

As with all industry sectors, the engine MRO sector has experienced a severe drop in normal business levels. The lack of engine shop visits is exacerbated by the increased availability of engines with green time. The rate of traffic recovery will be just one factor influencing the future market.

The engine MRO market outlook for 2021 & beyond

One of the markets directly hit by the drop in passenger numbers in 2020 due to Covid-19 is engine maintenance, repair and overhaul (MRO). In 2019, almost 6,000 turbofan shop visits (SVs) were carried out for engines on narrowbodies and widebodies. The fall in traffic and reduced utilisation across the fleet clearly hit the engine MRO market hard in 2020. The prospects for 2021 and going forward are considered here.

Engine MRO market

The engine SV and MRO market for 2019 was estimated to be 5,740 SVs for all engines equipping narrowbodies and widebodies. This was split between about 3,700 narrowbody engine SVs, and 2,000 SVs for widebody engines. There were about an additional 650 SVs for turbofans powering large regional jets (RJs) and turboprops.

The active fleet at the end of 2019 was about 16,650 narrowbodies in passenger, freighter and a few other configurations, and 6,035 widebodies in the same categories. This active fleet of 22,680 aircraft includes active passenger- and freighter-configured aircraft, and special variants, such as business jets and VIP aircraft, and also some military and government aircraft.

Narrowbody fleet 2019

There were about 139 JT8D-powered 737-200s, 727s and DC-9s; 145 MD-80s, 678 737 CFM56-3-powered 737s Classics and 660 757-200/-300s in active service at the end of 2019. These fleets generated a small amount of activity for the JT8D, JT8D-200, CFM56-3, RB211-535 and PW2000; totalling 618 SV events in 2019

(see table, page 26).

Most of the narrowbody fleet was accounted for by 6,657 active 737NGs and 6,940 A320 current engine option (ceo) family aircraft. The 737NGs are powered exclusively by the CFM56-7B, while the A320ceo family fleet was divided between 4,030 CFM56-5B-powered aircraft and 2,935 V2500-equipped A320 ceos and MD-90s. These two fleets generated just over 2,000 CFM56-5B and -7B SVs, and just over 1,000 V2500 SVs in 2019 (see table, page 27).

The youngest narrowbodies in service were the A320 and A321 new engine option (neo) fleets, with 612 aircraft powered by CFM LEAP-1A engines; and another 549 A320neo family aircraft plus 99 A220s equipped with PW1100G engines. These fleets first entered service in 2016 and 2017, and so have yet to generate any engine SVs, other than for some problematic engines (see table, page 26).

The total active narrowbody fleet at the end of 2019, before the start of the Covid-19 pandemic, was just under 16,650 aircraft. This included about 460 aircraft in corporate and specialist configurations, but most were passenger and freighter aircraft.

There were 736 narrowbody freighters in active service in December 2019. Most of these are old generation aircraft that included 23 DC-9s, 16 MD-80s, 29 737-200s, 37 727-200s, 287 737-300s/-400s, and 314 757-200s. There were also 30 younger 737NGs in the freighter fleet.

This total narrowbody fleet generated a total of almost 3,700 engine SVs. Almost 2,400 were for the CFM56 family, and another 1,030 for the V2500 family. The remaining market activity was for specialist types of the JT8D-200, PW2000 and RB211-535.

Widebody fleet 2019

The active widebody fleet in late 2019 was more diverse than the narrowbody fleet. The fleet can be broadly divided into nine main groups, plus a small number of additional aircraft.

The first group comprises 1980s generation aircraft powered by the CF6-50, CF6-80, PW4000-94 and RB211-524G/H. At the end of 2019, 1,603 of these aircraft were active (see table, page 26), equal to 26% of all active widebodies. These generated about 900 SVs in 2019.

The second group comprises aircraft powered by the Rolls-Royce Trent family of engines. This included 59 A340-500/-600s, 771 A330-200/-300s, 40 A330neos, 154 777 family types, 105 A380s, and 324 787s, and 330 A350s. This is a total of 1,783 aircraft, which accounts for 30% of active widebodies at the time.

The Trent 700, 1000 and XWB fleets generated an estimated 473 engine SVs in 2019 (see table, page 26).

The third group of aircraft were 1,855 777 family, 787 family and 747-8s equipped with GE90 and GENx engines. This was 31% of active widebodies at the time. These fleets generated about 450 SVs for the GE90 types, and 235 for the GENx.

The fourth group of aircraft are 453 A330s equipped with CF6-80E1 and PW4000-100 engines, and 127 PW4000-112-powered 777-200/-300s. This accounts for 9.6% of the widebody fleet.

The remaining 3.5% of the widebody fleet in late 2019 was accounted for by 82 CFM56-5C-powered A340-200/-300s, and 129 GP7200-equipped A380s.

The active widebody fleet was therefore 6,032 aircraft at the end of 2019. This included 4,589 passenger-configured aircraft, and 1,169 freighters. The widebody freighter fleet comprises several

NARROWBODY N& WIDEBOY FLEET DEVELOPMENT DURING 2020

Aircraft Type	Engine Type	Total Active Dec '19	Pax Active Dec '19	Freighter Active Dec '19	Total Active Dec '20	Pax Active Dec '20	Freighter Active Dec '20
NARROWBODIES							
DC-9	JT8D-200	28	3	23	25	3	21
MD-80	JT8D-200	145	118	16	85	55	19
737-200	JT8D	58	14	29	54	10	28
727	JT8D	53	2	37	51	2	36
737 Classics	CFM56-3	678	350	287	574	238	296
757	RB211-535	395	181	214	284	49	219
757	PW2000	267	154	100	215	107	96
Sub-Total		1,624	822	706	1,288	464	715
717	BR715	141	141	0	87	87	0
737NG	CFM56-7B	6,657	6,314	30	5,508	5,115	79
A318	CFM56-5B	43	24	0	42	23	0
A319	CFM56-5B	823	815	0	571	521	0
A320	CFM56-5B	2,511	2,504	0	1,684	1,668	0
A321	CFM56-5B	653	653	0	479	478	0
Sub-Total		4,030	3,996	0	2,776	2,690	0
MD-90	V2500	26	26	0			
A319	V2500	399	396	0	284	265	0
A320	V2500	1,573	1,565	0	1,119	1,107	0
A321	V2500	963	961	0	665	659	4
Sub-Total		2,935	2,922	0	2,068	2,031	4
737 MAX					20	20	0
A320neo	CFM LEAP	503	503	0	585	583	0
A321neo	CFM LEAP	109	109	0	157	157	0
Sub-Total		612	612	0	762	760	0
A220	PW1100G	99	99	0	122	119	0
A320neo	PW1100G	372	372	0	448	448	0
A321neo	PW1100G	177	176	0	249	249	0
Sub-Total		648	647	0	819	816	0
Narrowbody total		16,647	15,454	736	13,308	11,963	798
WIDEBOODIES							
A340-200/-300	CFM56-5C	82	68	0	48	33	3
747 Classic	JT9D/CF6-50	32	0	8	30	0	14
A300/310	CF6-50/-80C2	124	30	78	110	16	78
767 family	CF6-50/-80C2	610	265	319	519	141	353
747-400	CF6-50/-80C2	198	65	125	142	5	128
DC-10 & MD-11	CF6-50/-80C2	165	0	100	150	0	88
Sub-Total		1,097	360	622	921	162	647
A300/310	PW4000-94	107	2	103	108	3	103
767 family	PW4000-94	191	139	13	124	57	19
747-400	PW4000-94	84	21	58	75	5	65
DC-10 & MD-11	PW4000-94	41	0	40	39		38
Sub-Total		423	162	214	346	65	225
767 family	RB211-524G/H	5	5	0	5	5	0
747-400	RB211-524G/H	46	31	15	16		16
Sub-Total		51	36	15	21	5	16
A330-200/-300	CF6-80E1	273	259	0	165	140	9
A330-200/-300	PW4000-100	180	172	7	124	116	7
Sub-Total		453	431	7	289	256	16
777 family	PW4000-112	127	126	0	70	79	0
A340-500/-600	Trent 500	59	50	0	15	6	0
A330-200/-300	Trent 700	771	711	36	510	416	58
A330neo	Trent 7000	40	40	0	42	42	0
777 family	Trent 800	154	153	0	66	65	0
A380	Trent 900	105	105	0	18	17	0
787 family	Trent 1000	324	321	0	265	261	0
A350	Trent XWB	330	330	0	322	321	0
Sub-Total		1,783	1,710	36	1,238	1,128	58
777 family	GE90	1,163	975	178	960	725	224
787 family	GE90	561	557	0	555	549	0
747-8	GE90	131	35	89	112	11	93
Sub-Total		692	592	89	667	560	93
A380	GP7270	129	129	0	6	6	0
Widebody total	6,032	4,589	1,169	4,596	3,019	1,296	127
Total aircraft		22,679	20,043	1,905	17,904	14,982	2,094

groups. The first is 859 aircraft powered by the 1980s generation CF6, PW4000-94 and RB211-524 engines (*see table, this page*). Of these, 630 were equipped with CF6-50 and -80 series engines.

There were also 43 A330 freighters, and 178 777-200LRs, plus 89 747-8Fs in fleet in December 2019. This is a total of 310 aircraft with younger generation CF6-80E1, PW4000-100, GE90-115 and GENx engines.

2020 fleet activity

The Covid-19 pandemic started early in 2020, and had an immediate impact, with aircraft being operated at reduced levels of utilisation, and then being parked from January and February in China and the Asia Pacific.

The spread to Europe and North America saw a rapid reduction in aircraft activity in March 2020, with the active global fleet of aircraft reaching its lowest level in April and May 2020.

A large portion of the passenger fleet worldwide was parked or in storage at this time. The total number of narrowbodies active with airlines was 7,236 at the end of April 2020, a drop of just over 9,720 units in four months. This active fleet included 718 freighters, a small drop of 18 aircraft from December 2019. There were therefore 9,460 fewer passenger-configured narrowbodies in service in April 2020 than four months earlier.

The active widebody fleet in late April 2020 was 3,086 aircraft, a drop of 2,946 aircraft in four months. This included 1,185 freighter aircraft, an increase of 16 units from four months earlier.

The key point about total fleet development over this four-month period is that first the number of active freighter aircraft saw an overall increase of eight. During the same period the number of active passenger aircraft declined by 12,235 units, which were parked, placed into longer term storage or retired.

This small inactive fleet was, in fact, only temporary. The number of active aircraft gradually increased again during the middle of 2020, as the pandemic eased. By the end of 2020 there were 13,308 narrowbodies of all types in active service, including 11,963 passenger and 798 freighter aircraft, equivalent to 3,043 fewer passenger and 62 more freighter aircraft than the year before.

It also included a total of 4,596 active widebodies of all roles: 3,019 passenger aircraft, 1,570 fewer than December 2019; and 1,296 freighters, 127 more than in December 2019. The total widebody fleet in operation in December 2020 was 76% of the active fleet a year before.

Most passenger aircraft in the active fleet in most regions were operating at lower rates of utilisation than normal, and with lower than pre-pandemic passenger

Prior to the Covid-19 pandemic, a large number of CFM56-5B and -7B engines had not yet had their first shop visits. Many have now been delayed, with the increased possibility of a bow wave of engine maintenance activity in late 2021 and early 2022.

load factors. There were several reasons for airlines operating more aircraft than they actually required, including the need to avoid the costs of parking and storage, and later reactivation, and to keep pilots current. In addition, many aircraft, especially widebodies, have been operated as 'freighters' during the pandemic to make up for the lack of passenger aircraft belly capacity.

The large number of inactive aircraft, and the low utilisation rates of active aircraft both negatively affected the number of engine SVs. The overall engine MRO market during 2020 suffered its worst downturn in the industry's history. The additional effect of the downturn in passenger traffic and fleet activity will be the continued negative impact on the engine MRO market during 2021. A key question is how fast will passenger numbers and fleet activity recover?

Engine MRO 2020

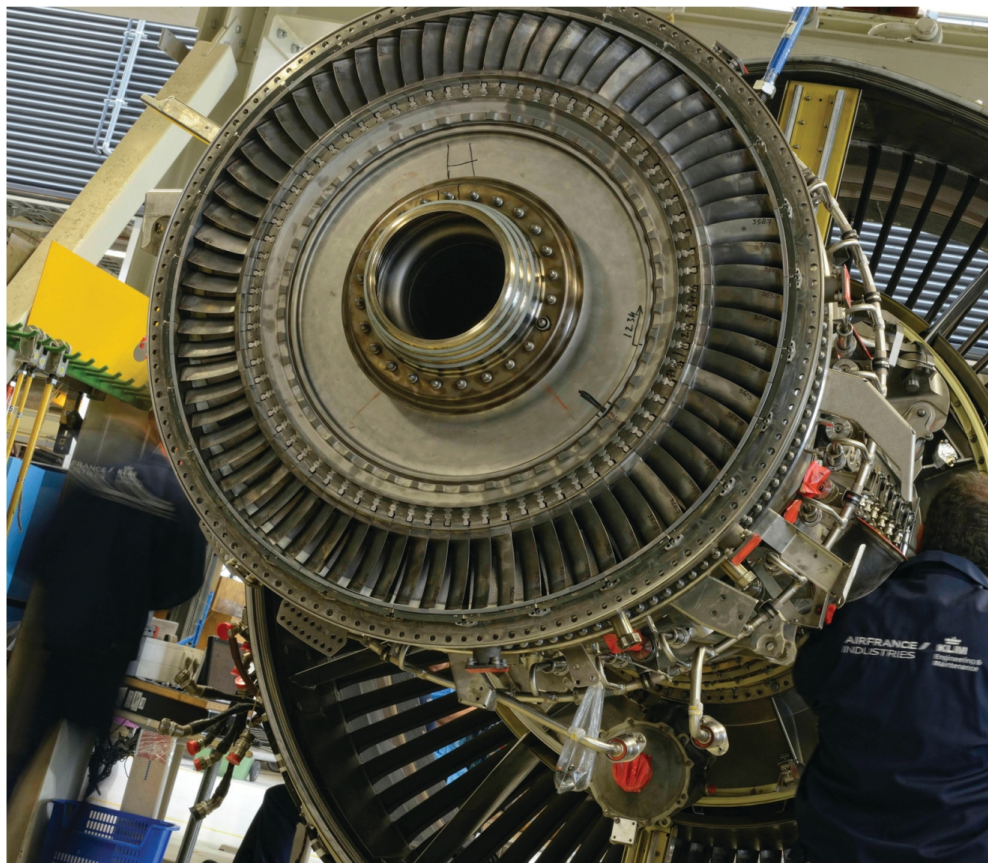
The engine MRO market, in terms of number of full SVs, is estimated to be down by 60-70%.

"The main issue for airlines during the sudden and steep drop in revenues from the spring of 2020 was using all possible measures to conserve cash. With engine SVs incurring high costs, deferring them whenever possible was an obvious policy for airlines," says Richard Brown, managing director at Naveo Consulting.

The type of maintenance contracts has some influence on how airlines managed their engines during 2020 and into 2021. First, airlines will continue to operate their youngest aircraft where possible, while the oldest examples with large maintenance coming due will be parked or retired.

Engines might be managed broadly under three main types of maintenance contract. Many younger engine types, and most engines powering younger and new generation widebodies, will be managed under power-by-the-hour (PBH) and other fixed-rate per engine flight hour (EFH) style contracts. These will be paid for on a monthly basis, so airlines will not incur a high cash outflow when these engines require removal for SV workscopes.

"Engines managed on these agreements did not have any removals or maintenance visits deferred, and any engines that fell due during 2020 would have been sent to the shop," explains Simon Mermod, director at Jet Engine Management.



"Airlines pay reserves each month according to the EFH flown, so maintenance events are pre-paid. There was some enforced demand for SVs in 2020 due to scheduled lease returns of aircraft, which had obligations related to the engines."

There has been some room for airlines to manoeuvre with respect to PBH and total care-style programmes. "The original equipment manufacturers (OEMs) have demonstrated flexibility during the pandemic by adjusting the contracts they have with airlines," says Jason Johnson, vice president of sales and business development at Standard Aero. "Most PBH contracts stipulate a minimum rate of utilisation, and this clearly affects the overall costs per EFH and per EFC."

Other types of engine maintenance contracts are payment on a fixed cost or not-to-exceed basis, or for the labour time (man-hours) and materials and parts used. These are used for some younger engines in a fleet, and are more widespread for older ones. They result in a large cash outflow when SVs must be performed. However, airlines define the SV workscopes, and they can reduce their size by swapping modules or using repair parts and used serviceable material (USM).

The deferment of SV workscopes was used as much as possible by airlines given the drop in SV activity during 2020. Low rates of aircraft utilisation was clearly one factor, while the other was the large number of parked and stored aircraft. These resulted in the fleet having a large

number of engines with maintenance time remaining that could be utilised. This is maintenance life available to either restore performance or replace life-limited parts (LLPs).

"About 50% of the fleet was grounded for most months of 2020, and some of the older parked and stored aircraft are highly unlikely ever to return to service. These factors all contributed to there being many engines with a lot of maintenance life, or 'green time', available for all aircraft types," says Francesco Baccarani, vice president of technical at SGI Aviation. "There was an unusually large number of engines of just about each type to swap between inactive and active aircraft throughout 2020."

"Another factor that affected the engine MRO market in 2020 is that airlines not on PBH and fixed rate per EFH contracts tried to use reduced SVs wherever possible to delay heavier workscopes and avoid high costs," continues Baccarani. "These alternative visits were small repairs on just some modules. The aim was to extract as much remaining life as possible on an engine's performance and its LLPs, or gain more maintenance life while avoiding big SVs by using smaller ones instead."

2020 market

As described, there were about 3,700 SVs for narrowbody turbofan engines and just over 2,000 SVs for widebody engines in 2019.



A third largest sector is the smallest turboprops powering the range of Bombardier and Embraer RJs. There were about 2,800 of these aircraft in active service at the end of 2019.

Before the pandemic, the market in 2020 was forecast to be about 5% higher than 2019. "It was originally anticipated that in the narrowbody sector, about 3,000 SVs would be carried out for the CFM56-5B and -7B, and the V2500 in 2020," says James Bennett, commercial director at Aerfin.

It is estimated that the total market for 2020 fell to 30% of 2019's 1,700-2,000 SVs for narrowbody and widebody engines. "The split in activity between narrowbody and widebody engines is 75% and 25%," says Baccarani. Some would argue that the drop was larger than 70%, since fleet growth was expected for 2020 before the pandemic.

Bennett says that in 2020 the actual global numbers for the CFM56-5B/-7B and V2500 were only 1,500 SVs. "Most of these were in the first half of 2020, while the August-December period was dead, so the market experienced a big drop," he adds.

There is a mix of shops in the engine MRO market, including maintenance and engineering (M&E) departments or subsidiaries of airlines, independent shops, and services divisions of the OEMs. Many shops, including OEMs, saw their activity levels drop to 20-30% of 2019 levels.

In addition to SV numbers, other sectors of the market have been hit. "As

airlines tried to have as many small worksopes as possible, we have seen a drop in the sale of parts that we salvage from teardown engines," says David Rushe, director of sales and marketing EMEA at Magellan Aviation Group. "All buying of engine material has become reactive, so parts are only acquired when they are absolutely needed. The global consumption of engine material is down by 40%. Airlines are also building engines to have a maintenance life of fewer EFCs as an insurance against falling engine values."

CFM56-5B/-7B

The largest portion of the market is accounted for by the CFM56-5B and -7B. There were 6,657 737NGs, all with -7B engines, and just over 4,000 A320neos with -5B engines in service in late 2019. This totals about 21,400 installed engines plus another 15% available as spares to support the fleet. This could take the total number of -5B and -7B engines for the active fleet to more than 23,000 units.

There would also be engines still installed on parked and stored aircraft that had yet to be broken down.

It was estimated in early 2020 that 60% of these engines had not yet had an SV. A wave of SVs was already building in late 2019 (*see CFM56-5B/-7B & V2500 experience surge in shop visit activity, Aircraft Commerce, August/September 2019, page 27*).

This was caused by a delay in many engines undergoing their first SV, and

The V2500 MRO market is smaller than the CFM56. Like the CFM56-5B/-7B, the V2500 has proven to be reliable, with the result that many engines are still due their first shop visit.

problems with a lack of parts and SV capacity. This wave and lack of SV space suddenly eased from March 2020.

The resulting market in 2020 was about 1,000 SVs for the CFM56-5B and -7B.

V2500-A5

The second most numerous type in the narrowbody sector is the V2500. The fleet of installed engines on the small remaining MD-90 and A320ceo fleets was close to 6,000 units. The V2500 SV market fell from more than 1,000 SVs in 2019 to fewer than 500 in 2020.

The other two main groups of engines are the new generation types that include: the CFM LEAP-1A engines powering the A320neo fleet, which had grown to 600 aircraft by the end of 2019, and had 612 units in operation at the end of 2020; and the PW1100G powering 550 A320neos and 99 A220-100/-300s at the end of 2019.

Most of these two engine types are relatively young, so collectively they are not expected to produce any significant numbers of SVs until 2022 and 2023.

JT8D, CFM56-3, PW2000 & RB211-535

The JT8D, JT8D-200, CFM56-3, PW2000 and RB211-535 all have significant numbers of the total active fleet powering freighters. Not only have freighter aircraft continued to operate at usual rates of utilisation, but the pandemic also stimulated demand for an increased number of passenger-to-freighter conversions.

The market for SVs for the relevant engine types therefore received a positive boost. In the case of the JT8D-200, many engines were made available from the retirement of large passenger fleets.

The CFM56-3 market received a boost. The few specialist shops still providing CFM56-3 capability include Aero Norway in Stavanger, Norway; and Israel Aircraft Industries (IAI), Tel Aviv, Israel.

"Aero Norway has been fortunate because of the renewed interest in the 737-300s and -400s as a freighter," says Glenford Marston, chief executive officer at Aero Norway. "Many freight carriers increased their rate of flying and consequently got more CFM56-3 SVs

during 2020 than we originally forecast. We predicted and planned for 22 CFM56-3 SVs out of a plan for 96 during the year, but in the end we actually performed 37 on -3s.

“January to March was normal, but then the market started changing from April,” adds Marston. “We quickly got a 50% jump in CFM56-3 activity.”

Widebody engines

The widebody engine fleet is more diverse, with up to seven main engine fleet groups.

CF6-50/-80, PW4000-94 & RB211-524

The first three groups comprise engines powering 1980s generation aircraft that were in service at the end of 2019: the CF6-50/-80C2, PW4000-94 and RB211-524G/H. More than 800 were 767s, while there were 328 747-400s.

Although at the end of 2019 844 of these aircraft were freighters, another 522 were in passenger configuration. Most of the passenger aircraft, especially 747-400s, were parked and stored during 2020, and many will never return to service.

This has released a large number of used CF6-80C2s and PW4000-94s on to the used market, so engine values have fallen and in turn the SV activity for these two particular engine types has collapsed. Estimates are that the CF6-50/-80C2 and PW4000-94 generated more than 700 engine SVs in 2019.

The increased market supply of CF6-80C2s and PW4000-94s during 2020 makes it possible for many carriers to acquire green-time or time-continued modules, and for engines to be dismantled to provide a large increase in the supply of USM. Carriers operating A300-600, A310, 767, 747-400 and MD-11 freighters will be able to take advantage of potentially large savings.

The market for these older types is buoyed, however, by the military aircraft types that also use them.

The only civil aircraft powered by these engines that will still have a significant number operating in the passenger role will be the 767-300ER. The last aircraft were built in 2014. There were 409 767-300ERs in passenger service at the end of 2019, and 203 at the end of 2020, divided between 141 with CF6-80C2 engines, and 57 with PW4000-94 engines.

The CF6-80C2-powered aircraft have to date been the most popular variant for freighter conversion. There are still a relatively large number of 767-300ERs of the right age and maintenance condition equipped with CF6-80C2 engines left for freighter conversion. The type is likely to remain popular for at least another 10 years.

The number of 767-300ERs with

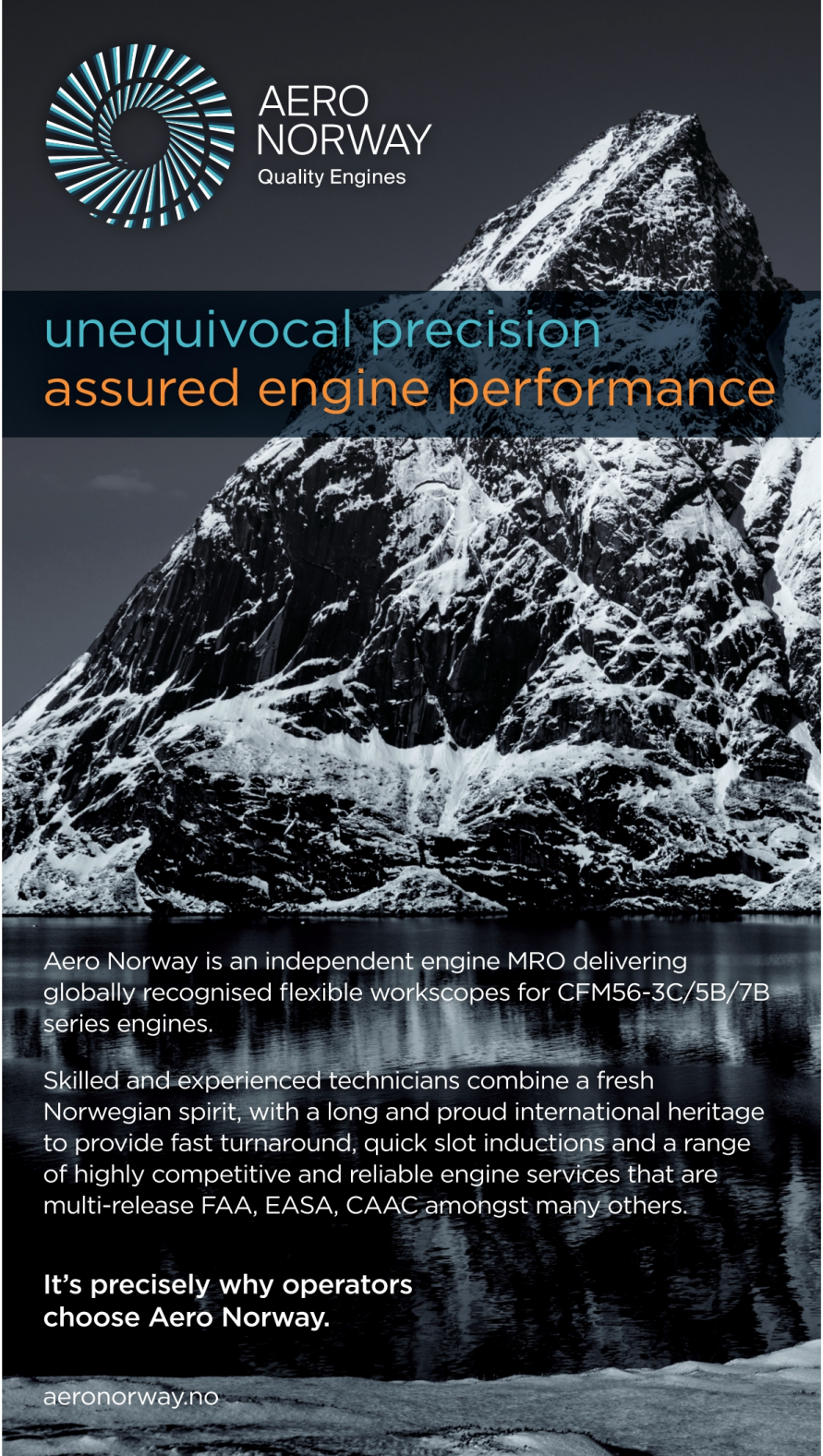
PW4000-94 engines that have been converted is fewer than 10. This is unlikely to become a popular choice, and so will have a negative impact on the PW4000-94 market.

CF6-80E1 & PW4000-100

The fourth and fifth widebody fleets are A330-200/-300s powered by CF6-80E1 and PW4000-100 engines, accounting for 273 and 180 active aircraft at the end of 2019. These two fleets

generated 100 and 70 engine SVs in 2019.

The active A330-200/-300 fleet had declined by more than 60% by the end of April 2020, although a larger number of aircraft were active at the end of the year. The parking, storage and retirement of large numbers of 767s, A340s and 747s means the A330 fleet is more likely to remain as a workhorse. Few are likely to be removed from active service for long periods, although some older A330-300s are likely to be retired. The A330 also presents itself as an attractive freighter



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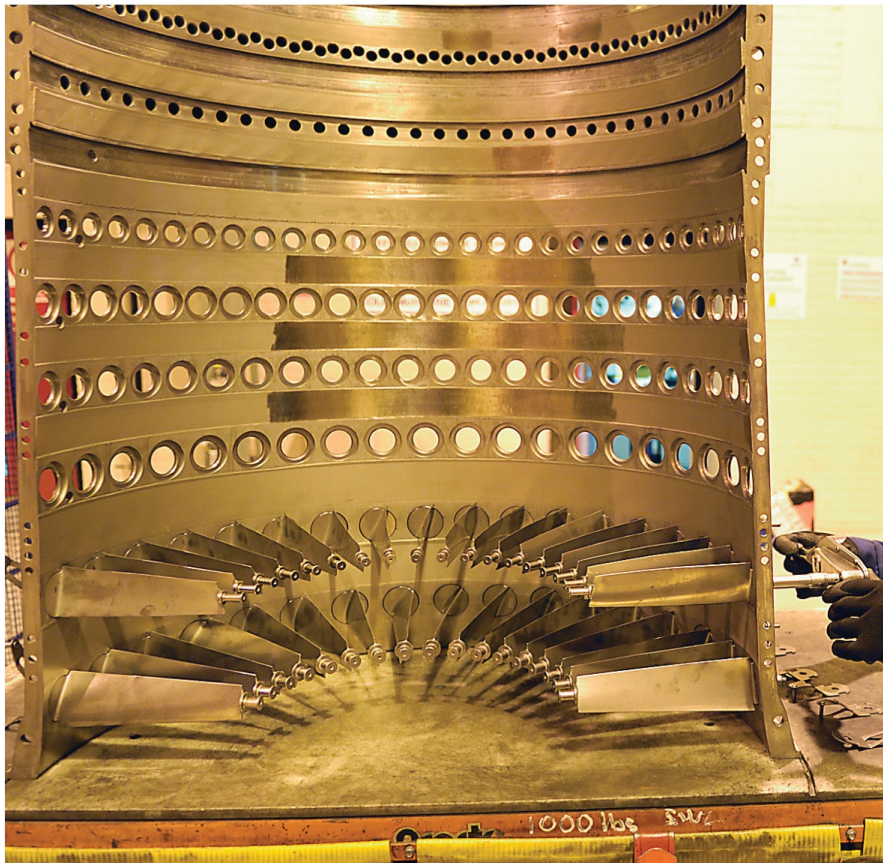
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conversion candidate.

The CF6-80E1 and PW4000-100 engine MRO market is therefore likely to remain strong.

PW4000-112

The sixth widebody fleet comprises the 127 PW4000-112-powered 777-200s that were operational at the end of 2019. These are some of the oldest 777s in service, and the active fleet had reduced to just 44 aircraft at the end of April 2020. While the number of active aircraft increased at the end of 2020, most of this particular fleet will retire over the next few years as its operators take delivery of replacements. The MRO market for the PW4000-100 is therefore likely to decline to a small base.

Trent family

The seventh main widebody fleet comprises the seven aircraft types powered by the Rolls-Royce Trent family. Most MRO activity for the Trent family is controlled by Rolls-Royce, although there are a few other providers of maintenance capability for the Trent 700 and Trent XWB that power the A330 family and A350.

The smallest fleets are the A340-500/-600, 777-200 and A380. The A340-500/-600 fleet has declined, and will not be operated in large numbers again.

The Trent 900-powered A380 fleet declined from 105 active aircraft to almost none by April 2020, and back up to 18 by

December 2020. The main operators of Trent 900-equipped A380s were British Airways (BA) (12), Emirates (25), Qantas (12), Lufthansa (14), Singapore Airlines (SIA) (17) and Thai International (6). Return to service looks unlikely for Thai, Lufthansa and Singapore Airlines. It is also unclear how many aircraft will eventually be operated by Emirates, BA and Qantas.

The Trent 800-powered 777-200 fleet was mainly operated by American Airlines (47), BA (19), Cathay Pacific (10), Delta Airlines (8), SIA (10) and Thai (16).

Despite the 777-200ER and -300 providing a backbone of capacity for these airlines, some, such as Cathay Pacific and Thai, have had the biggest problems since the start of the pandemic. Moreover, a large portion of the SIA fleet is due to be retired. All this will reduce the Trent 800's MRO activity. Delta has decided to retire its fleet. There are therefore several 777 fleets available on the market, and residual values have reportedly reached record lows.

The larger and most important Trent-powered fleets in December 2019 were the A330-200/-300 with 771 aircraft, the 787 family with 324 aircraft, and the A350 with 333; a total of 1,428 aircraft and almost 2,900 installed engines. Not only will most A330s continue in operation, but the 787 and A350 fleets will continue to grow as more outstanding orders are delivered.

It is possible that MRO activity for engines covered by Rolls-Royce's total care programme was down by 80% in 2020.

The market for types like the CF6-80E1 market is likely to remain strong because of wide scale retirement of older long-haul workhorses such as the 747-400 and many 767-300ERs.

GE90 family

The eighth group comprises the GE90-powered members of the 777-200 fleet. This group comprised 1,163 active aircraft in December 2019, one of the largest in the total widebody fleet, divided between 131 777-200/-200ERs powered by the original 94-inch fan engines, and 1,032 777-300ERs powered by the 115-inch fan engines.

The 94-inch powered fleet is small by comparison, so it only generated about 40 SVs in 2019. The temporary parking of aircraft will clearly have an impact on the MRO market for the 94-inch fan engine.

This second fleet is up to 16 years old, and serves as the long-haul workhorse. It will now be more in demand with the full retirement of all 747-400s and a lot of the A380 fleet, as well as most of the last A340s in 2020. The demand for engine SVs for the GE90-128 engine will therefore remain strong. This group generated about 350 engine SVs in 2019, and the overall number is estimated to have fallen by 30-50% in 2020.

GENx

The last main widebody fleet is the GENx-powered 787 family and the 747-8. Despite the downturn, most passenger-configured 747-8s have remained in operation, partly because they are being temporarily used to carry freight.

Estimates are that about 310 annual SVs took place for all GENx engines in 2020, compared to 470 SVs in 2019, so a drop of about 35%.

The 787 family temporarily shrank during 2020 by about 50%, but active aircraft numbers increased again later in the year. Like the A330 and A350, the 787 will remain as a long-haul workhorse due to the early retirement of the older types.

The main issue for CF6-80E1, PW4000-10, Trent 700, Trent 800, Trent 1000, Trent XWB, GE90-115 and GENx is how quickly intra- and inter-continental traffic will return to pre-pandemic levels, and so how quickly the main widebody fleets will return to late 2019's numbers.

2021 & future market

The two most important factors affecting activity in the engine MRO market are the overall amount of engine

'green time' available, and the rate at which passenger traffic and therefore fleet activity increases.

Assessing the total number of engines with 'green time' or maintenance life available, and therefore the total amount of green time in terms of EFH and EFC for each engine type, can only be done to a general level. The number of engines an airline has in its fleet with green time, and the availability of engines to buy or lease indicates how well the market is supplied.

Airlines are more influenced, however, by what is available locally and in their region, rather than what is available globally. It has to be remembered, for example, that Chinese domestic traffic had fully recovered by October 2020, and that the active narrowbody fleet comprised more aircraft in December 2020 than the year before. The narrowbody fleet of mainly A320 family and 737NGs is therefore back in full operation, so engines are using maintenance life at the usual rate, after a lull of a few months in the middle of 2020. The CFM56 and V2500 MRO market should return to normal relatively soon.

The number of active narrowbody aircraft on other continents in December 2020 had reached 70-80% of the number active a year before. Despite this, however, aircraft in the rest of the Asia Pacific and the rest of the world were operating at utilisation rates lower than the year before.

The number of parked and stored aircraft, the low rate of utilisation of active aircraft, and the amount of green time many engines had and the number of retired and leased engines available at the start of the pandemic, all combine to determine how fast the engine MRO market will return to normal. "As a rough guide the market should be about 20 percentage points higher than 2020, which is about 50% of normal in 2020," says Bennett. "The market recovery is also likely to be backloaded to the second half of the year."

"While most aircraft that were active have gone back into service, a lot depends on the rate of Covid-19 vaccinations around the world, the rate at which infections decline, how governments progress with easing travel restrictions, and the economic demand for travel," says Brown.

Brown further comments that engines need to have completed their SVs in time for the late spring and early summer recovery. "The many CFM56-5B/-7Bs and V2500s that have not had their first SV could contribute to a shortage of engines, if there is a sudden resurgence," says Brown. "Parked and stored aircraft could also be reactivated, but the status of parked engines is unknown. Forecasters tend to overstate the extent of downturns and underestimate the rate of recoveries."

The different fleets of engine types

should be considered. Older generation narrowbody engines have remained strong because of their use by freighter aircraft. Freighters have remained in high demand due to the lack of widebody passenger aircraft belly space, and the effect of increasing freight yields. The JT8D and JT8D-200 MRO markets remain because of the 105 freighters and small number of the same types still in operation.

The CFM56-3 market will continue to provide business for specialist shops that

have retained their capability. The number of 737-300 and -400 freighters added to the fleet increased by almost 20 in 2020, and the conversion market is likely to remain active for several more years. About 350 737 Classic freighters plus specialist variant aircraft will therefore need engine support, plus the remaining passenger fleet. "We got a 50% jump in CFM56-3 activity in the second half of 2020, because of the increased interest in airlines acquiring 737-300s and -400s for

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freighter conversions, and the increased rate of utilisation of existing freighters,” says Marston. “The CFM56-3 market looks to be stable for a few more years before it gradually declines again as aircraft are retired each year. It has lasted longer than we anticipated.”

The RB211-535 and PW2000 market has similarly received a boost from airlines’ increased interest in acquiring freighters. The RB211-535 in particular will continue to have a strong market, since Precision Conversions continues to convert aircraft. The best conversion candidate aircraft left are equipped with RB211-535 engines. Precision Conversions has more than 20 orders for conversions to fulfil, including some of the 19 ex-American Airlines aircraft acquired by AerSale. Precision Conversions says it could still convert another 30-40 757-200s before the programme stops. There is also a possibility of developing a conversion for the 757-300; only about 20 of the 55 -300s built would need to be converted to justify a programme. A converted 757-300 would have a main-deck capacity of 18 containers, versus 15 carried by a 757-200.

There is also the market for the military equivalent of the PW2000 that powers the C-17, which should add strength to annual SV volumes.

The bulk of the narrowbody engine market is and will continue to be the CFM56-5B and -7B, which have the same modules and parts except for the fan and low pressure compressor; plus the V2500.

The CFM56-5B and -7B have the largest market of all engine types. Fleet demographics have a large effect on the

number of SVs per year for these three types. A surge in SV activity was expected for them in 2020 before the onset of the pandemic. “Many -5Bs and -7Bs have still not yet had their first SV. Many were delayed in 2020,” says Rushe.

In 2019 the number of SVs for these three types was about 770 for the CFM56-5B, and almost 1,700 for the CFM56-7B; a total of about 2,500 SVs performed. “This was forecast to be similar in 2020,” says Marston. “The actual number was about half the number originally forecast, so about 1,300 SVs. We expect it to increase again in 2021. The total will probably be more than 2,000 SVs, about 900 more than in 2020, with most in the second half of the year. There are still some green time engines available, but there is evidence that availability is falling. We are now seeing signs that airlines are planning more full SVs again, with the number of requests we are seeing. This compares favourably to August 2020, when we saw very few proposals being requested.”

The V2500 market was about 900 SVs in 2019, slightly more than the -5B market, despite there being about 1,000 more aircraft with -5A and -5B engines. Original forecasts for 2020 were for 1,200-1,300 SVs for the V2500, but actual numbers did not materialise. The market is expected to increase again to similar levels in 2021 as in 2019, although activity in 2021 is expected to reach and peak at 1,300 SVs. The number would then steadily decline each year as the oldest aircraft retire.

“The wave of SV activity for these three engines that was due in 2020, will now probably occur in late 2021 and into

The GE90 will be the most numerous long-haul and widebody engine types with the retirement of many older generation aircraft types. The 777-300ER is the dominant widebody, long-haul workhorse.

2022,” predicts Marston.

“A wave of SVs for the CFM56-5B/-7B and V2500 could be an inevitable result of airlines using all possible green time during the pandemic,” adds Mermod. “The situation is slightly alleviated by aircraft utilisation rates being right down. I expect to see a definite increase in SV activity for the main types month by month, but a steady stream rather than a wave.”

Baccarani adds that an increase in SV activity for CFM56 Tech Insertion (-5B and -7B) engines was being seen in early 2020. “The first SVs had started for these engines, which have very long removal intervals due to their technical status. The same applies to higher specification variants of the V2500,” says Baccarani. “The engine shops were packed in late 2019, but the pandemic pushed the wave back. It will take two to three years to regain the level of SVs, but the wave will get smoothed out. Another element that will affect the market is that a new service bulletin (SB) was released in December for the V2500. This limits the high pressure turbine discs at 6,700EFC for lower thrust ratings, and 3,200EFC for 30,000lbs and 33,000lbs thrust ratings, requiring a full refurbishment of the module. There will therefore be an increased rate of V2500s being brought into the shop.”

The A320neo family fleet continued to grow throughout 2020, and reached nearly 1,580 passenger aircraft by the end of the year, including 760 with CFM LEAP-1A engines, and 816 with PW1100G engines.

In addition, the CFM LEAP-1B-powered 737 MAX family began to return to service in December 2020. Almost 400 are in storage, due for reactivation during 2021. There are also 3,985 aircraft on order, with 342 due for delivery in 2021.

There were also 99 A220s in service at the end of 2020, powered by PW1100G engines, with 45 aircraft due for delivery in 2021.

While the fleet of CFM LEAP- and PW1100G-powered aircraft will increase during 2021, these engines are not expected to need more than 200 SVs per year until 2022.

“These two main engine types have to be considered carefully,” cautions Baccarani. “The CFM LEAP was configured for the lowest possible fuel burn performance, and its core is pushed harder than the CFM56-5B and -7B. The LEAP engine should therefore have shorter removal intervals. Many engines are,

The need for airlines to conserve cash is likely to see airlines swapping PBH-style engine management contracts for other types, such as time and material. This will allow the use of USM, providing a potential for large savings for each shop visit.

however, managed on PBH and total care maintenance contracts. The PW1100G by comparison does not need a strong core engine by comparison because of its geared configuration. It has, however, had its fourth version of the combustion chamber since it entered into service.”

Widebody market

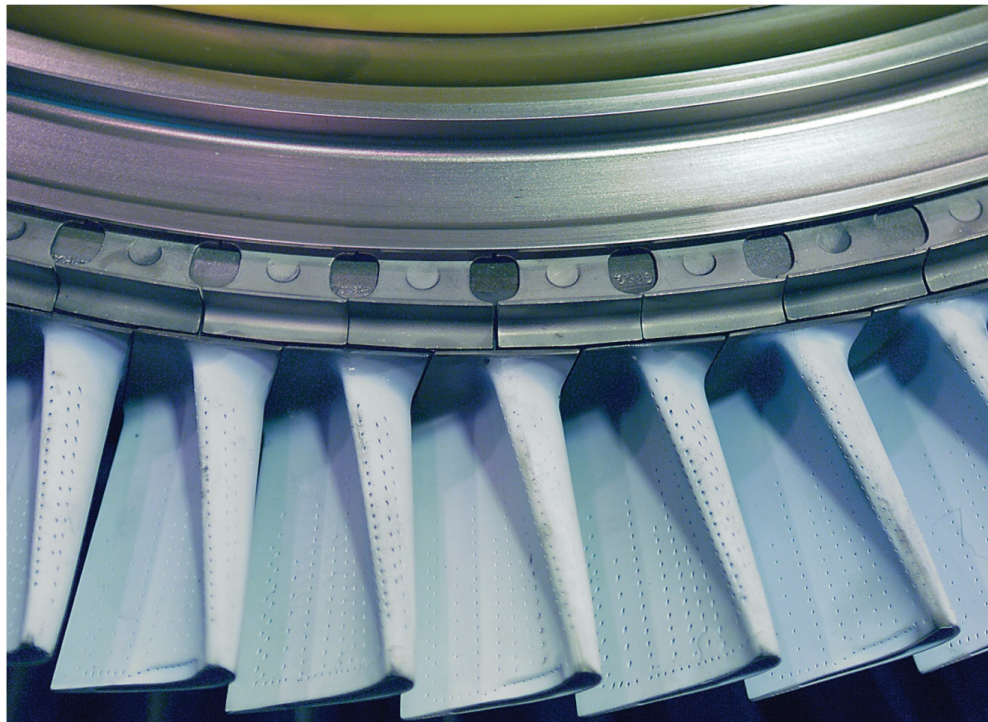
Most engines in the widebody fleet are modern and new generation types. The oldest of these is the CF6-80E1 and PW4000-100 powering the A330; while the most recent are the GEnx, Trent 1000 and Trent XWB powering the 787 and A350 fleets. The aircraft equipped with these engines account for about 72% of the widebodies in service.

The number of active widebodies in this generational category at the end of 2020 was 74%, a smaller percentage compared to narrowbodies. These medium and new generation aircraft serve the highest-density intra-continental and inter-continental routes. These markets will take the longest to recover, so these fleets will take the longest time to return to normal operational activity.

Most SV activity for these engines is controlled by the engine OEMs, and the engines are managed under fixed-rate-per-hour contracts. Many of these contracts are also all-inclusive, and so include additional support products, such as spare engine provisioning.

As these engines age, and the original support contracts expire, some airlines seek alternative support programmes. There are a few alternative shops for some of the widebody engine types.

At the end of December 2019, widebodies powered by the older generation CF6-50/-80, PW4000-94 and RB211 engine types accounted for 28% of active widebodies. Of this fleet of nearly 1,700 aircraft, just over 900 were freighters. The number of active widebody freighters increased during 2020 by nearly 70 units. Moreover, 660 of these aircraft are powered by CF6-50 and -80 engines: A300-600, A310, 767-300ER, 747-400 and MD-11 freighters. Most of these are popular with their operators, and will remain in service for the next 10-15 years. More 767-300ERs are likely to be converted. There are also military versions of the 767 and DC-10 that will supply SV volumes to this market.



A further 230 aircraft are powered by PW4000-94 engines. Most of these are A300-600 and 747-400 freighters.

The shops that provide capability for these engines experienced a smaller decline in business during 2020 than other engine types due to the high percentage of freighters in the fleet. Moreover, during 2020 60 aircraft of these types were added to the fleet. There have still, however, been a large number of 747-400 retirements from the passenger fleet, impacting both CF6-80C2 and PW4000-94 MRO markets.

Future development

Estimates are that with a return to a fully operational fleet the number of engine SVs for narrowbody and widebody engines will return to similar levels of 2019 in 2022, and increase thereafter to more than 6,300 SVs in 2023 and 7,600 in 2024. There will, for example, be an increase in CFM56-5B and -7B activity of about 600 SVs per year by 2024. There will also be increases in activity for GE90, GEnx and Trent 1000 and Trent XWB engines in particular.

It is estimated that the number of SVs for CFM LEAP-1A/-1B and PW1100G engines will grow to 1,300 per year as the first engines come due for their first SVs. This is following the development of the A320neo and 737 MAX fleets in particular to several thousand units.

In the meantime the number of SVs generated by older types such as the CFM56-3, CF6 family, Trent 700 and GE90 family will be reaching peak numbers as removal intervals reduce when coinciding with the number of A330s and 777-200LRs/-300ERs reaching their peak.

The older types are expected to continue in stable numbers as freighters over the next five to 10 years.

The experience of Covid-19, and the impact over an extended period is likely to trigger and stimulate airlines into seeking new types of contract. “While some airlines like the predictability of PBH-style engine maintenance contracts, the industry can expect to see more airlines switching to time-and-material, and fixed-price contracts,” says Bennett. “In this case, I expect that PBH rates will have to come down for new engines in the future.”

Rushe is in agreement. “While we have seen parts and component sales slump during the pandemic, the retirement of a large number of older A320neos and 737NGs, aided by delivery of more A320neos and 737 MAXs, will increase the supply of teardown engines. Airlines will try to use more USM in engine SVs, especially the CFM56 and V2500. Airlines can make large savings when using USM, and this will see a lot of airlines stepping away from PBH contracts. We have even seen the engine manufacturers buying material from us for use in SVs.”

There is a large number of specialist engine teardown shops, as well as specialist engine airfoil and component repair providers. Many are independent of the engine manufacturers. Bonus Tech, a subsidiary of Air France in Miami, is an engine teardown specialist for the CFM56, V2500, PW4000-94, CF6, and GE90. AFI KLM E&M also has specialist engine parts repair shops that include CRMA and Airfoils Advanced Solution in France. **AC**

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