (2)
China Airlines	36
China Eastern Airlines	370 (2)
China Eastern Airlines Guangdong	16
China Eastern Airlines Jiangsu	66
China Eastern Airlines Wuhan	64
China Eastern Yunnan	148
China Express Airlines	18
China Postal Airlines	42
China Southern Airlines	540
China United Airlines	98 (12)
China Xinhua Airlines	10
Chongqing Airlines	8
Citilink Indonesia	76
Dalian Airlines	24
Donghai Airlines	46
Druk Air	6
Eastar Jet	36
EVA Air	44
Express Air	10
Express Freighters Australia	10
Eznis Airways	2
Fiji Airways	10
Fuzhou Airlines	32
Garuda Indonesia	146
GoAir	36
Grand China Air	4
GX Airlines	14
Hainan Airlines	304
Hebei Airlines	44
Himalaya Airlines	6
Hong Kong Airlines	22 (2)
IndiGo	26
Indonesia AirAsia	48
Japan Airlines	100
Japan TransOcean Air	28
JC International Airlines	10
Jeju Air	82
Jiangxi Air	20
Jin Air	44
Joy Air	2
Juneyao Air	102
Kam Air	20
K-Mile Air	6
Korean Air	64
Kunming Airlines	50
Lao Airlines	8
Lion Air	204
Longhao Airlines	12
LongJiang Airlines	4
Loong Air	62
Lucky Air	88
Malaysia Airlines	96
Maldivian	4
Malindo Air	60
Mandarin Airlines	2
MIAT - Mongolian Airlines	8
My Indo Airlines	4
MY Jet Xpress	4
Myanmar Airways International	6
Myanmar National Airlines	8
Nam Air	22
Nauru Airlines	10
NewGen Airways	6
Nok Air	30
Okay Airways	50
Pakistan International Airlines	22
PAL Express	18
Peach	50 (6)
Philippine Airlines	20
Philippines AirAsia	46
Qantas	150
Qingdao Airlines	28
Raya Airways	2
Regent Airways	8
Ruili Airlines	38
SCAT	16
Serene Air	6
SF Airlines	34
Shandong Airlines	234
Shanghai Airlines	174
Shenzhen Airlines	260
Sichuan Airlines	64
SilkAir	34
Sky Angkor Airlines	4
Skymark Airlines	54 (4)
Solaseed Air	26
Solomon Airlines	2
Somon Air	12
SpiceJet	72
Spring Airlines	160
Spring Airlines Japan	12
SriLankan Airlines	6
Sriwijaya Air	74
Star Flyer	24 (2)
Suparna Airlines	44
Thai AirAsia	102
Thai Lion Air	56
Thai VietJet Air	16
Tianjin Air Cargo	2
Tianjin Airlines	20
Tibet Airlines	54 (2)
Tigerair Australia	10
Tri MG Airlines	4
Trigana Air	10
Turkmenistan Airlines	22
T'way Air	52
UNI Air	4
Urumqi Air	32
US-Bangla Airlines	6
Uzbekistan Airways	18
Vanilla Air	26
VietJet Air	112
Virgin Australia	128
Virgin Australia International	32
Vision Air International	6
West Air (China)	30
Xiamen Airlines	290
YTO Cargo Airlines	14
Zhuhai Airlines	4
Europe	**Total 6,566 (48)**
4You Airlines	2
Adria Airways	2
Aer Lingus	74
Aeroflot Russian Airlines	324
Aigle Azur	18
Air Belgium	4
Air Bucharest	2
Air Corsica	12
Air Europa	42
Air France	212
Air Horizont	6
Air Italy	14
Air Malta	18
Air Mediterranean	4
Air Moldova	8
Air X Charter	2
airBaltic	16
AirExplore	2
Alba Star	10
ALBAWINGS	6
Alitalia	142
ALK Airlines	4
ALROSA Air Company	10
Anadolu Jet	68
Anda Air	2
Armenia	2
ASL Airlines Belgium	52
ASL Airlines France	34
ASL Airlines Hungary	4
ASL Airlines Ireland	16
Atlantic Airways (Faroe Islands)	6
Atlasglobal	10
Atlasglobal Ukraine	2
Atran	10
Aurora	20
Austrian	70
Aviolet	4
Avion Express	6
Azerbaijan Airlines	18
Azores Airlines	6
Azur Air Russia	12
Azur Air Ukraine	6
Belavia	34
Blue Air	44
Blue Bird Airways	6
Blue Panorama Airlines	12
Bluebird Nordic	14
Bravo Airways	4
British Airways	6
Brussels Airlines	88
Bul Air	2
Bulgaria Air	8
Buzz	46

Cargo Air	16
CargoLogic Germany	2
Condor	34
Corendon Airlines	24
Corendon Airlines Europe	8
Corendon Dutch Airlines	4
Croatia Airlines	12
Cyprus Airways	4
Czech Airlines	2
Dream Wind	2
EasyJet	260
EasyJet Europe	272
EasyJet Switzerland	56
Edelweiss Air	36
Ellinair	8
Enter Air	44
Ernest Airlines	8
European Air Transport	12
Eurowings	146
Eurowings Europe	22
Evelop Airlines	2
Finnair	50
FlyBosnia	2
FlyOne	2
Freebird Airlines	4
Freebird Airlines Europe	2
Gazpromavia	4
Georgian Airways	4
Germania Flug	6
Germanwings	14
GetJet Airlines	10
Globus	42
Grand Cru Airlines	2
Hamburg International	(4)
Hi Fly	4
Hi Fly Malta	12
Iberia	78
Iberia Express	44
Ifly	4
Jet time	18
Jet Time Finland	2
Jet2.com	154
Jonika Airlines	2
Joon	38
KLM Royal Dutch Airlines	104
Lauda	18
Level (Austria)	10
LOT Polish Airlines	26
Lufthansa	258 (12)
Lufthansa CityLine	14
Luxair	14
Maleth Aero	4
Mistral Air	8
Myway Airlines	4
Neos	12
Nordwind Airlines	20
Norwegian	42
Norwegian Air International	116
Norwegian Air Norway	60
Norwegian Air UK	4
Novair	2
Orange2fly	4
Pegas Fly	10
Pegasus	112
Plus Ultra	12
Pobeda	58 (2)
Red Wings Airlines	4
Rossiya Airlines	86
Royal Flight	4
Ryanair	866
S7 Airlines	84
SAS	154
SkyUp	14
Smartavia	22
Smartlynx Estonia	4
SmartLynx Malta	2
Smartwings	20
Smartwings Czechia	18
Smartwings Hungary	2
Smartwings Poland	6
Smartwings Slovakia	2
Sundair	8
SunExpress	56
SunExpress Germany	16
Swiftair	14
SWISS	82
Tailwind Airlines	10
Taimyr Air - NordStar	16
TAP Air Portugal	104
TAROM	32
Taron-Avia	4
Thomas Cook Airlines	62
Thomas Cook Airlines Scandinavia	16
Titan Airways	8
Trade Air	4
Transavia Airlines	86
Transavia France	74
TUI Airlines Nederland	8
TUI fly Belgium	50
TUI UK	64
TUIfly	56
TUIFly Nordic	2
Turkish Airlines	160
Ukraine International Airlines	56
Ural Airlines	70 (14)
Utair	86 (16)
Volotea	28
Voyage Air	2
Vueling Airlines	100
West Atlantic	46
White	2
Windrose Airlines	4
Yakutia Airlines	10
Yamal Airlines	6
YanAir	6
Latin America	**Total 1,334 (12)**
Aer Caribe	4
Aerolineas Argentinas	86
Aerolineas Estelar	8
Aeromexico	94
AeroRegional	2
Albatros Airlines	2
Aruba Airlines	2
Avianca	108
Avianca Brazil	6
Avianca Costa Rica	2
Avianca Ecuador	20
Avianca El Salvador	12
Avior Airlines	14
Azul	4
Bahamasair	8
BoA	34
Caribbean Airlines	24
Cayman Airways	6
Copa Airlines	156
Cubana	6
DHL Aero Expreso	2
Estafeta Carga Aerea	8
Flybondi	10
GOL	228
Interjet	100
LATAM Airlines Brazil	100
LATAM Airlines Chile	92 (2)
LATAM Airlines Colombia	12
LATAM Airlines Peru	12
Magnicharters	20
Modern Logistics	8
Norwegian Air Argentina	6
One Airlines	2
Peruvian Air Line	14
Sideral Air Cargo	26
Sky Airline	20
Skybus Peru	4
Star Peru	4
Sunrise Airways	4
Surinam Airways	8
TUM AeroCarga	2
Turpial Airlines	6
Vensecar Internacional	2
Viva Air Colombia	32 (10)
Viva Air Peru	4
Volaris	2
Wingo	8
Middle East	**Total 740 (14)**
Air Arabia	78
ATA Airlines	4
AVE.COM	2
Caspian Airlines	6
Cham Wings	6
Daallo Airlines	2
El Al	52
Fly Baghdad	4
Fly Erbil	2
Fly Jordan	4
Flyadeal	22
flydubai	92
Flynas	56
Gulf Air	34
Iran Air	6 (14)
Iran Aseman Airlines	12

Iraqi Airways	32
Jazeera Airways	16
Jordan Aviation	12
Kish Air	4
Kuwait Airways	14
Mahan Air	16
Meraj Air	4
Middle East Airlines	8
Oman Air	52
Qatar Airways	16
Qeshm Airlines	4
Royal Jordanian	2
SAHA Airlines	4
SalamAir	6
Saudia	122
Sepehran Airlines	6
Syrianair	4
Taban Airlines	2
Texel Air	4
Varesh Airlines	10
Wings of Lebanon	4
Zagros Airlines	16
North America	**Total 5,280 (146)**
Air Canada	138
Air Canada Jetz	6
Air Canada Rouge	58
Air North	10
Air Transat	30
Alaska Airlines	458
Allegiant Air	168
Aloha Air Cargo	4
American Airlines	912
Canadian North	20
Delta Air Lines	814 (112)
EG&G Special Projects	12
First Air	8
Flair Airlines	16
Frontier Airlines	98
IBC Airways	2
Kalitta Charters II	8
Miami Air International	10
Nolinor Aviation	2
Northern Air Cargo	8
Sierra Pacific Airlines	4
Southern Air	12
Southwest Airlines	1,438 (34)
Sun Country Airlines	58
Sunwing Airlines	46
Swift Air	52
Swoop	12
United Airlines	658
WestJet	216
Xtra Airways	2
CFM INTERNATIONAL LEAP	**TOTAL 786 (10,640)**
Africa	**Total (136)**
Air Peace	(20)
Air Seychelles	(2)
Arik Air	(16)
Comair (South Africa)	(14)
Egyptair	(30)
Ethiopian Airlines	(50)
Royal Air Maroc	(2)
RwandAir	(2)
Asia Pacific	**Total 354 (3,850)**
9 Air	(6)
Air Changan	(4)
Air China	(16)
Air India	52 (2)
Air Niugini	(8)
Air Travel	(8)
AirAsia	54 (736)
Asiana Airlines	(50)
Bamboo Airways	6
Batik Air	(2)
Capital Airlines	10 (2)
Cathay Dragon	(64)
China Eastern Airlines	36 (16)
China Eastern Airlines Jiangsu	8
China Southern Airlines	40 (94)
Chongqing Airlines	14 (2)
Citilink Indonesia	16 (4)
City Airways	(20)
Donghai Airlines	(50)
Druk Air	(2)
Fiji Airways	(6)
Garuda Indonesia	(98)
GX Airlines	8
Hainan Airlines	(44)
Jeju Air	(80)
Jetstar	(198)
Korean Air	(60)
Lion Air	(824)
Loong Air	22 (6)
Lucky Air	8 (10)
Malaysia Airlines	(50)
MIAT - Mongolian Airlines	(6)
Nok Air	(12)
Okay Airways	(22)
Royal Brunei Airlines	14
Ruili Airlines	(76)
Shandong Airlines	(2)
Shanghai Airlines	(8)
Shenzhen Airlines	(6)
Sichuan Airlines	(40)
SilkAir	(62)
SpiceJet	(302)
Spring Airlines	10 (116)
SriLankan Airlines	12 (2)
Thai AirAsia	22
Thai Lion Air	(4)
Turkmenistan Airlines	(6)
Unconfirmed Chinese Airline	(154)
US-Bangla Airlines	(2)
Uzbekistan Airways	4
VietJet Air	(400)
Virgin Australia	(80)
Vistara	18 (82)
Xiamen Airlines	(6)
Europe	**Total 216 (1,820)**
Aer Lingus	(16)
Air Europa	(40)
Air Italy	(10)
Air Malta	2 (2)
Atlantic Airways (Faroe Islands)	(4)
Azores Airlines	4 (8)
Belavia	(8)
Blue Air	(24)
British Airways	28 (42)
Corendon Airlines Europe	(2)
EasyJet	58 (236)
Enter Air	(8)
Globus	(16)
Iberia	6 (38)
Icelandair	(6)
La Compagnie	(4)
LOT Polish Airlines	(14)
Lufthansa	(110)
Neos	(4)
Norwegian	(180)
Norwegian Air Sweden	(4)
Novair	2
Pegasus	48 (158)
Pobeda	(40)
Ryanair	(270)
SAS	30 (32)
SAS Ireland	18
SkyUp	(14)
Smartwings	(18)
Smartwings Czechia	(30)
SunExpress	(58)
SunExpress Germany	(6)
Taimyr Air - NordStar	(6)
TAP Air Portugal	20 (74)
TAROM	(10)
TUI Travel PLC	(44)
TUI UK	(60)
TUIfly	(6)
TUIFly Nordic	(4)
Turkish Airlines	(126)
Ukraine International Airlines	(2)
Ural Airlines	(30)
Utair	(56)
Latin America	**Total 104 (824)**
Aerolineas Argentinas	(18)
Aeromexico	(110)
Avianca	10 (20)
Avianca Brazil	(8)
Avianca El Salvador	8
Azul	50 (90)
Caribbean Airlines	(8)
Cayman Airways	(4)
Copa Airlines	(110)
GOL	(286)
Interjet	22 (82)
Sky Airline	14 (18)
Viva Air Colombia	(70)
Middle East	**Total 18 (828)**
Air Arabia	2 (10)
Arkia	4 (4)
Etihad Airways	(52)

flydubai	(474)
Flynas	4 (160)
Gulf Air	4 (54)
Jazeera Airways	2 (2)
Oman Air	(48)
SalamAir	2 (4)
SaudiGulf	(20)
North America	**Total 94 (1,550)**
Air Canada	(74)
Alaska Airlines	16 (128)
American Airlines	4 (348)
Frontier Airlines	74 (90)
Jetlines	(10)
Southwest Airlines	(520)
Sunwing Airlines	(4)
United Airlines	(290)
WestJet	(86)
ENGINE ALLIANCE GP7200	**TOTAL 520**
Asia Pacific	**Total 40**
Korean Air	40
Europe	**Total 40**
Air France	40
Middle East	**Total 440**
Emirates Airline	360
Etihad Airways	40
Qatar Airways	40
GENERAL ELECTRIC CF34	**TOTAL 5,292 (726)**
Africa	**Total 148 (4)**
African Express Airways	2
Air Botswana	2
Air Burkina	6
Air Djibouti	2
Airlink	24
Blue Bird Aviation (Sudan)	2
DAC Aviation East Africa	2
EastAfrican	2
Egyptair Express	18
Fly540	6
Freedom Airline Express	2
Kenya Airways	26
Libyan Airlines	2
Linhas Aereas de Mocambique	4
Mauritania Airlines	4
Nova Airways	4
Petroleum Air Services	4
Proflight Zambia	2
Royal Air Maroc	8
RwandAir	4
SA Express	10
Silverstone Air Services	2
Syphax Airlines	4
Tunisair Express	2
Uganda Airlines	4 (4)
Asia Pacific	**Total 500 (254)**
Air Astana	12
Airnorth	10
Chengdu Airlines	12 (40)
China Express Airlines	76
China Southern Airlines	34
City Airways	(20)
Colorful Guizhou Airlines	18
Fuji Dream Airlines	26 (2)
Garuda Indonesia	36
Genghis Khan Airlines	2 (48)
GX Airlines	34
Hebei Airlines	12 (2)
Henan Airlines	(100)
Ibex Airlines	20
J-Air	64
Mandarin Airlines	12
Myanmar Airways International	(4)
Myanmar National Airlines	4
Saurya Airlines	2
SCAT	12
Shandong Airlines	(20)
Shanghai Airlines	(10)
Shree Airlines	8
Tianjin Airlines	104
Urumqi Air	2 (8)
Europe	**Total 1,034 (24)**
Adria Airways	16
Air Dolomiti	28
Air Europa Express	22
Air France HOP	100 (12)
Air Italy	2
Air Moldova	2
Air Nostrum	56
Alitalia Cityliner	40
Aurigny Air Services	2
Austrian	34
BA CityFlyer	48
Belavia	24 (4)
Binter Canarias	8
Brussels Airlines	12
Bulgaria Air	6
Buta Airways	16
Croatia Airlines	4
Flybe	34 (8)
Georgian Airways	10
IrAero	8
KLM Cityhopper	102
LOT Polish Airlines	64
Lufthansa	8
Lufthansa CityLine	94
Luxair	2
Montenegro Airlines	6
Nordic Regional Airlines	24
Nordica	24
Pegas Fly	12
People's Vienna Line	4
Portugalia Airlines	26
Rusline	28
S7 Airlines	34
SAS	48
Severstal Aircompany	12
SWISS	18
TUI fly Belgium	8
Ukraine International Airlines	12
UVT Aero	14
West Atlantic Sweden	4
Yamal Airlines	18
Latin America	**Total 410**
ACSA - Air Century	4
Aerolineas SOSA	2
Aeromexico Connect	114
Aeronaves TSM	6
Amaszonas	16
Amaszonas Uruguay	4
Aruba Airlines	2
Austral Lineas Aereas	52
Avianca El Salvador	16
Azul	116
BoA	4
Conviasa	14
Copa Airlines	30
Copa Airlines Colombia	2
Estafeta Carga Aerea	4
FlyEst	2
Paranair	8
Satena	2
TAME	4
TUM AeroCarga	8
Middle East	**Total 40**
Arkia	8
Felix Airways	2
Fly Baghdad	2
Iraqi Airways	12
Oman Air	8
Royal Jordanian	8
North America	**Total 3,160 (400)**
Air Canada	36
Air Georgian	32
Air Wisconsin	126
American Airlines	40
Compass Airlines	112
Elite Airways	24
Endeavor Air	306
Envoy Air	140 (52)
ExpressJet Airlines	34 (48)
GoJet Airlines	104
Gulf & Caribbean Cargo	6
Horizon Air	52 (14)
Jazz	64 (18)
JetBlue Airways	120
Mesa Airlines	290
PSA Airlines	278 (28)
R1 Airlines	2
Republic Airways	376 (200)
Sky Regional Airlines	50
SkyWest Airlines	954 (40)
Voyageur Airways	14
GE AVIATION CF6	**TOTAL 3,024 (140)**
Africa	**Total 47**
Aeronexus	2
Afriqiyah Airways	2
Air Algerie	16
Air Mauritius	4
Allied Air Cargo	3
Almasria Universal Airlines	2
Astral Aviation	4

Global Aviation Services	2
Libyan Airlines	6
Royal Air Maroc	6
Asia Pacific	**Total 590 (10)**
Air Calin	4
Air Do	10
Air Hong Kong	16
Air Incheon	2
Air Japan	24
Air Niugini	2
ANA-All Nippon Airways	56
Ariana Afghan Airlines	2
Asiana Airlines	68
China Airlines	134
China Cargo Airlines	8
EVA Air	28
Express Freighters Australia	2
Japan Airlines	68
Jet Airways	(10)
MIAT - Mongolian Airlines	2
Qantas	84
Raya Airways	2
SF Airlines	14
Sunday Airlines	2
Suparna Airlines	16
Tasman Cargo Airlines	2
Thai Airways International	32
Uni-top Airlines	12
Europe	**Total 718 (4)**
ACT Air	4
Aer Lingus	26
Air Atlanta Icelandic	8
Air Europa	12
Air France	30
Air Italy	10
Air Serbia	2
AirBridgeCargo	24
Airbus Transport International	10
Alitalia	28
AMS Airlines	2
ASL Airlines Belgium	16
Atlasglobal	2
Azerbaijan Airlines	4
Azur Air Russia	4
Blue Panorama Airlines	6
CargoLogicAir	12
Cargolux	8
Condor	14
DHL Air	6
EuroAtlantic airways	4
Finnair	16
Iberia	40
Icelandair	10
Ifly	2
KLM Royal Dutch Airlines	66
Level (France)	4
Level (Spain)	6 (4)
Lufthansa	52
Lufthansa Cargo	36
Martinair	12
MNG Airlines	6
Neos	2
Pegas Fly	4
Privilege Style	2
Rossiya Airlines	32
Royal Flight	4
SkyTaxi	2
Solinair	2
Star Air	28
SunExpress Germany	14
TAP Air Portugal	14
Titan Airways	2
TransAVIAexport Airlines	4
TUI Airlines Nederland	4
TUI UK	4
TUIFly Nordic	4
Turkish Airlines	64
ULS Airlines Cargo	2
Utair	6
Virgin Atlantic Airways	32
Wamos Air	4
West Atlantic Sweden	4
XL Airways France	2
Latin America	**Total 125**
Aerolineas Argentinas	12
AeroUnion	12
BoA	8
LATAM Airlines Argentina	6
LATAM Airlines Brazil	26
LATAM Airlines Chile	32
LATAM Airlines Colombia	4
LATAM Cargo Brazil	6
LATAM Cargo Chile	4
LATAM Cargo Colombia	8
Mas Air	2
TAB Airlines	3
Transcarga International Airways	2
Middle East	**Total 176**
Arkia	2
C.A.L. Cargo Air Lines	8
DHL International Aviation EEMEA	12
Fars Qeshm Air Lines	4
Global Charter Services	8
Iran Air	16
Iran Airtours	4
Iraqi Airways	6
Jordan Aviation	4
Mahan Air	32
Qatar Airways	40
Qeshm Airlines	8
Royal Jordanian	2
Saudia	28
Taban Airlines	2
North America	**Total 1,368 (118)**
21 Air	4
ABX Air	26
Air Canada	12
Air Canada Rouge	26
Air Transat	12
Aloha Air Cargo	2
American Airlines	44
Amerijet International	14
ATI - Air Transport International	10
Atlas Air	118
Cargojet Airways	26
Delta Air Lines	114
Eastern Airlines	2
FedEx	451 (100)
Kalitta Air	54
National Airlines	8
Northern Air Cargo	4
Omni Air International	18
Polar Air Cargo	44
Prime Air	78
Sky Lease Cargo	11
United Airlines	32
UPS Airlines	209 (18)
Western Global	41
WestJet	8
GE AVIATION GE90	**TOTAL 2,238 (152)**
Africa	**Total 74**
Air Austral	6
CEIBA Intercontinental	2
Egyptair	12
Ethiopian Airlines	38
TAAG Angola Airlines	16
Asia Pacific	**Total 742 (42)**
Air China	56
Air China Cargo	16
Air India	28
Air Japan	(2)
Air New Zealand	16
ANA-All Nippon Airways	44 (8)
Biman Bangladesh Airlines	8
Cathay Pacific	104
China Airlines	20
China Cargo Airlines	12
China Eastern Airlines	40
China Southern Airlines	46 (4)
EVA Air	74 (2)
Garuda Indonesia	20
Hong Kong Airlines	(12)
Japan Airlines	48
Korean Air	72 (4)
Pakistan International Airlines	22 (10)
Philippine Airlines	20
Singapore Airlines	54
Thai Airways International	28
Turkmenistan Airlines	4
Virgin Australia International	10
Europe	**Total 512 (16)**
Aeroflot Russian Airlines	38 (6)
AeroLogic	22
Air France	140
Alitalia	24
Austrian	12
Azur Air Russia	4
British Airways	78
KLM Royal Dutch Airlines	58
Lufthansa Cargo	14

Nordwind Airlines	14
Rossiya Airlines	10
Royal Flight	2
SWISS	20 (4)
Turkish Airlines	76 (6)
Latin America	**Total 20 (4)**
LATAM Airlines Brazil	20
LATAM Cargo Brazil	(4)
Middle East	**Total 614 (22)**
Emirates Airline	308 (12)
Etihad Airways	50
Iraqi Airways	2
Kuwait Airways	20
Qatar Airways	146 (10)
Saudia	88
North America	**Total 276 (38)**
Air Canada	50
American Airlines	40
Delta Air Lines	20
FedEx	74 (30)
Southern Air	12
United Airlines	80 (8)
GE AVIATION GE9X	**TOTAL (688)**
Asia Pacific	**Total (122)**
ANA-All Nippon Airways	(40)
Cathay Pacific	(42)
Singapore Airlines	(40)
Europe	**Total (76)**
British Airways	(36)
Lufthansa	(40)
Middle East	**Total (470)**
Emirates Airline	(300)
Etihad Airways	(50)
Qatar Airways	(120)
GE AVIATION GENX	**TOTAL 1,488 (610)**
Africa	**Total 56 (4)**
Ethiopian Airlines	26
Kenya Airways	16
Royal Air Maroc	14 (4)
Asia Pacific	**Total 582 (142)**
Air China	28
Air India	48
Air Tahiti Nui	4 (4)
Biman Bangladesh Airlines	4 (4)
Cathay Pacific	56
China Eastern Yunnan	6 (8)
China Southern Airlines	40 (20)
EVA Air	6 (42)
Hainan Airlines	76 (8)
Japan Airlines	84 (14)
Jetstar	22
Juneyao Air	8 (2)
Korean Air	88
Nippon Cargo Airlines	32
Qantas	16 (12)
Shanghai Airlines	8 (8)
Suparna Airlines	2
Uzbekistan Airways	8 (4)
Vietnam Airlines	22 (16)
Xiamen Airlines	24

Europe	**Total 284 (86)**
Air France	16 (2)
AirBridgeCargo	48
Azerbaijan Airlines	4
CargoLogicAir	4
Cargolux	56
KLM Royal Dutch Airlines	26 (30)
Lufthansa	76
Silk Way West Airlines	20
TUI Airlines Nederland	6
TUI fly Belgium	4
TUI Travel PLC	(4)
TUI UK	24
Turkish Airlines	(50)
Latin America	**Total 36**
Aeromexico	36
Middle East	**Total 196 (98)**
Etihad Airways	60 (82)
Oman Air	20 (10)
Qatar Airways	68
Royal Jordanian	14 (6)
Saudia	34
North America	**Total 334 (236)**
Air Canada	74
American Airlines	84 (94)
Atlas Air	12
Hawaiian Airlines	(20)
Polar Air Cargo	28
United Airlines	90 (36)
UPS Airlines	40 (72)
WestJet	6 (14)
HONEYWELL ALF502	**TOTAL 120**
Africa	**Total 16**
Air Libya	4
Cronos Airlines	8
Fair Aviation	4
Asia Pacific	**Total 56**
Cobham Avtn Services Australia-Regional Services	28
Pionair Australia	16
Skyjet	8
TransNusa Air Services	4
Europe	**Total 20**
Air France HOP	4
Astra Airlines	4
Sky Express	4
WDL Aviation	8
Latin America	**Total 16**
Aerovias DAP	8
Star Peru	8
Middle East	**Total 12**
Mahan Air	12
HONEYWELL LF507	**TOTAL 280**
Africa	**Total 48**
Air Libya	12
Airlink	36
Asia Pacific	**Total 52**
Cobham Avtn Services Australia-Regional Services	32
Royal Air	12
Tez Jet Airlines	8
Europe	**Total 76**

Aer Lingus	8
BRA-Braathens Regional Airlines	40
CityJet	28
Latin America	**Total 36**
Aerovias DAP	16
Eco Jet	16
TAMep	4
Middle East	**Total 44**
Mahan Air	20
Qeshm Airlines	24
North America	**Total 24**
First Air	8
North Cariboo Air	8
Summit Air Charters	8
IAE V2500	**TOTAL 6,088 (16)**
Africa	**Total 78**
Air Seychelles	4
Almasria Universal Airlines	6
AMC Airlines	2
Comair (South Africa)	2
Egyptair	8
Global Aviation Operations	2
Mango	2
Nesma Airlines	6
Nile Air	10
Rahila Air	2
South African Airways	34
Asia Pacific	**Total 2,366**
Air Astana	22
Air Bishkek	2
Air Busan	50
Air Calin	4
Air China	104
Air Guilin	12
Air Macau	40
Air New Zealand	52
Air Seoul	14
Asiana Airlines	50
Avia Traffic Company	4
Bamboo Airways	6
Bangkok Airways	50
Cambodia Angkor Air	6
Capital Airlines	82
Cathay Dragon	46
China Eastern Airlines	178
China Eastern Airlines Jiangsu	34
China Southern Airlines	312
Chongqing Airlines	28
Citilink Indonesia	10
FlyArystan	2
HK Express	38
IndiGo	234
Jetstar	120
Jetstar Asia	36
Jetstar Japan	50
Jetstar Pacific	30
Juneyao Air	34
Lanmei Airlines	12
Nepal Airlines	4
Network Aviation	4

PAL Express	12
Pan Pacific Airlines	6
Philippine Airlines	36
Royal Brunei Airlines	4
Scoot	54
Shenzhen Airlines	82
Sichuan Airlines	174
SilkAir	20
Sky Angkor Airlines	4
SriLankan Airlines	8
Thai Smile	40
Tianjin Airlines	40
Tigerair Australia	20
Tigerair Taiwan	22
VietJet Air	2
Vietnam Airlines	112
Virgin Australia Regional Airlines	10
Vistara	26
West Air (China)	24
Europe	**Total 1,396 (6)**
Adria Airways	4
Aegean Airlines	98
Air Albania	2
Air France	2
Air Moldova	2
Air Serbia	20
Atlasglobal	16
Avion Express	2
BH Air	4
British Airways	254
Bulgarian Air Charter	12
Condor	4
Corendon Airlines	8
DAT - Danish Air Transport	8
Ellinair	4
Enter Air	2
Ernest Airlines	4
Eurowings	34
Eurowings Europe	18
Finnair	26
Fly2Sky	2
Freebird Airlines	6
GetJet Airlines	8
Hi Fly	2
Jet2.com	2
Lauda	18
Lufthansa	126
Nordwind Airlines	14
Norwegian	2
Olympus Airways	2
Onur Air	24
Orange2fly	2
Red Wings Airlines	24
S7 Airlines	2
SAS	46
Smartlynx Estonia	2
Thomas Cook Airlines	14
Titan Airways	4
TUI Airlines Nederland	6
TUIfly	4

Turkish Airlines	184
Ural Airlines	20
Vueling Airlines	114
Windrose Airlines	8
Wizz Air	202 (4)
Wizz Air UK	18 (2)
Yamal Airlines	16
Latin America	**Total 488 (8)**
Aruba Airlines	4
Avianca	6
Avianca Costa Rica	20
Avianca El Salvador	44
Avianca Peru	6
JetSMART	16
JetSMART Argentina	6
LATAM Airlines Argentina	26
LATAM Airlines Brazil	112
LATAM Airlines Chile	30
LATAM Airlines Colombia	6
LATAM Airlines Ecuador	8
LATAM Airlines Paraguay	4
LATAM Airlines Peru	32
Mexicana	(8)
Sky Airline	2
TAME	4
VivaAerobus	40
Volaris	116
Volaris Costa Rica	6
Middle East	**Total 236**
ATA Airlines	4
Cham Wings	2
Etihad Airways	60
Gulf Air	12
Iran Air	2
Iran Airtours	2
Iran Aseman Airlines	12
Iraqi Airways	4
Israir	8
Middle East Airlines	18
Qatar Airways	60
Royal Jordanian	20
SaudiGulf	10
Syrianair	12
Yemenia	6
Zagros Airlines	4
North America	**Total 1,524 (2)**
American Airlines	482
Delta Air Lines	80
JetBlue Airways	386
Spirit Airlines	244 (2)
United Airlines	332
IVCHENKO-PROGRESS AI-25	**TOTAL 69**
Asia Pacific	**Total 21**
East Kazakhstan Region Air Enterprise	6
East Wing	3
Zhetysu Aviakompania	6
ZhezAir	6
Europe	**Total 36**
Aerobratsk	3
Gazpromavia	9

Petropavlovsk-Kamchatsky Air Enterprise	9
Rossiya Special Flight Detachment	3
Severstal Aircompany	3
Vologda Air Enterprise	6
Zodiac Group	3
Middle East	**Total 12**
Syrianair	12
IVCHENKO-PROGRESS D-36	**TOTAL 66**
Europe	**Total 66**
Izhavia	24
KrasAvia	30
Turuhan Aviacompany	12
IVCHENKO-PROGRESS D-436	**TOTAL 14 (10)**
Asia Pacific	**Total 4**
Air Koryo	4
Europe	**Total 10 (2)**
Angara Airlines	10
Rossiya Special Flight Detachment	(2)
KUZNETSOV NK-8	**TOTAL 24**
Asia Pacific	**Total 6**
Air Koryo	6
Europe	**Total 18**
223rd State Airline Flight Unit	18
POWERJET SAM-146	**TOTAL 202 (102)**
Asia Pacific	**Total (12)**
Thai Kom Airlines	(12)
Europe	**Total 188 (74)**
Aeroflot Russian Airlines	100 (44)
Azimuth	18 (6)
CityJet	(16)
Gazpromavia	20
IrAero	8
Severstal Aircompany	6 (6)
Utair	8
Yakutia Airlines	4
Yamal Airlines	24 (2)
Latin America	**Total 14 (16)**
Interjet	14 (16)
PRATT & WHITNEY JT3D	**TOTAL 4**
Africa	**Total 4**
Trans Air Cargo Services	4
PRATT & WHITNEY JT8D	**TOTAL 738**
Africa	**Total 57**
African Express Airways	6
Air Charter United	5
Allegiance Airways - Gabon	2
Astral Aviation	5
Canadian Airways Congo	6
DANA Air	6
FlyCongo	2
JedAir	2
Multiple Solutions	2
Safe Air Company	3
Serve Air	15
SKA Air & Logistics (Uganda)	3
Asia Pacific	**Total 49**
AIRFAST Indonesia	8
Asia Pacific Airlines	3
Far Eastern Air Transport	16
Jayawijaya Dirgantara	4

Kam Air	4
My Indo Airlines	2
PSI Air 2007	3
Sigma Airlines	3
Sky Capital Airlines	2
South East Asian Airlines (SEAIR)	2
Vision Air International	2
Europe	**Total 35**
ALK Airlines	4
Anda Air	2
AviaStar Air Company	3
Bravo Airways	2
Bukovyna Airlines	2
Bulgarian Air Charter	18
DAT - Danish Air Transport	4
Latin America	**Total 166**
Aerodesierto	2
Aerolineas Estelar	4
Aeronaves TSM	42
Aeropostal	2
Aerosucre Colombia	13
Aerovias DAP	6
Air Class Lineas Aereas	3
Andes Lineas Aereas	10
Aviatsa	4
Avior Airlines	8
LASER	24
Lineas Aereas Suramericanas	15
Peruvian Air Line	2
Rutaca	2
SELVA Colombia	3
Sideral Air Cargo	6
Total Linhas Aereas	9
Uniworld Air Cargo	3
Venezolana	8
Middle East	**Total 90**
ATA Airlines	16
Caspian Airlines	12
Iran Air	6
Iran Airtours	10
Kish Air	14
Taban Airlines	12
Taftan Air	4
Zagros Airlines	16
North America	**Total 341**
Air Inuit	8
American Airlines	56
Ameristar Charters	12
Canadian North	4
Delta Air Lines	158
Everts Air Alaska	10
Gulf & Caribbean Cargo	9
Interjet West	3
Kalitta Charters II	21
Nolinor Aviation	14
SkyWay Enterprises	2
TransAir	10
USA Jet Airlines	20
World Atlantic Airlines	14
PRATT & WHITNEY JT9D	**TOTAL 22**

Europe	**Total 8**
Geo Sky	8
North America	**Total 14**
Atlas Air	8
Eastern Airlines	6
PRATT & WHITNEY PW1000G	**TOTAL 860 (4,114)**
Africa	**Total 4 (44)**
Air Peace	(20)
Air Tanzania	4
Egyptair Express	(24)
Asia Pacific	**Total 510**
Air Astana	12 (32)
Air Calin	(4)
Air China	26 (6)
Air Kiribati	(4)
Air Macau	2 (8)
Air Mandalay	(12)
Air New Zealand	14 (26)
Air Vanuatu	(8)
ANA-All Nippon Airways	40 (56)
Cebu Pacific Air	2 (72)
China Southern Airlines	46 (14)
Fuzhou Airlines	(4)
GoAir	62 (84)
HK Express	8 (10)
IndiGo	156 (412)
J-Air	(64)
Korean Air	20 (60)
Philippine Airlines	12 (30)
Qingdao Airlines	10 (6)
Scoot	4 (74)
Shenzhen Airlines	8 (4)
Sichuan Airlines	32 (8)
Tianjin Airlines	12 (2)
Unconfirmed Chinese Airline	(72)
VietJet Air	16 (128)
Vietnam Airlines	16 (22)
West Air (China)	12 (2)
Europe	**Total 204 (996)**
Aegean Airlines	(60)
Aeroflot Russian Airlines	(50)
airBaltic	30 (66)
Binter Canarias	(6)
BRA-Braathens Regional Airlines	(20)
Helvetic Airways	(24)
Lufthansa	42 (88)
Norwegian	(76)
Odyssey Airlines	(20)
Red Wings Airlines	(24)
S7 Airlines	30 (30)
SWISS	56 (54)
Turkish Airlines	10 (174)
Utair	(20)
Vueling Airlines	26 (68)
Wideroe	6
Wizz Air	4 (216)
Latin America	**Total 72 (390)**
Azul	(114)
JetSMART	(10)
LATAM Airlines Brazil	6 (32)

LATAM Airlines Chile	6 (60)
LATAM Airlines Peru	4
VivaAerobus	22 (108)
Volaris	34 (66)
Middle East	**Total (84)**
Gulf Air	(20)
Iraqi Airways	(10)
Middle East Airlines	(22)
SaudiGulf	(32)
North America	**Total 70 (1370)**
Air Canada	(90)
Air Transat	(34)
Delta Air Lines	22 (358)
Hawaiian Airlines	24 (12)
JetBlue Airways	(290)
Moxy Airways	(120)
Republic Airways Holdings Inc	(80)
SkyWest Airlines	(200)
Spirit Airlines	24 (86)
Trans States Holdings	(100)
PRATT & WHITNEY PW2000	**TOTAL 516**
Asia Pacific	**Total 16**
Asia Pacific Airlines	4
Raya Airways	2
Uzbekistan Airways	10
Europe	**Total 40**
Aer Lingus	6
ASL Airlines Belgium	2
Azur Air Russia	14
DHL Air	2
E-Cargo	2
European Air Transport	12
Royal Flight	2
Latin America	**Total 8**
DHL Aero Expreso	8
North America	**Total 452**
ATI - Air Transport International	10
Delta Air Lines	**254**
FedEx	90
United Airlines	28
UPS Airlines	70
PRATT & WHITNEY PW300	**TOTAL 26**
Europe	**Total 22**
Sun-Air of Scandinavia	22
North America	**Total 4**
Ultimate Jetcharters	4
PRATT & WHITNEY PW4000	**TOTAL 1,641**
Africa	**Total 42**
Afriqiyah Airways	2
Air Cairo	2
Air Zimbabwe	4
Astral Aviation	4
Egyptair	6
Ethiopian Airlines	12
MaxAir	12
Asia Pacific	**Total 520**
Air Astana	6
Air China	12
Air China Cargo	12
Air Hong Kong	8

Air India	16
Air Niugini	2
ANA-All Nippon Airways	54
Asiana Airlines	48
Cathay Pacific	24
China Cargo Airlines	4
China Southern Airlines	60
Hong Kong Airlines	10
Japan Airlines	32
Jin Air	8
Korean Air	118
Malaysia Airlines	48
MIAT - Mongolian Airlines	2
SF Airlines	4
Singapore Airlines	28
Uni-top Airlines	4
Uzbekistan Airways	16
Vietnam Airlines	4
Europe	**Total 290**
Aerotranscargo	12
Aigle Azur	4
Air Atlanta Icelandic	4
Air Cargo Europe	4
Air Cargo Global	8
Air Greenland	2
ASL Airlines Belgium	8
ASL Airlines Ireland	8
Austrian	12
Azur Air Russia	16
Azur Air Ukraine	6
Brussels Airlines	12
Condor	18
Corsair	12
Czech Airlines	2
EuroAtlantic airways	4
European Air Transport	42
Evelop Airlines	2
Hi Fly	2
Ifly	6
Martinair	4
MNG Airlines	4
Nordwind Airlines	4
Onur Air	2
Pegas Fly	6
Rossiya Airlines	4
Ruby Star Airlines	4
Silk Way West Airlines	8
Solinair	2
TAP Air Portugal	8
Turkish Airlines	22
Ukraine International Airlines	14
Virgin Atlantic Airways	4
Virgin Atlantic International	4
Wamos Air	16
Latin America	**Total 24**
Aerolineas Argentinas	8
Air Caraibes	10
French Bee	2
LATAM Airlines Chile	4
Middle East	**Total 48**

C.A.L. Cargo Air Lines	4
El Al	20
Iraqi Airways	4
Mahan Air	2
Meraj Air	4
Saudia	12
Yemenia	2
North America	**Total 717**
ABX Air	6
Air Canada Rouge	24
American Airlines	18
Atlas Air	34
Delta Air Lines	126
FedEx	96
Kalitta Air	52
Prime Air	4
Sky Lease Cargo	3
United Airlines	174
UPS Airlines	180
PRATT & WHITNEY PW6000	**TOTAL 8**
Latin America	**Total 8**
Avianca Brazil	8
ROLLS-ROYCE AE 3007	**TOTAL 1,026**
Africa	**Total 170**
Africa World Airlines	16
Air Katanga	2
Air Namibia	8
Air Peace Hopper	12
Airlink	50
ALS Limited	12
Camair-Co	2
CEIBA Intercontinental	2
Cronos Airlines	4
Diexim Expresso	2
FastJet Zimbabwe	6
Fly Angola	2
Global Aviation Services	2
Groupe Transair	2
Madagasikara Airways	4
Mauritania Airlines	2
Mocambique EXpresso	6
National Airways	8
Sahara African Aviation	4
SJL Aeronautica	4
Solenta Aviation	8
Solenta Aviation Mozambique	2
Swaziland Airlink	6
Walya Airways	4
Asia Pacific	**Total 10**
Aero Mongolia	2
Korea Express Air	4
Star Air (India)	4
Europe	**Total 80**
Air France HOP	28
Eastern Airways	4
Komiaviatrans	10
Loganair	28
Windrose Airlines	10
Latin America	**Total 46**
American Jet	2

Calafia Airlines	8
Satena	4
Sky High	2
TAG Airlines	2
TAR Aerolineas	22
Western Air	6
Middle East	**Total 12**
ATA Airlines	6
Ayit Aviation	2
Pouya Air	4
North America	**Total 708**
CommutAir	60
Corporate Flight Management	16
Envoy Air	214
ExpressJet Airlines	204
Piedmont Airlines	118
Trans States Airlines	90
Via Airlines	6
ROLLS-ROYCE BR700	**TOTAL 290**
Asia Pacific	**Total 40**
QantasLink	40
Europe	**Total 34**
Volotea	34
North America	**Total 216**
Delta Air Lines	176
Hawaiian Airlines	40
ROLLS-ROYCE RB211	**TOTAL 1,008**
Africa	**Total 4**
Cabo Verde Airlines	4
Asia Pacific	**Total 130**
Air Astana	8
Air China Cargo	8
Blue Dart Aviation	12
Cathay Pacific	4
China Air Cargo	2
China Postal Airlines	12
Pacific Air Express	2
Qantas	4
SCAT	4
SF Airlines	56
Sunday Airlines	2
Turkmenistan Airlines	6
YTO Cargo Airlines	10
Europe	**Total 422**
Aer Lingus	2
ASL Airlines Belgium	2
Aviastar-TU	6
Azerbaijan Airlines	4
Azur Air Russia	2
British Airways	136
Cargolux	28
Cargolux Italia	16
Condor	30
Cygnus Air	4
DHL Air	42
European Air Transport	6
Icelandair	52
Jet2.com	22
La Compagnie	4
Privilege Style	4

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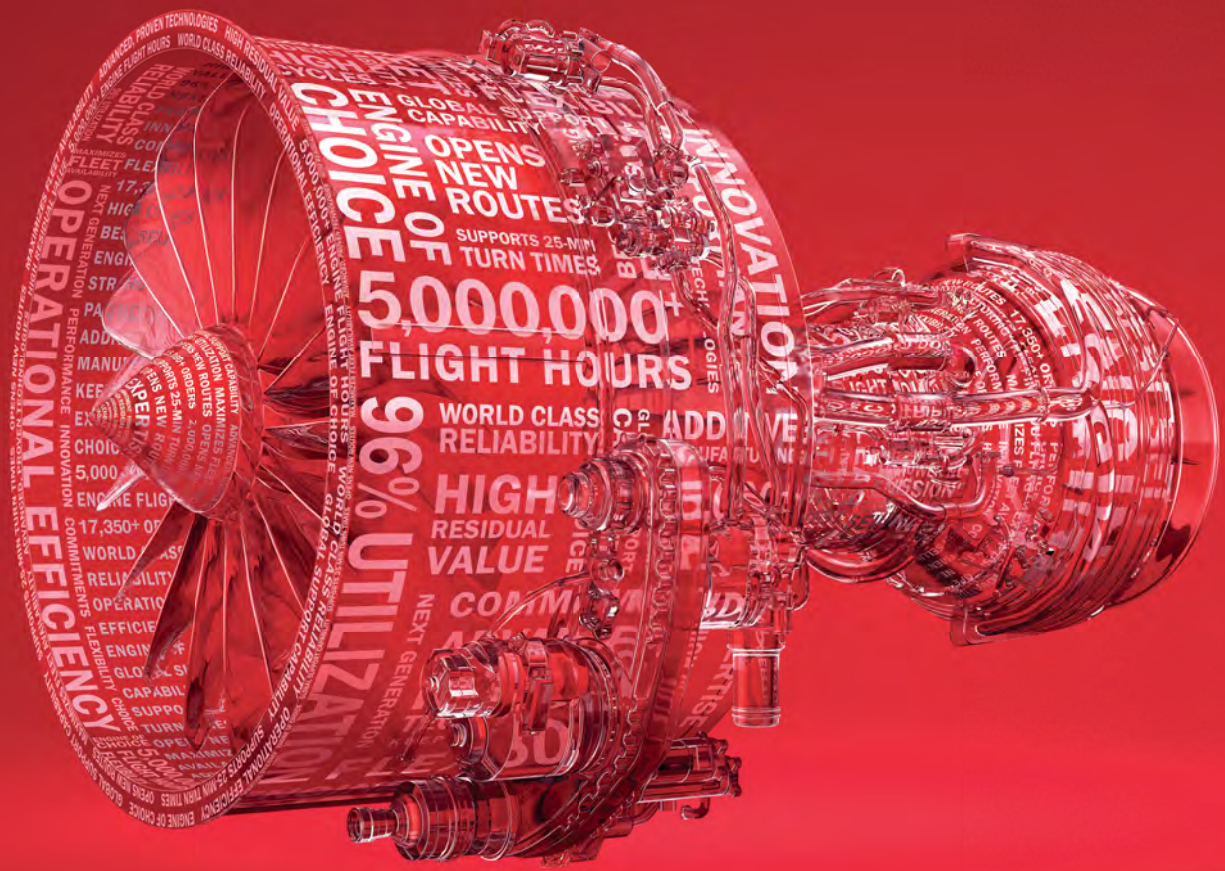
Royal Flight	14
Silk Way West Airlines	8
Sky Gates Airlines	8
SW Italia	4
TCA	4
Titan Airways	4
TUI UK	20
North America	**Total 452**
American Airlines	68
ATI - Air Transport International	6
Cargojet Airways	16
Eastern Airlines	8
FedEx	132
Morningstar Air Express	16
National Airlines	2
United Airlines	124
UPS Airlines	80
ROLLS-ROYCE TAY	**TOTAL 252**
Africa	**Total 4**
Ocean Airlines	2
Safe Air Company	2
Asia Pacific	**Total 170**
Air Niugini	26
Alliance Airlines	46
Bek Air	14
Network Aviation	34
Skippers Aviation	4
Virgin Australia Regional Airlines	46
Europe	**Total 28**
Air France HOP	2
Avantiair	4
Carpatair	6
Helvetic Airways	4
Montenegro Airlines	2
Trade Air	4
Tus Airways	6
Latin America	**Total 14**
Air Panama	6
Fly Allways	4
Wayraperu	4
Middle East	**Total 36**
Iran Air	2
Iran Aseman Airlines	14
Karun Airlines	8
Kish Air	4
Qeshm Airlines	8
ROLLS-ROYCE TRENT	**TOTAL 3,678 (2,072)**
Africa	**Total 158 (88)**
Afriqiyah Airways	(20)
Air Austral	8
Air Mauritius	6 (10)
Air Namibia	4
Air Peace	2
Air Senegal	2 (2)
Air Tanzania	2
Alexandria Airlines	2
Egyptair	24 (10)
Ethiopian Airlines	42 (26)
Libyan Airlines	(12)
RwandAir	4 (4)
South African Airways	58
Tunisair	4
Uganda Airlines	(4)
Asia Pacific	**Total 1,792 (730)**
Air Astana	(6)
Air Calin	(4)
Air China	160 (8)
Air Hong Kong	2
Air New Zealand	42
Air Niugini	(2)
Air Premia	(6)
AirAsia X	48 (152)
ANA-All Nippon Airways	134 (40)
Asiana Airlines	40 (44)
Capital Airlines	22
Cathay Dragon	50
Cathay Pacific	164 (30)
Cebu Pacific Air	16
China Airlines	28
China Eastern Airlines	118 (30)
China Southern Airlines	64 (40)
Fiji Airways	12
Garuda Indonesia	48 (28)
Hainan Airlines	76 (8)
Hong Kong Air Cargo	10
Hong Kong Airlines	42 (32)
Japan Airlines	(62)
Lion Air	6 (8)
Lucky Air	8 (2)
Malaysia Airlines	36
Nepal Airlines	4
NokScoot	10
Philippine Airlines	40 (2)
Qantas	48
Royal Brunei Airlines	10
Scoot	38 (6)
Shanghai Airlines	2
Shenzhen Airlines	12
Sichuan Airlines	30 (24)
Singapore Airlines	232 (142)
SriLankan Airlines	28 (8)
StarLux	(34)
Thai AirAsia X	20 (4)
Thai Airways International	126
Thai Lion Air	6 (4)
Tianjin Airlines	12 (2)
Tibet Airlines	10
Vietnam Airlines	26 (2)
Virgin Australia	12
Europe	**Total 922 (488)**
Aer Lingus	(10)
Aeroflot Russian Airlines	44 (28)
Air Europa	34 (26)
Air France	(42)
Azerbaijan Airlines	8
British Airways	144 (60)
Brussels Airlines	14
Condor	4
Corsair	8 (6)
Edelweiss Air	4
European Air Transport	6
Evelop Airlines	6 (2)
Finnair	28 (10)
Hi Fly	(2)
Iberia	76 (32)
Ifly	6
IrAero	6
Jet2.com	2
KLM Royal Dutch Airlines	(14)
LOT Polish Airlines	20 (6)
Lufthansa	182 (102)
Maleth Aero	4
MNG Airlines	2 (6)
Neos	6 (2)
Nordwind Airlines	4
Norwegian	44 (10)
Norwegian Air International	2
Norwegian Air Sweden	2
Norwegian Air UK	28 (2)
Onur Air	2
Orbest	2
Rossiya Airlines	10
SAS	16 (18)
SWISS	28
TAP Air Portugal	16 (32)
Thomas Cook Airlines	16
Thomas Cook Airlines Scandinavia	6
TUI Airlines Nederland	2
Turkish Airlines	52 (50)
Virgin Atlantic Airways	74 (24)
Virgin Atlantic International	4
Wamos Air	4
XL Airways France	6 (4)
Latin America	**Total 136 (84)**
Air Caraibes	4 (6)
Avianca	40 (26)
Avianca Cargo	10 (2)
Avianca Peru	2
Azul	14 (10)
French Bee	4
LATAM Airlines Brazil	14 (30)
LATAM Airlines Chile	48 (10)
Middle East	**Total 398 (442)**
Arkia	(4)
El Al	30 (10)
Emirates Airline	76 (140)
Etihad Airways	30 (40)
Gulf Air	18 (20)
Iran Air	4 (88)
Jordan Aviation	2
Kuwait Airways	10 (36)
Mahan Air	20
Middle East Airlines	10 (8)
Oman Air	20
Qatar Airways	100 (76)
Saudia	78
Yemenia	(20)
North America	**Total 272 (184)**
Air Canada	**18**
Air Transat	**34**
American Airlines	**124**
Delta Air Lines	**42 (94)**
Hawaiian Airlines	**48**
Omni Air International	**6**
United Airlines	**(90)**



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