OWNER'S & OPERATOR'S GUIDE: A340-200/-300

A340-200 & -300 specifications

The A340-200 and -300 family have a complex system of specification weights and fuel tank capacities, plus three main engine variants.

The A340 is the four-engined, long-range, widebody sister to the twin-engined A330. Powered by the CFM56-5C, the A340 is available in two fuselage lengths, with the shorter A340-200 capable of flying up to 8,000nm. The longer variant -300 has a range of up to 7,200nm.

The flightdeck design was finalised in 1988 and is virtually identical to that of the A320 family, with a six-screen electronic flight instrument system (EFIS) and side-stick controllers. Like the A320 family, the A330/340 has a digital fly-by-wire flight control system. This allows the two aircraft to benefit from a common type rating and cross-crew-qualification (CCQ). The A330 and A340 flightdecks differ only in the number of engine throttles and engine-related displays.

There are three variants each of the A340-200 series and of the A340-300 series: the A340-211/-311, A340-212/-312; and A340-213/-313. The final digit on the variant suffix refers to the installed engine thrust rating, not to maximum take off-weight (MTOW) capability. The MTOW capability of each variant is described in more detail *(see A340 modification programmes, page 13)*.

The A340-200/-300 family has complex weight specifications. There are first 'basic' variants, high gross weight models and a large number of different weight specification variants in between. There is an Airbus modification number and weight variant code for each weight specification version *(see first table, page 10)*. The overall weight specifications are summarised *(see table, page 8)*.

According to Airbus, the basic -200 series can carry its standard 263 passengers up to 7,350nm (566,588lbs MTOW), while the high gross weight (HGW) version (606,271lbs MTOW) with two auxiliary centre tanks (ACTs) has a range of 8,000nm with 239 passengers in three classes. The HGW variant is known as the A340-2000.

The -300 series can carry its standard 295 passengers over 6,650nm with an MTOW of 566,588lbs, and over 6,700nm with the intermediate 573,202lbs MTOW variant. The HGW version with 597,500lbs MTOW (referred to as the A340-300E) has a range of 7,100nm, or 7,200nm with one ACT.

Airbus states that the A340-300's typical operating empty weight (OEW) is 287,000lbs. A survey of airlines' basic empty weights (BEW) and their aircraft prepared for service (APS) weights reveals that BEWs are 277,500-286,000lbs and APS weights are 290,000-293,000lbs. APS comprises the BEW plus the weight of crew and their baggage, galleys loaded with food, drink and all other catering items, newspapers, magazines, blankets, pillows and water. The APS weight therefore excludes any payload or fuel.

Powerplant options

The A340-200/-300 is powered by three thrust variants of the CFM56-5C. The lowest thrust rating is 31,200lbs provided by the CFM56-5C2 for the A340-211/-311. The intermediate thrust rating is 32,500lbs provided by the CFM56-5C3 for the -212/-312, which became available in March 1994. The highest thrust rating is 34,000lbs provided by the -5C4 for the A340-213/-313, which became available from 1995.

The original -5C2/-5C3 design specified a maximum exhaust gas temperature (EGT) of 950ºC. The more powerful -5C4 entered service with Kuwait Airways and Air Canada, and has a higher EGT of 975ºC. Compared with the original -5C2 and -5C3, the -5C4 uses improved fan-blade and booster inlet guide vane (IGV) airfoils which allow an increase in the N1 fan speed limit, as well a fuel pump for 34,000lbs thrust rating.

Since the -5C4 model entered service, CFMI has offered progressive upgrades to allow existing -5C2s and -5C3s to operate with improved EGTs (965ºC and 975ºC) and thus improve time on wing. Engines with these two respective modifications were denoted with /F and /G suffixes. Specifically, the /F build-standard incorporates improved materials in the low pressure turbine (LPT) to enable it to operate at a take-off EGT redline of 965ºC, compared to the original 950ºC redline (for a limited time during the take-off phase only) and with a maximum continuous EGT raised from 915ºC to 930ºC. It is estimated that, depending on specific airline operation parameters, the /F could provide an additional two to three years on-wing time before the engine's first overhaul.

The /G build standard became available from 1995. This incorporates additional high pressure turbine (HPT) improvements over the /F, offers the same

The A340-200 and -300 have a complex system of a matrix of MTOW, MLW and MZFW specification weights. There are up to 22 specification weight permutations.

A340-200/-300 FAMILY SPECIFICATIONS

Variant	A340-200	A340-300
MTOW lbs	558,872-606,271	558,872-609,578
MLW lbs	399,037-407,855	410,060-423,288
MZFW lbs	372,581-381,400	383,604-403,446
OEW lbs (no tare)	282,400-286,000	287,000-291,300
Basic empty weight lbs (approx)	272,000-276,000	277,500-286,000
Typical gross structural payload lbs	57,420	64,900
Fuel capacity USG	36,489-40,782	37,39,138
Seats (3 class)	261	295
Range nm	7,350-8,000	6,650-7,200
Belly freight cu ft	4,813	5,751

975ºC take-off EGT redline of the higher thrust -5C4, and a maximum continuous EGT rising from 915ºC to 940ºC.

Furthermore, from 1996, CFMI manufactured -5C2 and -5C3 engines with /F or /G modifications incorporated on the production line as standard. The engines were also built with components that allow them to operate at the -5C4's thrust rating of 34,000lbs, and given a /4 suffix to denote that they have the full -5C4 hardware, including the higher-speed fan components, and so are capable of a rating of 34,000lbs thrust. The -5C2/4 and -5C3/4 engines are de-rated at 31,200lbs and 32,000lbs thrust, but both can have their ratings increased to 34,000lbs by purchasing the correct engine control unit (ECU) software from CFMI. Conversely, if an operator needs to de-rate a CFM56-5C4 to a -5C3 or -5C2 thrust rating for operation on the -211/-311 or -212/-312, or for an 'intermix' situation, the resultant engine designation becomes the -5C3/4 or -5C2/4.

The final version of the engine is the -5C4/P variant. This incorporates all prior improvements to the /G variant, while adding further ones. Available from 2003, the CFM56-5C4/P adds 3D-aero-turbomachinery for further improved EGT and time-on-wing performance. It has been ordered by Swiss, South African Airways, Air Mauritius and, more recently, by Finnair. A modification kit is also available to take -5C4, -5C3/G4 and -5C2/G4 engines to -5C4/P standard *(see A340-200/-300 modification programmes, page 13).*

Fuel capacities

Unlike the A330-300, the A340-200 and -300 both feature a centre section fuel tank holding 73,136lbs (10,916US Gallons; USG) usable fuel as standard.

The standard fuel capacities of the A340-211, -212 and -213 are 36,489USG and 36,520USG for aircraft configuration numbers 001 and 002. Standard fuel capacity for aircraft configuration number 021 is 36,992USG *(see second table, page 10).*

In addition, aircraft configuration number 021 can carry extra fuel in optional 1,900USG ACT fuel tanks. Two can be installed on the -200 series, providing another 3,800USG in the rear

cargo hold, taking the total fuel capacity for this specification up to 38,887USG with one ACT, and 40,782USG with two ACTs *(see second table, page 10)*.

There are three standard fuel configurations for the A340-311, -312 and -313. The standard fuel configuration depends on the configuration number of the aircraft *(see second table, page 10)*.

There are three standard fuel capacities for the A340-311, -312 and -313: 36,489USG, 37,243USG and 37,016USG *(see second table, page 10)*.

Aircraft weight specification variant 020 can also have an ACT fitted, taking total fuel capacity up to 39,138USG *(see second table, page 10)*.

Alan Pardoe, head of A330/340 product marketing at Airbus, points out that in practice, however, very few A340-300s were actually delivered with provision for an ACT, and most A340-300s fly without one.

Accommodation & interior

Airbus's standard long-range seating configuration for the A340-300 series is 295 passengers, with 12 in first class (62-inch pitch), 42 in business (40-inch pitch) and 241 in economy (32-inch pitch). The -300 has a standard configuration of 335 passengers in a two-class layout: 30 in business class (40-inch pitch), and 305 in economy (32-inch pitch).

Actual airline configurations have fewer seats. For example, Virgin Atlantic's 240-seat, three-class interior comprises 34 first-, 35 business-, and 171 economy-class seats.

Air France has fitted some of its -300s with 291 seats in two classes: 30 seats in business and 261 in economy. Its other -300s have 285 or 272 seats.

Cathay Pacific has a variety of configurations. Most have 287 seats in two classes, but some have only 243 in three classes. Lufthansa has a mix of two-class configurations of 221, 241, 247 and 266 seats. Air Canada uses 286 seats in two classes, and Emirates' -300s have 267 seats in three classes. Meanwhile, Swiss flies all its A340-300Es with just 228 seats in three classes. Finnair, however, is taking delivery of its new A340-313s each with 310 seats in two classes. The three-class configurations average a total of 244 seats, and the two-class configurations 271.

The smaller -200 has a standard configuration of 261 seats. This comprises 12 first- (62-inch pitch), 36 business- (40 inch pitch), and 213 economy-class (32-inch pitch) seats.

Another option is a 262-seat three-class arrangement, with 18 seats in first class at 60-inch pitch, 74 in business at 36-inch pitch and 170 in economy at 34-inch pitch.

In two classes, Airbus says the -200 can seat 300 passengers: 30 in business class (40-inch pitch), and 270 in economy (32-inch pitch).

The actual configurations used by airlines operating the -200 series are interesting. Although the -200 has a shorter fuselage than the -300 series, typical seating configurations in the -200s often provide as many seats as the -300s. For example, EgyptAir has 260 seats, Aerolineas Argentinas' aircraft has 249 seats, and Royal Jordanian has 254 seats in their -200s in a two-class arrangement.

The -200's higher average seating density is due to the fact that for the same MTOW and fuel capacity, the shorter -200 has a smaller airframe and lower OEW than the -300. As a result, the -200 can carry a higher payload and fuel load than the -300 on the same mission. The larger -300 is also payload-limited on long ranges, since it cannot carry its maximum structural payload when its tanks are filled to capacity and the aircraft is at MTOW at departure.

Interestingly, the A340-200's and -300's type certification data sheet specifies a maximum exit-limited capacity of 420 seats and 440 seats respectively when

A340-200 & -300 FAMILY WEIGHT VARIANT CODES

Airbus mod number	MTOW lbs	MLW lbs	MZFW lbs	A340-211	A340-212	A340-213	A340-311	A340-312	A340-313
A340-200 'basic'	558,872	399,872	372,581	Basic	Basic	Basic			
A340-300 'basic'	558,872	410,060	383,604				Basic	Basic	Basic
41302	556,588	399,037	372,581	001	001	001			
41302	566,588	410,060	383,604				001	001	001
44102	566,588	414,469	392,423				003	003	003
44229	573,202	399,037	372,581	002	002	002			
44228	573,202	410,060	383,604				002	002	002
44230	573,202	414,469	392,423				004	004	004
53243	573,202	414,469	392,423					029	
44791	573,220	418,8778	392,423						025
44625	577,611	418,878	392,423						023
43500	597,453	418,878	392,423						020
46650	597,453	423,288	392,423						027
44281	606,271	407,855	391,400			021			
44135	606,271	418,878	392,423						021
45738	606,271	423,288	396,832						024
51808	606,271	423,288	396,832						050
46613	606,271	423,288	399,037						026
51809	606,271	423,288	399,037						051
55677	606,271	423,288	403,446						054
51810	609,578	423,288	399,037						052
55566	609,578	423,288	403,446						053

A340-200/-300 USABLE FUEL CAPACITIES

Fuel configuration	Config 1	Config 2	Config 3	Config 4	Config 5
Aircraft variant	A340-211/ -212/-213 Basic, 001, 002	A340-211/ -212/-213 021	A340-311/ -312/-313	A340-313 020	A340-313
Standard fuel capacity-USG	36,489 36,520	36,992	36,489	37,243	37,016
Total with 1 ACT		38,887		39,138	
Total with 2 ACT		40,782			

four type-A doors are fitted.

Several optional facilities are offered for the A340 interior, some of which may also apply to the A330. A two-crew rest area can be installed. One option comprises a flightcrew area located behind the flightdeck, featuring two bunks, folding tables, coats and baggage stowage, reading lights, and fresh air nozzles. Another option features an underfloor crew rest area, created using a modified cargo container fitted with bunks, TV screens and video, dressing rooms and refrigerator, with access by way of stairs to the main deck. The optional ventilation of the lower cargo deck is available for carriage of livestock.

Belly cargo capacities

The A340-200 series' belly hold accommodates a maximum of 27 LD3s or nine 96-inch pallets. Its forward hold has structural provision for a maximum load of 40,801lbs (subject to weight and balance considerations), and can take 14 LD3s, equal to 2,212 ft^3.

The aft hold can support up to 33,601lbs plus up to 7,646lbs in additional rear bulk area (again, subject to weight and balance considerations) and its capacities are: 12 LD3s equating to 1,896 ft^3, plus another 695 ft^3 in the aft bulk hold; 13 LD3s with one in the bulk hold area, with a reduced bulk volume of 486 ft^3; or 632 ft^3 with two ACTs, a crew rest module, four LD3s, and another 695 ft^3 in the bulk hold.

The maximum total belly hold capacity of the A340-200 is therefore 4,803 ft^3 when configured with 26 LD3s plus bulk volume. This could typically be used for high-capacity missions over medium ranges. Over longer ranges, however, the A340-200's total lower hold volume reduces to 3,539 ft^3, with lower passenger seating density, and therefore lower underfloor baggage volume, two ACTs, a crew-rest-module, four LD3s, and bulk volume at the rear. With a standard passenger load on the maindeck, Airbus says that the A340-200's total structural (gross) underfloor cargo payload is 28,660lbs.

The longer A340-300 series' belly hold accommodates a maximum of 33 LD3 unit load devices (ULDs), or eleven 96-inch pallets. Its forward hold can structurally support up to 50,400lbs, with floorspace for 18 LD3s. This equates to 2,844 ft^3 of volumetric capacity.

The aft hold supports up to 40,801lbs and up to 7,646lbs in additional rear bulk area. Its capacities are: 14 LD3s, equating to 2,212 ft^3, plus another 695 ft^3 as bulk; 15 LD3s with one in the bulk hold area reducing the bulk volume to 486 ft^3; or 1,896 ft^3 plus 695 ft^3 bulk, with the optional crew rest module which then leaves room for 12 LD-3s.

The maximum total belly hold capacity of the A340-300 is 5,751 ft^{3}when configured with 32 LD-3s plus bulk. However, with the two optional ACTs, crew rest module, four LD-3s, plus bulk, the total cargo volume falls to 5,435 ft^3. With a standard passenger load on the maindeck, total structural (gross) underfloor cargo payload for the A340-300E is 31,305lbs (13.9 tons). AC

A340-200/-400 fleet analysis

There are 242 A340-200s and -300s in operation. The oldest are 14 years old, and a large number are no longer flown by their original operators.

The A340 and closely related A330 were launched in June 1987. The A340 entered service with Lufthansa and Air France in March 1993, following Joint Airworthiness Authority (JAA) certification in December 1992.

A total of 242 A340-200/-300 aircraft powered by several variants of the CFM56-5C engine have been delivered, and there is a backlog of 12 A340-300s. Most of the fleet are in service with their original operators.

The CFM-powered A340 fleet is split between the -200 and -300 models. The A340-200, of which there are 27 in passenger service, has a standard tri-class capacity of 261 passengers and a range of up to 7,450nm. South African Airways (SAA) is the largest A340-200 operator with six ex-Lufthansa aircraft. Overall, there are 10 A340-211s, 15 A340-212s, and three A340-213s. Two of the three -213s are in VIP service in Saudi Arabia.

The longer A340-300 is the more popular version, with 213 in the fleet. It also has the highest retention rate with original operators. Of the 213 A340-300 model series delivered, 166 aircraft (78% of those delivered) are still with their original operators, while only six of the 28 -200 series aircraft are with their original operator, giving a retention ratio of 21%.

The -200 and -300 are powered by three main variants of the CFM56-5C, which provides three thrust ratings. The A340-200 and -300 sub-variants are denoted by model-respective suffixes. The A340-211 and -311 are powered by four CFM56-5C2s rated at 31,200lbs thrust. The A340-212 and -312 are powered by four CFM56-5C3s rated at 32,500lbs thrust, and the A340-213 and -313 are powered by four CFM56-5C4s rated at 34,000lbs thrust.

It should be mentioned that most of the installed CFM56-5C3 fleet, which originally had an exhaust gas temperature (EGT) redline limit of 950°C at take-off, have been upgraded to the CFM56-5C/F standard, which incorporates improved low pressure turbine (LPT) hardware to increase the EGT redline limit to 965°C. CFMI subsequently offered an additional LPT and high pressure turbine (HPT) upgrade to further raise the allowable redline limit from 965°C to 975°C, thereby increasing the available EGT margin to improve time on-wing. These modified engines were subsequently denoted with -5C2/G and -5C3/G suffixes. However, most operators have not opted for this upgrade.

According to the Aircraft Fleet & Analytical System (ACAS) database, only three A340s with the /G suffix are in operation: a -5C2/G-powered A340-211 with the Government of Jordan (ex-Lufthansa); and two -5C3/G-powered A340-312s with Air Namibia (ex-Sabena). Lufthansa upgraded six CFM56-5C/F-powered A340-200s and eight A340-300s to /G standard, while still operating them as '/Fs' That is, it reverted to the 965°C redline limit in order to improve on-wing life. These aircraft are now flying with SAA, and are listed in ACAS as having CFM56-5C3/Fs.

A340-200

The shorter-fuselage A340-211 variant is powered by the lowest rated -5C2 engines (31,200lb thrust), and all 10 of these aircraft in the fleet are certified with a maximum take-off weight (MTOW) of 565,400lbs. Eleven -211s were originally delivered, but one Air France aircraft was destroyed in a non-fatal runway overrun accident. All but one of the -211 sub-fleet are no longer flying with their original operators, the exception being an aircraft operated by the Qatar Amiri Flight.

Of the 10 aircraft that have changed operators, four -211s originally ordered by Philippine Airlines are now flying with Aerolineas Argentinas, two aircraft delivered to Austrian are now with the French Air Force, one ex-Lufthansa aircraft is with the government of Jordan, one ex-UTA aircraft is with ConViasa, and one with Qatar Amiri Flight.

As early-build aircraft (with ages ranging from 12 to 14 years), these passenger examples have accumulated 39,300-54,300 flight hours (FH) and 5,300-7,000 flight cycles (FC). These are above the average for the entire A340 fleet. These aircraft have been operated at FH:FC ratios of 7.4:1-8.2:1 since delivery. Given their age, all -211s will have undergone their first D-check.

Only 15 A340-212s remain in operation, powered by CFM56-5C3/Fs, rated at 32,500lbs thrust. The MTOWs range from 557,700lbs to 572,000lbs for the -312s fleet, which were all delivered from January 1993 to June 1997. Most of the -212s have been sold by their original operators. For example, Lufthansa took delivery of six -212s in 1993, which are all now operated by SAA. Royal Jordanian operates four -212s, two of which came from Sabena, and two from UTA.

Although most of the 15 -212s have accumulated 7,000-8,000FC, there is a marked difference in the accumulated FHs. For example, the ex-Lufthansa and ex-UTA aircraft (delivered from 1993 to 1994) have FH:FC ratios of 7:1-8:1 and have each accumulated more than 56,000FH. However, the aircraft operated by EgyptAir and Royal Jordanian in particular have accumulated significantly fewer FH: EgyptAir's three aircraft each have 36,000-37,000FH; and Royal Jordanian's two ex-Sabena aircraft have 47,000-49,300FH. Its third aircraft, an ex-UTA model, has 56,000FH. These relatively low FHs are a result of low hour-to-cycle ratios, and range typically from 4.3:1 to 6.6:1. Given that all aircraft are at least 10 years old, all will have already undergone their first D-check.

The A340-213 is the most powerful

A340-200/-300 FLEET SUMMARY

Engine variant	CFM56-5C2	CFM56-5C3	CFM56-5C4
A340-211	10		
A340-212		15	
A340-213			3
A340-311	27		
A340-312		17	
A340-313			169
Total	37	32	172

The majority of A340s are -313s, powered by CFM56-5C4s. These are the most powerful engines that feature hardware that allows longer on-wing removal intervals than the older and less powerful -5C2 and -5C3 engines.

version of the -200 model, and shares the same -5C4 34,000lbs thrust engine with the larger A340-313. With these more powerful engines, the aircraft was dubbed the 'A340-8000' because it would have an 8,000nm range with 260 passengers. However, the high operating costs precluded sales success in this market. Only three were delivered, for use as long-range VIP transports. Two were originally delivered to the Government of Brunei, and are now with Afriqiyah Airways and a private operator in Saudi Arabia. The third aircraft is also owned by a Saudi Arabian VIP.

A340-300

The A340-300 fleet is subdivided into the A340-311, -312, and -313, depending on the installed engine thrust rating. As with the A340-211, the longer fuselage A340-311 variant is powered by the lowest rated engine at 31,200lbs thrust. Aircraft MTOWs range from 557,700lbs to 572,000lbs.

Of 27 A340-311s originally delivered between 1993 and 1997, all but one are still flying, with one Sri Lankan Airlines aircraft having been destroyed in a non-fatal terrorist-related incident at an airport. Of the 26 remaining aircraft, 20 are still flying with their original operators. The six exceptions include one aircraft originally delivered to Air France, one to Gulf Air, and four to Virgin Atlantic, all of which are now with other operators. The A340-311 fleet is 10-14 years old, and therefore most, if not all, -311s, will have already had their first D-check. These aircraft have accumulated 26,300-65,000FH and 4,725-10,420FC since delivery. These are above the average figures for the entire A340 fleet, whose average FH:FC ratios since delivery range from 5.8:1 to 8.7:1.

Lufthansa operates eight -311s, all of which are older than 12 years, and have accumulated high FHs and FCs with 60,000-64,600FH and 7,700-8,500FC. In fact, five of these Lufthansa aircraft have the highest accumulated FH of the entire A340 fleet.

The A340-312 variant is powered by more powerful CFM56-5C3/Fs rated at 32,500lbs thrust each. In turn, A340-312 MTOWs are generally higher than the -211's and range from 565,400lbs to 605,000lbs. Of 17 A340-312s originally delivered from 1993 to 2000, 11 are still flying with their original operators, and six are with new ones. Gulf Air continues to operate its six -312s (delivered from 1994 to 1996), and TAP Air Portugal operates four which it had delivered over 12 years ago. All -312s, apart from two, are over 10 years old. Two -312s operated by Sri Lankan are 6.5 years old, and will not have had their first D check.

The operational A340-312s have accumulated 26,340-61,000FH, and 4,248-13,430FC since delivery. These are FH:FC ratios of 4.2:1 to 7.8:1 since delivery. All the -312s belonging to Gulf Air have the highest number of accumulated cycles in relation to the number of hours flown, 11,000FC and 13,430FC. Indeed, while most of the other aircraft in this group have an FH:FC ratio of well above 6:1, the ratios for all of the Gulf Air -312s range from 4.2:1 to 4.6:1. All the five Gulf Air aircraft in this group have averaged more than 1,000FC annually since delivery.

The A340-313 is by far the most popular variant, with 169 being delivered to operators from 1995 to the end of 2006. This version is powered by the most powerful CFM56-5C4 engine rated at 34,000lbs thrust each. As with the A340-312, aircraft MTOWs range from 565,400lbs to 605,000lbs. Most of the fleet are still flying with their original tier-one flag-carrier operators. The main exception is Singapore Airlines, which has now disposed of its entire original fleet of 17 A340-313s as part of a deal with Boeing to buy 777s. Most of these -313s have gone to Emirates, Cathay Pacific or Gulf Air.

With ages ranging from brand new to just over 12 years, the operational A340-313s have accumulated up to 54,420FH and 9,860FC, since delivery. These figures reflect a range of average hours-to-cycle ratio from 2.2:1 to 5:1 (aircraft from China Eastern, Air China, Emirates, Gulf Air and Kuwait Airways in particular, fall into this category) and increasing to nine hours per FC for the highest utilised aircraft. The latter are typically operated by Air Canada, Virgin Atlantic, SAS, and South African Airways in particular.

It should be noted that to improve the EGT margin, and hence reliability of the CFM56-5C4, CFMI introduced an upgrade incorporating 3D hot-section blade aerodynamics. This improved version is denoted by a '/P' suffix and the same thrust rating as the original -5C4 *(see A340-200/-300 modification programmes, page 13)*.

To date, 15 aircraft are equipped with these improved /P engines. Swiss was the first customer to take delivery of the first of six CFM56-5C4/P-powered aircraft from November 2003, and South African Airways followed in March 2004 with deliveries of six (three of these are now being operated by Jet Airways in India). In addition, Air Tahiti Nui is operating one, and Air Mauritius operates two.

Another 11 CFM56-5C4/P-powered A340-313s are due for delivery. Ten are for Finnair, and according to ACAS's order-backlog database, these will be delivered from 2007 through to 2010. There is also one other -5C4/P-powered A340 listed for an undisclosed customer.

Of 243 A340-313s, 102 are younger than nine years and 130 are younger than 10 years. As a rough guide, more than half the -313 fleet have yet to undergo their first D-check. The oldest aircraft will be coming due their second IL check within the next one to two years. AC

A340-200/-300 modification programmes

The major modification programmes for the A340-200/-300 are weight upgrades and engine build-standard and thrust upgrades.

Upgrades and modification programmes for the A340-200 and -300 series fall into the following groups: changes to weight upgrades; engine thrust re-rates; and engine time on-wing and exhaust gas temperature (EGT) hardware upgrades. At this stage there is no passenger-to-cargo conversion planned for the A340 family. The fleet is still relatively young and enjoys a strong demand for long-haul passenger operations, so A340 hull values are too high to make conversion to freighter economic.

A340-200 weight upgrades

For the A340-200 series, Joint Airworthiness Authority (JAA) certification data lists four possible combinations of maximum take-off weight (MTOW), maximum landing weight (MLWs), and maximum zero fuel weight (MZFW) *(see table, page 10)*.

There are four MTOWs: 558,872lbs (253.5 tonnes), 566,588lbs (257t), 573,202lbs (260t), and 606,271lbs (275t). Only one of these highest MTOW variants was built.

There are two MLW options: 399,037lbs (181t) and 407,855lbs (185t). There are two MZFW options: 372,581lbs (169t) and 381,399lbs (173t).

Accordingly, these are grouped to give four possible JAA-certified combinations of these MTOWs, MLWs, and MZFWs.

The first is the 'basic aircraft' with an MTOW of 558,872lbs, MLW of 407,855lbs, and MZFW of 372,581lbs.

The most capable variant has an MTOW of 606,271lbs, an MLW of 423,287lbs, and an MZFW of 381,399lbs. If any of these combinations are subsequently applied to an A340 model (which was originally delivered with different specifications), this results in a 'configuration change', for which a particular service bulletin (SB)applies.

The A340-200 and -300 are also subdivided into three sub-variants based on engine variant: the A340-211, A340-212, and A340-213. Moreover, operators can choose from the weight options to match particular mission payload, range and take-off performance requirements.

There has been an evolutionary progression of weight capabilities corresponding to successive aircraft variants. The -211 (and -311) tend to have the lowest weights, while the -213 and -313 have the highest ones. Having more engine thrust in the -213/-313 allows operators to take better advantage of higher operational weights. This means the -211 with the 566,588lbs MTOW option can carry its standard load of 263 passengers and baggage over 7,400nm.

The higher weight -212 became available in 1994, using the 573,202lbs MTOW. The enhanced A340-213 model, was previously marketed by Airbus as the A340-8000 from 1997. This aircraft offers the highest MTOW of 606,271lbs. This is combined with CFM56-5C4s and two auxiliary centre tanks (ACTs) in the rear cargo hold, and can carry 239 passengers over 8,000nm, or a full payload over 6,000nm.

A340-300 weight upgrades

As with the A340-200 series, there is a menu of JAA-certified weights for the A340-300 series *(see table, page 10)*: seven MTOW, four MLW, and five MZFW options. The seven MTOW options are: 558,872lbs (253.5t), 566,588lbs (257t), 573,202lbs (260t), 577,611lbs (262t), 597,453lbs (271t), 606,271lbs (275t), and 609,578lbs (276.5t).

The four MLW options are: 410,060lbs (186t), 414,469lbs (188t), 418,878lbs (190t), and 423,287lbs (192t).

The five MZFW options are: 383,604lbs (174t); 392,423lbs (178t); 396,832lbs (180t); 399,036lbs (181t); and 403,400lbs (183t).

Furthermore, operators may choose from 18 combinations of these. The first is the 'basic aircraft' with an MTOW of 558,872lbs, an MLW of 410,060lbs, and an MZFW of 383,604lbs. At the other end of the scale is the most capable variant, with an MTOW of 609,578lbs, an MLW of 423,287lbs, and an MZFW of 403,446lbs.

It should be noted that in the case of both the A340-200 and A340-300 weight variants, an aircraft is either delivered new from the factory with the chosen MTOW, MLW and MZFW combination, or an SB relating to the particular 'variant change' can be implemented later on.

A small number of early A340-300s entered service at 'basic' MTOW. The 573,200lbs (260t) MTOW option became the norm from 1994. According to Airbus, most of the earlier aircraft have now been upgraded to this standard, which adds 150nm to the aircraft's range performance with a full passenger load. An option to increase MZFW by 8,880lbs, with an equivalent increase in payload, is also available, and provides a 4,410lbs increase in MLW.

The first high gross weight (597,453-606,270lbs) MTOW A340-300 was delivered to Singapore Airlines in August 1996. This is now flying with Etihad. As well as the increased MTOW, the high gross weight (HGW) A340 features a new strengthened landing gear and 4,400lbs in reinforced structure in various areas including the wing, and an optional ACT fuel tank in the rear cargo hold.

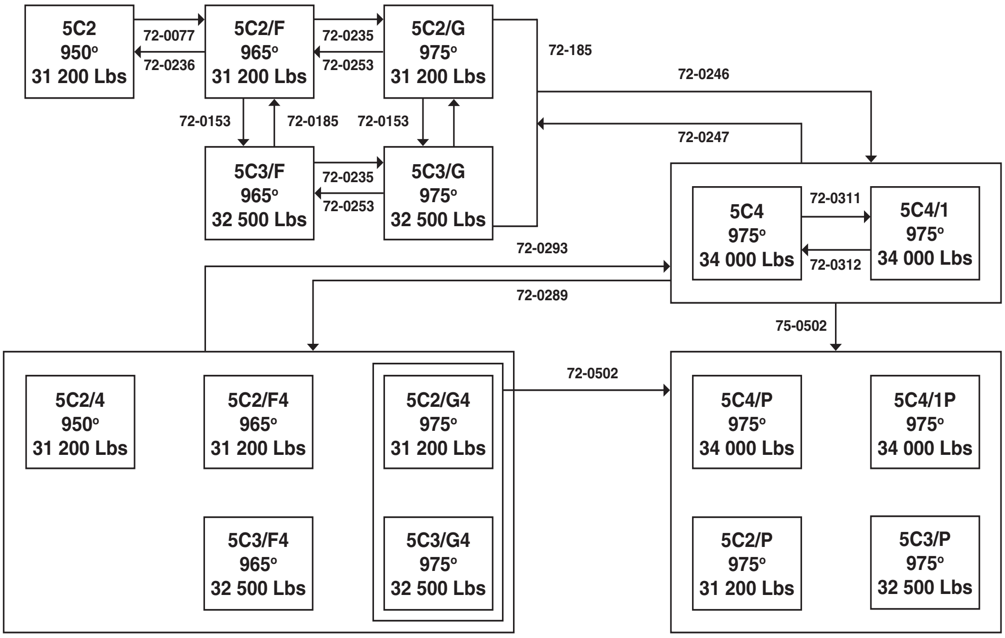
The A340-300E became available from 2004 (msn 544 onwards), and is powered by the improved CFM56-5C4/P as standard. This aircraft also comes with a further increased MTOW capability of 609,570lbs (275t).

CFM56-5C/P upgrade

The 34,000lbs thrust CFM56-5C4/P is a newer version of the CFM56-5C4, using the high pressure compressor (HPC) and high pressure turbine (HPT) (core) of the CFM56-5B/P on the A320 family, which further improves hot-and-high performance, cuts maintenance costs and increases time on wing.

This engine variant is standard on the A340-300E mentioned above, although the improved hardware can also be retrofitted to earlier -300s. The Aircraft & Fleet Analytical System (ACAS) database lists 15 aircraft equipped with these improved engines which improve hot-and-high performance, reduce costs and increase time on-wing. Swiss took delivery of its first CFM56-5B/P-powered A340-313 in November 2003, and now

CFM56 - 5C CONVERSION SERVICE BULLETINS



has six in service. South African Airways followed in March 2004 with deliveries of six; three of which are now being operated by Jet Airways in India. In addition, Air Tahiti Nui is operating one, and Air Mauritius operates two.

Another 11 CFM56-5C4/P powered A340-313s are on order. According to ACAS's order-backlog database these comprise 10 for Finnair, to be delivered from 2007 through to 2010, and one listed for an undisclosed customer.

As well as the new-build -5C/Ps, there is also an upgrade kit for operators to modify the CFM56-5C to the /P standard, which is achieved via SB72-0502. This requires revised engine control unit (ECU) software and '/G' hardware.

According to Martin Matthews, engineer at UK-based Total Engine Support, the -5C/P upgrade costs $600,000 per engine. It involves installing 3D-aero HPT blades, nozzle guide vanes (NGVs), HPC blades and stage-1 LPT NGVs. Matthews says that the upgraded engines average a 15-17°C lower EGT than fleet average (and hence a higher EGT margin), as well as a cruise fuel burn reduction of 0.5-1.0%. The on-wing life also increases by 2,000-3,000 engine flight hours (EFH). CFMI says the upgrade can be installed during normal overhaul, and the modified engines are fully interchangeable and intermixable with unmodified engines, being 'virtually transparent' on the flightdeck. In 2006, Lan Airlines placed a $48 million order with CFMI for CFM56-5C/P kits to upgrade 18 installed and spare engines on its fleet of A340-300s.

Engine re-rates & intermix considerations

Importantly, for some 'intermix' situations, such as where three -5C4 engines of an A340-313 have to be de-rated for an extended period of time to match, for example, a spare -5C2 fitted onto one of its pylons, the three -5C4s will be temporarily re-designated as -5C2/4s to comply with operational procedures. The /4 suffix shows that these engines have -5C4 hardware, but a -5C2 rating. The A340-313 has to be re-designated as an A340-311 to reflect its new temporary lower operational thrust limitation, and to be operated as such.

This is complicated mainly because of the documentation changes and approvals required. According to Christophe Bertrand, a senior flight test engineer with Airbus, the airline has to update all relevant documents to reflect the model change, and submit them to the airworthiness authorities. These documents include: the flight manual; the flightcrew operating manual (FCOM); take-off and landing charts; the weight and balance manual; and any documents mentioning the aircraft model.

For the actual hardware, full authority digital engine control (FADEC) software needs to be re-programmed to the lower thrust rating, engine rating plugs changed, engine nameplates changed, and the flight warning computers (FWC), SDAC and flight management guidance envelope computers (FMGECs) all have to be pin-programmed. All of the above, including the documenting changes, can take about two weeks. This makes it unsuitable in aircraft on the ground (AOG) situations.

To cater for AOG situations with engine intermix, Airbus has presented to the airworthiness authorities a policy which allows for temporary engine re-rating without aircraft model change. It is applicable for a short period of time only, whereby any deviation from the aircraft's limitations, procedures and performance must be approved in a Flight Manual Supplement. For example, Airbus mod 45912 has been approved to allow the A340-313 (CFM56-5C4) to undertake temporary operations with engines re-rated to -5C2 thrust levels. This is approved in the A340-313 Flight Manual Supplement chapter 6.03.07 for aircraft having mod 45912. Importantly, by going this route, the A340-313 aircraft model remains unchanged, since operations with this new rating are approved in the Flight Manual Supplement. The applicable sections (for example, regarding rotor speed limitations, procedure and performance items) supersede the basic Flight Manual while the aircraft is in 'intermix' configuration.

All CFM56-5C conversion SBs are summarised *(see chart, this page)*. AC

A340-300 fuel burn performance

The A340-200 & -300 are well known for their ultra long-range performance capability. Their fuel burn performances on long-distance routes are analysed.

The fuel burn and operating performance of the A340-200 and A340-300 are analysed. The three different thrust ratings of the CFM56-5C series are represented. The aircraft analysed include: the A340-211 and -311 powered by the CFM56-5C2 rated at 31,200lbs thrust; the A340-212 and -312 powered by the CFM56-5C3 rated at 32,000lbs thrust; and the A340-313 powered by the CFM56-5C4 and CFM56-5C4/P rated at 34,000lbs thrust *(see table, page 16)*.

Passenger routes described

Two city-pairs are used to analyse the aircraft: London Heathrow (LHR) to Los Angeles (LAX); and LHR to Singapore (SIN). Aircraft performance has been analysed in both directions to illustrate the effects of wind speed and direction on the actual distance flown. Wind speed and direction result in an equivalent still-air distance (ESAD).

The first city-pair (LHR-LAX) has a tracked distance of 4,963nm, and is within the payload range of all versions of the A340-200 and -300.

The second route (LHR-SIN) has a tracked distance of 5,879nm. The A340-311 and -312 are at the limit of their payload-range capabilities on this route in both directions. Both reach their maximum take-off weight (MTOW), and both have to be operated with a reduced payload in both directions.

In the flight plans performed by Airbus, 85% reliability annual winds have been used. The aircraft have been assumed to have full passenger payloads, unless limited, and to be carrying no additional belly freight. Tri-class passenger loads are 261 passengers for the A340-200s, and 295 for the A340-300s. The exceptions to these are the A340-311 and -312 on the LHR-SIN route *(see table, page 16)*.

The standard weight used for each passenger plus baggage is 220lbs. The payload for the non-restricted A340-200s is therefore 57,420lbs, and the payload target for the larger A340-300s is 64,900lbs *(see table, page 16)*. The payload for the two MTOW-restricted A340-300s varies according to the operating empty weight (OEW) version and route direction, but is equal to the weight of 18-38 fewer passengers *(see table, page 16)*.

The flight profile used in each case is based on international Federal Aviation Regulations (FAR) flight rules. This includes standard assumptions on: standard diversion plus holding fuel reserves; contingency fuel (based on a percentage of total trip time); a cruise speed of Mach 0.82; 220lbs per passenger; and using taxiing times of 15 minutes out and 10 minutes in. These taxi times and fuel used are included in 'block time' and 'block fuel' respectively. The taxi out is assumed to use 750lbs fuel, and the taxi in is assumed to use 500lbs fuel. In addition, 99lbs of fuel is burned during engine start-up.

LHR-LAX

In the LHR-LAX westerly direction, the aircraft encounter a 39-knot headwind component. This increases the tracked distance by 442nm to give an ESAD of 5,405-5,407nm *(see table, page 16)*. The aircraft maintain fairly uniform block times of 727-729 minutes on this route. The alternate is San Francisco.

These slight differences in ESADs and block times observed are due to differences in the climb profile between the -200s and the larger -300s. All variants have step climbs in their flight profiles. The -200s, however, have higher initial cruising altitudes.

On this route, the A340-200s burn less fuel than the longer -300s because of the lower actual take-off weight caused by the -200s' shorter fuselage and lower absolute airframe weight, which contribute to a smaller passenger count, and therefore a lower payload. However, even though the fuel burn in absolute terms is lower, the fuel burn per passenger is actually higher *(see table, page 16)*.

LAX-LHR

In the reverse direction, the aircraft are assisted by a 4-knot tailwind. This results in a reduced ESAD of 4,921-4,922nm, compared with the tracked distance of 4,963nm. All the aircraft maintain fairly similar block times to each other, but because of the wind strength and direction the flight times are reduced by almost one hour compared to the westerly sector. The alternate airport for LHR is London Gatwick (LGW).

LHR-SIN

For the LHR-SIN route, where there is an assisting tailwind component of 6 knots, the 5,879nm tracked distance flown compares with an ESAD of 5,806nm *(see table, page 17)*. Block times are 777-779 minutes in this direction. The slight differences in ESAD and block time observed *(see table, page 16)* are again due to differences in the step-climb profile between the -200s and the larger -300s. The alternate airport for SIN is Ho Chi Minh City (SGN).

SIN-LHR

On the SIN-LHR sector in a westerly direction, the aircraft are hindered by a large 35-knot headwind component. This results in an increased ESAD of 6,345-6,348nm, compared with the tracked distance of 5,879nm. All the aircraft maintain similar block times. The headwind results in varying flight times, however, and these can be up to 70 minutes longer than the outbound sector.

Aircraft fuel burns compared

There are two A340-200 models and four A340-300s variants compared *(see table, page 16)*. On the LHR-LAX and LAX-LHR round trip, all aircraft easily operate within their respective payload-range capabilities. That is, there are no restrictions on take-off weight, fuel capacity, or structural payload uplift.

The smaller -200's shorter fuselage means that its OEW is lower than the -300's by about 5%. The -200 also has lower airframe-induced drag. The A340-200s consequently burn less total fuel. This difference is about 7% for the LHR-LAX sector. However, because the -200s carry fewer passengers than the -300s, the block fuel burned per passenger by the -200s is higher than the -300s. The -200s burn 92 US Gallons (USG) per passenger compared to about 87 USG per passenger for the -300s. A similar pattern is observed for the other sectors *(see table, page 16)*.

In the easterly direction of LAX-LHR, all the aircraft burn proportionally less fuel *(see table, page 16)* for two main reasons. The first is because the ESAD is shorter due to a tailwind component, and second because less reserve fuel needs to be loaded due to the close proximity of the alternate airport (LGW).

Meanwhile, the effect of the much

FUEL BURN PERFORMANCE OF A340-200/-300

City-pair variant	Aircraft	Engine model	MTOW lbs	TOW lbs	Fuel burn USG	Block time mins	Passenger payload	ESAD nm	Fuel per seat	Wind speed
LHR-LAX	A340-211	CFM56-5C2	566,588	527,710	24,028	729	261	5,406	92	-39
LHR-LAX	A340-212	CFM56-5C3	566,588	527,710	24,028	729	261	5,407	92	-39
LHR-LAX	A340-311	CFM56-5C2	573,201	556,094	25,610	728	295	5,405	97	-39
LHR-LAX	A340-312	CFM56-5C3	573,201	555,193	25,409	727	295	5,406	86	-39
LHR-LAX	A340-313	CFM56-5C4	606,271	563,818	25,688	727	295	5,406	87	-39
LHR-LAX	A340-313	CFM56-5C4/P	609,578	562,511	25,509	727	295	5,406	86	-39
LAX-LHR	A340-211	CFM56-5C2	566,588	497,430	21,004	668	261	4,921	80	4
LAX-LHR	A340-212	CFM56-5C3	566,588	497,430	21,004	668	261	4,922	80	4
LAX-LHR	A340-311	CFM56-5C2	573,201	524,138	22,391	667	295	4,922	76	4
LAX-LHR	A340-312	CFM56-5C3	573,201	523,603	22,301	667	295	4,922	76	4
LAX-LHR	A340-313	CFM56-5C4	606,271	532,011	22,552	666	295	4,922	76	4
LAX-LHR	A340-313	CFM56-5C4/P	609,578	530,887	22,386	666	295	4,922	76	4
LHR-SIN	A340-211	CFM56-5C2	566,588	556,257	26,806	779	261	5,806	103	6
LHR-SIN	A340-212	CFM56-5C3	566,588	544,639	26,146	779	261	5,806	100	6
LHR-SIN	A340-311	CFM56-5C2	573,201	573,202	27,937	779	257	5,806	109	6
LHR-SIN	A340-312	CFM56-5C3	573,201	573,202	27,751	778	259	5,806	107	6
LHR-SIN	A340-313	CFM56-5C4	606,271	594,278	28,615	777	295	5,806	97	6
LHR-SIN	A340-313	CFM56-5C4/P	609,578	592,530	28,381	777	295	5,806	96	6
SIN-LHR	A340-211	CFM56-5C2	566,588	551,224	28,529	849	261	6,347	109	-35
SIN-LHR	A340-212	CFM56-5C3	566,588	538,534	27,767	849	261	6,348	106	-35
SIN-LHR	A340-311	CFM56-5C2	573,201	573,202	29,985	847	272	6,346	110	-35
SIN-LHR	A340-311	CFM56-5C3	573,201	573,202	29,786	846	277	6,346	108	-35
SIN-LHR	A340-312	CFM56-5C4	606,271	588,116	30,412	846	295	6,345	103	-35
SIN-LHR	A340-313	CFM56-5C4/P	609,578	586,590	30,192	845	295	6,345	102	-35

longer LHR-SIN/SIN-LHR route on the absolute trip fuel burns, and fuel burns per passenger can clearly be seen *(see table, this page)*.

Interestingly, the A340-311 and -312 are both the 573,202lbs MTOW certified version, so they reach their MTOW limits on this long-range mission, and have a reduced passenger payload. In these cases, the reduced passenger count results in a higher fuel burn per passenger *(see table, this page)* compared to the other aircraft. For example, on the LHR-LAX sector, the CFM56-5C2-powered A340-311 carries 257 passengers and has a block fuel burn per passenger of 109USG. The A340-313s, which are not payload restricted on the same route, have a lower block fuel burn per passenger of only 96-97USG.

There are small fuel burn variations across the four A340-300 variants. These are partly due to differences in actual take-off weight and take-off thrust powerplant turbomachinery between the CFM56-5C2, -5C3, 5C4, and -5C4/P.

Although the A340-311 and A340-312 both carry the same payload and also have the same airframe MTOW and OEW specification, they nevertheless have different engine thrusts: 31,200lbs for the CFM56-5C2-powered A340-311; and 32,500lbs for the CFM56-5C3-powered A340-312. The table shows that the A340-312 with its higher thrust actually burns less block fuel than the A340-311 which is identical in all respects, except for its lower engine thrust. According to Benoit Machefert, spokesperson for the long-range marketing team at Airbus, the main reason for this is that the more powerful -5C3 engines allow the A340-300 to climb to cruise altitude more efficiently than with the -5C2. A similar fuel burn situation is evident for the A340-211 compared to the A340-212, both of which have identical OEWs and payloads. Importantly, the A340-212 has the more powerful CFM56-5C3s which allow it to adopt a more efficient climb to cruise, thereby resulting in a lower overall fuel burn.

At the other extreme of model variants, the most capable A340-313 is powered by the /P engine. This improves on-wing life over the standard -5C4 by means of 3D-aero and single-crystal hot-section blades. Another feature of the /P engine is a small fuel burn improvement of up to 1%, and this probably reflects the observed 0.8-0.9% differences in the actual block fuel burn between the -5C4/P powered A340-313 and the standard -5C4-powered aircraft on both routes, and in both directions *(see table, this page)*. The aircraft also manages this fuel burn improvement, despite the fact that the CFM56-5C4/P-powered A340-313 has an OEW that is about 250lbs higher than that of the regular CFM56-5C4-powered A340. It is not surprising that the CFM56-5C4/P-powered A313 has the best fuel burn per passenger because the aircraft is not payload-restricted, its engines are the most fuel efficient, and the CFM56-5C4/P's high continuous thrust capability ensures the most rapid climb performance to optimum cruising altitude. AC

A340-300 maintenance analysis & budget

The A340-200/-300 are burdened by the four-engined configuration. This gives it high engine-related maintenance costs and high maintenance costs overall.

The A340-200/-300 are niche aircraft, having had limited success. There are only 241 in operation, the majority of which entered service from 1993 to 2000.

The A340-300 has a base check maintenance cycle of 10 years, and many aircraft have been through their first base cycle and are now in their second. Airlines and operators are likely to put the aircraft through two or three heavy checks, but they are unlikely to put them through a fourth heavy, which means that many A340-200s/-300s could remain in operation for more than 30 years.

A340-200/-300 in operation

The A340-200/-300 were launched in early 1987 as sister aircraft to the twin-engined A330. These two were aimed at the DC-10 and L-1011 replacement market, but they were more specifically targeted at the ultra-long-haul markets, such as the trans-Pacific, the liberalisation of which was being predicted at the time. However, liberalisation did not take place at the predicted rate, and the demand for the A340-200/-300 was weaker than forecast.

The A340-200/-300's other main attraction was as an alternative to the 747, which was too large for many carriers to operate it economically. The A340-200/-300 offer operators a more desirable combination of 230 to 280 seats and ultra-long-range capability. The A340-200's standard range of 8,000nm and the -300E's standard range of 7,300nm allow them to operate most city-pairs non-stop.

The A340-200/-300 were selected as the long-haul flagships for carriers such as Lan Chile, Air Mauritius, Air Lanka, Aerolineas Argentinas, Gulf Air, Air Portugal, Olympic Airways, SAS, Turkish Airlines, Air Macau and Air Jamaica. The aircraft are also a major long-haul choice for airlines including Air Canada, Cathay Pacific, Jet Airways, Qatar Airways, Virgin Atlantic, Air France, Lufthansa, Iberia, China Eastern and Air China.

A small number of aircraft have been traded and are now being used by secondary operators. Airlines that have disposed of aircraft include Singapore Airlines (SIA), Lufthansa, and Virgin Atlantic. Used aircraft have been acquired by airlines including Cathay Pacific and South African Airways (SAA).

The A340-200/-300 are used almost exclusively for ultra-long-haul services by all their operators, who also have multiple stop services on their networks. These reduce average flight cycle (FC) time. One example is Air Portugal, which operates a fleet of four aircraft on routes from its hub at Lisbon to Brazil and Africa. "Our aircraft have accumulated an average cycle time of 6.1 flight hours (FH) per flight cycle (FC)," says Mario Araujo, engineering director at TAP Maintenance & Engineering. "This average has increased to 8.0FH per FC since we reorganised our operation in 2006. Our aircraft are 12-13 years old and accumulate about 5,500FH and 680FC per year."

Iberia has a fleet of 16 -300s, ranging in age from five to 12 years old, which it operates to the Canary Islands, North and South America and South Africa. The fleet has an average FC time of 7.1FH, and accumulates about 5,000FH annually.

Swiss achieves one of the highest rates of utilisation, with 5,500-6,000FH per year at an average FC time of 8.5FH.

All A340-200/-300s are in operation as passenger aircraft, and their maintenance costs are analysed here for aircraft completing 5,000FH and 700FC per year, at an average FC time of 7.2FH.

Maintenance programme

The A340-200/-300 have a maintenance steering group 3 (MSG3) maintenance programme, which was developed in conjunction with their sister aircraft the A330.

The A340-200/-300's line and ramp maintenance programme consists of pre-flight, daily and weekly checks. The A340-300 is used by most carriers as a long-haul aircraft, so it consequently operates only two FCs per day. The aircraft therefore leave their homebase for an outstation and then make a return flight home. Most operators perform daily checks while the aircraft is at the homebase. These checks have a maximum interval of 48 elapsed hours. Pre-flight checks are performed at the outstation. Weekly checks have a maximum interval of eight days, so they are usually performed every sixth to seventh daily check, depending on the aircraft's pattern of operation.

A checks

In addition to pre-flight, daily and weekly checks, the A340-200/-300 have a system of A, C and structural checks, which are independent of each other. The A340-200/-300's maintenance programme has undergone 15 revisions since the aircraft was introduced into service in 1993, and the latest revision was made in 2006. The 16th revision is expected in July or August 2007. "The original maintenance programme had basic intervals of 400FH for A checks, 15 months for C checks, and five and 10 years for structural tasks," explains Jose-Luis Rosario, aircraft maintenance planning and production control manager at TAP Maintenance & Engineering. The two structural checks are sometimes referred to as the IL and D checks, or S1 and S2 checks.

There are four different multiples of A check tasks: the 1A, 2A, 4A and 8A tasks.

The original interval for the 1A tasks was 400FH under the original maintenance programme. The 2A tasks had an 800FH interval, so they were performed every second A check. The 4A tasks had a 1,600FH interval and were carried out every fourth A check, while the 8A tasks had a 3,200FH interval at the eighth A check. The A check tasks are therefore grouped according to their intervals into block checks as shown *(see table, page 20)*, with all tasks coming into phase and the cycle of A checks being completed at the A8 check.

The 1A interval was then escalated to 500FH in 1998. "The 1A interval was escalated again to 600FH at the 15th revision in 2006," says Pedro Saez Minguez, line maintenance & engineering vice president at Iberia Maintenance. "At the current interval of 600FH, the A1 check is performed at 600FH, the A2 check at 1,200FH, and the cycle finishes at the A8 check at 4,800FH."

Many operators of the A340-200/-300 now use 600FH as their basic interval for the A check. Lufthansa Technik, however, has managed to escalate its A check interval to 700FH. "A general escalation of the A check interval by Airbus to 800FH is expected

A340-200/-300 A & C CHECK TASK ORGANISATION

Check	Check task groups	Interval
Block A check system		
A1	1A	600FH
A2	1A +2A	1,200FH
A3	1A	1,800FH
A4	1A +2A +4A	2,400FH
A5	1A	3,000FH
A6	1A + 2A	3,600FH
A7	1A	4,200FH
A8	1A + 2A + 4A +8A	4,800FH
Equalised A check system		
A1-A8 checks	1A + 1/2 2A + 1/4 4A + 1/8 8A tasks	Every 600FH, cycle completing at 4,800FH
Block base check system *		
C1	1C	15 months
C2	1C + 2C	30 months
C3	1C	45 months
C4 + S1	1C + 2C + 4C+ S1	60 months
C5	1C	75 months
C6	1C + 2C	90 months
C7	1C	105 months
C8	1C + 2C +4C +8C + S2	120 months

*** C check intervals have recently been increased to 18 months and S1 check intervals to 72 months. The S2 check interval is expected to be increased to 144 months.**

in 2008 when the maintenance planning document (MPD) gets its annual revision," explains Minguez. "This would take the full A check cycle interval up to 6,400FH."

Some airlines, such as THY, choose to carry out their A checks as equalised checks. In this case the A check packages are similar in size, and each check includes the 1A tasks, about half the 2A items, one-quarter of the 4A items and one-eighth of the 8A tasks.

Base checks

There are four main groups of C check tasks: the 1C, 2C, 4C and 8C inspections. These have to be carried out in the respective multiples of the basic 1C interval, and all tasks come in phase at the C8 check. All four groups of inspections are performed at this check, making it the largest C check. The C8 check has an interval of 120 months, equal to 10 years. The second largest check is the C4 check, which has an interval of 60 months and comprises the 1C, 2C and 4C items *(see table, this page)*.

The two groups of structural inspection items are independent of the C check tasks, and initially had intervals of 60 and 120 months. These are known as the five- and 10-year or S1 and S2 inspections. They therefore conveniently coincide with the C4 and C8 checks, and combine to make two large checks: the IL and D checks *(see table, this page)*. Many operators also choose to carry out other large tasks such as major modifications, component changes and interior refurbishments at these checks.

The major revisions to the A340-200/-300's maintenance programme started in 1998. "A major revision took place in 2002, when the basic C check interval was escalated from 15 to 18 months," explains Rosario. "This raised the interval for the full cycle of eight checks to 144 months, which is equal to 12 years. This therefore put the C4 and C8 checks at 72 and 144 months, and also put them out of phase with the S1 and S2 checks at 60 and 120 months." These changes could have forced some operators to perform the C4 and C8 checks separately to the S1 and S2 checks, although doing this can increase the total downtime for maintenance, and incur a higher use of labour man hours (MH) for repeated access for heavy inspections.

The 15th revision in late 2006 was also an important one, which increased the interval for the smaller group of structural tasks, the S1 tasks, from five to six years. This therefore put the S1 tasks back into phase with the C4 check at 72 months, although some tasks have not been escalated and have remained with the five-year interval.

The interval for the larger group of structures tasks, the S2 tasks, was kept at 10 years, although it is generally expected that this will be increased to 12 years at some point. The current interval of 120 months for the S2 tasks means that it is out of phase with the C8 check, which now has an interval of 144 months. The consequence of this is that operators have to choose between performing the checks separately, or still combining them at an interval of 120 months and losing 24 months from the C8 check's maximum interval as a result.

The escalation of the S1 tasks from 60 to 72 months was relatively recent, however, so few aircraft will therefore have actually been able to take advantage of it. Airlines will so far have only been able to extend the timing of their combined C4 and S1 checks by up to 12 months. Moreover, there still remain about six years for Airbus Industrie to escalate the interval of the S2 tasks from 120 to 144 months. This will allow the S2 tasks to be combined with the C8 check so that they can both use their full intervals.

Turkish Technic follows a system of planning the C checks and structural checks separately. "Although the C checks are usually carried out separately from the structural checks, we will perform them together if: they come close to each other as a result of hangar slots; the airline operating schedule does not allow two different checks to be performed; or the two checks fall close together," says Ozcan. "In the case of one aircraft the C12 check, which is the C4 check in the second base maintenance cycle, will be performed in February 2008, while the S3 check is planned for November 2008. There is therefore a nine-month gap between the two. It will become more difficult to combine C and structural checks if the C check interval is extended to 20 months."

Line, ramp & A check inputs

Workscopes for pre-flight, daily and weekly checks for most operators include MPD tasks and interior checks. These interior items usually involve checking and rectifying the appearance of the cabin, making small repairs and repairing any defects to passenger seats.

Defects also occur during operation, and operators use line checks wherever possible to clear and rectify them. Rectifications will be made during the ground time if allowed, or if the defect is a no-go item. If the defect is large and can be deferred, the airline will rectify it at a larger check, such as a daily or weekly check, or an A check if one is due in a relatively short time.

In addition to MPD items, workscopes for pre-flight, daily and weekly checks also include interior checks and deferred items, hard-timed tasks, troubleshooting and component changes.

The A340-200/-300 has had several increases in its A check interval. It is currently 600FH, but could be increased to 800FH. The aircraft's lower checks are pre-flight, daily and weekly checks.

Total labour inputs for these checks are variable, due to variation between airlines' operations, patterns of utilisation and operating environment. Approximate inputs for pre-flight checks are an average of 2MH, and a budget of $50 should be allowed for materials and consumables. Using a generic labour rate of $70 per MH results in a total cost of about $200 for the check. The daily check can use an average of 12MH and an allowance of $200 should be made for materials and consumables, thereby taking the total cost for the check to about $1,000. The weekly check can use an average of 20MH and $500 in materials and consumables, thereby taking the total cost to about $1,900.

Under the utilisation pattern described, the aircraft will require about 350 pre-flight checks, 350 daily checks and 50 weekly checks per year. On this basis the line and ramp checks will incur a total annual cost in the region of $520,000, equal to $105 per FH *(see table, page 32)*.

Despite the differences in the routine tasks contained in the A checks, Rosario explains that these only have a small effect on the total number of MH used for the check. "The A check workpackage includes routine MPD inspections, non-routine rectifications, clearing deferred defects, component replacement, inspections driven by the operator's experience, and exterior and interior cleaning," says Rosario. "The total labour used for the whole workpackage averages about 630MH, only about 110MH of which is accounted for by routine MPD tasks. The check also uses about $25,000 of materials and consumables."

Similar inputs are recorded by Turkish Technic. "We use an average of 600MH for the whole A check, and have a corresponding cost of $35,000 for materials and consumables," says Ozcan.

A generic labour rate of $70 per MH for line and light maintenance would take the total cost for an A check to $65,000-75,000.

Given the escalated A check interval of 600FH, operators will probably be able to to perform A checks every 450-480FH once scheduling and operational constraints are taken into consideration. On this basis, the reserve for A checks will be $135-170 per FH *(see table, page 32)*.

Base check contents

Many operators take advantage of the extended downtime and access provided by base checks to perform additional tasks such as: modifications and upgrades; engineering orders (EOs); removing rotables for overhaul; engine changes; clearing deferred defects; exterior and interior cleaning and refurbishment; and stripping and repainting. The combined effect of these tasks is to create large workpackages which consume a large number of MH and materials.

Inspections

The arrangement of MPD tasks for the base checks is summarised *(see table, page 18)*. These tasks are covered by the current MPD revision. The revision made in late 2006 increased the S1 check interval to 72 months, so that it now coincides with the C4 check. The S2 check interval is likely to be extended from 120 months to 144 months over the next five to six years in time for most operators to combine it with the C8 check.

Check planning and workscope contents first have to consider probable interval utilisation. This cannot be 100% due to the constraints of aircraft operational requirements and appropriate hangar and facility availability. A typical interval utilisation rate of 85% means that C checks will be performed about every 15 months. The C8 check will therefore be performed every 120-122 months. This means that most operators will be able to combine the C8 check with the S2 check. The C4 check and S1 tasks will be performed in a check at about 61 months. If the S2 task interval is extended to 144 months, operators will have to strive to increase interval utilisation to 90-95% to take full advantage of the escalation. This would take the C8/S2 interval to 130-136 months.

"In addition to the MPD tasks, each operator also adds items unique to their own maintenance programme," explains Rosario. "These are items such as regular cabin cleaning and other interior work which increase the routine inspections. The C2 check in the second base check cycle, for example, requires about 940MH for routine inspections, and an additional 1,200MH for non-routine rectifications. This represents a non-routine ratio of 125-130%. The additional items that we have in our maintenance programme take the total MH for the routine tasks from 940 to 1,530. This is an increase of about 600MH.

"The IL check, which includes the C4 and five-year or S1 structural tasks, requires about 4,100MH when our additional items are added," continues Rosario. "The C8 check, together with the five-year/S1 and 10-year/S2 tasks, requires a total of about 6,750MH for routine labour once all our own items are added to the MPD tasks. This is split between 4,600MH for the C8 tasks and 2,150MH for the five- and 10-year tasks."

The aircraft's age and production number must also be taken into consideration. "There are large differences between the oldest and more

The A340-200/-300's base check system is a cycle of eight C checks. The fourth and eighth checks are combined with the S1 and S2 structural tasks to form two larger checks. The basic C check interval has been increased from 15 to 18 months, and the S1 interval to 72 months. The S2 interval is still at 120 months, but is likely to be increased to 144 months.

recently built aircraft in terms of routine requirements and findings," explains Fernando Velasco Agudo, A340 overhaul manager at Iberia Maintenance. "We have six aircraft that are line numbers 135 to 250, and we found about 200 major findings in the C8/D checks. These are reports from findings following inspections that require special attention. These findings have repairs developed for them which have to be approved by Airbus Industrie. Repetitive repairs get included in the structural repair manual, and sometimes Airbus will issue a service bulletin (SB) to prevent the cause of the problem. Younger aircraft will have had improvements incorporated on the production line, so they will benefit from having a lower level of findings and non-routine requirements that older aircraft have."

Engineering orders

The A340-200/-300 has had two major airworthiness directives (ADs). The first of these relates to the frame 40 modification. This was covered by AD 99-448-126 and is mandatory. "There are two compliance thresholds for the A340-300, depending on which configuration a particular aircraft falls into," explains Velasco. "Aircraft with configuration 1 have to comply before they accumulate 35,270FH or 6,170FC, while aircraft with configuration 2 have to comply before they reach 28,790FH or 5,260FC."

The compliance threshold for the A340-200 is 65,500FC and 42,000FH, whichever is reached first.

"Both labour MH and a kit are required to complete this modification," says Stan Pugh, senior sales executive at Gamco. "Aircraft with configuration 1 require about 700MH according to the AD, but this should be multiplied by a factor of about 3.5. The price of the kit is about $12,000. Aircraft with configuration 2 require about 400H, but again this should be multiplied by a factor of 3.5 The price of the kit is about $7,000."

This modification was incorporated into IL1 or D1 checks by most operators.

A second major modification addresses the problem of cracking caused by heavy loads at the sixth wing rib, where the main landing gear is attached to the wing structure. This modification is covered by AD CNF-2006-0098, which is mandatory and has to be complied with by 31st December 2010. The repair requires landing gear removal, and Velasco says it uses about 400MH to complete.

A third major modification on the A340-200/-300 is the engine pylon modification. This relates to AD 00-179-147, issued in 2000, and is a reinforcement plate installation on the engine pylons. This consumes about 750MH.

A future modification relates to engine thrust reversers. The outer fixed structure of the thrust reversers will have to be modified because of dis-bonding in the structure. The modification has to be completed before 11,600FC since new, which is equal to 15-20 years of operation. Eight reverser halves have to be modified, and a shipset has to be borrowed while the work is done. Pugh estimates that each thrust reverser half will require up to 300MH, so the full shipset of eight halves and the four reversers will use a total of 2,400MH, plus cost of materials.

Rotable components

Base checks will also involve the removal of a small number of rotable components that have hard times for repair and overhaul. The exact number of part numbers installed on each aircraft first depends on customer configuration, because it will be affected by the specification of interior equipment and the modification and upgrade status of its numerous systems.

Paul Graf, head of customer support and product management at SR Technics, estimates that there are about 2,100 serial numbers installed on the A340-300. The number of different rotable components installed on the aircraft can be as high as 2,600. These are accounted for by about 1,400 different part numbers, so there is an average of almost two parts for every different rotable part number installed on the aircraft. "The part numbers installed not only vary between operators, but also between different aircraft in the same fleet," explains Saron Faria, logistics material planning at TAP Maintenance & Engineering. "While the average number of different part numbers on an aircraft is 1,400, our fleet of four aircraft uses a total of about 1,700 different part numbers, which we have to stock in our inventory."

Graf estimates that about 400 of the rotable units installed on the aircraft are maintained on a hard-time basis. These are mainly safety- and emergency-related items that include escape slides, oxygen bottles and life rafts. There are a small number of system components, such as batteries, that also have hard-time maintenance programmes. These items will be removed during A or base checks. Their repair cycle time may allow the same items to be reinstalled on the same aircraft, while parts with repair cycle times longer than the downtime of the check will have to be exchanged with serviceable items.

The majority of rotables on the A340-300, about 80% or 2,000 of the units, are maintained on an on-condition basis. These will be removed during line maintenance and checks and replaced with serviceable items.

As well as hard-timed rotables, base checks will be used to change engines, landing gear seats, the auxiliary power unit (APU) and thrust reversers as

Besides routine tasks, most operators use base checks to perform major SBs and ADs, undertake refurbishment of the aircraft's interior, perform heavy component and engine changes, and strip and repaint the aircraft.

required. The landing gear overhaul interval is calendar-time and FC-related, while the APU and thrust reversers are maintained on an on-condition basis.

The relatively small number of hard-timed components means that the MH used for their removal and replacement are small in relation to other elements of the base checks.

Interior work

The use of the A340-300 as a long-haul aircraft means that the work on the aircraft's interior will be substantial. The five- to six-year intervals between heavy C and structural checks, their downtime of four or five weeks and the high level of deep access provide operators with the ideal opportunity to refurbish aircraft interiors. Airlines also periodically undertake interior redesigns for marketing reasons.

Iberia, for example, used the IL1 and D1 checks as opportunities to reconfigure its aircraft from a tri-class to a dual-class layout, and install a new business-class cabin with lie-flat seats and in-flight entertainment (IFE) system. These interior reconfigurations, however, use more MH and materials than a refurbishment of an existing interior.

Airlines use lighter C checks on the A340-200/-300 for interior cleaning and on-condition repair and refurbishment of interior items as required. Refurbishment of the interior during heavy checks will include the removal and refurbishment of seats, overhead bins and passenger service units (PSUs), bulkheads, ceiling and sidewall panels, toilets, galleys and carpets.

Other work

Operators have further items to add to the workscope of base checks, in addition to routine inspections and non-routine rectifications that arise as a consequence, EOs and modifications, interior cleaning and refurbishment, removal and reinstallation of rotable components and interior work. These extra items include repetitive inspections that are in addition to the C check task cards, such as: cleaning the fuselage exterior; engine changes; changes of other large rotables such as the landing gear or APU; clearing deferred defects; and performing out-of-phase (OOP) tasks. Repetitive inspections are inspections imposed by SBs and ADs, and other inspections that an operator's engineering department thinks will improve reliability. OOP tasks are items without intervals, which are multiples of the basic A or C inspections.

Examples of the labour used for component changes are 100MH for an engine, 500MH for a landing gear shipset, and 20MH for the APU.

Up to another 100MH can be used for OOP tasks, and 20MH for clearing defects.

Base check inputs

As described, there are several elements to the base checks. There are six light base checks with just C check inspections, and the two heavier checks. Operators have some flexibility in organising their base checks. One option is to have relatively large C checks with a large number of inspections. This results in medium-sized heavy checks. An alternative is to have relatively light C checks, with many inspections performed in the two heavy checks, thereby increasing their content.

The option of relatively large checks and medium-sized checks is considered first.

C checks

The lighter checks are the C1, C2, C3, C5, C6 and C7 checks *(see table, page 18)*. Four of these appear on 1C tasks cards, while the C2 and C6 checks include the 1C and 2C inspections. "The difference in MH required for routine inspections and maintenance programme items between checks with just 1C and those with 1C and 2C inspections is small, and only equal to about 200MH," explains Rosario. "MPD items in a C2 or C6 check for an aircraft in its second base check cycle require about 940MH. About another 600MH are required for our own additional items, taking the total to 1,530MH for routine work for the maintenance programme part of the check. This compares to 1,300MH for C1, C3, C5 and C7 checks, which have just the 1C tasks.

"The maintenance programme portion of 1,300-1,530MH generates another 1,000-1,200MH for non-routine rectifications. This is a non-routine ratio of about 80%," continues Rosario. "EOs, SBs and modifications consume an average of 840MH for this type of check, while changing hard-timed rotable components uses about 100MH. The three elements of routine inspections, EOs and component changes total 2,100-

The total cost for engine-related maintenance is about $210 per EFH. This cost is comprised of the three elements of shop visit costs, LLP reserves, and reserves for the QEC. The total cost per FH for all four engines is relatively high compared to the larger 747-400.

2,500MH. Non-routine work adds a further 4,500MH, including some cabin cosmetic items, while other items add 1,350MH. This takes the total for a C2 check to the region of 8,300MH." This total is similar for the C6 check. Totals for the C1, C3, C5 and C7 checks will be about 7,800MH for aircraft in their second base check cycle.

The larger C2 and C6 checks will use about $345,000 of materials and consumables. The maintenance programme portion of the check uses about $39,000 of materials and consumables, which is just 22% of the total. Another $210,000 are required for the non-routine portion of the check. About $40,000 of materials and consumables are used for EOs, and the balance of $55,000 is for the other items of the check. Smaller C1, C3, C5 and C7 checks will use $300,000 in materials and consumables.

Heavy checks

Rosario estimates that the C4/five-year checks use about 4,100MH for the routine maintenance programme items of the MPD inspections and the airline's additional routine work. "EOs, SBs and modifications use about 3,600MH for this check. This was used for a total of 91 modifications performed on the aircraft, the large majority of them being retrofits, since we operate aircraft between serial numbers 41 and 91."

Component changes require a further 120MH, and the sub-total for these three elements reaches 7,900MH.

The MH for non-routine rectifications that arise out of these three elements total about 5,000MH, which is equal to a non-routine ratio of 65%. This gives a sub-total of 13,000MH.

The refurbishment of the interior at this check consumes in the region of 2,500MH, with the same process consuming more MH in the larger C8/10-year (D) check. A further 750MH are used for other items, taking the total for the check to 16,000MH for an aircraft's first C4/five-year check (IL1). This could reach 20,000MH for the second check, which is the IL2 check.

The cost of materials and consumables for the IL1 check will approach $400,000. The maintenance programme portion of the check will use about $35,000. A further $41,000 will be required for EOs and $20,000 for other items. The largest portion of $304,000, however, is used for non-routine rectifications and interior refurbishment.

The first heavy C8/10-year check that the aircraft undergoes will consume in the region of 26,000MH. The maintenance programme portion of the check uses about 6,800MH, with 4,600MH coming from the C8 element of the check and 2,200MH coming from the 10-year structural inspections. The corresponding cost of materials and consumables for this part of the check is $122,000.

EOs account for another large portion, using up to 5,300MH. This check included three major modifications. The first of these was the cockpit door installation, which used about 700MH. The second was the installation of lie-flat seats, which used about 500MH. The third was the engine pylon modification, covered by AD 00-179-147, which used about 750MH. These three modifications therefore used 1,950MH and $260,000 of materials and consumables. This amount only covered the cost of the modification kits, however, not the lie-flat seats.

Component changes use about 130MH and $800 of materials and consumables. Non-routine items use 9,400MH and the large interior refurbishment at this check uses about 3,500MH. The corresponding cost of materials and consumables for the non-routines and interior refurbishment is in the region of $400,000.

Other items added about 1,250MH and $107,000 in materials and consumables.

The total for the check will be 26,000-27,000MH, with about 1,950MH of this being accounted for by the installation of the cockpit door, new lie-flat seats and the pylon modifications. The total cost of materials and consumables for the check is $875,000.

The total MH used for the six C checks in the base check cycle will therefore be 46,000-48,000. Each check uses $300,000-350,000 of materials and consumables, so the six checks in the cycle will use a total of $1.7-1.9 million.

The two heavy checks will use 42,000-44,000MH and $1.2-1.3 million in consumables and materials, including items for interior refurbishment.

The eight checks in the cycle will therefore consume a total of 88,000-92,000MH and $3.1-3.3 million in materials and consumables. A standard labour rate of $50 per MH would take the total cost for the eight checks in the cycle to $7.6-7.8 million. On the basis that the base check cycle is completed every 120-122 months, this cost will be amortised over an interval of about 50,000FH. The reserve for base maintenance will therefore be $150-155 per FH *(see table, page 32)*.

Light C & heavy IL/D checks

The option of relatively light C checks and heavier C4/five-year and C8/10-year checks will have a similar consumption of labour, materials and consumables over the base check cycle.

Lufthansa operates a system of relatively light C checks for its fleet of 28 A340-300s, which were delivered from 1993 to 2001. The aircraft are now mature in maintenance terms, with most having gone through their IL1 and D1 checks, and the first coming due for their IL2 checks in the winter of 2011.

Lufthansa first operated a smaller fleet of A340-200s, which have since been sold to SAA. "The -200 fleet had a lot of inspections implemented via EOs (modifications). These were introduced into the -300's maintenance programme, as additions to the -200's maintenance programme. Many of these items are related to structural tasks," explains Andreas Drosdowski, leader of maintenance planning services at Lufthansa Technik. "The MH used for routine inspections and EOs in the base checks are about equal for the -200 and -300, but the -200 has a relatively high number of MH for EOs, while the -300 has a higher number for routine inspections.

"Another additional large modification required on the A340-200 and -300 was the frame 40 modification. This concerns the structure in the wing-to-fuselage joining area, where cracks required a large modification and insertion of a new piece of structure," continues Drosdowski. "This was covered by a mandatory AD, which had to be completed by 2003. "This heavy modification was included in the IL1 or D1 checks of aircraft, depending on their age. It required the aircraft to be raised on jacks, a process that was sensitive to weight changes on the aircraft. This modification used a large number of MH in addition to the other elements of the base checks."

A340-200/-300 HEAVY COMPONENT MAINTENANCE COSTS

Number of main & nose wheels	10 + 2
Tyre retread interval-FC	270/220
Tyre retread cost-$	600/450
Number of retreads	4
New main & nose tyres-$	1,200/1,000
$/FC retread & replace tyres	**32**
Wheel inspection interval-FC	270/220
Main & nose wheel inspection cost-$	1,000
$/FC wheel inspection	**45**
Number of brakes	10
Brake repair interval-FC	2,000
Brake repair cost-$	40,000
$/FC brake repair cost	**200**
Landing gear interval-FC	7,000
Landing gear exchange & repair fee-$	1,200,000
$/FC landing gear overhaul	**171**
Thrust reverser repair interval-FC	6,000
Exchange & repair fee-$/unit	215,000
$/FC thrust reverser overhaul	**143**
APU hours shop visit interval	3,500
APU hours per aircraft FC	2.6
APU shop visit cost-$	200,000
$/FC APU shop visit	**149**
Total-$/FC	**740**
Total-$/FH passenger aircraft @ 7.2FH per FC	**102**

C checks

Drosdowski explains that the routine inspections of the lighter C checks use about 1,500MH. "The non-routine ratio for long-haul aircraft is generally 1:1, so another 1,500MH will be used for non-routine rectifications in these checks," explains Drosdowski. "A few modifications that are covered by SBs or small ADs will add some MH, and while this is unpredictable and variable, 500-1,000MH can be expected to be required. Other items, like light interior refurbishment or cleaning, will take the total to 4,000-4,500MH. A further 500MH can be added for exterior cleaning, which we do about every base check interval. This can therefore result in about 5,000MH for light C checks for a mature aircraft in its second base check maintenance cycle. The associated cost of materials and consumables is $80,000."

Heavy checks

"The first C4/five-year or IL check (IL1 check) had a downtime of about 23 days," says Drosdowski. "Excluding painting, this check under our programme used 12,000-13,000MH for routine inspections and a similar number of MH for non-routine rectifications, taking the sub-total for the check to 25,000-27,000MH. About 400MH of the routine inspections were used for cabin work and 2,500-3,000MH of the non-routine rectifications were used for cabin refurbishment. Another 2,500MH are required for SBs and smaller ADs. More labour can be required for component changes. Changing a shipset of engines can use about 800MH, while changing the landing gear will use 600MH. Engine changes are likely to be made over several checks, while the landing gear will be changed every 10 years or so, and will therefore probably done at the D check. An allowance for some engine changes and other heavy components will take the total for the check to 28,000-30,000MH. The associated cost of materials and consumables will be about $800,000. This does not include large modifications, like the frame 40 AD. We expect that the IL2 check will be heavier, because there will be more routine inspections and the non-routine ratio will increase with age."

The first D checks were about 30% larger in total than the IL1 checks. "The routine inspections for the D1 check used about 16,500MH, and a similar number of MH were required for non-routine rectifications," says Drosdowski. "Like the IL1 check, this sub-total of about 33,000MH includes 3,000-3,500MH for cabin inspections and refurbishment. We refurbish the interior about every six years. Component changes will require another 1,000-1,500MH, while EOs will use another 2,500MH. This will take the total up to about 36,000MH, but stripping and repainting will take the overall total for the check close to 40,000MH. The associated cost of materials and consumables will be $1.0-1.1 million. The downtime for this size of check was about 36 days."

This takes the total consumption for the eight checks in the cycle to about 100,000MH and $2.6-2.8 million in materials and consumables. A standard labour rate would take this to a total cost of $7.6-7.8 million. Amortised over the interval of about 50,000FH, this would be equal to a reserve of $150-155 per FH *(see table, page 32)*.

Heavy components

Heavy components comprise four categories: the landing gear; wheels and brakes; thrust reversers; and the APU.

The A340's landing gears comprise the following: four landing gear legs with two main outboard landing gears, each supporting four wheels; a centre main landing gear that supports two wheels; and a nose landing gear that also supports two wheels. The 10 wheels on the main gears have carbon brakes.

The landing gear overhaul interval is a calendar time of 10 years or 20,000FC; whichever is reached first. The landing gear is therefore likely to be removed at the D check. Most operators use exchange programmes with specialist landing gear overhaul shops. These charge exchange and overhaul fees, with an average of $1.2 million for the A340-200/-300. Over a 10-year interval equal to about 7,000FC, this gives a reserve of $171 per FC *(see table, page 27)*, or $23 per FH at the stated FC time.

The thickness of brake units is monitored during operation, and these are removed for repair and overhaul. Average repair intervals are 2,000FC and the repair cost for a single unit is in the region of $40,000. Reserves for the shipset of 10 brakes are $200 per FC *(see table, page 27)*, equal to $28 per FH.

Wheels are removed when tyre treads are worn. Tyres are remoulded up to four times and then replaced at the fifth removal. Wheels are inspected at removal. Taking typical tyre remould and replacement costs, the overall cost for the complete shipset of 12 tyres is $32 per FC *(see table, page 27)*, equal to $5 per FH.

Reserves for inspecting and repairing the full shipset of wheels are about $45 per FC *(see table, page 27)*, equal to $6 per FH.

The A340-200-300 are equipped with the GTCP 331-350 APU. Martin Matthews, engineer at Total Engine Support, explains that the first removal interval has increased from about 1,600 APU hours when the aircraft entered service in the 1990s. Reliability has improved and mature intervals are about 3,500 APU hours. This is equal to 1,300 aircraft FC. The average shop visit cost is about $200,000, which equals a reserve of $150 per FC *(see table, page 27)*, or $21 per FH .

Thrust reverser removals are on-condition, and average 6,000FC. Shop visit costs also vary with condition and findings at removal, but average $215,000 per reverser. The reserve for each unit is thus $36 per FC, equal to $144 per FC for the shipset of four *(see table, page 27)*.

Overall, the reserves for these four groups of components are equal to a cost of $740 per FC. This is equal to $102 per FH at the FC time of 7.2FH.

Rotable components

As described, the A340-200 and -300 have 1,100-1,400 rotable part numbers, and up to 2,000-2,600 different rotable components installed on the aircraft, depending on configuration.

A minority of up to only 400 rotable components are maintained on a hard-time basis. The remainder are maintained on an on-condition or condition-monitored basis.

Operators can use a number of specialist providers to provide them with turn-key rotable support packages. Rotable support package providers for the A340-200 and -300 include AJ Walter, Avtrade, SAS Component and Lufthansa Technik.

Once failed or hard-time parts are removed from the aircraft by the operator, the rotable support provider handles all transport, testing, repairing, documentation and return of serviceable parts to the inventory. The provider also maintains an inventory of rotables at a pre-agreed level of availability. A core of parts is provided to the operator through a lease agreement. The remaining parts are available from the support provider's inventory pool, and access is paid for by a power-by-the-hour (PBH) rate. The operator pays a third PBH rate to the support provider for the repair and management of the logistics process.

Actual costs depend on fleet size, location of homebase, route network and position of outstations, and style of operation. Simon Clements, director of business development manager at AJ Walter says that a fleet of 10 A340-300s operating at about 5,000FH per year would require homebase stock of inventory with a value of about $5 million. The monthly lease for this stock would be about $60,000, and would be shared between the 10 aircraft. This would be equal to about $15 per FH.

"PBH rates for the access pool fee will be about $77 per FH," says Clements. "The third element of the PBH repair and management fee would be about $170 per FH."

The total of the three elements would therefore be about $262 per FH *(see table, page 32)*.

Engine maintenance

The A340-200 and -300 are powered exclusively by the CFM56-5C series. This engine is the highest rated of the CFM56 family. The -5C was developed from the -5B series, which has a highest rating of 32,000lbs thrust.

There are three main variants of the -5C series: the -5C2 rated at 31,200lbs thrust; the -5C3 rated at 32,500lbs thrust; and the -5C4 rated at 34,000lbs thrust.

The basic -5C2 variant has a redline exhaust gas temperature (EGT) limit of 950°C, the basic -5C3 a red line temperature of 965°C, and the basic -5C4 variant a redline temperature of 975°C.

There are several sub-variants of each each variant. These different sub-variants are a result of several modification and upgrade programmes that have been introduced since the engine entered service.

The -5C series has generally suffered from a high rate of EGT margin erosion since entering service, mainly because the CFM56 has been developed to the limit of its thrust capability.

The first series of upgrades was applied to the -5C2 and -5C3 engines to bring their redline temperatures up to 965°C and 975°C. The /F suffix on the variant's name denotes the upgrade to an EGT limit of 965°C, while the /G suffix denotes the upgrade to an EGT limit of 975°C *(see A340 modification programmes, page 13).*

Engines were later built to the standard of the -5C4, therefore giving them the potential to operate at 34,000lbs thrust. This is denoted by a /4 suffix. The -5C2/G4 and -5C3/G4 are therefore the -5C4 de-rated to 31,200lbs thrust and 32,500lbs thrust, where the operator does not require 34,000lbs thrust.

CFMI also introduced an upgrade programme, whereby the /P suffix denotes that the engine has been upgraded with the 3-D aerodynamic configuration. This modification reduces EGT and increases EGT margin by about 13°C and reduces specific fuel consumption by about 1% *(see A340 modification programmes, page 13).* All engines with the /P modification have a redline limit of 975°C, and the increase in EGT margin can increase time on wing by 2,000-3,000 engine flight hours (EFH).

CFM56-5C in operation

As described, the A340-200 and -300 are generally used as long-haul aircraft. This analysis uses an average FC time of 7.2FH. FC times of this length generally mean that removal intervals are more related to EFH time on wing and to mechanical deterioration, rather than EFC time on wing and performance loss. The CFM56-5C is an exception, however, with rapid performance loss being a problem for most operators. This explains the various modification programmes that have been introduced.

"There have been two major ADs for the engine," says Gurkan Darende, chief engine shop engineer at Turkish Technic. "The -5C has only a small EGT margin recovery following a shop visit, and the EGT margin retention is also poor. This is a major problem with the engine. The average EGT margin of new -5C4 engines was 62°C, with a standard deviation of 9°C. This new EGT margin did increase, however, as the manufacturing of the engine progressed. The last engines built had an average EGT margin of about 87°C, although there was a large variation.

"The average EGT margin for -5C4s following a shop visit is 36.5°C," continues Darende.

Matthews explains that the EGT margins of the later-produced new engines are: 90°C for the lowest rated -5C2; and 80°C for the -5C3. "The restored EGT margin of engines following a shop visit up to about 2001 was typically about 60% of new engines," explains Matthews. "From 2002 CFMI aimed to increase this to about 70% with various modification and improvement programmes."

This will result in post-shop-visit EGT margins of 55-63°C for -5C2 engines, 48-55°C for -5C3 engines and 36-42°C for -5C4 engines. Later built engines should have slightly higher margins, however.

The significance of EGT margin is greater for engines operating in hot environments. Many A340 operators are European and experience temperate climates, while some operate in higher temperatures.

All variants have a corner point temperature of 30°C, so they will experience a reduction in EGT margin for operating temperatures higher than this. Engines may have to be removed before all EGT margin at standard temperature is eroded, due to a lack of EGT margin at higher operating temperatures.

Matthews estimates that the initial rate of EGT margin loss following a shop visit is about 14°C in the first 2,000EFH. This then settles to a rate of 2-3°C per 1,000EFH. This would allow intervals of up to 18,000EFH for -5C2 engines, 15,000-16,000EFH for -5C3s, and 11,000-12,000EFH for -5C4 engines. "Mature rates of EGT margin loss can be higher, however, for airlines operating in hotter climates, or those not using water washing to recover some lost EGT margin," comments Matthews.

The main removal cause for the -5C is EGT margin loss, with about 70% of engines removed for this reason. The majority of other removal causes relate to mechanical deterioration. These include high pressure turbine (HPT) and high pressure compressor (HPC) blade distress, and HPC rotor-to-stator contact.

"We find that most engines are being removed due to performance and EGT margin loss, but a large number of engines are also being removed due to number four bearing failure," says Darende. "The feature of long-haul operations is that most engines only accumulate about 700EFC per year. This compares with life limits of 15,000EFC and 20,000EFC for most life limited parts (LLPs). This means that most of the oldest engines delivered in 1993 will have accumulated up to about 10,000EFC so far, so LLP expiry is not yet forcing many removals."

Shop visit activity

Most engines are now mature, although a minority are still on their first removal interval. "The first removal intervals naturally depended on the initial EGT margin, the style of operation and the operating environment, but these were 15,000-25,000EFH," says Matthews. This is equal to three to six years of operation.

"The -5C2 was not a good engine, and experienced rapid EGT margin loss. Many of these engines had modifications made at their first removal," adds Darende. "Some of the-5C2s were forced off wing early, so their intervals were not representative of what the engine was capable of. The first removals for the -5C4 were up to about 30,000EFH, however. The /P modification increases on-wing time, but we find it too expensive.

"We are experiencing mature removal intervals of 11,000-13,000EFH with our -5C4 engines, which is about what would be expected with the EGT margin," continues Darende. Matthews adds that second-run engines can expect to have intervals of 14,000-17,000EFH, depending on several factors.

The -5C has few SBs or ADs that influence removal intervals. "There is an SB (72-427) which involves the borescope inspection of the HPC stage 3 and 2 rotor-to-stator contact for high-time engines that have exceeded 24,000EFH since the replacement of variable stator vane bushings," says Matthews. "The engine requires repeat inspections every 1,600EFH, and has to be removed if the 'J' hooks have worn away. SB 72-431 also requires borescope inspections every 3,000EFH or 500EFC for HPT trailing edge cracking."

In addition to having poor performance and EGT margin retention, the CFM56-5C also requires relatively high maintenance inputs. "The engine requires a performance restoration and a minimum workscope on the low pressure turbine (LPT) and low pressure compressor (LPC) modules every shop visit. The workscope on the LPT and LPC can escalate, however," says Matthews.

Darende comments that, in addition to a core performance restoration, the LPT usually requires some work every

DIRECT MAINTENANCE COSTS FOR PASSENGER-CONFIGURED A340-200/-300

Maintenance Item	Cycle cost $	Cycle interval	Cost per FC-$	Cost per FH-$
Line & ramp checks	520,000	5,000FH		105
A check	65,000-75,000	450-480		135-170
Base checks	7.6-7.8 million	50,000		150-155
Heavy components:			740	102
LRU component support				262
Total airframe & component maintenance				**754-794**
Engine maintenance:				
4 X CFM56-5C: 4 X $210 per EFH				840
Total direct maintenance costs:				**1,594-1,634**

Annual utilisation:
5,000FH
700FC
FH:FC ratio of 7.2:1

shop visit. "The core and LPT need improving, and every shop visit some of the HPC blades and vanes and the interstage seals need replacing, making it an expensive module on the engine," says Darende. "The LPT usually requires a full workscope every second shop visit, while the fan and LPC module can last four or five shop visits."

The inputs for a performance restoration are 2,500-3,000MH in labour, $1.1-1.3 million in materials, and $150,000-250,000 in sub-contract repairs. At a labour rate of $70 per MH, this equals a total cost of $1.4-1.75 million.

Workscopes on the LPT will be $500,000-575,000, and $130,000-150,000 for the fan and booster module.

A full overhaul will use 3,500-4,000MH in labour, $1.6-2.0 million in materials and consumables, and $250,000-350,000 in sub-contract repairs, taking the total to $2.1-2.6 million.

The pattern of three workscopes would therefore result in shop visits with costs averaging $1.9 million, $2.1 million and $2.4 million for a mature engine. The total cost of $6.4 million amortised over an interval of 36,000EFH for the three removals would equal a reserve in the region of $178 per EFH.

Life limited parts

The -5C series has 19 LLPs. The majority of parts have lives of 15,000EFC or 20,000EFC. There are several part numbers for many of the LLPs, and life limits are also determined by engine variant and sub-variant.

The fan disk and booster spool have lives of 20,000EFC and list prices totalling $323,000. The fan shaft has a life of 11,000-18,200EFC and has a list price of $95,000.

The HPC module has five parts. There are 10 different part numbers, which have life limits of 15,000EFC or 20,000EFC. The module has a list price of $67,000. The Stage 1-2 spool has a life limit of 15,000EFC in most cases, and 20,000EFC in a few. Its list price is $95,800. The Stage 3 disk also has lives of 15,000EFC or 20,000EFC in most cases, and a list price of $30,000. The stage 4-9 spool has a life of 15,000EFC and a price of $214,000, while the compressor rear air seal is priced at $41,000. The combined list price of these five parts is $448,000.

The HPT has four LLPs. These have the most limited lives, which vary from 10,000EFC to 15,000EFC in most cases. Some parts have more limited lives, however. The combined list price of these four LLPs is $473,000.

The LPT has seven or eight parts, depending on engine configuration, with most lives at 20,000EFC. The LPT case is an additional LLP in engines with the /P modification. The stage 4 disk is limited to 15,800EFC in some cases. The combined list price of the seven parts is $593,000. The LPT case has a list price of $151,000.

Reserves for LLP replacement will depend on the stub life that can be left at replacement. Given the typical removal intervals of 11,000-15,000EFC, remaining stub lives are likely to be up to 2,000EFC. This would put reserves at $78 per EFC for parts with lives of 15,000EFC and a further $51 per EFC for parts with lives of 20,000EFC, thereby taking the total to about $129 per EFC. An additional $9 per EFC would be added for /P engines with the LPT case.

This is equal to a cost of $18 per EFH for an engine operating at 7.2EFH per EFC, and about $19 per EFH for a /P engine.

The third element comprises reserves for the quick engine change (QEC) kit, which is $10-12 per EFH. This takes total reserves to $210 per EFH, and $825-840 per FH for all four engines *(see table, this page)*.

Maintenance cost summary

Total maintenance costs are $1,594-1,634 per FH *(see table, this page)*. This is high in relation to the 747-400. That is, the average seat count for the A340-300 is about 245 compared to about 360 for the 747-400. The 747-400's total maintenance costs are $1,780-1,800 per FH *(see 747-400 maintenance analysis & budget, Aircraft Commerce, April/May 2007, page 14)*. This gives the A340-300 a relatively high maintenance cost per seat.

The main contributors to the A340-300's relatively high maintenance costs are its engine reserves. These are $210 per EFH, and $840 per FH in total, which are comparable to the 747-400's engine reserves. The A340-300 compares poorly with the 777-200ER on this point, because the latter has engine reserves of $280-300 per EFH, or $560-600 per FH.

The A340-300, however, has competitive base maintenance reserves compared with the 747-400, which has base maintenance reserves of $200-220 per FH. The A340-300's reserves for heavy components are also comparable on the basis of its size.

The A340-300's costs related to its line replaceable units (LRU) are, however, similar to the 747-400's. This is not surprising, given that there is little difference in the capital costs of LRU units.

Engine reserves are mature, and LLPs still have several years before expiry. Reserves for A and base checks are the two elements likely to experience any significant increase in maintenance costs as the aircraft ages. The A340-200/-300 are still in high demand, given the current general shortage of widebodies. The aircraft still offer acceptable operating costs, although they will be overshadowed by the 787 and A350 as these enter service and then operate in larger numbers. AC

A340-200/-300 technical support providers

The A340-200/-300 operates in limited numbers. This survey highlights the capabilities and services the major technical support providers.

The A340-200/-300 are clearly niche aircraft, with just 240 in service. This limits the potential third-party technical support market. The fleet is spread over a wide operator base, with 37 different airlines across the world. The average fleet therefore comprises just six aircraft. There are only another 12 aircraft on order. Most operators are European, with Air France, Iberia and Lufthansa having the largest fleets. The next largest fleet is in the Middle East and Africa, with 11 operators. All have medium-sized fleets.

This survey summarises the major aftermarket and technical support service providers for the A340-200/-300 family. It is grouped into seven sections covering the categories of technical support offered by each of the providers: engineering management and technical support *(see table, page 33)*; line and light maintenance *(see first table, page 34)*; base maintenance *(see second table, page 34)*; engine maintenance *(see first table, page 36)*; spare engine support *(see second table, page 36)*; rotables & logistics support *(see first table, page 37)*; and heavy component maintenance and support *(see second table, page 37)*.

In some cases, companies are listed in most or all of the seven sections, and such organisations can loosely be referred to as one-stop-shop service providers for the A340-200/-300 family. This means that they provide most, if not all, the technical services that a third-party customer would require. These services include: maintenance and engine management; line and light maintenance; base and heavy airframe checks; interior refurbishment; stripping and repainting, engine maintenance management and engine shop visits; repair and overhaul of major components; and rotable inventory supply and management services. In addition to this, spare engine leasing support services are also provided.

The providers that offer a complete range of services for the A340-200/-300 are Air France Industries, Iberia Maintenance and Lufthansa Technik. This is hardly surprising given the the scale of their maintenance capabilities and the size of their fleets.

The ability to provide one-stop services is rare, given the degree of specialisation of technical support and maintenance providers. Besides the major elements of line and base maintenance, and engineering management, most other technical support activities are specialised and are offered by few providers. These specialised activities include: interior refurbishment; stripping and painting; engine health monitoring; maintenance and maintenance management; auxiliary power unit (APU) shop visits and testing; landing gear overhaul and exchanges; and complete rotable logistics and support services.

SR Technics and TAP Maintenance & Engineering provide virtually all the technical services of a one-stop shop for the A340-200/-300. The only services that they do not provide are the specialised activities of landing gear overhauls and exchanges.

European providers

As described, Europe's largest operators are Air France, Iberia and Lufthansa. These three airlines have third-party maintenance support partners that offer the most comprehensive levels of support for A340-200/-300 operators. Lufthansa Technik not only offers all services for the aircraft, but its network of services and facilities is well known. Besides its facilities in Germany, examples

A340-200/-300 ENGINEERING MANAGEMENT & TECHNICAL SUPPORT

	Outsourced engineering service	Maint records service	DOC & manuals manage	Maint prog manage	Reliability stats	AD/SB orders manage	Check planning	Config & IPC manage	Total tech support
Air Canada Technical Services Technical Services (ACTS)	Yes	~	Yes	~	~	~	~	~	~
Air France Industries	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Airbus	~	~	Yes	~	Yes	~	~	Yes	~
GAMCO	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Iberia Maintenance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik Philippines	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Messier Services	Yes	Yes	Yes	Yes	Yes	~	Yes	~	Yes
SAA Technical	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sabena Technics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SIA Engineering Company	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SAS Component	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SAS Technical Services	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SR Technics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TAP M&E	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Triumph Group	~	~	~	~	Yes (APUs)	Yes	~	~	~

A340-200/-300 LINE & LIGHT MAINTENANCE SUPPORT

	Maint operations control	AOG support	Line checks	A checks	Engine QEC changes	Engine changes	Landing gear changes	APU changes	Thrust reverser changes
Air Canada Technical Services (ACTS)	~	Yes	~	Yes	~	Yes	Yes	Yes	Yes
Air France Industries	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Airbus	~	Yes	~	~	~	~	Yes	Yes	Yes
Ameco Beijing	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AVTRADE	~	Yes	~	~	~	~	~	~	~
GA Telesis	~	Yes	~	~	Yes	Yes	~	~	~
GAMCO	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Iberia Maintenance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interturbine Logistik	~	Yes	~	~	~	~	~	~	~
Lufthansa Technik	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik Philippines	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Messier Services	Yes	Yes	~	~	~	~	Yes	Yes	~
SAA Technical	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sabena Technics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SAS Technical Services	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SIA Engineering Company	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Snecma Services	~	~	~	~	Yes	Yes	~	~	~
SR Technics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TAP M&E	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Triumph Group	~	Yes (APUs)	~	~	~	~	~	~	~
Turkish Technic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

A340-200/-300 BASE MAINTENANCE SUPPORT

	C checks	IL/ 5-year checks	D/ 10-year checks	Interior refurb	Strip & paint
Air Canada Technical Services (ACTS)	Yes	Yes	Yes	Yes	Yes
Air France Industries	Yes	Yes	Yes	Yes	Yes
Air Mauritius	Yes	Yes	Yes	Yes	Yes
Ameco Beijing	Yes	Yes	Yes	Yes	Yes
GAMCO	Yes	Yes	Yes	Yes	Yes
Iberia Maintenance	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik Philippines	Yes	Yes	Yes	Yes	Yes
SAA Technical	Yes	Yes	Yes	Yes	Yes
Sabena Technics	Yes	Yes	Yes	Yes (104)	Yes
SAS Technical Services	Yes	Yes	Yes	Yes	Yes
Shanghai Technologies (STARCO)	Yes	Yes	Yes	Yes	Yes
SIA Engineering Company	Yes	Yes	Yes	Yes	Yes
SR Technics	Yes	Yes	Yes	Yes	Yes
ST Aviation Services (SASCO)	Yes	Yes	Yes	Yes	Yes
ST Mobile (MAE)	Yes	Yes	Yes	Yes	Yes
TAP M&E	Yes	Yes	Yes	Yes	Yes
Triumph Group	~	~	~	backshops	n/s
Turkish Technic	Yes	Yes	Yes	Yes	Yes

of Lufthansa Technik's facilities are Lufthansa Technik Philippines (LTP) in the Asia Pacific, and Ameco Beijing, which is its joint venture with Air China.

Other major technical support providers in Europe include Sabena Technics, TAP Maintenance & Engineering, SR Technics, SAS Technical Services and Turkish Technic.

TAP has a small fleet of four aircraft, but TAP Maintenance and Engineering still provides almost all technical services for the A340. The exceptions are shop visit maintenance for the GTCP 331-350 APU and landing gear overhaul and exchange services. TAP Maintenance & Engineering has a long history of providing all levels of maintenance and technical support for TAP's fleet.

SR Technics is a similarly-sized technical support services provider that has built up an extensive technical support capability. Traditionally SR Technics has received about half its business from its previous partner airline Swissair, although it now receives a smaller proportion of its maintenance activity from Swiss Airlines, and a larger share from third-party airlines.

Sabena Technics is a product of the original maintenance and engineering division of Sabena, TAT Industries, Sogerma. Sabena operated A340s prior to its bankruptcy, so Sabena Technics inherited a large A340 maintenance capability. Sogerma's hangars in Bordeaux are some of Europe's largest widebody base maintenance facilities. Sabena Technics also has a facility at Brussels.

SAS Technical Services, the maintenance and engineering division of SAS, is an airframe specialist provider, providing a full range of engineering management, line and light maintenance, base maintenance, interior refurbishment; and stripping and painting.

SAS Component is a joint venture between SAS Technical Services and Singapore Technologies Aerospace. SAS Component is a well-known major component repair and maintenance provider, offering services for wheels, brakes and thrust reversers. It is also one

A340-200/-300 ENGINE MAINTENANCE (CFM56-5C)

	Engine health monitor	Engine maint manage	On-wing engine maint	Engine shop visits	Parts repair schemes
Air Canada Technical Services (ACTS)	Yes	Yes	Yes	Yes	Yes
Air France Industries	Yes	Yes	Yes	Yes	Yes
Air Mauritius	Yes	Yes	Yes	Yes	Yes
Ameco Beijing	Yes	Yes	Yes	~	~
GA Telesis	Yes	Yes	~	~	~
GAMCO	Yes	Yes	Yes	~	Yes
GE Aviation Engine Services	Yes	Yes	Yes	Yes	Yes
Iberia Maintenance	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik Philippines	Yes	Yes	Yes	~	~
Pratt & Whitney (Eagle Services)	Yes	Yes	Yes	Yes	Yes
SAA Technical	Yes	Yes	Yes	line	~
Sabena Technics	Yes	Yes	Yes	~	~
Snecma Services	Yes	Yes	Yes	Yes	Yes
SR Technics	Yes	Yes	Yes	Yes	Yes
TAP M&E	Yes	Yes	Yes	Yes	Yes
Total Engine Support	Yes	Yes	Yes	~	~
Turkish Technic	Yes	Yes	Yes	Yes	~

A340-200/-300 SPARE ENGINE SUPPORT PROVISIONING (CFM56-5C)

	On-wing support	AOG services	Short-term leases	Med/long-term leases	Engine pooling
Air Canada Technical Services (ACTS)	Yes	Yes	~	~	~
Air France Industries	Yes	Yes	Yes	Yes	Yes
Ameco Beijing	Yes	~	~	~	~
Engine Lease Finance	~	~	Yes	Yes	Yes
GA Telesis	Yes	Yes	Yes	Yes	Yes
GAMCO	Yes	Yes	Yes	Yes	Yes
Iberia Maintenance	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik Philippines	Yes	Yes	~	~	~
SAA Technical	Yes	Yes	~	Yes	Yes
Shannon Engine Support	~	~	Yes	Yes	Yes
Snecma Services	Yes	Yes	Yes	Yes	Yes
SR Technics	Yes	Yes	Yes	Yes	Yes
TAP M&E	Yes	Yes	Yes	Yes	Yes
Triumph Group	~	accessories	~	~	~
Turkish Technic	Yes	Yes	Yes	Yes	~
Willis Lease	~	Yes	Yes	Yes	~

of the few companies that can provide full, turn-key rotable support packages for the A340-200/-300.

Turkish Technic in Istanbul is the maintenance and engineering division of Turkish Hava Yollari (THY) Airlines, which has has seven A340-300s. Turkish Technic provides all line, light and base maintenance services, and has a comprehensive engine and component capability. It provides all engine services, except repair schemes for parts, as well as most engine support services, including short- and long-term leasing.

Middle East & Africa

The two most prominent technical support providers in the Middle East and Africa are: Gamco, Abu Dhabi, UAE; and SAA Technical, Johannesburg, South Africa.

Gamco is best known for its support of Gulf Air's fleet, but it has a large number of other customers which include Kuwait Airways, Royal Jordanian, Qatar Airways and Emirates.

Gamco provides all levels of engineering and management support, line and light maintenance, base maintenance, interior refurbishment and stripping and repainting. It also has an engine shop, but it does not provide maintenance for the CFM56-5C series. It does, however, offer engine health monitoring and maintenance management, as well as light on-wing engine maintenance. Gamco also provides a full range of spare engine support services, such as aircraft-on-ground (AOG) services and spare engine leasing. In addition, Gamco provides repair and document management for rotables, although it does not offer rotable inventories or power-by-the-hour (PBH) rotables provisioning packages. Gamco does overhaul and repair the simpler major components of wheels, tyres, brakes and thrust reversers, as well as offering shop visits for the GTCP 331-350 APU.

SAA Technical, the maintenance and engineering division of South African Airways (SAA), is another comprehensive provider of technical support for the A340-200/-300.

SAA Technical's largest capabilities are in engineering management, line and light maintenance, base maintenance, interior refurbishment and stripping and painting. SAA Technical has built up these capabilities over several decades to support SAA's fleet. As it has left the engine market, SAA Technical does not provide engine shop visit capability, although it does offer engine management and light on-wing engine maintenance services.

Air Mauritius is another significant provider of A340-200/-300 maintenance and technical support, specialising in base and engine maintenance.

Asia Pacific

The four main technical support providers in the Asia Pacific are Lufthansa Technik Philippines (LTP), Ameco Beijing, SIAECO of Singapore, SASCO of Singapore, and STARCO of Shanghai.

LTP is the Philippine Airlines facility bought by Lufthansa Technik, of which it is now a subsidiary. LTP provides a comprehensive service for the A340-200/-300. The services that it offers do exclude engine shop visits and repairs, although these are available via the Lufthansa Technik network.

Ameco Beijing provides full airframe maintenance services and some engine management and on-wing maintenance. It also provides repair and maintenance for various component categories.

SIA Engineering Company (SIAECO), the maintenance and engineering division of Singapore Airlines, retains a lot of capability to support the A340-200/-300. SIAECO specialises in engineering management and technical support, line and light maintenance, and base maintenance.

ST Aviation Services (SASCO) and Singapore and Shanghai Technologies (STARCO) specialise in base maintenance activities.

North America

The three major A340-200/-300 support providers in North America are Air Canada Technical Services (ACTS), ST Mobile Aerospace Engineering (MAE), and Aeroframe Services.

ACTS is owned by ACE holdings, after it was separated from Air Canada following the latter's financial restructuring in 2004. Air Canada Maintenance provides most of the engineering and technical management and some of the line and light maintenance for its own fleet, but it does not carry out third-party maintenance work. ACTS provides most line and light maintenance services and the full range of base maintenance support activities, as well as full engine maintenance services for the CFM56-5C and on-wing and AOG engine support.

MAE of Mobile, Alabama is owned by Singapore Technologies Aerospace. MAE specialises in heavy maintenance of all Airbus types, and can offer base maintenance, interior refurbishment, and stripping and painting. The company also provides wheels and brakes repair capability.

Aeroframe Services, Lake Charles, Louisiana was previously a subsidiary of EADS. The company specialises in airframe checks for all Airbus types, but in particular it performs C and heavy checks. The company also has a strip and paint hangar, as well as the capability to repair and overhaul some components.

Specialist services

In addition to the main support providers, there are specialist providers for engine maintenance, spare engine leasing, heavy component repairs, and rotables support.

Pratt & Whitney Engine Services (PWES), Snecma Services, and GE Engine Services are major engine maintenance providers, while Total Engine Support (TES) specialises in third-party engine maintenance management.

Specialist engine lessors include Shannon Engine Support (SES), Engine Lease Finance, GA Telesis and Willis Lease.

Examples of specialist heavy component repair providers include: Messier Services for landing gears, wheels and brakes; Revima for the APU; and Middle River Aircraft Systems for thrust reversers.

Companies that specialise in rotable support packages, and provide turnkey total support packages, include AJ Walter, Avtrade and SAS Component. AC

A340-200/-300 ROTABLES & LOGISTICS

	Rotable inventory leasing	Rotable inventory pooling	Repair & doc manage	AOG support	PBH rotables support
Air France Industries	Yes	Yes	Yes	Yes	Yes
Airbus	Yes (proprietary parts)	~	~	Yes	~
AJ Walter	Yes	Yes	Yes	Yes	Yes
AVTRADE	Yes	Yes	Yes	Yes	Yes
GA Telesis	Yes	Yes	Yes	Yes	Yes
GAMCO	~	~	Yes	Yes	~
Kellstrom	Yes	Yes	Yes	Yes	~
Iberia Maintenance	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik Philippines	Yes	Yes	~	Yes	Yes
Messier Services	Yes	Yes	Yes	Yes	Yes
Sabena Technics	Yes	Yes	Yes	Yes	Yes
SAS Component	Yes	Yes	Yes	Yes	Yes
SAS Technical Services	Yes	Yes	Yes	Yes	Yes
SR Technics	Yes	Yes	Yes	Yes	Yes
TAP M&E	Yes	Yes	Yes	Yes	Yes
Triumph Group	Yes	Yes	Yes	Yes	Yes
Turkish Technic	~	~	~	Yes	Yes

A340-200/-300 HEAVY COMPONENT MAINTENANCE

	Wheels, tyres & brakes	APU test & repair (GTCP331-350)	Thrust reversers	Landing gear	Landing gear exchanges
Air Canada Technical Services (ACTS)	Yes	Yes	~	~	~
Air France Industries	Yes	Yes	Yes	Yes	Yes
Ameco Beijing	Yes	~	~	Yes	Yes
GAMCO	Yes	Yes	Yes	~	~
Honeywell Aerospace	~	Yes	~	~	~
Iberia Maintenance	Yes	Yes	Yes	Yes	Yes
Lufthansa Technik	Yes	Yes	Yes	Yes	Yes
Messier Services	Yes	~	~	Yes	Yes
Revima APU	~	Yes	~	~	~
SAA Technical	Yes	Yes	Yes	Yes	Yes
Sabena Technics	Yes	Yes	Yes	Yes	Yes
SAS Component	Yes	~	Yes	~	~
SR Technics	Yes	Yes	Yes	~	~
ST Aviation Srvcs (SASCO)	Yes	Yes	Yes	Yes	Yes
TAP M&E	Yes	~	Yes	~	~
Triumph Group	~	Yes	Yes	~	~
Turkish Technic	Yes	Yes	Yes	Yes	Yes

A340-200/-300 aftermarket & values

The A340-200/-300 are no longer first generation aircraft. Supply of widebodies remains tight, and values and lease rates of used aircraft are strong. The supply of spare CFM56-5C engines is tight.

The A340-200 and -300 are niche aircraft, operating in small numbers with a group of particular airlines. A large number were traded up to 2004, but sales have been minimal in the past two years due to the general shortage of widebodies.

The major trades of A340s since the aircraft's entry into service involve three main groups of -200s and four to six main groups of -300s.

The -200s that have been traded include seven ex-Lufthansa aircraft, six of which were sold to South African Airways (SAA), and one to the Government of Jordan. Four Philippine Airlines aircraft were sold to Aerolineas Argentinas, while four Sabena aircraft went to Royal Jordanian and another to Air France.

The largest and best-known trade of -300s is the 17 Singapore Airlines (SIA) aircraft that were bought by Boeing as part of an order for 777-200s. These A340s were subsequently leased to new operators, and then sold to lessors with leases attached. The three main operators of these aircraft are Cathay Pacific, Emirates and Gulf Air. One aircraft is also operated by China Airlines and another by Etihad.

Another three aircraft were sold by SAA to Jet Airways. Virgin Atlantic disposed of four aircraft, of which one went to Finnair, another to lessor AerCap and two to Air Comet of Spain.

Air Canada also disposed of three aircraft, and Aom of France sold its two to SriLankan. Sabena's two -312s are now in operation with Air Namibia.

The general surplus of aircraft in the 2002 to 2005 period has been superseded by a shortage of aircraft and a consequent hardening of values and lease rates. Few aircraft are coming available, and those that are, are being traded in a short period. "The extent of the shortage is illustrated by the fact that airlines are now signing five-year leases that do not start for another 18 to 24 months," explains Bill Cumberlidge, director of asset finance, head of aviation asset management at Allco Finance.

The A340-300 market is not a liquid one, but values have firmed up in recent years. "Lease rates have hardened over the past two years from about $450,000 per month to the region of $550,000 per month," continues Cumberlidge. "The general supply of aircraft will remain tight when future delivery slots of 787s, 777s and other types are considered, so lease rates for A340-300s could pass the $650,000 mark over the next few years. Sale values are more theoretical, because operators are holding on tight to their aircraft."

Gary Fitzgerald, commercial and contracts direct at Avinco explains that trading and market values have to consider maintenance condition: "The A340-300 requires a heavy check every five years, which is relatively frequent, and is one factor affecting value. The maintenance status of the four engines also has to be considered, as well as time remaining on the landing gear." One final issue is the cost of interior refurbishment or reconfiguration. This can incur a cost of $5-8 million for an aircraft of this size.

Heavy maintenance visits are either IL or D checks, and can cost $1.2-3.1 million. Performance restorations cost $1.4-1.6 million, while overhauls cost $2.2-2.6 million. Landing gear exchange and overhauls cost in the region of $1.2 million. An aircraft that requires a heavy check and has little remaining time on two or three of its engines can therefore be devalued by $5.5-9.5 million. Additional consideration has to be given for interior reconfigurations, which can incur costs of $4-5 million.

Cumberlidge estimates that values of aircraft with a low maintenance status are in the region of $30 million, while examples in an average maintenance condition will have values of $40-45 million. Prices of $45 million or more are being asked for aircraft that are 12-13 years old. The A340-300 is, of course, no longer a first generation aircraft.

These are general values, and as Fitzgerald explains there are many variants and combinations of maximum take-off weight (MTOW) and engine types in the fleet. "A lot of the older aircraft have -5C2/F or -5C3/F engines, which give the aircraft poor operating performance. The value of aircraft with these engines is therefore discounted," says Fitzgerald. "Later aircraft with -5C4 engines have the best performance, and the aircraft is relatively cheap to operate

There have been several trades of A340-200s and -300s. The supply of widebodies has tightened in recent years, and values have strengthened as a consequence. Monthly lease rates of have climbed over the past two years from about $450,000 to about $550,000. The shortage of aircraft means rates could rise further to about $650,000.

and has good performance. It can carry about 20 tons of belly freight, for example. The values of these aircraft are strong, but transactions also have to be considered in relation to them having leases attached or not attached. Many aircraft are stuck with major operators, and are not coming available.

"Lease rentals for mid-1990s aircraft are in the $500,000-550,000 per month range," continues Fitzgerald "and rates for -200s are not much lower. Values for older aircraft are in the $30-40 million range, but younger aircraft with -5C3 and -5C4 engines and higher take-off weights are worth in excess of $50 million if they are in a good maintenance condition."

One issue to consider is possible future roles for the A340. Some lessors have reportedly expressed interest in a possible passenger-to-freighter conversion programme. While the aircraft would make a good long-range freighter and provide an attractive volumetric payload, its values are too high at present to make conversion economically viable.

CFM56-5C

A crucial element in the aftermarket is the CFM56-5C. The engine has a reputation for limited on-wing removal intervals, and is consequently in high demand. "We have more than 10 -5Cs in our portfolio, and demand is strong because of the removal intervals. The engines we have are new, which we ordered from CFMI in 2007. These are all -5C4s," says Don Nunemaker, executive vice president and general manager leasing at Willis Lease. "There is always demand for leased engines, many of them for more than five years. We have even signed some leases for 10 years in 2007."

Another factor driving demand is that a larger number of A340s have been traded, and when this occurs spare engines do not always follow the aircraft. "There is not an overhang of engines in the market, so there are few available for short-term leases and aircraft-on-ground (AOG) situations. This keeps values and rentals strong," explains Nunemaker. "An example of the level of demand is that we have an engine coming back off lease, and have three airlines that all want to sign a long-term lease for it after it comes out of the shop visit. Other factors are that there were relatively few CFM56-5Cs manufactured, their reliability is not so good, and airlines do not seem to want to invest in widebody engines. This last point is probably because the A340 is no longer a first generation aircraft, and airlines are thinking of phasing it out at some point. One more problem is that operators also want the quick engine change (QEC) kit, which has to be custom built by CFMI, and usually takes six to eight weeks."

The continued shortage of engines and the high demand created by their general short supply could have negative consequences for the aircraft in the secondary market, therefore making it expensive for second-tier users to operate. This will have a negative impact on the A340's values.

Lease rentals are close to the market rates for the CFM56-5A/-5B. Nunemaker estimates long-term rates for used engines are $75,000-85,000 per month, and $85,000-95,000 per month for younger and new engines. Rates for short-term leases, of less than a year, are higher.

Engine lessees also have to pay maintenance reserves, which include the three elements of shop visit maintenance, life limited parts (LLPs) and the QEC. Total reserve depends on style and environment of operation, average flight cycle time, and average de-rate. Reserves for engines operating at average cycle times are in the region of $210 per engine flight hour *(see A340 maintenance analysis and budget, page 17)*. AC