

The A330/A340 family is one of the most numerous widebodies in operation. The fleet operates globally, but with the majority in Europe and the Asia Pacific. This generates more than 700 base checks and 750 engine shops visits per year, with these numbers forecast to rise by 60% or more.

# A330/A340 family maintenance market

**T**he A330/A340 became the world's first combined aircraft programme, when it was launched in 1987. The programme has had varying levels of success, with the A330 accounting for 704 of 1,076 aircraft, or 65% of the fleet.

The A330 is split between the -200 and -300. The A340 fleet is split between the -200, -300, -500 and -600 series. The A330 and A340 share flightdeck commonality, as well as commonality in aircraft design, maintenance programmes and procedures, and rotatable components.

The engines are the main difference between the two types. The A340 is powered by four engines: the CFMI CFM56-5C on the A340-200 and -300; and the Rolls Royce (RR) Trent 500 series on the A340-500 and -600. The A330 has three engine options: the General Electric (GE) CF6-80E1A; the Pratt & Whitney PW4000-100; and the RR Trent 700.

## Current fleet

Currently there are 1,076 aircraft with over 1,000 in active service. There are just 49 aircraft parked.

Over a third of the global fleet is in Asia Pacific (35% or 378 aircraft) and a third in Europe (34% or 368 aircraft). The next largest geographical fleet is in the Middle East, which accounts for 15% or 164 aircraft. It is followed by North America, South America and Africa who share the remaining 16%.

The large maintenance facilities are located with the biggest operators in the Middle East and Asia, and in Airbus's traditional home ground of Europe.

Lufthansa is the largest operator with 66 aircraft, consisting of 15 Trent-powered A330s and 51 A340s (27 A340-300s with CFM56-5C engines and 24 A340-600s with Trent 500s). Cathay Pacific Airways and Emirates each have 47 aircraft. Qatar Airways (QR) and Air

France (AF) are large operators, each with 33 examples. Other large operators are Delta Air Lines, with 32 PW4000-powered A330-200s and -300s, and Thai Airways International and China Eastern Airways each with 30 aircraft.

Further large operators include Air China, Etihad Airways, Iberia, Air China, Etihad, Swiss, Virgin Atlantic Airways, China Airlines, South African Airways (SAA), Singapore Airlines and TAM Linhas Aereas. These all operate 20-35 aircraft.

The A330 fleet totals 704 aircraft: 43% in the Asia Pacific; 25% in Europe, 15% in the Middle East; and 9% in North America. The Trent 700 is the most popular engine option, powering nearly half the A330 fleet. The CF6-80E1A and PW4000-100 represent about a quarter each, with the CF6 being slightly more popular.

The largest A330 operators are Cathay Pacific and Delta Air Lines, followed by Emirates, Qatar Airways, Air China, China Eastern Airlines and Thai Airways.

The A340 fleet totals 372. It is popular in Europe, where half the fleet is located. Lufthansa is the biggest A340 operator, with a fleet of 51 aircraft from three variants.

The A340 is not so popular in the Asia Pacific region, with just 73 aircraft operated there. There are 55 aircraft in the Middle East. The A340 is relatively popular in Africa, with 36 A340s in operation. There are no active A340s in North America.

Large operators include Iberia (29), Virgin Atlantic (25) and SAA (21). Air France and Emirates each have 18 A340s, followed by Cathay Pacific and Swiss, each with 15.

## Future fleet

There are firm orders for 400 A330s and A340s as of mid-2010. Just over 60

of these are for the A330-200F.

The A330-200F entered service in September 2010. Customers include MNG Airlines, Turkish Airlines and Malaysia Airline's MASKargo subsidiary, as well as Aircastle Limited, Intrepid Aviation Group and BOC Aviation.

There are only six A340-500 orders outstanding. All A340-200, -300 and -600 orders have been delivered.

The order book for the A330 has a backlog of more than 300 aircraft. About 45% is destined for the growing Asia Pacific fleet, in particular Hong Kong Airlines (24 aircraft), Air China (20), Air AsiaX (19), Malaysia Airlines (17), Kingfisher Airlines (17) and China Eastern Airlines (16).

Orders from Europe and North America have been placed by Intrepid Aviation Group (20), US Airways (18), Turkish Airlines (13), the UK Royal Air Force (12), Aeroflot-Russian Airlines, Air One (Italy), Virgin Atlantic Airways and Gulf Air.

## Maintenance programme

Two main factors affecting the maintenance market for the A330 and A340 are the fleet size and the intervals and checks dictated by the maintenance programme.

The original maintenance planning document (MPD) for the A330/A340 family is over 15 years old, so it has been updated many times. The 18th revision of the A330 MPD and the 19th revision of the A340 MPD were issued in 2010.

Revisions have resulted from operators' and original equipment manufacturers' (OEM) experiences of the aircraft and its engines. Revised MPDs have therefore offered reduced maintenance costs through increased efficiencies and extended check intervals.

As well as the standard manufacturer's maintenance programme, operators have developed their own. By

## A330/A340 FAMILY GLOBAL AIRCRAFT FLEET

Aircraft Variant	Africa		Asia Pacific		Europe		Middle East		N. America		S. America		Aircraft sub-total
	Active	Parked	Active	Parked	Active	Parked	Active	Parked	Active	Parked	Active	Parked	
A330	17		297	8	173	7	105	2	63	3	29		704
CF6-80E1A	9		79		67		32		2		5		194
PW4000-100	1		72		40		2		42		17		174
Trent 700	7		154		72		73		22		7		335
Unspecified					1								1
A340	35	1	69	4	172	16	51	6		2	16		372
CFM56-5C	25		50		124		28		2		14		243
Trent 500	11		23		64		29				2		129
A330/A340	53		378		368		164		68		45		1,076

Source: Flight Global's ACAS system

developing in-service knowledge and experience of an aircraft type, an operator may, with approval from Airbus and their local aviation authority, customise the standard programme. Some operators, such as Air Calin, Air France, Emirates, Jetstar Airways, LAN Airlines, Philippine Airlines and SAA, may use an equalised check structure to divide some checks into equally-sized maintenance inspections, as well as combining certain check aspects. An airline may use a customised maintenance programme that shortens or lengthens their intervals due to their operation of the aircraft and the experiences they have had.

Those airlines with smaller fleets or without their own engineering departments, will generally comply with the standard MPD. Some may have their aircraft maintained by facilities that have already developed customised MPDs.

Several operators offer third-party maintenance services through their maintenance divisions. These services can vary from light line maintenance to full heavy checks and engine shop visits.

Some airlines offer capability through their maintenance divisions, but do not actually operate the aircraft themselves. These include Air Berlin Technik, Austrian Airlines, British Airways Engineering, Evergreen Aviation Tech Corp (EGAT), Jet Aviation and United Services.

The third group of maintenance, repair & overhaul (MRO) providers are those that are independent of airlines. These companies can be small, specialising in only a few areas, or may have large multi-faceted facilities such as those at Aveos Fleet Performance Inc (Aveos), Abu Dhabi Aircraft Technologies (ADAT), Bedek Aviation, HAECO, John Holland Aviation Services, SR Technics (SRT) and ST Aerospace.

Independent MRO facilities do not have direct operational experience to develop maintenance programmes like airlines. They do, however, have a vast maintenance knowledge gleaned from the

experiences of their customer airlines. These large independents and the comprehensive airline facilities are often called one-stop-shops because they cover most, if not all, of an operator's maintenance needs.

'Since we have a long experience with the reliability of A330 and A340 fleets from several operators, we can perfectly optimise the maintenance programme for our customers,' says Jean-Marc Lenz, senior vice president aircraft maintenance and group technical training at SR Technics.

## Line & A checks

While line maintenance and A checks will mostly be performed by operators, they can also be done by local suppliers or other airlines at outstations.

The majority of A330 operators now have an 800 flight hour (FH) interval for A Checks. Air China and Egyptair both have a 500FH interval, while Lufthansa's is 550FH. Many of the operators that work in hotter climates, or have a high utilisation, have shorter intervals.

'We have carried out several A and C check extensions for many customers,' says Lenz. 'The A check interval has now been extended to 800FH and the C check to 18 months. We keep the Maintenance Programme on a state-of-the-art level and use a half-year major revision period with the option for temporary revisions.' QANTAS, and therefore Jetstar Airways, are currently escalating A Checks from 600FH to 800FH. The latter also has semi-equalised A checks.

Air France's equalised check system comprises: 1A plus half 2A plus quarter 4A. Turkish Airlines (THY) does something similar, with an A plus half a 2A, a third of a 3A plus a quarter of a 4A. This results in 800FH intervals, plus a ramp check every seven days.

Many airlines will divide their A check blocks into equalised checks to spread tasks more evenly. This is practised by Air Calin and Thomas Cook,

while Qatar Airways and Cathay Pacific have a block maintenance programme.

All A330/340 maintenance providers offer line maintenance at their main bases, as do the major operators. Many, such as Cyprus Airways, British Airways, Air Calin and National Air Services, offer line maintenance capabilities at their secondary airports or even down route.

British Airways, for example, does not operate any A330/A340s, but has responded to customer demand by developing a network of stations with pre-flight, transit, daily, weekly and monthly check capability.

Lufthansa Technik has a similar set-up, with 550 A checks and comparable events completed each year at five European airports. This number increases to 18,700 per annum when daily and weekly checks are included.

For the A340, the intervals and maintenance programmes are generally the same as for the A330. The MPD is often based on that of the A330, or vice versa, depending on which aircraft the airline operated first. Cathay Pacific, China Airlines, Egyptair, Emirates, Etihad, Finnair and Qatar are just some of the airlines that operate the same MPD for both aircraft types.

## C checks

Base checks include C checks, heavy checks and structural checks. The heavy and structural checks are most likely to be undertaken by third-party MRO facilities. This is due to the increased need for specialist testing and repair that materialises as checks get bigger. Some choose to equalise the C checks as well, integrating them into the A checks. Basic C checks are every 18 or 21 months, depending on the operator. It follows therefore that Cathay Pacific undertakes 2C checks every 42 months, since its C check is every 21 months. Finnair has a shorter interval of 18 months for the 1C, 2C and 3C, with the 4C being even less at 15 months, although internal



development of this manufacturer's MPD should lead to extended intervals. Turkish Airlines has an interval of 18 months, resulting in Turkish Technic conducting nine C checks per year.

Delta AirLines has a 653-day C check interval. Hainan also counts differently, with 6,000FH between C checks. While most operators use intervals of 18 months, there are understandably some variations. Some Chinese operators have C checks of 15 months, while Garuda Indonesia Airways has a 24-month interval due to its experience and regulatory allowances.

All the A340 C check intervals seem to be undertaken in months, with the most common being 18 months, but the lower 15 months is also very common. There are a few with intervals of 21 months, but these are almost exclusively for large operators, such as Virgin Atlantic, Air France and Cathay Pacific. Air France chooses to equalise its C checks as well as the A Checks. For example, during the 1C check it will also do half of the 2C check tasks.

While most operators do their own line and A checks in-house, this is not the case as the tasks become more in-depth. Just 28% of C checks are completed in-house, with an additional 6% being unknown. No facility has a major share of the market, and 6% of contracts are up for tender. Lufthansa Technik (LHT) has the highest ranking, with 6.5% of available maintenance contracts. This share is made up from LHT (Malta), Lufthansa Technik Philippines (LTP) and the main LHT facilities in Germany.

The maintenance group comprising AFI and KLM Engineering & Maintenance (KLM E&M) manages 5% of the available contracts. Austrian Airlines and HAECO have just over 4%

each of the market share, while ADAT, SR Technics and SIA Engineering Company (SIAEC) each undertake about 3% of the C check contract market.

## Heavy checks

The fourth and eighth C checks (C4 and C8 checks) have a large number of heavy structural tasks, and so result in large checks. The C8 check is particularly large. These large checks are the catalysts for equalising checks and spreading out the workload by dividing some of the tasks across other C checks. Equalised checks also mean an aircraft is not taken out of action for several weeks every five years or so.

The vast majority of A330s and A340s have 4C checks with 72-month (six-year) intervals. Some operators with less equalised checks have an interval of 60 months (five years). Equalising tasks does not seem quite as popular for heavy checks as it was for A checks, with many operators just having block C-checks. The largest heavy check interval is for Garuda Indonesia, which is 96 months, although it still has a heavy check at 72 months. The 4C checks are now being escalated to six years, and the 8C to at least 12 years, from the original five- and 10-year intervals.

Air France has an equalised system of checks for the A and C checks. While its 4C is 72 months, its 8C is expected at 11 years (132 months) or 60,000FH. Air France and KLM seem to be the only operators with 132-month 8C checks.

Virgin Atlantic has longer intervals of six and 12 years for its 4C and 8C checks. The 4C, 5-year and 4,500 flight cycle (FC) fatigue tasks, and the 10-year and 8,750FC fatigue tasks are performed during the 8C check.

*The global market for annual base checks on the A330/A340 is currently about 570, but this is forecast to rise to about 1,000 annually by 2019. The global market for engine shop visits for the A330/A340 is currently about 750 each year, and is predicted to rise to about 1,200 per year.*

There are also large groups of structural inspections, with intervals of 13,000-20,000FC. Egyptair chooses to reduce this to 8,750FC, while a few have intervals measured in months. For example, LAN Airlines has limited structural tasks, as well as some five-year items included in its 3C at 54 months. Structural inspections therefore often result in intervals of five to six years. These consequently come due at similar times to the C4 and C8 checks, and are combined by virtually all operators into two heavy checks. Turkish Technic deals with two or three S checks each year.

Most operators will sub-contract these checks to large maintenance providers. This is reflected in the market share of heavy check contracts, where a further reduced 23.5% of contracts are in-house. Nearly 10% of contracts are up for tender and 5.5% are unknown. This means that the remaining 61% of heavy maintenance is currently completed by known third-party maintenance facilities.

LHT's facilities in Germany and the Philippines account for 12% of the total market, the largest single company figure. The share then drops with AFI (with KLM E&M), HAECO and SR Technics undertaking 3.5-4.75% each. ADAT, STARCO and SIAEC each control 3% of the market. All these major facilities are in Europe or the Asia Pacific.

This is understandable given that these geographical areas account for 70% of the global fleet. European and Asia Pacific facilities have 50% of contracts, leaving just 10% for African, Middle Eastern and American providers to share. Major airlines that are not in Europe or Asia Pacific, such as Egyptair, Royal Jordanian, Qatar Airways and SAA, are likely to undertake their own heavy checks. JorAMCo and South African Airways Technical each gain about 2% each of the market, the latter due to SAA's large fleet.

ST Aerospace's facility in Alabama, ST Aerospace Mobile, has 1.5% of the market. This could increase as the local market grows by at least 50 new aircraft as the fleet ages and more heavy checks come due. Aveos and Egyptair M&E have about 1% of the contract market (aided by the fleet sizes of Air Canada and EgyptAir). In simple terms, Africa has 5% of the fleet, but maintains just 3%, the Middle East operates 15% of the fleet and has maintenance contracts for 6%, North American aircraft account for



## A330/A340 FAMILY AIRFRAME MAINTENANCE - MAJOR PROVIDERS

Maintenance facility	A Check	C Check	Composites	Heavy Check	Strip/ Paint	Interiors/ Furnishings	Landing Gear	Wheels/ Tyres/Brakes
<b>Africa</b>								
Air Algeria		Y	Y	Y	Y			
EgyptAir Maint. & Engineering	Y	Y	Y	Y	Y			
South African Technical	Y	Y	Y	Y	Y			
<b>Asia Pacific</b>								
Air India	Y	Y	Y	Y	Y			
Ameco Beijing	Y	Y	Y	Y	Y	Y		Y
Asiana Airlines	Y	Y	Y	Y	Y			
China Aircraft Svcs (CASL)	Y	Y	Y	Y	Y	Y		Y
Evergreen Aviation Tech Corp.	Y	Y	Y	Y	Y	Y		Y
Gameco	Y	Y	Y	Y	Y			
GMF AeroAsia	Y	Y	Y	Y	Y			
HAECO	Y	Y	Y	Y	Y		Y	
Hypercoat			Y	Y	Y			
Jet Airways (India)	Y		Y	Y	Y			
John Holland Aviation Svcs	Y	Y	Y	Y	Y	Y		Y
Kingfisher Airlines	Y		Y	Y	Y			
Korean Air	Y	Y	Y	Y	Y	Y		Y
Lufthansa Technik Philippines	Y	Y	Y	Y	Y	Y	Y	Y
Malaysia Airlines	Y	Y	Y	Y	Y	Y		Y
PekAMCO Technologies	Y	Y	Y	Y	Y			
QANTAS	Y	Y	Y	Y	Y	Y	Y	Y
Sepang Aircraft Engineering	Y	Y	Y	Y	Y			
SIA Engineering Company Ltd	Y	Y	Y	Y	Y			
SriLankan Airlines	Y	Y	Y	Y	Y			
ST Aerospace Services Co Pty	Y	Y	Y	Y	Y	Y		Y
STARCO	Y	Y	Y	Y	Y			
TAECO	Y	Y	Y	Y	Y	Y		
Thai Airways International	Y	Y	Y	Y	Y			Y
Vietnam Airlines	Y	Y	Y	Y	Y			
<b>Europe</b>								
Aeroflot-Russian Airlines	Y	Y	Y					
Air Berlin Technik Dusseldorf	Y	Y	Y	Y				
Air France Industries	Y	Y	Y	Y	Y	Y	Y	Y
Airbus	Y	Y	Y	Y	Y			
Airline Services Ltd						Y		Y
APPH Basingstoke MRO							Y	Y
Austrian Airlines	Y	Y	Y					
BCT Aviation Maintenance Ltd	Y							
Beagle Aerospace			Y		Y			
Dublin Aerospace	Y	Y	Y	Y	Y			
Europe Aviation	Y	Y	Y	Y	Y			
Finnair Technical Services	Y							Y
Globalia Mantenimiento	Y	Y						
Iberia	Y	Y	Y	Y	Y	Y		Y
Jet Aviation Basel	Y	Y	Y	Y	Y	Y		
KLM Engineering & Maint.	Y	Y	Y	Y	Y			
Lufthansa Technik	Y	Y	Y	Y	Y		Y	Y
Lufthansa Technik (Malta)	Y	Y	Y	Y	Y			
Lufthansa Technik Maint. Intl.	Y		Y		Y			
Meridiana Fly	Y	Y		Y				
Messier Services France							Y	Y
Monarch Aircraft Engineering	Y	Y	Y	Y				
OEMServices						Y		Y
Olympic Airways - Services SA	Y	Y	Y	Y	Y			
SABENA Technics (Bordeaux)	Y	Y	Y	Y	Y	Y		Y
SABENA Technics (BRU)	Y	Y	Y	Y	Y	Y	Y	Y
SAS Tech	Y	Y	Y	Y	Y			
SR Technics	Y	Y	Y	Y	Y			Y
SR Technics Ireland	Y	Y	Y	Y	Y		Y	Y
SR Technics Spain						Y		Y
TAP Maint. & Engineering	Y	Y	Y	Y	Y	Y		Y
Tarmac Aerosave	Y	Y	Y	Y	Y			
Thomas Cook A/C Eng.	Y	Y						
Turkish Technic	Y	Y	Y	Y	Y	Y		Y
<b>Middle East</b>								
Abu Dhabi Aircraft Technology	Y	Y	Y	Y	Y	Y		Y
Bedek Aviation (Divn of IAI)	Y	Y	Y	Y	Y	Y	Y	Y
Emirates	Y	Y	Y	Y	Y	Y		Y
Goodrich Cust. Svcs - Dubai			Y	Y	Y	Y		
JorAMCo	Y	Y	Y	Y	Y	Y		
Kuwait Airways	Y	Y						
MASCO	Y	Y	Y	Y		Y		Y
Oman aviation Services Co	Y				Y			
Qatar Airways	Y		Y					
Yemenia	Y	Y		Y				
<b>North America</b>								
AAR Component Svcs - N.Y.			Y			Y		Y
Aeroframe Services	Y	Y	Y	Y	Y	Y		
Air Transat	Y	Y						
Allflight			Y		Y	Y		
Aveos Fleet Performance Inc.	Y	Y	Y	Y	Y	Y		Y
Aviation Exteriors Louisiana	Y				Y			
Aviation Technical Services	Y	Y	Y	Y	Y			
Certified Aviation Services	Y	Y	Y	Y	Y			
Delta TechOps	Y	Y	Y	Y	Y			Y
First Wave MRO Inc.			Y					
Hawker Pacific Inc. USA							Y	Y
Lufthansa Technik Component							Y	Y
Mexicana	Y	Y	Y	Y	Y			
Skyservice Maintenance	Y	Y						
ST Aerospace Mobile Inc.	Y	Y	Y	Y	Y			
Stewart Industries Intl						Y	Y	Y
TIMCO (Greenboro)						Y	Y	Y
Triumph Fabrications Ft Worth			Y		Y			
United Services	Y	Y						
<b>South America</b>								
Aerolineas Argentinas	Y	Y	Y	Y	Y			
LAN Airlines	Y	Y						
TAM Lineas Aereas	Y	Y	Y	Y	Y			
TAP M&E Brazil (Rio)	Y	Y	Y	Y	Y			

Source: Flight Global's ACAS system

6% of the fleet, while less than 3% are maintained there. South America's 4% global fleet share is reduced to less than 1%. These figures exclude fleets that are maintained in-house by operators that do not offer third-party capability to others.

The oldest examples of the type are 16 years old. Under the original MPD, they will be over half-way through their second base check cycle or, if operated on the escalated maintenance programme, they will be just a third into the second base check cycle. The age of most A330s and A340s means that they have yet to complete their first base check cycle.

Many operators have aircraft that are too young for an individual maintenance programme to have been defined. With many of their fleet yet to reach a heavy check, the manufacturer's MPD is used.

The number of heavy checks each year can be sizeable, and includes all levels of C check. SR Technics performs 1,000 base maintenance checks a year, about a third of which will be on the A330/A340. "LTP can accommodate up to 60 maintenance events each year, having averaged 42 events annually over the past five years," comments Dominik Wiener-Silva, vice president for marketing and sales at Lufthansa Technik Philippines. He adds that two of LTP's production lines have specialised docking equipment to accommodate the A330/A340 for heavy maintenance.

Sabena Technics averages 160 C and D checks each year across the company, while Iberia says it averages about 50 A330/A340 checks each year (about a quarter of all the checks it performs). SIAEC has completed over 6,500 airframe checks on Boeing and Airbus aircraft, including at least 60 heavy maintenance checks on the A330/A340 fleet.

Aerostrategy collects data on aircraft fleets and the number of major and minor heavy maintenance events performed each year. It also uses its knowledge and experience to predict the future volume of maintenance checks, taking into account aircraft age, MPDs and fleet size. Aerostrategy makes similar predictions for engine shop visits. Its data for 2009, 2010, 2015 and 2019 are shown (see table, page 40). The table shows that the A330 maintenance events are likely to increase by 116% over the space of 10 years. The numbers fluctuate each year due to aircraft age (and years when higher deliveries were made), but overall the figures show an increase. The A340 fleet is not expected to grow, but its maintenance volume will increase slightly (20%) as the younger examples start to come due for heavier checks. The total number of maintenance events (both C and D checks) for both the A330 and A340 is likely to increase by nearly 80% according to Aerostrategy.

## Landing gear

According to LTP, the interval for landing gear overhaul on the A330/340 family is now 10 years or 7,000-12,000FC. Assuming an average interval of nine years, about 120 landing gears are being overhauled each year.

Landing gear overhaul is a specialist activity, so most operators sub-contract it.

An airline with comprehensive capability on an aircraft type may develop capabilities for landing gears, as is the case for AFI and LHT (with shops in Asia Pacific, Europe and North America). MRO facilities like SABENA Technics and TIMCO (Greenboro) have also developed this service.

Companies that dedicate themselves to just a handful of jobs are able to specialise in tasks such as the landing gear. The most popular locations for landing-gear repair are Europe and North America. Some work is completed in other areas by MRO facilities such as Bedek, HAECO, LTP and QANTAS, which already offer a multitude of services.

Two popular landing-gear overhaul providers include Messier Services and Hawker Pacific, each with a shop in both North America and Western Europe. In Europe there are also APPH Basingstoke

MRO, Madrid Aerospace Services, Paramount Aircraft Services and Revima. In North America providers include America Barfield Inc, CIRCOR Aerospace, Global Aerospace Corporation, Sargent Controls & Aerospace and Stewart Industries Intl.

## Thrust reversers

Thrust reversers are another specialist component. These have long removal intervals, and require specialist tooling and equipment. The removal interval for the CFM56-5C is about 6,000FC and the interval for the engines on the A330 is similar.

"We usually recommend a maintenance system for thrust reversers based on scheduled shop events and 'soft time limits' (as we do with Lufthansa), because our data show that this, when the soft time limit is correctly defined, leads to minimum maintenance cost," says Dr Christian Sauer, manager engineering, airframe related component services, Lufthansa Technik. "The soft time limit is recommended and customised by our engineering department for every type and customer fleet individually, based on parameters such as fleet age, service bulletin (SB) status, FH:FC ratio, operational profile and operating environment.

Most A330/340s accumulate 4,000-5,500FH or 600-900FC per year. The current average is 4,045FH/900FC for the A330 and 4,400FH/600FC for the A340. Given that each A330 has two units, each aircraft has a reverser removed for an overhaul on average once every three to four years.

With each A340-200/-300 having four units, an aircraft can expect a reverser to be removed for overhaul on average once every five to six years. Together, the A330/A340 fleet has a global thrust reverser overhaul market of about 200-250 shipsets per year.

The main providers of thrust reverser repair and overhaul are AFI, Aircelle, Aveos, Eagle Services Asia Pte Ltd, GE Engine Services (at five global locations), HAECO, Iberia, LHT, Middle River Aircraft Systems, Nordam, Parker Hannifin Corp., Rolls Royce, SAESL, SNECMA, SR Technics, ST Aerospace and Turkish Technic.

## Engine market

With many airlines operating both the A330 and the A340, mixed engine fleets are inevitable. Older fleets tend to have a wider variation on engine models and variants.

Due to the large investment required in facilities, tools, equipment and



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## FORECAST NUMBER OF ANNUAL HEAVY CHECKS &amp; ENGINE SHOP VISITS

		2009	2010	2015	2019
<b>Annual C and D checks</b>					
A330	A330-200	188	258	382	376
	A330-300	166	191	323	390
	A330 total	354			766
A340	A340-200/-300	153	171	152	154
	A340-500/-600	63	94	80	104
	A340 total	216			258
A330/A340	Grand total	570	714	937	1,024
<b>Annual engine shop-visits</b>					
Africa	CF6-80E1				16
	PW4100		2		4
	Trent 700	2	6	14	20
	CFM56-5C	28	48	28	32
	Trent 500		8	20	20
	Africa total	30	64	62	92
Asia Pacific	CF6-80E1	24	18	50	42
	PW4100	34	32	74	64
	Trent 700	24	14	120	120
	CFM56-5C	104	60	104	100
	Trent 500	12	28	28	4
	Asia Pacific total	198	152	376	330
Europe	CF6-80E1	12	54	54	58
	PW4100	22	32	42	40
	Trent 700	32	22	46	52
	CFM56-5C	248	204	260	228
	Trent 500	32	20	100	76
	Europe total	346	332	502	454
Middle East	CF6-80E1	10	22	22	32
	PW4100				4
	Trent 700	32	16	36	58
	CFM56-5C	40	44	36	52
	Trent 500	8	8	28	44
	Middle East total	90	90	122	190
North America	CF6-80E1				6
	PW4100	26	22	38	50
	Trent 700	6	6	20	28
	CFM56-5C				4
	N. America total	32	28	58	88
South America	CF6-80E1	10	2	4	6
	PW4100	6	2	16	14
	Trent 700			4	10
	CFM56-5C	16	24	12	12
	Trent 500	8			4
S. American total	40	28	36	46	
Global total	CF6-80E1	56	96	130	160
	PW4100	88	90	170	176
	Trent 700	96	64	240	288
	CFM56-5C	436	380	440	428
	Trent 500	60	64	176	148
	Global total	736	694	1,156	1,200

Source: AeroStrategy / OAG Aviation.

training, many operators do not add to their engine capabilities. This is generally the case across all engine types, but some engines are more popular than others when it comes to keeping the visits in-house. In addition some engines are more restricted in where they can be maintained due to manufacturers' hold on market contracts.

SR Technics says engine removal

intervals are reliant on an engine's life limited part (LLP) limit and/or the condition of the engine. "The condition of the engine will be determined by inspections and the Engine Condition Monitoring (ECM) data. To set up an engine removal plan we use the hard time from the LLP, and a soft time based on our experience," says Frank Walschot, vice president engine maintenance for SR

Technics. "LLPs have lives of 10,000-30,000 per engine flight cycle (EFC)."

### CF6-80E1

The CF6-80E1, manufactured by General Electric (GE), is the second most popular engine on the A330, and powers 194 aircraft.

This engine is rated at 67,000-72,000lbs thrust. According to LHT Hamburg, the CF6-80E1 has removal intervals of 10,000-15,000 engine flight hours (EFH). This depends on the derate, engine version, hardware configuration and the EFH:EFC ratio. In addition, LHT comments that, depending on the part number, the fan and low pressure compressor (LPC) LLPs can have lives of 20,000EFC, the high pressure compressor (HPC) LLPs have lives of 12,000-20,000FC, the high pressure turbine (HPT) LLPs have lives of 3,400-15,000FC, and the low pressure turbine (LPT) LLPs have lives of 8,400-20,000FC.

As would be expected, GE is the largest group of engine overhaulers for the CF6-80E1. It deals with the engine at three locations; one in the US and two in the UK. In total, GE accounts for well over a third of the contract market. The largest single facility that deals with the CF6-80E1 is KLM Engineering & Maintenance, with 22% of the market share. This is followed by GE's Scottish facility with 20%. LHT's joint venture (JV) with QANTAS, LTQ Maintenance, has 12.5% of the contract market due to QANTAS's fleet, while LHT itself has just 3%. A low proportion of CF6-80E1 engines, just 6%, is maintained in-house.

### PW4000-100

The PW4000-100 was introduced in 1994. Despite being the third option for the A330, it still powers 174 aircraft. This engine is rated at 64,500-70,000 lbs thrust with four variants.

Mature removal intervals on the PW4164/68 powering the A330-200 and -300 are 11,000-15,000EFH and 2,000-4,000EFC. Both variants have LLPs with uniform lives of 15,000EFC.

The PW4000-100 has a higher level of engine shop visits undertaken in-house than other engine types: nearly 12%. Understandably, PW has a large share of the market with nearly a third of all shop visits being undertaken at PW's Eagle Services Asia and PW's Cheshire Engine Center. SR Technics has 23% of contracts, which is high for an independent provider. This is the second most active facility after PW's Cheshire Engine Center. GE Engine Services Malaysia and Ameco Beijing each account for 7.5% of the market, although about a fifth of the contract market is

listed as tender or contractor unknown.

In addition to the engines already on aircraft, there are a number of spare ones. "We offer spare engine support for CFM56-5C and PW4168 engines," says Walschot. "For total customer support, we also offer dedicated spare engine availability. This is also offered to single-event customers who bring their engines to our shop where we are able to provide spare engines."

### Trent 700

The Trent 700 is the most prolific engine option on the A330, having entered into service in 1995. The engine is rated up to 72,000lbs thrust, and was the first in-service engine to have the second-generation wide chord fan blade.

According to LHT Hamburg, a Trent 700's shortest LLP life is 6,000FC and the removal interval for the whole engine is about 20,000EFH. LHT's JV with RR, N3, overhauls 20 Trent 700s annually.

A very small proportion of Trent 700 engines are maintained in-house; just below 4%. The largest single facility with Trent 700 capabilities, is HAESL which has 35% of the contract market share. RR undertakes shop visits for 28% of the global fleet at its Derby facility. It also influences over half of all shop visits, due to two additional JV facilities in Germany and Singapore. The first, N3, is a JV between LHT and RR, and only deals with Trent engines, accounting for 6% of global contracts. SAESL is the second, and is a JV between SIAEC, RR and HAESL. This also means that HAESL influences more than half of contracts.

### Trent 500

The Trent 500 entered service in 2002. It powers the A340-500 and -600, and accounts for 35% of all A340s. It is rated at 53,000-56,000 lbs thrust, although it is certified up to 60,000lbs.

Although there are two and a half times as many aircraft with Trent 700 engines, compared to Trent 500 engines, N3 overhauls four times as many Trent 500s. N3 currently performs about 80 Trent 500 engine shop visits per year.

LHT says the removal intervals for the Trent 500 are about 15,000EFH, while the shortest LLP life is 2,600FC. "Trent 500 intervals are pretty variable since removal causes are quite random due to unscheduled removal, performance and LLPs," says Gorika Nunez Fernandez, marketing manager for Iberia. "The most limiting LLP is the HPT disk with just 2,600EFC."

Like the Trent 700, the maintenance market for the Trent 500 is heavily RR-related. While RR itself overhauls nearly a third of engines at its Derby facility, they are linked to over 80% of shop visits due to its connections with N3 and SAESL. SAESL has 31% of the contract market, and N3 deals with 19%. Again, the in-house share is small at nearly 3%, while contracts up for tender account for 4% of the market.

### CFM56-5C

The CFM56-5C is the original engine option for the A340, which entered service in 1993. It now powers over 240 aircraft. The engine is rated at 31,200-

34,000 lbs thrust with three variants.

Iberia and Turkish Technic agree that the average removal interval is about 15,000EFH. Nunez Fernandez adds that this is equal to about three years, and removals are driven by performance.

LHT Hamburg has a more varied window for removals, of 8,000-30,000FH, depending on the engine version and thrust rating and environmental impacts. "Up to now LLPs have not been a removal factor on CFM56-5C4 engines," says Fernandez. "The most limiting LLP is the HPT front air seal, with a life of 7,700EFC." Fan LLPs have lives of 20,000EFC, HPC LLPs have lives of 15,000EFC, HPT LLPs have lives of 10,000EFC, and LPT LLPs can expect lives of 20,000EFC. Exceptions are possible in all modules.

Turkish Technic and PW have formed a JV in Turkey, Turkish Technic Engine Center (TEC), that now deals with the majority of Turkish Airlines' engine maintenance. TEC has performed an average of 16 CFM56-5C shop visits every year over the past few years.

As well as SR Technics' spare engine capability for the CFM56-5C, Iberia and LHT Engine Services can also offer spare engine support.

The support market for the CFM56-5C is much bigger and more varied than other A330/A340 engines. This is in part due to it being the second most popular engine for the entire A330/A340 fleet.

The CFM56-5C's popularity also accounts for just over 7% of maintenance being undertaken in-house. The top MRO facilities for this engine are airline-connected facilities, and a few

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## A330/A340 FAMILY ENGINE AND ENGINE COMPONENT MAINTENANCE

Maintenance facility	Engine type					Engine Overhaul	HSI	Accessory drive gearbox	Electrical system	Fuel system	LRU	Lubrication system	Thrust reverser
	CF6-80E1	PW4100	Trent 700	Trent 500	CFM56-5C								
Air France Industries	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y
Aircelle			Y										Y
Alitalia Maint. Sys	Y					Y	Y						
Ameco Beijing		Y				Y	Y						
Aveos Fleet Performance Inc.					Y			Y	Y	Y	Y	Y	Y
Bedek Aviation (Divn of IAI)					Y	Y	Y						
Eagle Services Asia Ltd		Y				Y	Y						Y
Eaton Aerospace (California)			Y							Y			
EgyptAir Maint. & Eng.			Y		Y	Y	Y						
Evergreen Aviation Tech Corp.	Y					Y	Y						
GE Caledonian Ltd	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Celma Engine Svs	Y							Y	Y	Y	Y	Y	Y
GE Engine Svs - HQ	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Engine Svs - Malaysia		Y				Y	Y	Y	Y	Y	Y	Y	Y
GMF AeroAsia	Y					Y	Y						
Goodrich			Y	Y						Y			
HAECO			Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
Iberia					Y	Y	Y	Y	Y	Y	Y	Y	Y
KLM Engineering & Maint.	Y					Y	Y						
LTQ Maintenance	Y					Y	Y						
Lufthansa Technik	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Lufthansa Technik (Philippines)	Y				Y		Y						
Middle River A/C Sys N3	Y	Y		Y	Y	Y	Y						Y
Nordam Repair Division			Y										Y
OEM			Y		Y						Y		
P&W Cheshire Eng. Center		Y				Y	Y	Y	Y	Y	Y	Y	
P&W Shanghai Eng. Center					Y	Y	Y						
P&W & Turkish Technic Engine Maintenance					Y	Y	Y	Y	Y	Y	Y	Y	Y
Parker Hannifin Corp.			Y	Y						Y			
Rolls Royce Aero Repair & Overhaul			Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
SAESL			Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
SNECMA (MRO Division)	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y
SR Technics		Y			Y	Y	Y	Y	Y	Y	Y	Y	Y
ST Aerospace Solutions A/S		Y	Y		Y								Y
TAP Maint. & Engineering					Y	Y	Y						
Woodward A/C Engine Sys			Y	Y	Y					Y			

Source: Flight Global's ACAS system and direct from airlines

independents.

LHT has the largest share of the market, with 22% of market contracts, followed by AFI with 20%, and SR Technics with 15%.

The engine manufacturers are lower down the list for this engine. GE has 6% (at three locations) and PW has nearly 5% (at two locations). Iberia and SNECMA (MRO division) have 6% and 5% respectively. Just 2.5% of contracts are up for tender.

## Additional services

In addition to airframe and engine maintenance, many MRO facilities offer other services. SRT, for example, offers clients a chemical and physical laboratory service. "We can analyse metallurgical chips, or different engine oil, fuel and hydraulic fluid," says Walschot, "as well as offer our knowledge to support new airlines for entry into service." Providing support to new entrants or a new fleet type is also offered by, among others, LHT and SIAEC.

It has been mentioned previously that some maintenance organisations offer spare engine support. In addition to SR Technics, Iberia and LHT, spare engines can be leased from AFI, GE Engine Services, P&W Engine Services, RR, Snecma Services and TAP Maintenance & Engineering. There are also dedicated leasing companies such as Engine Lease Finance, GA Telesis and Willis Lease that can assist with various options from short- to long-term leases, as well as engine pooling.

Every aircraft operator needs an inventory of spare parts or access to a pool. The majority of maintenance facilities will offer a parts inventory service, as well as document management and aircraft-on-ground (AOG) support. There are also specialist companies that offer inventory leasing, pooling, sale & leaseback, repair and logistics, as well as AOG and power-by-the-hour (PBH) support. These include AJ Walter, AvTrade, ST Aerospace Solutions and the Triumph Group. Some of these, LHT and its LHT Component subsidiary for

example, also offer parts manufacturer approved (PMA) parts as an effective, but cheaper, alternative to OEM parts.

The final large service that companies can offer an operator is engineering management and technical support. If an airline is small, young or lacking in a large engineering infrastructure it will need assistance. MRO facilities offer this service as an extension of the maintenance they already do for a customer. The service will involve a number of different actions, one of which is keeping maintenance records. The service can also be linked to document and manual management, maintenance programme management, reliability statistics, line and base check planning and managing ADs and SBs. In other words, a complete service that means all an operator needs to do is deal with the operations of an airline, rather than the engineering side. [AC](#)

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