

There are more than 6,000 active and stored aircraft in the global widebody fleet, with production ranging in date from the early 1970s to present day. Fleet sizes, regional distribution, age and forecasted maintenance requirements are examined here.

Size of the widebody airframe base check market

The global widebody fleet of just over 6,000 aircraft comprises about 19% of the commercial jet transport fleet, compared to the narrowbody fleet of just over 17,000 aircraft. For the purposes of this article, the fleet of established widebody types includes in-service and stored Boeing 767-200/-300/-300ER/-400s, 777-200/-300s, 747-300/-400s and 787-8/-9/-10s. The Airbus fleet includes A300-B4/C4/F4/-600s and A310s, A330-200/-300s, A340-200/-300/-500/-600s and A380-800s.

Also included are the new emerging fleets of the 747-8F/-8Is, A350-900/-1000s, the A330-800/900s new engine option (neo) family, and the yet-to-enter service 777-X (-8/-9).

The survivors of the legacy fleet included are the MD-11 and DC-10-10/-30/-40.

Finally, the current listing of Ilyushin IL-80 and IL-96 fleet quantities is noted. Due to the fleet size and location, the maintenance & repair organisation (MRO) market for this type is extremely limited, however.

In addition to the commercial fleet, a small number of military widebodies is in use as tankers and transporters, including: 62 DC-10s, designated as KC-10A and KDC-10; and eight 767-200s, designated as KC-767A (4 aircraft) and KC-767J (4). New models entering the tanker/transporter fleets include 58 767-2Cs (KC-46A). Such fleets generally do not enter the commuter and freighter MRO market.

Data for most of the aircraft in service (including build details, operational statistics, and ownership) are available throughout the industry in different formats for analysis. Such data supplied to *Aircraft Commerce* for this article provides a snapshot of the characteristics of the widebody fleet from mid-December 2018 (see table, page 27).

This data of course is fluid in nature. Aircraft move in and out of storage or are

retired, and new aircraft enter service every day. Fleet details including quantity, status, purpose, age and utilisation can be used to gain insight not only into the size of the fleet, but also its base maintenance check requirements.

As an example, widebody quantities, region of use, utilisation characteristics, maintenance programme type, and predicted maintenance events are examined here. Details of the widebody fleet engine MRO market are also available (see *Widebody engine MRO market analysis, Aircraft Commerce, June/July 2017, page 54*).

There are also details of the narrowbody airframe check market (see *Size of the narrowbody airframe base check market, Aircraft Commerce, October/November 2018, page 30*).

The widebody fleet

The widebody fleet is used operationally for its long-range performance and ability to move large numbers of passengers over short distances, so fleet locations and operational usage vary widely.

The regions with the three largest widebody fleets are the Asia Pacific (2,055 aircraft), North America (1,484) and Europe (1,423). The smaller fleets are in the Middle East (916), Africa (222) and South America (202) (see table, page 28).

There are a small number of widebody aircraft (11) with no assigned operator country, and an 'undisclosed' operator. All these aircraft are stored.

The A330ceo makes up the larger fleet numbers in Europe and the Asia Pacific. The 777-200/-300 family makes up the larger fleet numbers in the Middle East, while the 767 family is the most prevalent in North America.

In Africa, the fleet numbers of 777, A330ceo and the 787 are closer in size. In South America, the 767, A330ceo and 787 fleets are dominant.

The four largest regions in terms of fleet orders are the Asia Pacific (611), Middle East (605), North America and Europe (417). Orders currently unassigned to a country total 108 (see table, page 28).

The 'on order' figures noted are always considered as guides only. Airlines are sometimes able to negotiate some flexibility (or even the option to cancel) when they place orders.

An overview of fleets per region now follows.

North America

The North American fleet is made up of 1,386 in-service and 98 stored aircraft over 63 listed operators in the United States (US) and Canada.

The US widebody in-service fleet comprises 1,245 aircraft. The larger fleet sizes include United Airlines (182), American Airlines (155) and Delta Airlines (150).

The Canadian widebody in service fleet comprises 141 aircraft. The larger operator fleet sizes include Air Canada (74) and Air Canada Rouge (25).

Of the North American fleet, 638 aircraft are configured as freighters. The larger fleets are with FedEx (265), UPS (173) and Prime Air (41).

The business- and VIP-configured widebody fleet comprises seven aircraft. Other primary role functions include: five Waterbombers; three aircraft listed as experimental (still with the original equipment manufacturer (OEM)); one medevac; 62 tanker/transporters; and three with military roles.

One unique primary role is the 'Air Launch Platform' 747-400 listed as in service with Virgin Galactic.

The region has 417 widebody aircraft on order for 15 different operators and leasing companies, including 405 in the US and 12 in Canada, all of which are due for delivery in the next 10 years. The larger orders in terms of US airlines

GLOBAL WIDEBODY FLEET - IN SERVICE AND STORED AIRCRAFT

Aircraft type	In-service & stored fleet	In-service passenger	In-service freighter	In service VIP or special	Stored aircraft	Youngest aircraft	Oldest aircraft	Average fleet age	Highest listed FH	Highest listed FC	Aircraft on order
747-300	6	4	1	1		28	35	31.33	84,830	25,708	
747-400	418	131	199	20	68	9	29.5	19.3	140,458	21,169	
747-8	131	36	80	6	9	←1	7.3	4.5	36,780	6,878	20
767-200*	113	13	58	12	22	15	36	30.22	109,350	50,706	
767-2C KC46A											58
767-300	548	388	90	19	59	4	32.2	20	134,952	45,326	
767-300ERF	148		148			←1	23.3	9	74,299	27,178	64
767-400	38	37		1		10	18.9	17	79,089	14,649	
777-200	656	438	151	8	59	←1	24.1	14	105,493	26,827	53
777-300	853	837		2	14	←1	21.2	7	67,335	20,722	38
777X (-8/-9)											326
787-8	361	329		2	30	←1	8.8	3.8	28,275	5,679	89
787-9	398	389		1	8	←1	5.2	2	19,682	2,966	387
787-10	12	11		1		←1	1.5	←1	2,271	691	158
A300 (B4/C4/F4)	18	4	10		4	34	38.8	35.7	67,399	42,359	
A300-600	205	21	179		5	11	32	21.25	62,672	35,607	
A310	63	20	8	19	16	21	32.4	28.25	111,150	27,292	
A330-200	647	531	36	36	44	←1	21	9.6	94,907	22,530	37
A330-300	722	698	2		22	←1	26.1	7.92	82,497	28,925	31
A330-700	1		1			←1	←1	←1	NO DATA	NO DATA	
A330-800neo	1			1		←1	←1	←1	NO DATA	NO DATA	8
A330-900neo	3	1		2		←1	1.2	←1	NO DATA	NO DATA	233
A340-200	9			7	2	23	26.7	23.6	54,444	15,059	
A340-300	119	91		8	20	10	27.1	18.34	108,643	18,724	
A340-500	30	3		7	20	8	15.5	12.86	49,068	2,750	
A340-600	88	58		2	28	8	17.5	12.7	69,601	9,494	
A350-900	214	211			3	←1	5.5	←2	17,961	2,698	504
A350-1000	15	12		3		←1	2.1	←1	2,371	477	161
A380-800	232	229		1	2	←1	13.6	5.5	44,359	6,206	98
MD-11	127		121		6	17	28	24.2	130,179	17,406	
DC-10-10	22		21		1	37	47.8	42.45	87,321	33,368	
DC-10-30**	85		14	66	5	30	45.7	34.6	122,041	29,298	
DC-10-40**	2			1	1	39	42.7	40.5	84,301	43,916	
IL-80	4			3	1	33	33	33	NO DATA	NO DATA	
IL-96 300	20	4	1	8	7	2	28	15.85	NO DATA	NO DATA	
IL-96 400	4			2	2	7	21	12	NO DATA	NO DATA	
TOTALS (DEC 2018)	6313										2,265

INFORMATION FROM FLEET SURVEY DEC 2018 IN SERVICE AND STORED AIRCRAFT ONLY

* Includes the KC -767A/J variants

** Includes the KC variants (Tanker/Transport)

←1 = LESS THAN ONE YEAR OF AGE - NEW AIRCRAFT ENTERING SERVICE

include FedEx (71), United Airlines (70), American Airlines (49) and Delta Airlines (49). In Canada this includes WestJet (10) and Air Canada (2).

Lessors with a high number of aircraft orders include Air Lease Corporation (51) and GECAS (7).

In North America there are 98 aircraft stored for 40 different operators and lessors. Excluding Boeing itself, the operator with the highest number of stored aircraft is United Airlines, with a mix of stored 747-400s (9) and 767-300s (3).

For aircraft fleet types and aircraft on order for the North American region (see tables, page 28).

Europe

The European fleet includes 1,323 in-service and 100 stored aircraft over 137 operators and 31 countries. Europe has the highest number of listed operators.

Countries with a high number of in-service aircraft include the United Kingdom (237), Germany (190), Russia (135), France (148) and Turkey (116).

The largest in-service passenger fleets include British Airways (BA) (134), Lufthansa (103), Turkish Airlines (88), Air France (103) and KLM Royal Dutch Airlines (60).

Of the European fleet, 192 aircraft are freighters. Large fleet numbers are

with European Air Transport (23), Cargolux (23), Lufthansa Cargo (17) and AirBridgeCargo (17).

Europe's business and VIP fleet comprises 27 aircraft. Other varying primary role functions include six Combi (passenger and freight), 12 aircraft listed as experimental, 21 as tanker/transporters, four with military roles, and three with special roles (Russian Air Force).

The are 417 aircraft on order for 33 different operators in the region. The larger orders include Turkish Airlines (54), Lufthansa (33), BA (30) and KLM (24). Lessors with large orders include AerCap (33) and Avolon (32).

CURRENT IN-SERVICE AND STORED GLOBAL WIDEBODY FLEET PER OPERATOR REGION

Region	747 -300/ -400	747 -8	767 -200/ -300/ -400	777 -200/ -300	777X (-8/ -9)	787/ -8/-9/ -10	A300 (B4/C4/F4) & A300-600	A310	A330 -200/ -300	A330 -700/ -800neo/ -900neo	A340 -200/300/ -500/ -600	A350 -900/ -1000	A380 -800	MD-11	DC-10 -10/ -30/	IL-80/ -96	Total By Region
Africa	11	1	21	49		39	6		48		33	12		2			222
Asia Pacific	117	47	146	546		317	20	7	639		24	128	64				2,055
Europe	146	51	110	293		143	38	17	379	5	134	31	40	12	2	22	1,423
Middle East	38	10	20	352		100	32	21	140		36	36	128	3			916
North America	112	22	491	254		116	121	18	117		7	11		110	105		1,484
South America			57	13		56	6		46		7	11		2	4		202
Unassigned			2	2							5					2	11
TOTAL BY TYPE (DEC 2018)	424	131	847	1,509	0	771	223	63	1,369	5	246	229	232	127	109	28	

CURRENT ON ORDER GLOBAL WIDEBODY FLEET PER OPERATOR REGION

Region	747 -300/ -400	747 -8	767 -2C/ -300ER/ -300ERF	777 -200/ -300	777X (-8/ -9)	787/ -8/-9/ -10	A300 (B4/C4/F4) & A300-600	A310	A330 -200/ -300	A330 -800neo/ -900neo	A340 -200/300/ -500/ -600	A350 -900/ -1000	A380 -800	MD-11	DC-10 -10/ -30/	IL-80/ -96	Total By Region
Africa				1		20			1	4		34					60
Asia Pacific			2	23	61	191			34	86		203	11				611
Europe				13	20	145			23	39		157	20				417
Middle East				15	235	111			8	38		144	54				605
North America		19	120	27		124				55		72					417
South America				2		9			1	5		30					47
Unassigned		1		10	10	34			1	14		25	13				108
TOTAL BY TYPE (DEC 2018)	0	20	122	91	326	634	0	0	68	241	0	665	98	0	0	0	

Unassigned = unknown country & unannounced commercial customer

There are 100 aircraft stored across 45 operators and lessors. The operators with the highest number of stored aircraft are European Aviation Ltd with A340-300 (1), A340-500 (1), and A340 (6), along with VEB-Leasing with a mix of 747-400 (5), 767-200/300 (2), and 777-200 (1).

Aircraft fleets and orders for Europe are summarised (*see tables, this page*).

Asia Pacific

The Asia Pacific fleet comprises 1,924 in-service aircraft and 131 stored aircraft over 99 operators and 29 countries.

Countries with a high number of in-service aircraft include China (445), Japan (285), Hong Kong (222), South Korea (187), Singapore (142) and Taiwan (122).

The largest in-service passenger fleets include Cathay Pacific (132), All Nippon Airways (ANA) (139), Singapore Airlines (SIA) (118), Korean Air (101), Air China (115), Japan Airlines (JAL) (114) and China Eastern Airlines (70).

Of the Asia Pacific fleet, 180 aircraft are freighters. Korean Air has the largest widebody freighter fleet with 23 aircraft: four 747-400s, seven 747-8s, and 12 777-

200. Cathay Pacific Airlines has the second largest freighter fleet with six 747-400s and 14 747-8s.

The region's business and VIP fleet comprises 13 aircraft. Other primary role functions include 11 tankers/transporters, and four 'Special Purpose' aircraft with the Japan Air Self-Defence Force.

On order in the region are 611 aircraft for 42 different operators. The larger orders include SIA (98) and AirAsia X (78).

The Asia Pacific region has the highest number of stored aircraft, with 131 across 45 different operators and lessors. The operator with the highest number of stored aircraft is Thai Airways International with a mix of 747-400s (5), 777-200 (1), 787-8s (4), A330-300s (5), and A340-500/-600s (9).

The airline fleets and aircraft on order for the Asia Pacific region are summarised (*see tables, this page*).

South America

The South American fleet comprises 191 in-service and 11 stored aircraft with 34 operators and 15 countries.

Countries with large fleets include Brazil (47 aircraft), Chile (43), Columbia

(32) and Mexico (25).

The largest in-service passenger fleets operate with LATAM Airlines Chile (40), LATAM Airlines Brazil (30), Avianca (21) and Aeromexico (17).

Of the South American fleet, 24 aircraft are freighters. AeroUnion has the largest freighter fleet with two 767-200s and five A300s. The next highest is Avianca Cargo with five A330-200s.

The South American business and VIP fleet is just four aircraft. Other primary role functions include one military multi-role, and one tanker/transport aircraft.

The region has 47 widebodies on order for eight different operators. The larger orders include LATAM Airlines Brazil (17) and Avianca (13).

There are 11 stored aircraft in the region across eight operators and lessors. Aircraft of interest are four new 787-8s across various operators, and two IL-96-300s with Cubana.

The South American fleet and aircraft on order are summarised (*see tables, this page*).

Africa

The African fleet comprises 192 in-service and 30 stored aircraft over 44

WIDEBODY FLEET ESTIMATED C CHECK & HEAVY MAINTENANCE VISITS (HMV): PER AIRCRAFT TYPE

Aircraft type	2019			2020			2021		
	in service fleet	2019 C checks	2019 HMV	in service fleet	2020 C checks	2020 HMV	in service fleet	2021 C-checks	2021 HMV
747-400	332	170	39	313	160	46	294	140	45
747-8	130	55	20	136	67	24	136	57	20
767-200/-300/-400	751	475	130	738	473	123	718	462	126
777-200/-300	1,483	482	243	1,496	446	256	1,494	452	263
777X (-8/-9)			0	42	0	0	106	0	0
787-8/9/10	925	290	105	1,074	334	137	1,213	393	168
A300	9	5	1	7	4	1	6	4	1
A300-600	181	83	39	171	75	38	162	70	39
A310	33	19	7	27	14	6	21	7	6
A330-200/300	1,309	553	276	1,299	590	297	1,285	531	315
A330neo	83	24	0	152	59	0	221	93	1
A340-200/-300	79	31	20	64	25	18	52	22	14
A340-500/-600	59	29	15	53	19	14	47	23	10
A350-900/-1000	385	103	0	502	163	0	619	220	0
A380	240	110	42	247	105	53	254	110	57
DC10	35	16	2	29	16	0	24	14	1
MD11	110	83	25	102	75	26	94	74	20
Total	6,144	2,528	964	6,452	2,625	1,039	6,743	2,672	1,086

Source: ICF Consulting proprietary MRO forecast model

operators and 24 countries.

Countries with the largest number of in-service aircraft include Ethiopia (57), South Africa (29) and Egypt (23). The largest operators include Ethiopian Airlines (57), South African Airways (28) and Air Algerie (11).

The African fleet includes 19 freighters. Ethiopian Airlines has the largest widebody freighter fleet, with nine 777-200LR aircraft.

Africa also has seven business and VIP aircraft. No other primary role options are listed.

There are orders for 60 aircraft in the region for nine different operators. The larger orders include Ethiopian (15), Afriqiyah Airways (10) and Arik Air (9).

Stored aircraft in Africa include 30 aircraft across 20 operators and lessors. The spread of stored aircraft numbers is relatively even across the operators.

The fleet and aircraft on order are summarised (see tables, page 28).

Middle East

The Middle East fleet comprises 839 in-service and 77 stored widebodies, with 53 operators and 13 countries.

Countries with large fleets include the United Arab Emirates (363), Qatar (189), Saudi Arabia (129) and Iran (52).

The largest passenger aircraft fleets include Emirates (258), Qatar Airways (157), Saudia (102), Etihad Airways (72) and Mahan Air (31).

Of the Middle East fleet, 67 aircraft are freighters. Qatar Airways has the largest widebody freighter fleet of 747-8s (2), 777-200s (15), and A330-200s (8).

The Middle East has 35 business and

VIP aircraft. Other primary role functions include nine tanker/transport aircraft.

There are 605 widebodies on order for 14 different operators. The larger orders include Emirates (210), Qatar Airways (138) and Etihad Airways (134).

Stored aircraft in the region include 77 aircraft across 28 operators and lessors. The operator with the highest number is Saudia with one 747-400, 17 777-200s, one A330-200 and one MD-11 stored.

For aircraft fleet types and aircraft on order for the Middle Eastern region (see tables, page 28).

Base maintenance

The OEM maintenance planning documents (MPDs) combines mandatory repeat scheduled maintenance inspections required for the continued airworthiness of the aircraft. This includes the system/powerplant, structural, and zonal inspection tasks that airlines have in their aircraft maintenance programmes (AMP). These MPDs are constantly evolving to factor in fleet service experience and maintenance philosophy changes.

Two maintenance philosophies are mainly in use, depending on aircraft type, to determine 'C' check (or base check) and the 'D' check or Heavy Maintenance Visits (HMs).

In more modern MPDs, the aircraft and aircraft component flight hour (FH), flight cycle (FC), and calendar time are used for the main threshold and repeat interval operational parameters. To cover calendar time, hour (HR), day (DY), month (MO) and year (YE) can be used.

In older aircraft's MPDs, maintenance

checks are structured around the familiar letter checks of 'A', 'C' and 'D'. 'A' checks contain the high frequency repeat tasks that fall between the C checks, 'C' checks contain the cycle of scheduled base inputs tasks (for example, 1C, 2C and 4C tasks), and 'D' checks include the heavier access structural tasks. Each aircraft and MPD will have slightly different groupings and check titles.

The difference between the more modern MSG-3 logic and older MSG-2 logic is detailed further (see *Size of the narrowbody airframe base check market, Aircraft Commerce, October/November 2018, page 30*).

For much of the active in-service fleet, the base check intervals currently fall in multiples of 15MO, 18MO, 24MO or 36MO. Structural checks or HMs are at intervals of 5YE, 6YE, 8YE, 10YE or 12YE. Along with most calendar limits will be FH or FC backstops, which work on a whichever comes first (WCF) basis. For example, many 24MO tasks in an MPD may also have a 12,000FH backstop. If the FH limit is reached before the calendar limit, then the check will be scheduled before the 12,000FH limit is exceeded.

There are also some permitted 'maximum variations', which can be applied to listed individual inspection intervals and can provide some flexibility to schedule the maintenance input. These vary per MPD. For example, on tasks controlled by FC, a task with an interval of more than 500FC can have an allowed variation of 5% or 250 landings, whichever is the least. For a calendar example, a task with an interval of more than three years, can have a 3MO variation allowance.

For high FH and FC aircraft, the base checks will include additional inspections that will impact the size of the check. For example, the 767's threshold of 50,000FC (and 40,000FC for the 767-400ER, -300F and specific converted freighters), is the major threshold for introducing large groupings of fatigue-based supplemental structural inspection programme (SSIP) tasks, including flight length sensitive (FLS) tasks.

A general overview of the C Check and HMV requirements, as well as fleet utilisation characteristics of each widebody type follows.

767 family

The 767 family entered service in September 1982. Two variants are still in production: the 767-300ERF for the commercial fleet, and the 767-2C/KC-46 for the military fleet.

The 767 base maintenance programme is based around a 18MO check cycle.

The basic C check parameter



frequencies of 6,000FH/18MO, 12,000FH/36MO, 18,000FH/54MO and 24000FH/72 MO, are used to complete one base check cycle over a 6YE period. This can be referred to as a four C-check cycle.

The basic structural or 'SC' check parameters as per the 767 MPD language are frequencies of 3,000FC/18MO, 6,000FC/36MO, 9,000FC/54MO, and 12000FC/72 MO. These are used to complete one base check cycle over a six-year period.

Tasks with intervals that fall between the base checks are planned into what are still commonly known as A checks. The largest grouping of A check tasks is at 750FH. Based on daily utilisation of 8FH, the A check will fall due every 3 months.

The 767 MPD changed from the industry familiar letter checks to FH, FC and or calendar threshold and repeat interval task parameters in 2012.

An exception to this is the Boeing Low Utilisation Maintenance Programme (LUMP) for operators that accumulate fewer than 100FH per month per aircraft, or 1,200FH per year; this still refers to letter checks.

A snapshot of current 767 operational characteristics shows the highest annual FH utilisation aircraft is a passenger 767-300 with 9,222FH and 1,202FC equalling 7.7FH per FC on average.

The highest annual FC utilisation aircraft is also a passenger 767-300 with 2,592FC and 2,222FH, equalling 0.9FH per FC on average.

The average annual passenger fleet

utilisation from information available is 3,580FH and 730FC, equalling a rate of 4.9FH per FC. This would equate to the C check calendar interval being reached before the FH backstop.

The average annual freighter fleet utilisation is 2,120FH and 750FC. This works out at 2.8FH per FC, which puts the fleet within normal parameters for base checks.

747-300/-400

The 747-300 entered service in 1985 and the 747-400 in 1989. Both variants have ceased production. Before this the 747-100/-200 models were in operation from the early 1970s.

There are only six 747-300s left in service, compared to more than 350 747-400. The variants use different MPDs for their maintenance programmes.

The 747-400 MPD still has letter checks listed among FH, FC and calendar utilisations. The letter checks equate to a calendar threshold and repeat interval.

Originally the 747-400's MPD was operated on maintenance steering group two (MSG-2) principles for the structure, while the system and zonal programmes were already MSG-3. The MPD was changed to complete MSG-3 principles in 2002.

The C check interval is in the region of 10,000FH or 24 MO. While the aircraft still has structural inspections at 6YE, many deep access structural inspections or HVM tasks fall at 8YE which changes to 6YE after the aircraft is older than 16 years. Additionally, there is

The global widebody fleet will use varying bespoke AMPs developed from the base MPD to match the primary role of the aircraft.

a large number of 16YE tasks, with repeat intervals at 12YE, so the HVM cycle and work content will alter as the aircraft ages.

The A check interval is in the region of every 1,000FH. In the 747-400 MPD, more than 80 inspections are listed under the threshold and repeat interval of 1A. Not all tasks will apply to all aircraft.

The highest annual FH utilisation aircraft is a 747-400 freighter with 5,649FH and 895FC, equalling 6.3FH per FC.

The highest annual FC utilisation aircraft is a passenger 747-400 with 1,740FC and 2,496FH per year, equalling 1.4FH per FC on average.

The average annual utilisation for the passenger fleet from the information available is 3,600FH and 550FC. This equates to 6.5FH per FC.

In addition, the average annual utilisation of the remaining freighter fleets is 3,540FH and 680FC, equalling 5.2FH per FC.

In general, the passenger and freighter aircraft utilisations do not put pressure on the calendar C check intervals.

747-8 series

The new model 747-8F freighter entered service in 2011, and the passenger version 747-8I in 2012.

The aircraft's A check interval is 1,000FH, and the C check interval is a combination of 10,000FH and 24MO, wcf. This allows an aircraft utilisation of up to 5,000FH per year without compromising the calendar interval.

The 747-8 has an eight-year interval for the first two HVM or D checks, which is reduced to six years for the third and subsequent D checks like the 747-400. The oldest of the 747-8 fleet are now approaching their first HVM scheduled at 8YE.

The highest annual FH and FC utilisation aircraft is line number (L/N) 1,504 with 5,423FH with 938FC, equalling 5.8FH per FC on average. The aircraft is a 747-8F freighter operating in Europe.

In comparison the highest annual FH utilisation passenger aircraft is L/N 1,514 with 4,984FH and 490FC, equalling 10.2FH per FC on average. The aircraft is a passenger 747-8I also based in Europe.

The average annual passenger and

WIDEBODY FLEET ESTIMATED C CHECK AND HEAVY MAINTENANCE VISITS (HMV): PER REGION

World region	Aircraft group	2019 Fleet	2019 C chks	2019 HMVs	2020 Fleet	2020 C chks	2020 HMVs	2021 Fleet	2021 C chks	2021 HMVs
Africa	747-400	2	1	0	2	2	0	2	2	0
	747-8	1	0	0	2	1	0	2	0	0
	767-2/3/400	17	11	4	17	13	3	17	11	3
	777-2/300	43	8	7	45	12	9	47	19	9
	777X			0	0	0	0	1	0	0
	787-8/9/10	42	14	6	44	12	8	50	16	7
	A300/-600	4	1	1	3	2	1	3	1	1
	A330-2/300	49	23	6	51	21	12	52	25	16
	A330neo	4	3	0	6	1	0	9	5	0
	A340	18	9	4	15	6	4	12	6	3
	A350-8/9/1000	27	8	0	39	11	0	45	16	0
	A380	0	0	0	1	0	0	1	0	0
	MD11	2	1	1	2	1	1	2	1	0
Africa Total		209	79	29	227	82	38	243	102	39
Asia Pacific	747-400	105	54	13	100	51	13	94	44	12
	747-8	48	23	8	49	22	9	49	23	9
	767-2/3/400	119	80	21	115	71	23	110	71	22
	777-2/300	545	164	93	544	179	89	536	168	83
	777X			0	4	0	0	22	0	0
	787-8/9/10	382	109	42	446	152	49	507	154	65
	A300-600	15	7	3	14	6	3	14	6	4
	A330-2/300	607	249	132	598	278	125	587	251	129
	A330neo	23	3	0	54	20	0	84	34	0
	A340	10	4	2	9	4	2	7	3	2
	A350-8/9/1000	195	53	0	239	87	0	280	108	0
	A380	65	32	12	66	26	13	65	26	16
	Asia Pacific Total		2,114	778	326	2,238	896	326	2,355	888
Europe	747-400	128	66	18	116	58	20	105	49	16
	747-8	51	24	7	51	27	10	50	20	10
	767-2/3/400	116	75	20	112	69	18	107	68	17
	777-2/300	277	93	47	283	80	51	285	84	53
	777X			0	8	0	0	18	0	0
	787-8/9/10	170	45	17	203	68	26	234	69	31
	A300/-600	37	17	8	34	13	8	32	16	7
	A310-2/300	11	7	2	9	5	2	7	2	2
	A330-2/300	341	141	73	336	152	85	330	130	87
	A330neo	30	12	0	40	18	0	55	22	1
	A340	80	35	20	67	27	19	55	22	15
	A350-8/9/1000	64	17	0	97	21	0	124	41	0
	A380	36	16	8	36	16	10	36	14	10
DC10	1	0	0	1	1	0	1	0	0	
MD11	11	8	2	11	7	2	10	8	2	
Europe Total		1,353	556	222	1,404	562	251	1,449	545	251
Middle East	747-400	20	15	1	20	5	3	19	13	3
	747-8	7	0	2	8	6	2	8	0	0
	767-2/3/400	17	9	3	17	9	4	17	13	3
	777-2/300	349	120	57	348	91	67	346	106	72
	777X			0	28	0	0	59	0	0
	787-8/9/10	132	44	14	169	45	19	188	59	25
	A300/-600	18	9	4	14	6	3	11	5	2
	A310-2/300	10	7	1	8	3	1	6	3	1
	A330-2/300	147	63	29	148	65	36	149	61	41
	A330neo	12	4	0	19	8	0	26	11	0
	A340	24	11	7	21	6	6	18	12	3
	A350-8/9/1000	70	16	0	88	31	0	116	39	0
	A380	137	62	23	143	62	29	149	68	30
Middle East Total		943	360	141	1,031	337	170	1,112	390	180

Source ICF Consulting proprietary MRO forecast model

WIDEBODY FLEET ESTIMATED C CHECK AND HEAVY MAINTENANCE VISITS (HMV): NORTH AND SOUTH AMERICA

World region	Aircraft group	2019 Fleet	2019 C chks	2019 HMVs	2020 Fleet	2020 C chks	2020 HMVs	2021 Fleet	2021 C chks	2021 HMVs
North America	747-400	75	33	7	74	44	10	72	33	14
	747-8	22	8	3	26	11	2	26	13	1
	767-2/3/400	428	265	72	425	276	64	419	268	70
	777-2/300	250	88	36	256	80	39	258	66	43
	777X			0	2	0	0	4	0	0
	787-8/9/10	135	52	15	147	39	23	165	65	29
	A300-600	113	51	24	109	48	23	104	44	25
	A310-2/300	12	5	3	10	6	3	8	2	3
	A330-2/300	122	58	26	124	56	28	126	48	31
	A330neo	11	1	0	26	10	0	39	16	0
	A340	1	1	0	2	1	0	2	1	0
	A350-8/9/1000	14	6	0	19	6	0	25	8	0
	A380	1	0	0	2	1	0	3	1	1
	DC10	31	14	2	26	14	0	21	13	0
MD11	96	73	22	89	65	23	81	63	18	
North America Total		1,311	655	210	1,337	657	215	1,353	641	235
South America	747-400	1	0	0	1	1	0	2	1	0
	747-8	0	0	0	1	0	0	1	0	0
	767-2/3/400	54	34	10	52	36	11	49	32	11
	777-2/300	19	8	2	20	4	1	21	9	3
	777X			0	0	0	0	1	0	0
	787-8/9/10	63	25	11	66	18	13	69	29	11
	A300/-600	5	3	1	4	3	1	4	1	1
	A330-2/300	43	20	10	43	19	11	41	16	11
	A330neo	4	1	0	7	2	0	8	5	0
	A340	5	2	2	4	1	1	3	2	1
	A350-8/9/1000	14	3	0	20	7	0	29	7	0
DC10	2	2	0	2	1	0	2	1	0	
South America Total		210	98	35	220	92	38	230	103	38

Source: ICF Consulting proprietary MRO forecast model

freighter fleet utilisation from available information is 4,370FH and 670FC, equalling 6.5FH per FC. Using the average utilisation figures the aircraft would reach the C check calendar target of 24MO.

777 family

The 777-200 entered service in 1995 and the 777-300 in 1998. The 777F entered service in 2009.

The MSG-3 logic that defines modern MPDs like the 777 highlights the variations of the standard C check concept. The 777's MPD does not reference tasks against C check parameters, but it does provide a guide A and C check cycle example in the appendices. This is based on the assumption of an average utilisation of 14FH a day, at an FH:FC ratio of 5.6:1.

The MPD suggests that lighter A checks take place at 1,000FH intervals and the C or base check groups of tasks are to be carried out every 14,000FH. Given an FH:FC ratio of 5.6:1 this equates to the aircraft achieving 2,500FC between checks.

A recent *Aircraft Commerce 777*

maintenance feature provided operator feedback that base checks are being scheduled with a wide range of 18MO to 36MO (see *Ageing 777 airframe maintenance analysis, Aircraft Commerce, October/November 2017, page 47*).

An aircraft with a utilisation of 14FH a day would reach 14,000FH every 1,000DY (close to 33MO). An aircraft flying 5FC a day would reach 2,500FC in fewer than 18MO. The resultant varying base check intervals would have to incorporate at the appropriate stage the heavier structural checks that are due at 6YE, 9YE and 12YE.

The current highest annual FH utilisation aircraft is a passenger 777-300 with 6,161FH and 710FC, equalling 8.7FH per FC on average.

The highest annual FC utilisation aircraft is a passenger 777-200 with 2,296FC and 2,008FH per year, equalling 0.9:1FH per FC.

The average annual utilisation of the in-service passenger fleets from information available is 4,410FH and 690FC. This equates to 6.4FH per FC.

The average annual utilisation of the freighter fleets in comparison is similar at

4,610FH and 730FC. This works out to be in the region of 6.3FH per FC.

The 777-X is due to enter service in 2020. The two current listed variants are the 777-8 and 777-9, and will use an independent MPD to the existing 777 family.

787 family

The 787-8 aircraft first entered service in 2011, the 787-9 in 2014, and the 787-10 in 2018.

Given the title Dreamliner, the 787 features new design architecture that includes composite materials within the fuselage and wing structure. FH, FC and calendar utilisation parameters are used in its MPD for inspection task threshold and repeat intervals to form a series of eight base checks over a 24YE cycle.

As a guide, A checks or lighter line inputs can be planned at 1,000FH intervals, the C checks or base checks are at 12,000FH/36MO intervals, and the structural base checks or HMVs at every 6YE and 12YE intervals. All other FH/FC/calendar interval tasks will be de-escalated and slotted into the nearest convenient base check or A checks.



MROs have begun to perform the first lighter structural inspection HMV inputs at 6YE, as the oldest in-service aircraft are now over seven years old.

The highest annual FH utilisation aircraft is a passenger 787-8 with 5,975FH and 689FC, equal to 8.7FH per FC on average.

The highest annual FC utilisation aircraft is a passenger 787-9 with 1,145FC and 4,443FH, equalling 3.9FH per FC on average.

The average annual utilisation of the in service passenger fleets from available information is 4,560FH and 660FC.

Given that most of the larger airline 787 fleets have average rates of utilisation near to 4,500FH per year, and an average daily flight time of 12-14FH, the aircraft are likely to reach the FH guide intervals for the base checks before they reach the calendar intervals, and reach the structural check's calendar interval before they reach the FC interval. It is therefore likely that FH tasks that fall due within the systems, structures and zonal sections of the MPD will drive much of the base check input scheduling.

A380

The A380-800 first flew in April 2005 and began operational service in October 2007. The oldest A380s are now completing their first 12-year cycle of maintenance inputs.

The A380 was the first Airbus to enter service on a 24MO/12,000FH base check interval. This equates to a six-check cycle over 12 years, rather than the more

familiar 18MO base check interval, eight-check cycle. The A380 MPD does not use letter checks in the task's threshold and repeat intervals, like the MPDs of preceding Airbus widebody aircraft.

By the end of 2017, airlines had the option to escalate the 24MO base check cycle to 36MO, resulting in the aircraft moving to a four-check cycle over 12YE. This allows even greater planning flexibility and increases the in-service revenue for the fleet.

The traditional lighter structural inspection at six years, and a heavy structural check interval of 12YE, slot into either the four or six-check cycle at 72MO and 144MO.

The A380 MPD uses a variation of FH, FC and/or calendar intervals to optimise the utilisation of each individual scheduled maintenance task. An increase from 24MO to 36MO required equivalent FH escalations from 12,000FH to 18,000FH.

Line checks or A checks initially were set at an interval of 750FH, but have been extended to 1,000FH. Realistically there is not a large grouping of tasks at these intervals. Line and A checks will comprise all the tasks that fall short of the C check interval, along with other FH and FC tasks as the utilisation is reached.

The highest annual FH utilisation A380 aircraft has 5,753FH and 592FC, equalling 9.7FH per FC on average.

The highest annual FC utilisation aircraft has 767FC and 4,327FH per year, equalling 5.6FH per FC.

The average annual fleet utilisation from available information is 4,530FH

The widebody fleet FH to FC utilisations vary greatly due to the long range flying capabilities and ability for mass passenger number movement over short distances.

and 540FC, equalling a rate of 8.3FH per FC. This puts the fleet within normal parameters for a calendar-driven base check cycle.

A350 family

The A350-900 entered service in January 2015 and the A350-1000 in February 2018.

The A350 MPD contains a large number of tasks with intervals that are multiples of 1,200FH, which could be regarded as being a replacement for traditional A checks. Other groups that are multiples of 36MO and could be regarded as a replacement for traditional C checks.

There are, however, two large groupings of tasks at 24MO (58) and 48MO (52). If the 36MO base check interval is kept, airlines will have to slot these additional large groupings into the A checks and closest preceding C check respectively.

When considering FH utilisation there is a large grouping of tasks at 12,000FH, 24,000FH and to a lesser extent 36,000FH. Large groupings of structural calendar tasks fall due at 72MO and 144MO, so there are many variables to consider when forecasting base and HMV checks on the A350s.

A snapshot of the current fleet shows a wide range of utilisations. The highest annual FH utilisation aircraft is a A350-900 with 5,815FH and 644FC, equalling 9FH per FC on average.

The highest annual FC utilisation aircraft is also an A350-900 with 1,049FC and 4,295FH per year, equalling 4.1FH per FC.

The average annual utilisation for in-service fleets from information available is 4,430FH and 610FC. This works out at 7.3FH per FC. If targeting a 36MO check cycle, then the FH tasks will bring the aircraft in just before that threshold.

The A350 maintenance programme and maintenance requirements have been initially analysed (*see The A350 MPD analysis and maintenance planning, Aircraft Commerce, December 2017/January 2018, page 36*).

A340 family

The A340 family entered service from 1993, and ceased production in 2011.

The A340 and A330 have interesting

MPDs with a display of 'FH-optimised' and 'FC-optimised' task thresholds and repeat intervals alongside 'non-range' sensitive thresholds and repeat intervals. Therefore, one MPD task listing may have more than one threshold and repeat interval, depending on the maintenance programme the aircraft is approved against.

Additionally, letter check task groups, such as 1A tasks, are still listed along with FH, FC and calendar intervals.

The current A check interval for the A340 is 800FH, and like many aircraft this figure has escalated over its operating life. The C check interval is 24MO, with a large grouping of tasks left at 18MO.

For the A340, the C check escalations ahead of the structural check escalations over the life of the MPD have created difficulties. For example, a C check cycle of escalation from 15MO to 18MO created a full cycle of eight checks in 144MO. This was out of alignment with the S1 and S2 structural checks at 60MO and 120MO

Over time, however, the S1 tasks were escalated from 5YE to 6YE, putting the S1 tasks back into phase with the C check at 72MO. The interval for the larger group of structures was also raised to 144MO, which then lined up with the C check cycle.

Among the A340 fleet, the highest

annual FH utilisation aircraft is an A340-300 with 5,847FH with 561FC per year, equalling to 10.4FH per FC.

The highest annual FC utilisation aircraft is a A340-200 with 1,146FC and 4,191FH, equalling 3.7FH per FC.

The average annual utilisation of the in-service passenger fleet from information available is 3,750FH and 450FC. This works out at 8.3FH per FC.

A330 family

The A330-300 entered service in 1994, and the A330-200 in 1998. Both variants are still in production. One A330-700 (A330-743L) prototype freighter (build year 2018) is still listed with Airbus.

As mentioned, like the A340 the A330 MPD contains options of 'FH-optimised' and 'FC-optimised' tasks, alongside 'non-range' sensitive threshold and repeat intervals and letter checks.

The A330 C check cycle is now based around a large number of tasks at 18MO and 24MO intervals, with varying FH backstops. For example, for 24MO tasks these backstops can range from 4,000FH to 12,000FH. Each aircraft's applicability, modification status and approved FC- or FH-optimised AMP will impact the number of tasks required out of more than 3,700 tasks in the MPD.

An additional complexity is that the MPD still has a large number of tasks at 42MO and 48MO. These will either enter the preceding C check or closest A check. Structurally there is a large number of FC-optimised threshold and non-range sensitive structural tasks at tasks at 6YE and 12YE to consider.

The A330 fleet utilisations vary widely. The highest annual FH utilisation aircraft is a passenger A330-300 with 6,047FH and 706FC, equal to 8.6FH per FC.

The highest annual FC utilisation aircraft is also a passenger A330-300, with 1,632FC and 3,560FH, equalling 2.2FH per FC.

The average annual utilisation of the passenger in-service fleets from information available is 3,880FH and 800FC. This works out at 4.9FH per FC.

An average annual utilisation of the freighter in-service fleets is 3,800FH and 900FC. This works out at 4.2FH per FC.

The A330 fleet base check intervals will be driven by a mix of calendar and FH/FC thresholds.

Late in 2018 the A330-900neo began to enter commercial service. The sister A330-800neo is due to enter service by the first half of 2020. The aircraft has new Rolls-Royce Trent 7000 engines to improve fuel burn, but has about 95% parts commonality with the A330ceo.



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A300/A310 family

The A300B4 variants entered service in 1975, and the A300-600 in 1983. Preceding A300 variants entered service from 1974 onwards. The type ceased production in 2007. The A310 entered service in 1983 and ceased production in 1998.

Of the remaining A300 fleet, only four A300B4 and 21 A300-600 passenger aircraft remain in service. The remaining aircraft are freighters.

Of the remaining A310 fleet, only 20 passenger aircraft are still in service. The rest are freighters, VIP or for military use.

The A300 and A310 MPDs have also undergone periods of C check escalation at different stages to the structural or D check elements to the MPD programme.

For the purposes of the maintenance programme development, it was assumed that a C Check at 2,500FH would be carried out every 12MO to 15MO. A check task multiples would be carried out every 250FH. If actual utilisation differs significantly from this, an option would be to adjust to a LUMP programme.

Today due to the varying modified roles of the airframes AMP base check cycles will vary. The base C check interval is in the region of 18MO, although there are additional larger groupings of calendar tasks at 24MO and 48MO.

Structural task check intervals are heavily FC-driven with more unique 9YE threshold and 5YE repeat intervals than seen in other MPDs. It is the systems section tasks of the MPD that contains the more familiar 72MO and 144MO large groups of intervals.

The highest annual FH utilisation aircraft is a passenger A310 with 4,063FH and 890FC, equalling 4.6FH per FC.

The highest annual FC utilisation aircraft is a freighter A300-600 with 1,865FC and 2,258FH, equalling 1.2FH per FC.

The average annual utilisation of passenger in-service fleets from available information is 1,700FH and 550FC. This equates to 3.1FH per FC.

In comparison, the average annual utilisation of freighter in-service fleets is 1,300FH and 780FC. This equates to 1.7FH per FC.

MD-11

The MD-11 entered service in 1990 and ceased production in 2000.

The remaining 121 aircraft in service are now converted freighters, and operate for seven different operators across Europe, North America and Africa. The aircraft's MPD has evolved from A checks at 600FH to over 800FH, and C checks at 15MO and up to 24 MO. The freighter C check programme will, however, be bespoke to the operator and Supplemental Type Certificate (STC) design used for the conversion.

As far as utilisation of the current fleet goes, one aircraft has both the highest annual FH and FC utilisation with 5,040FH and 943FC. This equates to 5.3FH per FC.

An average annual utilisation of the fleet from available information is 3,020FH and 600FC, equalling 5FH per FC.

The widebody fleet 'C' check cycles range from 15MO to 36MO. High FH utilisation can impact these calendar targets.

DC-10

The passenger DC-10 variants entered service from 1971, and ceased production in 1988. The remaining fleet consists of freighters and aircraft with special purpose roles.

The KC-10 military version tanker of the DC-10-30CF was introduced in 1981, and accounts for more than 50% of the still operational DC-10 fleet.

The oldest DC-10s are now more than 45 years of age. All except one commercially operated aircraft are with FedEx, and these are due to retire over the next few years.

Ilyushin

The small number of Ilyushin widebodies provides a limited MRO market need outside of Russia.

Of the 28 aircraft on record, 22 list Russia as the operator country, four list Cuba, and two are listed as unassigned and have been stored for a long period.

There is currently no data on FH and FC, or order information available for evaluation.

Base maintenance market

ICF Consulting specialises in MRO advisory services in its aviation and aerospace division. It provides comprehensive strategy, market research, market analysis, and maintenance benchmarking for its customers.

ICF generates annual estimates of the number of C and HMV airframe checks for the global regional, narrowbody and widebody fleets from its own proprietary MRO forecast model. It sub-divides these into the number of C and HMV checks for each main aircraft type. A sample of this is shown (*see table, page 34*).

For reference, the HMV numbers are a sum of any check higher than the basic C check repeat interval requirements, including structural checks and D checks. Grouping checks by the same title can be difficult, especially since each MPD and operator can group and title work packages differently.

As detailed, base check programmes tend to have a C check interval of close to 24MO for most passenger aircraft, 15MO to 18MO for legacy aircraft and some freighters, and 36MO for the newer aircraft into service. Structural checks occur near or at 6YE and 12YE. In reality, many factors affect the timing of an aircraft's scheduled maintenance visits,

The widebody fleet profile will change dramatically over the next five to 10 years. Large numbers of older generation DC-10s, MD-11s, A310s, A300s, A310s, 767s and 747s will be replaced by larger numbers of 777s, 787s and A350s. These modern types have longer base check intervals, so the fleet change will impact the widebody MRO market.

even the availability of slots.

As an overview of the size of the current widebody fleet check numbers, ICF estimates that through 2019 there will be a need for 2,528 C check slots and 964 HMV slots. This is predicted to rise to 2,625 C check and 1,039 HMV slots in 2020, and 2,672 C check and 1,086 HMV slots in 2021 (see table, page 34).

The table shows the specific fleet types with a greater increase in C check requirements. For example, HMV checks for the 787 are predicted to rise from 105 in 2019, to 168 in 2021. The table also forecasts fleet reductions. For example, there are more than 330 747-400s in service in 2019, down to 294 in 2021.

ICF also evaluate the widebody fleet check requirements per fleet type per global region (see table, page 34). This provides a more detailed breakdown of any predicted patterns in the check requirements per type per region.

In Africa, for example, fleet check numbers increase from 79 C checks in 2019 to 102 in 2021. In Europe, however, the fleet C check quantities fluctuate, rising from 556 in 2019, to 562 in 2020, and then falling to 545 in 2021.

The same table shows the growing number of slots required in MROs per region over the next three years for new aircraft types, such as the A350. In Europe, for example, the A350 C checks increase from 17 in 2019, to 41 in 2021.

Retirement trends

An aircraft's operational status is tracked over its life, from 'on order' through to 'in-service', 'stored', 'retired' and 'parted out'. Retirement trends can therefore be monitored for the impact on the MRO base check market.

The legacy fleets of aircraft including the 747-300/-400, 767-200, A300, A310, A340, MD-11 and DC-10 fleets are naturally declining because the types are out of production and existing aircraft are getting older.

The introduction of the A330neo and 777-8/-9 will also see movement of the original variants to new operators, as well as retirements of the older aircraft.

A summary of the last three years of retirements per fleet type follow:

- 747-300/-400 with a change of status to retired: 34 in 2016, 43 in 2017



and 29 in 2018. The average age at retirement has been 24 years. All but one of these aircraft have been 747-400s.

- 767 aircraft with a change of status to retired: 38 in 2016, 31 in 2017, and 15 in 2018. The average age at retirement has been 27 years. 26 of these have been 767-200s and 58 have been 767-300s.

- 777 with a change of status to retired: 12 in 2016, 22 in 2017, and nine in 2018. The average age at retirement has been 19 years, and 41 of these have been 777-200s and two 777-300s.

- 787-8s with a change of status to retired: just one L/N 5, which retired in March 2018, at almost eight years of age. There are no listed operator retirements at this early stage of the aircraft's in-service life.

- A300s with a change of status to retired: 11 in 2016, nine in 2017, and three in 2018. The average age at retirement has been 31 years. Ten of these aircraft have been A300-600s and 13 A300B2/B4.

- A310s with a change of status to retired: 23 in 2016, 12 in 2017, and three in 2018. The average age at retirement has been 27 years.

- A330s with a change of status to retired: 12 aircraft in 2016, seven in 2017 and seven in 2018. The average age at retirement has been 20 years. 13 of these were A330-200s, and 13 A330-300s.

- A340s with a change of status to retired: 14 in 2016, 31 in 2017 and 14 in 2018. The average age at retirement has been 19 years. By variant these equate to nine -200s, 41 -300s, two -500s and seven -600s.

- A380s with a change of status to retired: one aircraft in 2016, one in 2017 and two in 2018. The average age at

retirement has been a relatively young 12 years.

- DC-10s with a change of status to retired: 12 in 2016, two in 2017 and four in 2018. All but one were freighters. The average age at retirement has been 41 years. By variant these numbers are 14 -10s, two -30s, and two -40s.

- MD-11s with a change of status to retired: 17 in 2016, five in 2017 and four in 2018. All have been freighter aircraft. The average age at retirement has been 21 years.

- Il-86/-96 with a change of status to retired: four in 2017. The average age at retirement has been almost 25 years.

Summary

There is a growing focus on engine and airframe health monitoring solutions, and predictive maintenance software. These primarily target the reduction of costs around unscheduled maintenance events. C checks and HMVs, however, are scheduled maintenance events.

In the widebody MRO check market, longer and less predictable maintenance intervals are challenging traditional check forecast models and predicted man-hour (MH) requirements. For example, over a 12-year period the 767's cycle has eight checks, while the newer 787's has four, leading to an estimated reduction of as much as 65% in scheduled maintenance MH for the 787. For airlines, this is a reduced maintenance burden, and for third-party MROs this is lost revenue that needs to be replaced. **AC**

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