OWNER'S & OPERATOR'S GUIDE: A300-600 & A310

A300-600 & A310 specifications

The A300-600 & A310 family have a wide range of variants, models and roles. The different types and their specifications are described.

The A310 was Airbus's second product, and featured a shorter fuselage than its predecessor, the A300B2/4. The A310 first entered service in 1982 and was manufactured until 1998. The A300-600 was a direct replacement for the A300B2/4, with the -600 series featuring a small fuselage stretch. The A300-600 entered service in 1984 and was manufactured until 2007.

The A300-600 and A310 were the first two Airbus aircraft to feature commonality, sharing the same electronic flight instrument system (EFIS) flightdeck, the same basic engine models, and many of the same rotable components. The two aircraft also have medium- to long-haul capability. These features combined with their two sizes meant that they were the first aircraft from Airbus to be marketed under a 'family' concept. The common EFIS flightdeck provides the A300-600 and A310 with a common type rating, which obviates the need for transition training between the two. The A300-600 and A310 were also among the pioneers of extended-range twin-engine operations (Etops).

Two main variants of the A300-600 were built by Airbus: the basic A300-600, and the extended-range A300-600R. Each is available in all-passenger, passenger/freight convertible and freighter versions. There is also a choice of three main types of powerplant: the JT9D-7R4 series, the PW4000-94 series and the CF6-80C2 series. This results in a total of nine sub-variants.

Similarly, two versions of the A300-600's smaller and longer-range cousin, the A310 were offered: the basic A310-200, and the extended-range A310-300. Each was originally available in all-passenger and passenger/freight convertible form, but no factory freighter was produced.

All versions of the A300-600 and A310 are certified for 180-minute Etops missions. For this they are equipped with the required redundancy for AC generation and 260-minute continuous cargo-hold fire suppression.

Model & variant nomenclature

The extended-range variants of the A300-600s are identified with an additional 'R' suffix. Within each of these two groupings, the last two digits in the variant suffix indicate the engine type powering it. For example '-601', '-603' and '-605' (where the middle digit is '0') all refer to specific General Electric (GE) engine types. The third digit refers to the specific GE engine model. That is, -A1, -A3, and -A5. Similarly, '-620' and '-622' (where the middle digit is '2') both refer to Pratt & Whitney engines. Moreover, within the extended-range family, there is a factory-built freighter version, denoted with an 'F4' in the model type. There was also a very small number of hybrid A300-600R 'convertible' versions built. To summarise, there are three principal airframe versions of the A300-600: the baseline A300B4-600, the A300B4-600R and the A300F4-600R. The latter features a maindeck side cargo door, reinforced maindeck floor beams, bespoke cargo loading system on both decks, no cabin windows, and removal of passenger doors 2, 3, and 4 on both sides. In addition to this 'factory freighter', about 30 A300-600s have been converted from passenger to freighter configuration *(See Modification and upgrade programmes, page 9)*.

A similar system of nomenclature applies to the A310-200 and -300 series, of which there are eight sub-variants. Four of these are -200s, and four are -300s. The extended-range variants of the A300-600 family are indicated by an 'R'. In the case of the A310 family, the -200 series is the basic model and the -300 series is the extended-range model.

Like the A300-600, the second and third digits in the A310's name suffix indicate the engine make and model. For example, a '0' middle digit indicates a GE powerplant, while a '2' denotes a P&W powerplant. In all cases, the third digit refers to a specific engine model. It should be noted that there was no A310 factory freighter variant. About 75 A310s operate as converted freighters, however.

For both the A300-600 and A310, there are further specification differences which are identified on the relevant Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) type-certificate data sheet (TCDS). These differences mainly relate to maximum take-off weight (MTOW), maximum landing weight (MLW), maximum zero-fuel weight (MZFW), and fuel capacity options. Also identified in the aircraft TCDS are relevant engine types. In turn, each engine family has its own TCDS in which are specified respective engine-operating parameters, limits and options (such as exhaust gas temperature (EGT) margins, engine speed limits and thrust options).

A300-600 series

The A300B4-600 series features a longer fuselage section and the same two-crew EFIS flightdeck as the A310. The wing is essentially the same as on the original A300B2/4, but all -600Rs and

A300-600 AIRFRAME-ENGINE COMBINATIONS

Base model	Aircraft sub-variant	Aircraft configuration	Engine variant	Engine thrust lbs
A300-600	A300-601	Passenger	CF6-80C2A1	57,860
	A300-603	Passenger	CF6-80C2A3	58,950
	A300-620	Passenger	JT9D-7R4H1	56,000
	A300-622	Passenger	PW4158	58,000
	A300-622F	Freighter conversion	PW4158	58,000
A300-600R	A300-622R	Passenger	PW4158	58,000
	A300-622RF	Freighter conversion	PW4158	58,000
	A300-605R	Passenger	CF6-80C2A5	60,100
	A300-605RF	Freighter conversion	CF6-80C2A5	60,100
A300-600R	A300F4-605R	Factory freighter	CF6-80C2A5/A5F	60,100
	A300F4-622R	Factory freighter	PW4158	58,000
	A300C4-605R	Convertible	CF6-80C2A5	60,100
	A300C4-605R	Convertible	JT9D-7R4H1	56,000

some later-build -600s have small wingtip fences to reduce vortex drag. Other changes from the A300B include an increased use of composite materials in primary and secondary structures.

The A300-600's TCDS (document 'A35EU' revision 21, dated March 2007) specifies four engine options for the standard-range A300B4-600 series: the JT9D-7R4 rated at 56,000lbs thrust to power the A300B4-620; the PW4158 rated at 58,000lbs thrust to power the A300B4-622R; the CF6-80C2A1 rated at 57,860lbs thrust to power the A300B4-601; and the CF6-80C2A3 rated at 58,950lbs thrust to power the A300B4-603.

Regarding the certified weights, the standard-range A300B4-600 has an MTOW of 363,760lbs, MLW of 304,230lbs, and MZFW 286,600lbs. Meanwhile, fuel tankage for this model totals 16,380 US gallons (USG), with outboard tanks providing 2,450USG, inboard tanks providing 9,280USG and centre tanks providing 4,650USG.

The passenger version A300-600 series is certified to accommodate up to 345 passengers, although in typical two-class configuration, the aircraft seats up to 266. The maximum absolute load for the forward cargo compartment is 40,800lbs, while for the aft compartment it is 28,300lbs. The rear bulk compartment can support up to 6,110lbs. The lower deck can accommodate up to 23 LD-3 unit load devices (ULDs), or alternatively, four pallets plus up to 11 LD-3s, plus bulk volume of up to 610 cubic feet. The A300-600's standard range capability with 266 passengers plus baggage (56,000lbs approximate payload) is 3,600nm. With 266 passengers and 34,750lbs of freight, its range is about 2,200nm *(see table, page 6)*.

The A300B4-600R series has two engine options listed in the A300 TCDS document *(see table, page 4)*: the PW4158 rated at 58,000lbs thrust powering the A300B4-622R; and the CF6-80C2A5 rated at 60,100lbs thrust powering the A300B4-605R.

In contrast to the standard-range A300B4-600, the A300B4-600R is specified in four different weight variants: MTOWs range from 369,930lbs to 378,530lbs; MLWs from 304,235lbs to 308,650lbs; and MZFWs from 271,170lbs to 288,800lbs *(see table, page 6)*. The maximum passenger loads, as well as the maximum absolute loadings for the forward, aft and bulk cargo/baggage compartments, are all the same as those of the basic A300B4-600 passenger version.

In terms of fuel capacity, the '-R' model is fitted with a supplementary tail 'trim tank', which brings the total fuel load to 18,000USG, thereby providing an extra 1,620USG. This higher fuel capacity gives the A300-600R a range of about 4,000nm with 266 passengers and baggage. Range is about 2,600nm with 266 passengers plus 34,250lbs of freight.

The A300F4-600 factory freighter has the same engine type options and related '-622' and '-605' variant designations, thrust ratings, and fuel tank arrangement and capacities as the A300B4-600R passenger version detailed above. The F4's weight variant specifications differ slightly to the passenger version. MTOWs range from 363,990lbs to 375,890lbs, MLWs from 303,970lbs to 315,900lbs, and MZFWs from 286,600lbs to 300,930lbs. It should be noted that the F4 variant can either be fitted with all the tanks activated, or the trim and centre tanks may be deactivated in conjunction with an increased MZFW to allow a greater payload to be carried over shorter mission ranges.

The F4 also has an optional 'payload' mode. According to Airbus, where fuel capacity is reduced from 18,000USG to 11,730USG, the maximum structural payload is increased to 118,390lbs at the expense of range. In this case, MZFW also has to be increased to 295,000lbs and MLW to 309,950lbs.

As a full freighter, the A300F4-600's lower and main deck maximum certified loadings are as follows: 40,800lbs for the lower forward compartment; 30,400lbs for the lower aft compartment; and 3,900lbs for the lower bulk compartment. The maindeck cargo compartment can have a maximum of 100,900lbs. It should be noted that these are the absolute certified loadings, whereas the actual overall maximum loadings for a given mission will be subject to MZFW, MTOW and weight and balance restrictions. Operationally, the freighter can accommodate up to 15 pallets. These are nine 88/96-inch X 125-inch pallets and six 88-inch X 125-inch pallets on the main deck.

According to Airbus other arrangements include: 16 88-inch X 125-inch main deck pallets; 14 96-inch X 125-inch pallets; or 21 88-inch X 125-inch pallets, with 18 in a double row. On the lower deck, the aircraft has exactly the same pallet/ULD capability as the passenger variant. This is either an arrangement of four pallets plus 11 LD-3s, or 23 LD-3s. The aircraft's maximum structural payload capacity is 121,100lbs. The maindeck's structural capacity is 101,000lbs *(see table, page 6)*.

The A300F4-600 can carry a 121,100lbs structural payload up to 1,950nm, while the aircraft can operate up to 2,650nm with a lighter 112,750lbs payload. However, practical examples cited by Airbus show that the aircraft can carry an 80% volumetric payload of 97,200lbs up to 3,350nm. This would allow routes such as New York-Anchorage, New York-London, London-Dubai, or Dubai-Singapore.

A310-200 and -300

Airbus developed the A310 by mating a shortened A300B4-200 fuselage with a smaller, more advanced wing, revised wingtip fences (a design later adapted for the A320 and now also the A380), and new horizontal tail surfaces. It also fitted a two-crew EFIS flightdeck as standard (the A310 being the first Airbus to have this feature), and a modified landing gear. Airbus has built two major A310 variants: the medium-range -200 and the longer-range -300. The latter also features a new computerised fuel distribution system, and can accommodate up to two

A310 AIRFRAME-ENGINE COMBINATIONS

Base model	Aircraft sub-variant	Aircraft configuration	Engine variant	Engine thrust lbs
A310-200	A310-221	Passenger	JT9D-7R4D1	48,000
	A310-222	Passenger	JT9D-7R4E1	50,000
	A310-222F	Freighter conversion	JT9D-7R4E1	50,000
	A310-203	Passenger	CF6-80A3	48,970
	A310-203F	Freighter conversion	CF6-80A3	48,970
	A310-204	Passenger	CF6-80C2A2	52,460
	A310-204F	Freighter conversion	CF6-80C2A2	52,460
A310-300	A310-322	Passenger	JT9D-7R4E1	50,000
	A310-324	Passenger	PW4152	52,000
	A310-324F	Freighter conversion	PW4152	52,000
	A310-304	Passenger	CF6-80C2A2	52,460
	A310-325	Passenger	PW4156A	56,000
	A310-308	Passenger	CF6-80C2A8	57,860
	A310-308F	Freighter conversion	CF6-80C2A8	57,860

A300-600 & A310 FAMILY SPECIFICATIONS

Aircraft variant	A300-600	A300-600R	A300F4-600R
MTOW options-lbs	363,760	369,930/375,890/378,530	363,990/370,375/375,890
MLW options-lbs	304,230	304,235/308,650	303,970/308,650/315,900
MZFW options-lbs	286,600	271,170/286,600/288,800	286,600/294,980/300,930
OEW typical-no tare-lbs	198,600	199,000	174,200
Typical structural payload (gross) - lbs	56,000	56,000	97,200-121,100
Maximum structural payload (gross) - lbs	88,050	87,600	121,100
Fuel capacity-USG	16,380	18,000	11,730-18,000
Typical 2-class passengers	266	266	N/A
Belly freight maximum loading-lbs	75,210	75,210	75,210
Belly freight containers	23 LD-3s	23 LD-3s	23 LD-3s
Main deck maximum freight-lbs	N/A	N/A	101,000
Main deck freight containers	N/A	N/A	16 88 X 125 pallets
Typical range-nm	3,600	4,000	1,950-2,650

Aircraft variant	A310-200	A310-300
MTOW options-lbs	291,007/305,558/313,053	330,750/337,365/346,185/361,620
MLW options-lbs	261,247/267,859	271,215/273,420
MZFW options-lbs	239,201/245,813	249,165/251,370
OEW typical-no tare-lbs	177,600	178,200
Typical structural payload (gross) - lbs	44,000	44,000
Maximum structural payload (gross) - lbs	73,450	72,900
Fuel capacity-USG	14,558	16,140/19,940
Typical 2-class passengers	220	220
Belly freight maximum loading-lbs	55,105	55,105
Belly freight containers	15 LD-3s	15 LD-3s
Main deck maximum freight-lbs	N/A	N/A
Typical range-nm	3,600	4,300-5,150

1,900 USG auxiliary centre tanks (ACTs) in the rear cargo hold if required.

The A310-200 has four certified engine options: the CF6-80A3 rated at 48,970lbs thrust for the A310-203; the CF6-80C2A2 rated at 52,460lbs thrust for the A310-204; the JT9D-7R4D1 rated at 48,000lbs thrust for the A310-221; and the JT9D-7R4E1 rated at 50,000lbs thrust for the A310-222 *(see table, page 5)*.

The A310-200 is specified with four different weight variants: MTOWs range from 291,007lbs to 313,053lbs; MLWs from 261,247lbs to 267,859lbs; and MZFWs from 239,201lbs to 245,813lbs *(see table, this page)*.

The A310-200 series is certified to accommodate up to 265 passengers when equipped with 'Type-III' over-wing emergency exits. The maximum absolute freight load for the forward lower cargo compartment is 27,999lbs, and 20,999lbs for the aft lower compartment. The rear bulk compartment can support up to 6,107lbs. The lower freight compartment can accommodate freight in 16 LD-3s, or three pallets plus six LD-3s plus either 610 or 318 cu ft bulk *(see table, this page)*.

Typical two-class seating capacity is 220 passengers. Fuel capacity for this model comprises 1,980USG in outboard tanks, 7,384USG in inboard tanks, and 5,194USG in centre tanks. Total useable fuel capacity for the A310-200 series is therefore 14,558USG. Range with 220 passengers plus baggage is about 3,600nm, while with 220 passengers and 29,450lbs of cargo the range is about 2,100nm.

For the A310-300, the TCDS specifies five certified engine options: the CF6-80C2A2 rated at 52,460lbs thrust powering the A310-304; the CF6-80C2A8 rated at 57,860lbs thrust powering the A310-308; the JT9D-7R4E1 rated at 50,000lbs thrust powering the A310-322; the PW4152 rated at 52,000lbs thrust powering the A310-324; and the PW4156A rated at 56,000lbs thrust powering the A310-325.

The A310-300 is specified with five different weight variants. MTOWs range from 330,750lbs to 361,620lbs; MLWs from 271,215lbs to 273,420lbs; and MZFWs from 249,165lbs to 251,370lbs *(see table, this page)*. The maximum passenger capacity and the maximum absolute floor loadings for the lower deck forward, aft and bulk cargo/baggage compartments are all the same as those of the A310-200.

Fuel capacity totals 16,140USG, with the outboard tanks providing 1,955USG, the inboard tanks 7,371USG, the centre tanks 5,189USG, and a supplementary trim-tank in the tail providing 1,625USG. In addition, the -300 can have optional fuel tanks in the cargo hold to raise total fuel capacity to 19,940USG. However, additional fuel will be at the expense of maximum structural payload capacity.

In terms of payload-range, the A310-300 (361,600lbs MTOW version) equipped with ACTs can fly 220 passengers plus baggage a distance of 5,150nm. Without ACTs, the aircraft can fly 220 passengers plus baggage up to 4,300nm. With 220 passengers and 15,000lbs additional cargo, the A310-300 flies up to 4,050nm. AC

A300-600 & A310 fleet summary

The A300-600 & A310 fleet is varied, with many sub-variants and engine types and variants.

There are 458 A300-600s and A310s in operation out of 539 built. The oldest A310s and A300-600s are 24 and 23 years old respectively.

A total of 539 A300-600s and A310s powered by several variants of the JT9D-7R4, PW4000 and CF6-80 series have been delivered, the last an A300-F4600R freighter delivered to UPS in July 2007. Most A300-600s are still flown by their original operators, while many A310s have been converted into freighters.

The A300-600s come in standard -600 and extended-range -600R versions. For each of these there was a passenger as well as a factory-built freighter, resulting in four A300-600 sub-models *(see A300-600 & A310 specifications, page 4)*.

The A310s, meanwhile, are subdivided into the baseline A310-200 (initial version), and A310-300. The latter has an improved payload-range capability with higher weights, increased fuel capacity, more advanced engines, and drag-reducing wingtip fences *(see A300-600 & A310 specifications, page 4)*. The A310-300 was only built as a passenger aircraft, but a large number of A310-200s have been converted into freighters.

A300B4-600 & -600R

The first delivery of the A300-600, which was launched in 1980, was made to Saudi Arabian Airlines in 1984.

Only 35 of the the initial A300B4-600 variant were built. Depending on the engine powering it, this comes in four designations: the A300B4-601 fleet (five active, one parked) powered by CF6-80C2A1s; the -603 fleet (11 active) powered by CF6-80C2A3s; the -620 fleet (one active, 11 parked) powered by JT9D-7R4H1s; and the -622 fleet (one active as passenger, plus five freighter converted) powered by the PW4158 *(see table, page 8)*.

The A300B4-600R, of which 274 were built, has a longer range than the -600 *(see A300-600 & A310 specifications, page 4)*, achieved by an additional trim fuel tank in the tail. The -622R model is powered by the PW4158, engine, and the -605R model by the CF6-80C2A5. The first delivery of a -600R was made in 1988 to American Airlines, and all A300s built since 1989 (freighters included) are -600Rs. American remains the larger customer and operator of the type, with 34 GE-powered A300B4-605R airliners in operation. Japan Airlines took delivery of the last new-built passenger-configured A300, an A300-622R, in November 2002. This carrier has 12 PW4158-powered A300B4-622Rs in service.

A total of 167 -600Rs were built, of which 155 are still in active service. Of these, 62 -622Rs are flying in passenger configuration while 23 are in service as converted freighters. Meanwhile, of the 75 -605Rs originally built, 69 are in service as passenger aircraft and one as a converted freighter *(see table, page 8)*.

The A300F4-600R, sometimes referred to as the A300-600RF, is the official factory-built freighter version of the -600R. It has the same basic aerodynamics, structure and systems as the passenger version.

FedEx was the original launch customer for the A300F4-600R in 1991, with an initial order of 25 aircraft, which it later increased to 36. UPS also ordered 30 (plus 30 options) A300-620Fs in September 1998, followed by a further 60 firm and 20 options in January 2001 (later cancelling 37 of its outstanding orders and all 50 options). A version of the A300-600F designed to carry general freight was delivered to Air Hong Kong from 2004. It differed from the earlier aircraft as it had a cargo loading system and a side door able to handle small packages as well as larger items of freight.

All A300s delivered from November 2002 to July 12, 2007, when the last ever A300 delivery was made, were A300-600RFs. In total 101 A300F4-600Rs were delivered, all of which are still in service. Of these, 47 are powered by CF6-80C2A5s and 54 by the PW4158. The largest A300F4-600R fleets are operated by UPS (53 A300F4-622R, PW4158-powered aircraft) and Fedex (36 A300F4-605R, CF6-80C2A5-powered aircraft). There was also a 'convertible' version, the A300C4-600R, of which only six were built. All are still in service *(see table, page 8)*, four powered by JT9D-7R4H1s, and two by CF6-80C2A5s.

The specifications section of this guide *(see page 4)* outlines all the airframe suffixes and respective engine models powering them. Overall, the most popular engine option for the A300-600 family is the PW4100 series, with 145 aircraft in the current fleet. The CF6-80C2 is a close second, powering 135 aircraft. There are also two JT9D-7R4 powered A300-600s in service.

The largest sub-fleet of A300-600Rs is the aircraft powered by the CF6-80C2A5. American Airlines has a fleet of 34.

A300-600 & A310 FLEET SUMMARY

Aircraft variant	Aircraft configuration	Engine variant	Fleet (built)	Fleet (active)
A300-601	Passenger	CF6-80C2A1	6	5
A300-603	Passenger	CF6-80C2A3	11	11
A300-620	Passenger	JT9D-7R4H1	12	1
A300-622	Passenger	PW4158	1	1
A300-622F	Freighter conversion	PW4158	5	5
Sub-total			**35**	**23**
A300-622R	Passenger	PW4158	69	62
A300-622RF	Freighter conversion	PW4158	23	23
A300-605R	Passenger	CF6-80C2A5	74	69
A300-605RF	Freighter conversion	CF6-80C2A5	1	1
Sub-total			**167**	**155**
A300F4-605R	Factory freighter	CF6-80C2A5/A5F	47	47
A300F4-622R	Factory freighter	PW4158	54	54
A300C4-605R	Convertible	CF6-80C2A5	2	2
A300C4-605R	Convertible	JT9D-7R4H1	4	4
Sub-total			**107**	**107**
Total			**309**	**285**
A310-221	Passenger	JT9D-7R4D1	4	0
A310-222	Passenger	JT9D-7R4E1	10	5
A310-222F	Freighter conversion	JT9D-7R4E1	18	18
A310-203	Passenger	CF6-80A3	15	1
A310-203F	Freighter conversion	CF6-80A3	31	31
A310-204	Passenger	CF6-80C2A2	6	1
A310-204F	Freighter conversion	CF6-80C2A2	1	0
Sub-total			**85**	**56**
A310-322	Passenger	JT9D-7R4E1	6	2
A310-324	Passenger	PW4152	33	22
A310-324F	Freighter conversion	PW4152	15	15
A310-304	Passenger	CF6-80C2A2	55	47
A310-325	Passenger	PW4156A	14	11
A310-308	Passenger	CF6-80C2A8	18	16
A310-308F	Freighter conversion	CF6-80C2A8	4	4
Sub-total			**145**	**117**
Total			**230**	**173**

A300-600s and A300-600Rs in the fleet have cumulative flying hours (FH) ranging from over 59,000FH to fewer than 1,000FH (for the most recently delivered A300F4-600Rs). Meanwhile, the cumulative flight cycles (FC) range from over 36,000FC to fewer than 1,000FC. Interestingly, the average FC time ranges from 1.0FH to 3.8 FH, reflecting the intra-regional (short- and medium-range) missions that the A300 was originally designed to perform.

A310-200 & -300

The A310 was launched in July 1978. Total deliveries reached 230, of which 173 are still in active service. The first A310 entered service with Swissair in 1983. These aircraft were JT9D-7R4-powered, and designated as A310-222s. The A310-200 models accounted for 85 deliveries, of which 56 are still in active service *(see table, this page)*.

In 1983, the longer-range A310-300 was launched, in particular to improve transatlantic payload-range performance and to close the gap with the more capable and bigger-winged Boeing 767. The A310-300 entered service in 1985 with Air Niugini, Air India and Swissair. The last A310 from the Airbus factory was delivered in 1998 to Uzbekistan Airways. Total A310-300 deliveries reached 145, of which 117 are in active service.

There are four engine types for the A310 series: CF6-80A, CF6-80C2, JT9D-7R4, and PW4100 series. The specific A310 model suffixes reflect the engine type which powers it. These airframe and engine combinations are summarised *(see table, this page)*.

By far the largest A310 fleet is operated by FedEx with 68 passenger-to-freighter-converted aircraft in service, most of which are the -200 model. It should be noted that FedEx has tended to acquire its aircraft from major first-tier carriers such as Lufthansa (13 aircraft), Air France (six aircraft), KLM (10 aircraft), and Pan Am (13 aircraft), Singapore Airlines (four aircraft), Kuwait Airways (seven aircraft), and Swissair (five aircraft).

The biggest passenger operator of the A310 family is Air India, with 18 aircraft, while both Air Transat and PIA each have 12. Turkish Airlines operates seven, and TAP Air Portugal operates six.

The most popular A310-200s are the -203s powered by CF6-80A3s. Of the 46 built, only one is active as a passenger airliner, while 31 are operating as converted freighters. Meanwhile, 32 A310-222s powered by JT9D-7R4s were built, of which five are active as passenger airliners, and 18 as converted freighters *(see table, this page)*.

Regarding the more capable A310-300, the best selling variant was the CF6-80C2A2-powered A310-304, of which 55 were originally delivered. Today 47 are still in service as passenger aircraft, and six are operating as converted freighters. The A310-324 powered by PW4152s, achieved 48 deliveries, of which 22 are still in service as passenger aircraft and 15 as converted freighters. Other notable A310-300 fleets include: the A310-325, powered by PW4156As (of 14 delivered, 11 remain active as passenger aircraft); and the A310-308s, powered by CF6-80C2A8s (of 22 delivered, 16 remain active as passenger aircraft and four as converted freighters).

Overall, the most popular engine option for the A310 family is presently the CF6-80C2 series with 96 aircraft in operation. Meanwhile, the PW4100 powers 48 A310s and its predecessor engine, the JT9D-7R4, powers 25 A310s.

In contrast with the low FH:FC ratio of the A300s, the A310s have average FC times of up to 6.0FH to less than 1.0FH. The fleet leader in terms of cumulative FH is Royal Jordanian's A310-300 with 81,300FH, contrasting with the lowest typical figure for a passenger aircraft, which is more than 20,000FH. Meanwhile, the older converted A310-200 series freighters operated by FedEx have the highest accumulated FC of 30,000FC. In contrast, FedEx's younger A310-300 aircraft range from 8,000 to 18,000FC. AC

A300-600/A310 modification programmes

The most important modification and upgrade programmes for the A300-600 & A310 are freighter conversion and various avionic improvements.

Production of A300-600s and A310s has ended and there are now two passenger-to-freighter conversion lines. Another quarter-century of active life as freighters means that there is also scope for what was, in its day, a ground-breaking flightdeck to be upgraded.

Airbus has produced a total of 821 A300-series aircraft, including 313 A300-600s and 255 A310-200s and -300s. The last of these was delivered to FedEx on 12th July 2007, by which point the A300 had been in production for more than 30 years. Airbus expects to be supporting it for at least another 30, predicting that half the current fleet of more than 630 aircraft will remain in service beyond 2025.

Freighter conversion

The majority of A300-600s and A310 are likely to remain in service as freighters.

Deutsche Airbus started offering cargo conversions at the beginning of the 1990s. The design was based on the A300-600F series production aircraft, of which FedEx ordered the first 25 in July 1991, and adapted to meet the requirements of the A300B4 and A310. Airbus has delivered a total of 109 new-build -600 series factory freighters, including 61 A300F4-600Rs (53 of them for UPS), 42 -605Rs for FedEx, five convertibles and a single A300-600F.

The conversion process in Dresden, where EFW started converting A300B2s and B4s in 1995, takes about four months and uses parts produced on the same jigs used to build the assemblies for the production aircraft. That was a constraint in the past. Production was limited to 20 shipsets annually, and to accommodate demand for new aircraft EFW could offer only 14 conversion slots each year. A new hangar extension combined with the end of new freighter production has increased annual capacity to 20.

The new maindeck cargo door, 141 inches wide and 101 inches in height, along with upper and lower frame shells, is supported by four new milled frames. The maximum height of the maindeck sill is 181 inches, and the door can be opened to 70 degrees, raising the lower lip 134 inches above the sill, or a full 145 degrees.

The new maindeck floor involves new crossbeams with support rods and fittings, reinforcement of the frames in the vicinity of the support rod fittings, and new seat rails. Windows are plugged and passenger doors deleted or deactivated, and the conversion is completed by a safety barrier net, smoke curtain and smoke detection system.

A300-600 payload

The converted A300-600 can be equipped with a single-row or a side-by-side maindeck cargo-loading system (MDCLS).

With a single-row system it can accommodate 15 88-inch or 14 96-inch pallets, or seven 96 X 125-inch AMA containers.

The maindeck can also be loaded with 96-inch X 125-inch pallets loaded side by side in two rows. Eight pairs can be loaded plus another four in a single row making a total of 20.

Another configuration is for nine pairs of 88-inch X 125-inch containers and three single containers making a total of 21. Each of these containers has an internal volume of 476 cubic feet, taking the total maindeck volume to 9,996 cubic feet *(see table, page 10)*.

The lower deck cargo hold has room for four pallets or 12 LD-3 containers forward and 10 LD-3s aft. There is also a bulk hold of 610 cubic feet. Each LD-3

The list price for conversion to freighter by EADS-EFW is $8.5-9.0 million, including the freight handling system.

PAYLOAD CHARACTERISTICS OF A300-600RF & A310F CONVERTED BY EADS-EFW

Aircraft type	A300-600RF	A310-300F
MZFW-lbs	286,600	249,120/251,320
OEW-lbs	179,230	162,920
Gross structural payload	107,370	86,200/88,400
Maindeck containers	21	16
Number maindeck containers	88" X 125"	88" X 125"
Unit volume maindeck containers-cu ft	476	476
Total volume maindeck containers-cu ft	9,996	7,616
Tare weight maindeck containers-lbs	5,313	4,048
Type lower deck containers	LD-3	LD-3
Number lower deck containers	22	14
Unit volume lower deck containers-cu ft	146	146
Total volume lower deck containers-cu ft	3,212	2,044
Tare weight lowerdeck containers-lbs	4,730	3,010
Total volume all containers-cu ft	13,208	9,660
Total tare weight all containers-lbs	10,043	7,058
Net structural payload-lbs	97,327	79,142/81,342
Packing density-lbs/cu ft	7.36	8.19/8.42

has an internal volume of 146 cubic feet and the 22 containers provide a total capacity of 3,212 cubic feet *(see table, this page)*.

The total container capacity for the aircraft is therefore 13,208 cubic feet. The bulk volume takes the total to 13,818 cubic feet *(see table, this page)*.

The A300-600RF has a maximum zero fuel weight (MZFW) of 286,600lbs and an operating empty weight (OEW) of 179,230lbs. This provides the aircraft with a maximum structural payload of 107,370lbs *(see table, this page)*.

The tare weights of the main and lower deck containers are 5,313lbs and 4,730lbs, totalling 10,043lbs. This leaves the aircraft with a net structural payload of 97,327lbs *(see table, this page)*. Considered against total containerised volume, the aircraft has a maximum packing density of 7.36lbs per cubic foot.

A310 payload

The A310 was designed to accept 96-inch as well as standard 88-inch pallets on its cargo deck. It has a 106-inch freight-hold door and a semi-automatic loading system.

The aircraft can accommodate three pallets or eight LD-3 containers in the forward hold and six LD-3s aft. The bulk hold has a volume of 610 cubic feet. The unit volume of 146 cubic feet for each LD-3 takes the total LD-3 belly capacity to 2,044 cubic feet *(see table, this page)*. The additional bulk capacity takes the total to 2,654 cubic feet.

With containers loaded in a single row, the A310's maindeck can carry 12 88-inch or 11 96-inch pallets on the main deck, or five 96 X 125-inch AMA containers.

In a double-row configuration, the maindeck can accommodate 16 88-inch or 15 96-inch containers. The unit capacity of 476 cubic feet of the 88-inch containers means that total capacity for the maindeck is 7,616 cubic feet *(see table, this page)*.

The aircraft's total containerised cubic capacity is therefore 9,660 cubic feet.

The A310-300F has two MZFW options of 249,120lbs or 251,320lbs and an OEW of 162,920lbs. This gives the aircraft a gross structural payload of 86,200lbs and 88,400lbs.

The tare weight of the main deck containers is 4,048lbs, and the tare weight of the lower deck containers is 3,010lbs. This provides a total tare weight of 7,058lbs which leaves the aircraft with net structural payloads of 79,142lbs and 81,342lbs *(see table, this page)*. This allows a maximum packing density of 8.19lbs per cubic foot and 8.42 lbs per cubic foot.

The A310-200F's MZFW is 246,910lbs and its OEW is 159,610lbs. This gives the aircraft a gross structural payload of 87,300lbs.

The container tare weight of 7,058lbs leaves the aircraft with a net structural payload of 80,242lbs, and allows a packing density of up to 8.3lbs per cubic foot.

B/E Aerospace

Before EADS established the freighter conversion line in Dresden, a number of A300B2/B4 airframes had been converted in Hamburg, while Sogerma had converted 17 in Toulouse. Starting in 1996, the former BAE Systems Aviation Services division at Filton in the UK converted 39 A300B4s.

Flight Structures (FSI), BAE's partner in the programme, and now a subsidiary of B/E Aerospace, had developed the supplemental type certificate (STC) in 1995. In 2002 it took over the line, along with the STC and engineering work in order to support a move into the A300-600 market. Last year B/E announced that FSI would develop the engineering and certification package, and manufacture the necessary structural components for the conversion of six A300-600s operated by China Southern Airlines.

The conversions are being carried out in Guangzhou by GAMECO, the carrier's maintenance joint venture with Hutchison Whampoa. The first aircraft, B2315, arrived to start the process on 31st May 2007.

Glass cockpits

The two-pilot 'forward-facing crew cockpit' introduced by the A310, and used subsequently on the A300-600, was advanced enough in its day to be a cause of major controversy. That was 25 years ago, and flightdeck upgrades are becoming attractive for operators planning to fly the aircraft for another quarter of a century.

Lufthansa has specified the CMA-9000 flight management system (FMS) from Canada's CMC Electronics as a retrofit for its 14 A300-600s, which remain in passenger service. Stephane Villeneuve, CMC's director of sales and marketing for Europe, Asia and Australasia, says that while Lufthansa has opted for just the dual CMA-9000s, the FMS can also form the core of more extensive cockpit retrofits.

For example, the German airline is happy to use the global positioning system (GPS) card in the enhanced ground proximity warning system (EGPWS) to feed the FMS with position data. The CMC could also integrate its own GPS hardware in the form of the CMA-5024 satellite-based augmentation system (SBAS) receiver. This combines the GPS with precision approach functions and supports advanced capabilities, such as automatic dependent surveillance (ADS-B), required navigation performance area navigation (RNP-RNAV) and RNP-based special aircraft and aircrew authorisation required (SAAAR) procedures. "We do not make

The A300-600RF has a net structural payload of 97,327lbs, and the A310-300P2F a net structural payload of 79,142lbs or 81,342lbs.

displays ourselves for this type of application, but we do integration work. We are the prime integrator when required by the customer," says Villeneuve.

An electronic flight bag (EFB) that can be coupled with an enhanced vision system (EVS) is another option. "It is a check box type of approach," says Villeneuve. "We start from the FMS and then we add on as per customer requirements."

The reasons why an operator might want to retrofit an A300 vary. Long-term considerations include the size of the navigation database that can be accommodated in the existing system, and capabilities that might prove limiting over a further 25 or 30 years of service. "A lot of airlines will have big operational constraints because of the size of the database," he says. "The CMA-9000 is state of the art with a larger database which will allow them to enter all their routes and all their alternates, and be able to do precision approaches further down the line."

Villeneuve points out that other operators have more short-term operational reasons, such as wanting to save weight. The CMA-9000 combines the flight management computer and multi-function control display unit (MCDU) in a single box. Replacing the existing four boxes with just two new ones can save up to 60lbs in a typical FMS application.

"When you are looking at a 25-year lifespan, the growth potential becomes much more important," elaborates Villeneuve. "Another airline may just want the operational savings, to be able to have tighter routes, more routes, and save weight for more short- or medium-term benefits."

CMC believes the whole A300 fleet is a potential retrofit candidate, Villeneuve says, pointing out that with the existing system, it is possible to use a portable data loader with multiple diskettes to update the navigation database. But it can take around 90 minutes to reload a full database. "There are big operational constraints if you are planning to use the aircraft to go somewhere, and it takes an hour and a half to reload a new navigation database."

Some of the operators Villeneuve has canvassed are looking at the combination of FMS and GPS, others at FMS plus displays. While declining to specify costs, he says that Airbus's cockpit upgrade proposals tend to be, "way too big and way too expensive for any of the airlines to be able to move forward. The result of that is people like us going in at a much more reasonable price, with a much more reasonable, scalable approach to be able to answer the specific needs."

Flat panel displays

Innovative Solutions & Support has developed a glass cockpit upgrade for 737 Classics using flat panel liquid crystal displays (LCDs). The company says that it has also developed an architecture for the A300 cockpit, using thin displays that can be fitted in the cockpit without requiring excessive structural work.

Fuel system

Airbus offers an auto fuel feed controller (AFFC) upgrade for the A310 and A300-600. Developed with Goodrich Fuel and Utility Systems, the new AFFC is designed to improve maintainability and reliability by replacing the original system, which consists of up to 30 fault and control relays housed in multiple avionics panels. The system controls the centre and inner tank fuel pumps and the water scavenge pumps. Troubleshooting it requires substantial system knowledge, and can be further complicated as the relays themselves become less reliable with age.

The AFFC replaces all but six of the relays with a line replaceable digital computer that takes inputs from the aircraft power circuits, flight deck push-button switches and the refuel panel, as well as the tank level sensors, the fuel quantity computers and pump feedback signals. Automatic operation is selected by the crew on the overhead fuel panel.

The controller's built-in test equipment (BITE) provides improved assistance to maintenance crews for troubleshooting when genuine system failures are indicated. Light-emitting diodes (LEDs) on the AFFC's front panel display fault codes, while for base maintenance an ARINC 429 transmitter can be interrogated to provide system data for the previous 20 flights.

Airbus service bulletins (SBs) cover the two-stage provisioning and installation process.

Goodrich also offers a fuel-quantity-indicating system in-tank retrofit kit for the A300 and A310. Replacing all existing in-tank composite fuel probes, composite compensators, coaxial connectors and wet-side wiring, the kit avoids the problem of water shorting the compensator while improving reliability and avoiding connection corrosion. It uses heavier-gauge nickel-plated wiring with gold-plated round terminal lugs, chafe-resistant shielding, non-hygroscopic metal fuel probes and a wide gap all-metal compensator to provide what the vendor says is a mean time between failures (MTBF) of 70,000 hours. AC

A300-600 & A310 fuel burn performance

The operating and fuel performance of the A300-600 & A310-300 in a variety of roles is analysed.

The fuel burn and operating performance of the A300-600R, A310-200, and A310-300 families are analysed.

Each of these families has passenger and freighter variants. Of the passenger variants, the A300-600R and A310-300 have been analysed. In the case of freighter variants, the A300F4-600 factory freighter and the converted freighters of the A310-200 and -300 are analysed.

Performance is also dependent on engine selection. For the A300-600R passenger and freighter versions, the two most powerful engines from General Electric (GE) and Pratt & Whitney (P&W) are used: the CF6-80C2A5F (60,100lbs thrust); and PW4158 (58,000lbs thrust).

For the A310 family a wider range of engine types is represented in the analysis. For the A310-200P2F the previous generation CF6-80A3 (48,970lbs thrust) and JT9D-7R4E1 (50,000lbs thrust) have been used. For the A310-300P2F the CF6-80C2A2 (52,460lbs thrust), CF6-80C2A8 (57,860lbs thrust), PW4152 (52,000lbs thrust), and PW4156A (56,000lbs thrust) have been used.

In the case of the A310-300 passenger aircraft, the CF6-80C2A8 (57,860lbs thrust), JT9D-7R4E1 (50,000lbs thrust), PW4152 (52,000lbs thrust), and PW4156A (56,000lbs thrust) have been used.

Passenger aircraft analysis

One city-pair is used to analyse the A300B4-600R aircraft. This is Munich (MUC) - London Heathrow (LHR), which has a tracked distance of 534nm. For the A310-300, two city pairs are used: Lisbon (LIS) - Paris Charles de Gaulle (CDG), which represents a typical short-range route with a tracked distance of 833nm); and LIS - Toronto (YYZ), which has a tracked distance of 3,253nm, and represents a typical long-range route.

In all cases, aircraft performance has been analysed in both directions on each route 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).

In the flight plans performed by Airbus, 85% reliability winds have been used. The aircraft have been assumed to have full passenger payloads plus baggage, cruising at long-range cruise speed (LRC) of Mach 0.79 and to be carrying no additional belly freight. Two-class passenger loads have been assumed: 266 for the A300-600; and 220 for the A310.

The standard weight for each passenger plus baggage is 220lbs. The payloads for the A300-600 and A310s are therefore 58,643lbs and 48,502lbs respectively.

The flight profile used in each case is based on international Federal Aviation Regulations (FAR) flight rules. It includes standard assumptions on standard diversion plus holding fuel reserves, contingency fuel (based on a percentage of total trip time), optimum long-range cruise (LRC) speed for each aircraft, and using taxi times of nine minutes' taxi out and five minutes' taxi in.

A300-600R performance

Birmingham (BHX) in the UK is selected as an alternate airport for MUC-LHR. The two versions of the A300-600R, which all have a maximum take-off weight (MTOW) of 378,533lbs, encounter a 48-knot headwind component during cruise. This effectively increases the tracked distance of 534nm by 57nm to give a resultant ESAD of 592nm *(see table, page 14)*.

In the reverse direction to MUC, the alternate airport is Nuremburg (NUE). The headwind component is reduced to 8 knots on this sector, which results in a reduced ESAD of 543nm.

Comparing the performance of the PW4000 with that of the GE CF6-80C2A5-powered aircraft, it can be seen that while the operating empty weight (OEW) of the GE-powered aircraft is 176lbs heavier than the PW-powered aircraft, the GE-powered aircraft actually has a lower block fuel burn in both directions *(see table, page 14)*.

A310-300 short mission

For the A310-300 variants analysed on the LIS-CDG route, Lille is selected as the alternate airport when operating to CDG. The aircraft encounter a 6-knot headwind component during cruise. This adds to the tracked distance of 833nm by 10nm to give a resultant ESAD of 843nm *(see table, page 14)*.

In the reverse direction when operating to LIS, Faro (FAO) is the alternate airport. The headwind

The A310-300 is powered by several engine types and variants. Aircraft powered by the PW4000 have the lowest fuel burn per seat-mile.

FUEL BURN PERFORMANCE OF PASSENGER-CONFIGURED A300-600 & A310-300

City-pair	Aircraft variant	Engine type	Seats	Payload lbs	MTOW lbs	Actual TOW lbs	Fuel burn USG	Block time mins	ESAD nm	USG per pax-nm
MUC-LHR	A300-605R	CF6-80C2A5	266	58,643	378,533	286,274	2,517	100	591	0.018
MUC-LHR	A300-622R	PW4158	266	58,643	378,533	286,806	2,571	101	592	0.018
LHR-MUC	A300-605R	CF6-80C2A5	266	58,643	378,533	287,392	2,384	93	543	0.017
LHR-MUC	A300-622R	PW4158	266	58,643	378,533	285,642	2,434	94	543	0.017
LIS-CDG	A310-308	CF6-80C2A8	220	48,502	361,558	257,985	2,943	132	843	0.016
LIS-CDG	A310-322	JT9D-7R4E1	220	48,502	337,307	259,704	3,027	134	843	0.017
LIS-CDG	A310-324	PW4152	220	48,502	346,125	257,158	2,909	134	843	0.016
LIS-CDG	A310-325	PW4156A	220	48,502	361,558	257,980	2,916	134	843	0.016
CDG-LIS	A310-308	CF6-80C2A8	220	48,502	361,558	260,158	3,176	142	917	0.017
CDG-LIS	A310-322	JT9D-7R4E1	220	48,502	337,307	262,010	3,283	143	918	0.018
CDG-LIS	A310-324	PW4152	220	48,502	346,125	259,305	3,147	143	917	0.017
CDG-LIS	A310-325	PW4156A	220	48,502	361,558	260,154	3,157	143	917	0.017
LIS-YYZ	A310-308	CF6-80C2A8	220	48,502	361,558	328,469	12,652	490	3,660	0.018
LIS-YYZ	A310-322	JT9D-7R4E1	220	48,502	337,307	333,067	13,159	490	3,658	0.018
LIS-YYZ	A310-324	PW4152	220	48,502	346,125	325,896	12,398	489	3,658	0.017
LIS-YYZ	A310-325	PW4156A	220	48,502	361,558	326,936	12,435	489	3,658	0.017
YYZ-LIS	A310-308	CF6-80C2A8	220	48,502	361,558	313,261	10,723	428	3,173	0.015
YYZ-LIS	A310-322	JT9D-7R4E1	220	48,502	337,307	317,337	11,146	429	3,173	0.016
YYZ-LIS	A310-324	PW4152	220	48,502	346,125	311,290	10,535	428	3,174	0.015
YYZ-LIS	A310-325	PW4156A	220	48,502	361,558	312,284	10,566	428	3,174	0.015

component increases to 45 knots, resulting in a significantly increased ESAD of 917nm.

Comparing the performance of the different A310 variants, certain hardware variations should be noted. First, different MTOW/OEW versions are used, with different engine types powering them *(see tables, this page and page 15)*. Interestingly, the A310-322 powered by JT9D engines has the lowest MTOW, but a slightly higher OEW due to the installation of heavier engines. In addition, it suffers from higher fuel burn (and consequently requires a greater fuel load for a given mission) than do the other A310-300 airframe/engine variants that are powered by PW4100s or CF6-80C2s.

The PW4152 has slightly lower fuel consumption than the PW4156A and CF6-80C2A8 *(see tables, this page and page 15)*. All four aircraft/engine variants on this route can carry the full nominal payload of 220 passengers without restriction. In the reverse direction, there are also no restrictions, although the 45-knot headwind and ESAD of 917nm (compared with 833nm) result in 300 US gallons (USG) more fuel being burned in each case.

A310-300 long mission

The alternate airport used for the A310-300s on the LIS-YYZ direction is Pittsburgh (PIT), and the aircraft encounter a 53-knot headwind component during cruise. This adds 407nm to the tracked 3,253nm distance to give an ESAD of about 3,660nm *(see table, this page)*.

In the reverse direction, there is an assisting tailwind component of 12 knots, resulting in a reduced ESAD of 3,173nm.

Comparing the performance of the aircraft, which all have identical weight specifications to those analysed in the LIS-CDG city pair, it can be seen that there is a more marked difference in the fuel burn differences between the four aircraft/engine variants. For example, the worst performing aircraft is still the JT9D-powered A310-322, which burns 1,000 USG more fuel than the other variants. As before, the best performing aircraft is the PW4152-powered A310-324. All four aircraft/engine variants on this route can carry the full nominal payload of 220 passengers without restriction. In the reverse direction, there are also no restrictions.

Freighter aircraft analysis

Three types of A300/A310 freighters are analysed. Both the A300F4-600 (factory freighter) and the A310-200P2F (passenger to freighter conversion) are analysed on Memphis (MEM) - Calgary (YYC), which is representative of a typical medium-distance freighter route. This has a tracked distance of 1,487nm, and is typical of the type of route both these aircraft would operate.

The A310-300P2F (passenger to freighter conversion) is analysed on Dubai (DXB) - Istanbul (IST), which has a longer tracked distance of 1,705nm. This represents the longer-range capabilities of the A310-300P2F as a package freighter platform.

A300F4-600R performance

The A300F4-600 is represented here by two engine types (CF6-80C2A5F) and two MTOW variants (370,376lbs and 375,888lbs). The lighter variant is configured in 'payload mode' to allow for higher payload-packing densities. This has a high maximum zero fuel weight (MZFW) of 300,931lbs. This compares to the heavy MTOW variant which has an MZFW of 286,601lbs.

The aircraft with the higher MZFW consequently has a higher maximum structural gross payload of 122,248lbs. This is the same as the available payload demonstrated on the MEM-YYC route, since the aircraft is not MTOW-restricted. On the other hand, the aircraft with the lower MZFW has a maximum structural gross payload of only 107,918lbs. It has the same available payload uplift on the route since it is not MTOW-restricted.

Regarding any engine-related differences, there is a very slight fuel burn

FUEL BURN PERFORMANCE OF FREIGHTER-CONFIGURED A300-600 & A310-300

City-pair	Aircraft variant	Engine type	Payload lbs	MTOW lbs	Actual TOW lbs	Fuel burn USG	Block time mins	ESAD nm	USG per ton-nm
MEM-YYC	A300F4-605R	CF6-80C2A5F	107,918	375,888	344,542	6,938	235	1,664	0.097
MEM-YYC	A300F4-605R	CF6-80C2A5F	122,248	370,376	361,216	7,217	234	1,663	0.089
MEM-YYC	A300-F4-622R	PW4158	107,918	375,888	344,364	6,920	238	1,666	0.097
MEM-YYC	A300F4-622R	PW4158	122,248	370,376	361,086	7,210	238	1,665	0.089
YYC-MEM	A300F4-622R	PW4158	122,248	370,376	354,439	6,323	213	1,463	0.078
YYC-MEM	A300F4-605R	CF6-80C2A5F	107,918	375,888	337,569	6,017	211	1,463	0.084
YYC-MEM	A300F4-622R	PW4158	107,918	375,888	337,556	6,008	214	1,462	0.084
YYC-MEM	A300F4-605R	CF6-80C2A5F	122,248	370,376	354,346	6,314	210	1,463	0.078
MEM-YYC	A310-203P2F	CF6-80A3	85,246	313,056	298,435	6,268	237	1,663	0.111
MEM-YYC	A310-222P2F	JT9D-7R4E1	85,246	313,056	300,516	6,406	231	1,661	0.113
YYC-MEM	A310-203P2F	CF6-80A3	85,246	313,056	293,314	5,498	212	1,463	0.097
YYC-MEM	A310-222P2F	JT9D-7R4E1	85,246	313,056	295,547	5,655	206	1,463	0.100
DXB-IST	A310-304P2F	CF6-80C2A2	87,823	346,125	304,191	6,669	260	1,870	0.100
DXB-IST	A310-308P2F	CF6-80C2A8	87,823	361,558	304,191	6,669	260	1,870	0.100
DXB-IST	A310-324P2F	PW4152	87,823	346,125	304,044	6,590	262	1,870	0.099
DXB-IST	A310-325P2F	PW4156A	87,823	361,558	304,044	6,590	262	1,870	0.099
IST-DXB	A310-304P2F	CF6-80C2A2	87,823	346,125	300,327	6,018	237	1,681	0.090
IST-DXB	A310-308P2F	CF6-80C2A8	87,823	361,558	300,327	6,018	237	1,681	0.090
IST-DXB	A310-324P2F	PW4152	87,823	346,125	300,360	5,976	238	1,681	0.089
IST-DXB	A310-325P2F	PW4156A	87,823	361,558	300,360	5,976	238	1,681	0.089

advantage for the P&W-powered A300F4-622R compared with the GE-powered A300F4-605R. This results in the CF6-powered aircraft having a slightly higher fuel burn and having to carry a higher fuel load *(see table, this page)*. All the aircraft nevertheless operate comfortably within their MTOW limits despite differences in total fuel loads.

It is also worth noting that Edmonton is used as the alternate when operating to YYC. The aircraft encounter a 51-knot headwind, which results in an ESAD of 1,664nm, compared with an actual tracked distance of 1,487nm.

Greenville is the alternate airport on the return route to MEM, and here there is an assisting 8-knot tailwind which reduces the tracked distance to an ESAD of 1,463nm. These different ESADs result in a difference in block fuel burn of about 900 USG for the four variants. An exact aircraft-by-aircraft comparison on both directions is shown *(see table, this page)*.

A310-200P2F performance

The A310-200P2F, being an older aircraft, is powered by two earlier-generation engines: the GE CF6-80A3 and the P&W JT9D-7R4E1. Both A3100-200 variants have the same OEW, MTOW, and structural payload capability *(see table, this page)*. Both variants carry the same actual payload (85,246lbs) in both directions on the MEM-YYC city pair.

The main aircraft-related difference to note therefore, is the lower fuel burn for the CF6-80A-powered A310-203P2F, equating to a difference of 100-200 USG per sector.

The A310-200P2F encounter the same 51-knot headwind component as the A300F4-600R on the MEM-YYC direction, and the 8-knot tailwind component on the YYC-MEM operation. The effect these different ESADs have on aircraft block fuel burn is an approximate difference of 700USG. An exact aircraft-by-aircraft comparison in both directions is summarised *(see table, this page)*.

A310-300P2F performance

The final city-pair of DXB-IST is a longer route with a tracked distance of 1,705nm. This is suitable for the longer-range capability of the A310-300P2F converted freighter.

Here, all four variants are able to carry their maximum structural payload of 87,823lbs in both directions. All variants also have the same OEW of 163,503lbs, whereas the MTOW capabilities are either 346,125lbs or 361,558lbs *(see table, this page)*. Both GE and P&W provide an optimised engine variant for these two MTOW versions: the CF6-80C2A2 (52,460lbs thrust) for the lower MTOW A310-304P2F; CF6-80C2A8 (57,860lbs thrust) for the higher MTOW A310-305P2F; the PW4152 (52,000lbs thrust) for the lower MTOW A310-324P2F; and the PW4156A (56,000lbs thrust) for the higher MTOW A310-325P2F.

The P&W-powered aircraft enjoy a slightly lower fuel burn advantage over the GE-powered aircraft on the route in both directions *(see table, this page)*.

The aircraft encounter a 43-knot headwind when operating to IST, which increases the tracked distance of 1,705nm to an ESAD of 1,870nm. Despite this, the aircraft does not suffer a payload limitation. The variants' actual take-off weights are well within their respective MTOW capabilities. AC

A300-600/A310 maintenance analysis & budget

The maintenance costs of the A300-600 & A310-300 in their varied passenger roles are examined.

The A300-600 and A310 have become niche aircraft, with about 485 operating in a variety of models and roles. They are powered by four major engine groups, and were among the pioneers of extended range twin-engine operations (Etops) in the mid-1980s.

The A300-600 and A310 were used by many major airlines as short-, medium- and long-haul flagships. They have now been relegated to secondary roles, with many A310s having been converted to freighter. While most A300-600s are still in passenger operation, about 100 are factory-built freighters. The aircraft are no longer manufactured, but ages range from one to 25 years, so most are mature in maintenance terms.

A300-600 & A310 in operation

The A310-200 was launched in 1982, and designed as a short- and medium-haul aircraft. Only 85 were built, and all 65 remaining -200s are in operation with Fedex as freighters. These aircraft are used in the US and Europe as package carriers, and generate low rates of utilisation of 1,500-2,000 flight hours (FH) per year, and have average flight cycle (FC) times of 1.2-2.2FH.

The A310-300 is a higher gross weight model with a wing centre box fuel tank. Its longer range made it more appealing, and 170 were built. A small number of these have been converted to freighter, and are used as medium-haul aircraft. Most are still in passenger service, and large fleets are operated by Air India, Air Transat, Pakistan International Airlines (PIA), Turkish Airlines THY, and TAP Air Portugal. Passenger -300s are used on medium-haul operations, with FC times of 2-4.5FH. Annual utilisations are 3,000-4,000FH per year. TAP, for example, operates its aircraft at average FC times of 5.4FH, generating 4,100FH per year, on routes from Lisbon to Europe, Africa and Brazil. THY uses the aircraft from Istanbul on services mainly to Middle Eastern cities, with aircraft averaging FC times of 2.8FH and generating 3,400FH per year.

A total of 309 A300-600s were built. There are 33 passenger-configured -600s in service. Of the original 155 longer-range passenger-configured -600Rs built, 85 are still in operation as passenger aircraft, and 70 have been converted to freighters. There are also 101 factory-built -600R freighters in operation.

Most A300-600Rs are operated by American, which has 34. Other carriers are Korean Air, Thai International and Japan Airlines. Most of these aircraft generate 2,500-3,000FH per year at FC times of 1-3FH.

The majority of the 171 -600RFs are operated by FedEx and UPS, both of which use them at low rates of utilisation on short and medium FC times.

Overall, the A310 and A300-600 are mainly used on FC times of 1-3FH, although a small number of A310-300s are used on longer operations by a few carriers.

The maintenance costs of the A300-600 are analysed here on a short-haul operation with an average FC time of 1.2FH, and the aircraft generating 2,500FH and 2,000FC per year.

The maintenance costs of the A300-600R and A310 are analysed on medium-haul operations with average FC times of 2.8FH, and annual utilisations of 3,400FH and 1,200FC.

Maintenance programme

The A300-600 and A310 have a maintenance programme that is derived from the standard programme for all Airbus types. This comprises a cycle of eight C checks with an individual original interval of 15 months and cycle interval of 10 years, plus two sets of structural inspections with original intervals of 60 and 120 months. The first set at 60 months could therefore be combined with the fourth C check, the C4 check, to form what is usually known as the IL check. The first set would then become due again at 120 months together with the second set of structural inspections and combined with the eighth C check, the C8 check, to form the D check.

There have been 24 revisions to the maintenance planning document (MPD) since its original development.

The line maintenance programme is the standard for all types, with a daily check that has a maximum interval of 48 hours, a pre-flight (PF) check performed prior to the first flight of each day's operation, a transit (TR) check performed prior to all other flights in a day's service, and a weekly check that has a maximum interval of eight calendar days. As with most aircraft types, most operators have PF and TR checks performed by flightcrew, while daily and weekly checks are carried out by mechanics. The A300-600 and A310 are still frequently used for Etops services, however, in which case TR checks have to be performed by line mechanics.

The original A check interval was 400FH. There have been three revisions with some operators having intervals of up to 600FH in their maintenance programmes.

There is a cycle of eight C checks. The basic C check multiple has an interval of 15 months. The remaining multiples are the 2C, 4C and 8C tasks with intervals of 30, 60 and 120 months. The C2 check therefore includes the 1C and 2C tasks, the C4 check the 1C, 2C and 4C tasks, and the largest check, the C8, has the 1C, 2C, 4C and 8C tasks.

"The basic C check interval was later revised upwards to 18 months," explains Erhan Ozcan, manager production planning and control at Turkish Technic. This takes the full interval for the complete cycle of the eight C checks to 144 months.

In parallel with the C checks, there are also the two main groups of structural checks. Their original MPD intervals were five and 10 years, which conveniently coincided with the MPD intervals of the C4 and C8 checks.

The escalation of the C check interval to 18 months means that the C4 check now has an interval of 72 months, and the C8 check an interval of 144 months.

"The C2 check with the 1C and 2C tasks has an interval of 36 months, the C3 check an interval of 54 months, and the C4 check an interval of 72 months," says Thorsten Rauer, manager system engineering structure at Lufthansa Technik.

"The first set of structural tasks had their interval escalated to 72 months in 1999, meaning that the IL check was also extended to a 72-month interval. The cycle of C checks is repeated and the first set of structural tasks comes due again at 144 months. The second set of structural tasks for the D check still has an interval of 120 months, which means that all the tasks that formed the D check do not come due at the same time. This gives flexibility in planning base maintenance, but it also means that the aircraft can

A300-600/-A310 C CHECK TASK ORGANISATION

Check	Check task groups	MPD interval
C1	1C	15 months
C2	1C + 2C	30 months
C3	1C	45 months
C4/IL	1C + 2C + 4C+ 5-year	60 months
C5	1C	75 months
C6	1C + 2C	90 months
C7	1C	105 months
C8/D	1C + 2C +4C +8C + 10-year	120 months

require increased downtime for heavy maintenance. Given that most operators are unable to use all their check intervals, it is still likely that they will have the usual cycle of the IL check at the fourth C check and the D check after the next fourth C check in succession."

This means that most operators are likely to complete the maintenance cycle in eight to ten years. This will be equal to 24,000-32,000FH for aircraft operating at 3,000-4,000FH per year.

The number of FH accumulated during the calendar interval between subsequent C checks and over the full cycle of eight checks influences reserves per FH for base checks.

Line check inputs

The total amount of inputs for labour, materials and consumables depends on the number of each type of check being performed annually. This would be 50 weekly and 250-300 daily checks, irrespective of the number of FH and FC that the aircraft completes in a year.

Annual rates of utilisation and average FC times determine the number of PF and TR checks required each year. However, PF and TR checks for aircraft on non-Etops services are performed by flightcrew so they only require a few man-hours (MH) to be expended by mechanics for a minority of TR checks when no-go defects occur. Aircraft operated on Etops services have a higher MH requirement from mechanics for the TR checks performed at outstations.

PF and TR checks require a few materials and consumables. Airlines can expect to use an average of 1MH for each PF and TR check, and $5-10 in materials and consumables. Most airlines now use flightcrew to carry out PF and TR checks, so these checks do not incur labour costs.

Mario Araujo, engineering director at TAP Engineering & Maintenance, estimates that daily checks consume an average of 10MH. An aircraft will therefore need 2,500-3,000MH per year for its daily checks. Each daily check will use $80 of materials and consumables.

Araujo estimates that labour requirements for the larger weekly checks are 16MH, so an aircraft will consume 800MH for its weekly checks. A budget of $125 for materials and consumables should be used.

The total annual labour requirement for the PF/TR, daily and weekly checks is 5,800-6,300MH. About $55,000 of materials and consumables is required for aircraft operating on short-haul operations completing 3,000FH and 2,500FC per year.

The total input for aircraft used on medium-haul operations completing about 3,400FH and 1,200FC per year will be 4,500-5,000MH and $40,000 in materials and consumables.

Assuming a labour rate of $70 per MH for line maintenance and mechanics, the total cost for labour and materials is $460,000-495,000 for aircraft used on short-haul operations, and $355,000-390,000 for aircraft on medium-haul operations *(see tables, page 27)*.

This is equal to $155-165 per FH for aircraft used on short-haul operations, and $105-115 per FH for aircraft used on medium-haul operations *(see tables, page 27)*.

A check inputs

As described, the A check interval has been escalated from its original 400FH to as high as 600FH in some operators' cases. Actual intervals will be 350-500FH considering the usual limitations on using all of the check's interval.

"The labour required for the routine portion of an average A check is about 350MH," says Ozcan. "This requires another 250MH for non-routine work. An A check will also have some engineering orders (EOs), and will use an average of 30MH for this. This will need another 70MH for the non-routines that result. This takes the total labour expenditure to 700MH for the average A check on a mature aircraft."

Araujo estimates a similar labour requirement for the A310's A checks, with a total of 760MH required for the complete check. Using a generic labour rate of $70 per MH, the labour portion would cost $53,000. The associated cost of materials and consumables for the check is $13,000-15,000.

The total cost for the check would therefore be $66,000-70,000. Amortised over an interval of 350-500FH this would result in a reserve of $140-190 per FH *(see tables, page 27)*.

Base check contents

The C, IL and D checks in the maintenance programmes of Airbus aircraft provide airlines and operators with the opportunity to carry out tasks in addition to the routine inspections specified in the MPD and the rectifications that may arise as a consequence. These tasks include: service bulletin (SB) modifications; airworthiness directive (AD) inspections; inspection, testing, removal and installation of rotable components; clearing deferred defects; cleaning; interior refurbishment; and stripping and repainting. These elements will create large workpackages, particularly for the IL and D checks.

The IL and D checks are the larger checks, where most of these additional items are added. While operators are not forced to use these checks to complete these additional tasks, IL and D checks do provide the best opportunity for operators to complete them. Using other or additional checks will increase aircraft downtime.

"We use the C checks to make a deep clean of the whole interior of the aircraft," says Holger Jacobi, engineer maintenance planning services at Lufthansa Technik. "This does not involve the removal of seats, galleys or toilets. We do remove the complete interior at the IL and D checks. Here the items are refurbished. We also have a smaller refurbishment half-way between the IL and D checks without removing the interior."

All of the described items will be included for passenger-configured aircraft, particularly in the D check. Freighter aircraft require fewer MH for the element of interior cleaning and refurbishment, but do nevertheless require some labour input to maintain the aircraft's freight loading and handling system. This means that freighters will require only slightly fewer MH than passenger aircraft for the IL and D checks.

Engineering orders

The A300-600 and A310 has had few major ADs and SBs.

The A310 has recently had an AD relating to cracks that were found in the fuselage centre wingbox: AD 07-184.

A large number of A300-600s and A310s operate with their primary operators on short- and medium-haul services. Most airlines' aircraft operate at flight cycle time of 1.0 to 3.0 flight hours.

There are two SBs relating to this AD. The first SB is A310-53-2111, and is a mandatory inspection with threshold intervals of 6,200-7,100FC and 14,300-31,000FH depending on aircraft configuration. The inspections add only 2-5MH.

The second is SB A310-53-2119, and requires a modification to rectify cracks in the event of findings during the inspection. This is usually done in an IL or D check, and Sebastian Eichentopf, aircraft system engineer at Lufthansa Technik, estimates that it requires 590MH and $1,500-2,000 for each side of the aircraft.

A second major AD is French AD number CN-F 200-5-084, and has two SBs related to it. The first is SB A310-53-2117, relating to a mandatory inspection of the nose area of the fuselage at frame 12A. This is not needed until the aircraft has accumulated 12,700-19,300FC, and is estimated to use about 99MH.

The second SB is SB A310-53-2116, and is a mandatory modification in the event that findings arise from the inspection. It involves improving the fitting on frame 12A with the frame 12A cabin floor crossbeam. Eichentopf estimates that this uses 360MH and $5,500 in materials and consumables.

This AD also affects the A300-600. The two SBs for the aircraft are SB A300-53-6138 for the inspection and SB A300-53-6137 for the modification.

A third major AD is French AD number CN-F 2005-001. Ozcan refers to the mandatory inspection, covered by this AD, on the rear spar internal angle and tee fitting. SB A310-57-2047 is estimated to use 600MH and up to $18,500 in materials for completion. The threshold for the inspection is 9,100-41,300FC and 16,600-66,500FH depending on aircraft type and configuration.

A fourth major AD relates to a mandatory modification required on the A310, which was the reinforcement to the fuselage at the butt joint at frame 55 and 58. The inspection is covered by AD07-0111 and the modification by SB A310-53-2125. The modification would be completed in an IL or D check, and Eichentopf estimates that completion of the modification uses 2,500MH, while the kit of parts costs $4,640.

A fifth major AD affecting the A310 is covered by AD 2007-0195. This concerns a mandatory inspection of the main landing gear attachment at the fifth wing rib on the rear wing spar. This is covered by SB A310-57-2091. The initial inspection interval is 12,000FC, and only uses about 6MH. The recommended modification is covered by SB A310-57-2090 and involves fixing bushings at the main landing gear attachment. This would be done during an IL or D check, and would use about 350MH and $4,000 in materials for each side of the aircraft.

There are three major ADs affecting the A300-600/-600R. The first is AD 2007-0173, which concerns a mandatory modification to change a fastener at frame 91 of the fuselage. This is covered by SB A300-53-6156 and has an initial threshold of 2,500FC accumulated from November 2006. Eichentopf estimates that completion of this requires 61MH and $38,000 of materials.

The second major AD is French AD CN-F-2006-016, which concerns a mandatory inspection of the upper radius of the frame 47 in the fuselage. This is covered by SB A300-53-6029, and has an initial interval of 10,000FC. It should be done during an IL or D check and uses 30MH and $125-750 on materials. The repair to the frame 47 upper radius required in case of findings is covered by SB A300-53-6114. It should be completed during an IL or D check.

The third major AD is not yet applicable, but is expected to be issued within one year. This is a mandatory inspection covered by SB A300-57-6107 for the rivets at frames 47 and 48 at a threshold of 12,000FC, but only uses 5MH. The recommended modification is covered by SB A300-57-6106 and requires an improvement to the drainage of the forward fuselage section. This is estimated to require 40MH and $4,000 in materials for each side of the aircraft.

A major modification affecting several aircraft types, following the in-flight deployment of a thrust reverser of a PW4000 engine on a Lauda Air 767-300 in 1991, also affects the A300-600 and A310. This involved a safety mechanism to prevent in-flight deployment referred to as the 'third line of defence'. This affects both PW4000 and CF6 engines. Jose Luis Rosario, planning and production control manager at TAP Maintenance & Engineering, estimates that completion of the modification requires a total of 800MH, and involves a material cost of $100,000.

Base check inputs

The C, IL and D checks comprise several elements, as described.

The C1, C2, C3, C5, C6, and C7 checks are lighter C checks, and although the number of routine MH varies for the element of routine tasks, there is a big difference between the total MH used for the checks. The C1 and C3 checks are smaller than the C2 check because there are many 2C tasks.

For the A310, 1,500MH are used for the routine element of the check. Another 700MH are used for findings arising from the routine inspections and 400MH are used for the interior cleaning and refurbishment. Another 300MH can be budgeted for ADs and SBs, 500MH for out-of-phase (OOP) tasks and 50MH for component changes. This takes the total to about 3,500MH. The associated cost of materials and consumables for the check is $72,000.

The A300-600 & A310 have a base maintenance programme base on a cycle of eight C checks, with a standard interval of 15 months. This interval has been escalated to 18 months. The complete cycle of eight checks consumes 75,000-85,000 man-hours.

The inputs for the A300-600/-600R are marginally higher, with most elements requiring another 100MH, taking the total to 3,900MH. The associated cost of materials is $75,000.

The IL and D checks consume the majority of MH in the cycle of eight base checks. In the case of the A310, the IL check will use about 25,000MH, depending on age and non-routine ratio. The routine tasks will use about 13,000MH, the non-routine findings another 7,000-10,000MH, the ADs and SBs 1,500MH, OOP tasks 800MH, component changes about 500MH and interior cleaning and refurbishment about 1,500MH. The ratio of material and consumable consumption per MH used is about twice the rate as for C checks, and the IL check will require $1.05 million.

The A300-600/-600R will use 2,000-3,000MH more, the routine element using about 1,500MH more and the resulting non-routines another 1,000MH. The check will also use $1.08 million of materials and consumables.

The D check uses another 5,000MH and $170,000 more in materials than the IL check in the case of both aircraft types.

Stripping and repainting should be added to this. Intervals between new paint jobs vary, but many operators will take the opportunity to strip and repaint the aircraft at the IL and D checks. This uses 1,500-1,900MH and about $50,000 in materials. A generic labour rate of $50 per MH will take the total cost to $125,000-145,000.

The total cost for the eight checks for the A300-600 is 85,000MH and $2.6 million in materials and consumables for the A300-600 operated on short-haul services with an average FC time of 1.2FH. Using a generic labour rate of $50, this is equal to a total of $6.85 million. Amortised over the interval of 22,500FH that would be accumulated over nine years *(see first table, page 27)*, this is equal to $310 per FH.

The total expenditure for the eight checks is about 79,000MH and $2.8 million in materials and consumables for the A310. Using a generic labour rate of $50 per MH for base maintenance, this takes the total to about $6.8 million. Amortised over the nine-year interval for the cycle of base checks, in which the aircraft accumulates about 31,000FH in its medium-haul operation, the reserve is equal to $220 per FH *(see second table, page 27)*.

The total cost for the eight checks for the A300-600R is about 89,000MH and $2.9 million in materials and consumables for the A300-600/-600R. This is equal to a total of $7.4 million at a generic labour rate of $50 per MH. This is equal to $240 per FH when amortised over the same interval *(see second table, page 27)* for an aircraft that is used on short-haul operations of about 1.2FH and completes its base maintenance cycle every eight to nine years.

Rotable components

Like all modern types, the majority of rotable components on the A300-600 and A310 are maintained on an on-condition basis. The two aircraft share many of the same component part numbers, and each uses about 800 different rotable part numbers. Each type has a total of about 1,500 rotables installed, although the number varies according to aircraft configuration.

About 120 parts numbers and 250 installed parts on the aircraft are maintained on a hard-time basis, while the remaining 1,270 or so are maintained on-condition.

Total support rotable packages will have three cost elements: a lease rate for a consignment of homebase stock at $20-30 per FH; a pool access fee for the remaining stock of parts which will be $55-60 per FH; and a power-by-the-hour (PBH) fee for repair and management of about $150 per FH. This will total $225-240 per FH *(see tables, page 27)*.

While some operators choose to depend on all-inclusive rotable support packages, rotables are required during A and base checks, as well as during line maintenance and operations. Operators therefore have to source on-condition rotables that fail on test during base checks. Rotables are repaired at several different facilities and providers. Northeast Aero repairs a large number of rotables on the A300-600 and A310, in particular pneumatic system components originally manufactured by Honeywell, and hydraulic system components made by Parker Eaton. "We also repair many of the flight control and other hydraulic components," says Vic Calabrese, vice president of operations and quality control at Northeast Aero Inc. "We specialise in pneumatics, hydraulics and electro-mechanical actuators for the A300-600 and A310."

The A300-600 and A310 have entered the secondary market, and some have been converted to freighter. The disposal of some fleets provides opportunities for airlines to dispose of their rotable inventories, and for new carriers to acquire surplus stock from the aftermarket. Northeast Aero's sister company Jetaway Aviation Services (JAS) is a specialist component aftermarket consumable and rotable supplier, which offers exchange rotable components, and acquires and provides rotable inventories. "We have bought and disassembled various aircraft types for their rotables and then either made them available for sale on the aftermarket or made them available for exchange," says Cliff Lorenzo, operations manager at JAS. "We also buy packages of surplus rotable stocks from airlines, and would also consider entire rotable inventories. We have also previously provided complete rotable support packages for airlines, and in the past supported Polar Air Cargo's European 747 operation at its base in Prestwick, Scotland. We could potentially support small fleets of A300-600s and A310s for an airline that might be operating a fleet of freighter converted aircraft. Our advantage is that we share some facilities and overheads with our sister company Northeast Aero, which can provide repair services for many of the rotables and so save time and costs."

Heavy components

Besides rotable components, consideration must be given to the costs of the four categories of heavy components: wheels and brakes; landing gear; thrust reversers; and the auxiliary power unit (APU). The removals of wheels and brakes, and thrust reversers are related to FCs, and therefore the cost of these components, are affected by aircraft utilisation and FC time.

The two main engine types on the A300-600 and A310 are the PW4000 and CF6-80, which both have similar thrust reversers with similar removal intervals in the region of 6,000FC. The workscope for repair and overhaul varies with condition, which worsens as removal interval increases. Disbonding on panels and materials results in the highest costs. A typical shop visit cost of $320,000 results in a reserve of $54 per FC for each shipset, and $108 per FC for the two units *(see table, page 24)*.

Landing gear exchange and overhaul fees at current market conditions are in the region of $600,000, which is low compared to the figure for other widebody types. Landing gear overhaul has a calendar interval of eight years, which is equal to 9,600FC for the A300-600R and A310 used on short-haul operations and accumulating about 1,200FC per year. The interval for an A300-600 on short-haul operations and accumulating about 2,000 per year will be 16,000FC.

Reserves for landing gear will therefore be about $65 per FC for aircraft used on medium-haul operations and $38 per FC for aircraft used on short-haul operations *(see table, page 24)*.

The A300-600 and A310 both have eight main wheels and two nose wheels. Wheels are removed when tyre treads have become worn. Tyres are then remoulded four or five times before being replaced. Wheels are also inspected when tyres are removed for remoulding. Average intervals for wheel removals are about 300FC.

Brake units are removed for repair when disc thicknesses have worn to the legal minimum.

Typical tyre remould costs are $500-600 per tyre, while new tyres cost $900-1,200. Wheel inspections cost in the region of $1,000, while brake unit repairs cost $40,000 per unit.

The overall cost for remoulding and replacing the aircraft's complete shipset of tyres, inspecting the wheels, and repairing the eight brake units is about $224 per FC *(see table, page 24)*.

The A300-600 and A310 use the GTCP 331-250 APU. The GTCP 331-250 had poor reliability, but this has improved and shop visit intervals have now increased to about 3,000 APU hours. How this relates to aircraft FH and FC depends on how the APU is used during turnarounds between flights. The APU is used for one hour in many cases, and so the shop visit removal interval will be equal to about 3,000FC. An average shop visit cost of $250,000 will see APU reserves of $85 per FC *(see table, page 24)*.

Total costs per FC for aircraft used on short-haul operations and accumulating about 2,000FC per year will be about $455 per FC. This will be equal to about $380 per FH *(see table, page 24)*.

Total costs per FC for aircraft used on medium-haul operations and accumulating about 1,200FC per year will be about $485 per FC. This will be equal to about $175 per FH *(see table, page 24)*.

A300-600 & A310 HEAVY COMPONENT MAINTENANCE COSTS

Number of main & nose wheels	8 + 2
Tyre retread interval-FC	270/220
Tyre retread cost-$	600/450
Number of retreads	5
New main & nose tyres-$	1,200/1,000
$/FC retread & replace tyres	**26**
Wheel inspection interval-FC	270/220
Main & nose wheel inspection cost-$	1,000
$/FC wheel inspection	**38**
Number of brakes	8
Brake repair interval-FC	2,000
Brake repair cost-$	40,000
$/FC brake repair cost	**160**
Landing gear interval-FC	16,000/9,600
Landing gear exchange & repair fee-$	600,000
$/FC landing gear overhaul	**38/65**
Thrust reverser repair interval-FC	6,000
Exchange & repair fee-$/unit	320,000
$/FC thrust reverser overhaul	**108**
APU hours shop visit interval	3,000
APU hours per aircraft FC	1.0
APU shop visit cost-$	250,000
$/FC APU shop visit	**85**
Total-$/FC	**455/485**
Total-$/FH passenger aircraft @ 1.2FH per FC	**380**
Total-$/FH passenger aircraft @ 2.8FH per FC	**175**

Engine maintenance

The A300-600 and A310 fleets are powered by four main engine types. A minority of A300-600s and A310-200s are powered by the JT9D-7R4 series and CF6-80A2 engines. A larger number of the higher gross weight A300-600Rs and A310-300s are powered by the PW4000 and CF6-80C2 engines.

Engine maintenance costs are dependent on thrust ratings and average FC times of operation.

PW4000

The PW4000 is rated at 58,000lbs thrust for the A300-600R (PW4158), and at 52,000lbs and 56,000lbs for the A310-300 (PW4152 and PW4156A).

The PW4000 can be sub-divided into two fleets of engines which have had the Phase III upgrade to improve exhaust gas temperature (EGT) margin and EGT margin retention during operation. Auvanish Narayen, engine programme manager at Total Engine Support, explains that the PW4152 Phase III engine has a mature EGT margin following a shop visit of about 50 degrees centigrade. This compares to about 36 degrees for non-Phase III engines. These are test cell EGT margins, and on-wing installed EGT margins are 5-10 degrees higher than this.

Narayen explains that initial rates of EGT margin loss are about 13 degrees in the first 1,000EFC on-wing. This rate then reduces to 5-10 degrees centigrade per 1,000EFC, although the rate depends on the operating environment and whether the practice of water washing is used.

The PW4000 has high enough EGT margin for most of these engines not to be removed due to EGT margin and performance loss. More common removal causes are deterioration of high pressure turbine (HPT) stage 1 and stage 2 blades.

A large number of engines have had to be removed to comply with the ring case modification, which is covered by AD 2003-19-115. This modification requires each engine to have a new rear case on the high pressure compressor (HPC). The deadline for completing this modification on all PW4000 engines is 2009. The AD also requires stability tests to be done on the HPC on unmodified engines at 2,800EFC since overhaul. The test is done on a complete engine in the test cell. If the the engine fails the test it has to be split in the shop and the modification must be done. This costs about $300,000 and is usually incorporated in a shop visit.

Removal intervals depend on average EFC time. For the PW4152 powering the A310 they are: 4,500EFC and 9,000EFH at an average EFC time of about 2.0EFH; about 4,000EFC and 12,000EFH at an average EFC time of 3.0EFH; and about 3,800EFC and 15,500EFH at an average EFC time of 4.0EFH.

The intervals for the PW4158 powering the A300-600 are about 5,000EFH and EFH at an average EFC time of 1.0EFH, about 7,500EFH and 3,750EFC at an average EFC time of 2.0EFH and about 11,000EFH and 3,500EFC at an average EFC time of 3.0EFH.

There are two main shop visit workscopes for the PW4000: a core heavy maintenance; and an engine heavy maintenance.

The core heavy maintenance is used to restore engine performance and focuses on the HPC and HPT core modules. This includes visual inspections of the low pressure compressor (LPC) and low pressure turbine (LPT) modules. Heavy maintenance is performed on the HPC and HPT, and a check and repair is made on the gearboxes.

This level of workscope will use 3,500-4,000MH of labour, about $1.1 million in materials and parts, and up to about $0.8 million in sub-contract repairs. A generic labour rate of $70 per MH will take the total cost of the shop visit to about $2.1 million.

The engine heavy maintenance workscope performs heavy maintenance on all modules, and is used to restore the maximum amount of performance possible.

This workscope will use 4,500-5,000MH of labour, about $1.7 million in parts and materials, and $1.0 million in sub-contract repairs. The same labour rate will take the cost of the shop visit to about $3.0 million.

Narayen explains that most PW4000s typically follow a shop visit pattern of alternating core heavy maintenance and engine heavy maintenance workscopes.

Engine removal patterns have to be managed around life limited parts (LLPs). All except two LLPs in the PW4000 have lives of 20,000EFC, and a full shipset of parts has a list price of $3.4 million.

The removal intervals of most engines are 3,500-5,000EFC, so most engines could have their LLPs replaced every fourth shop visit. Shorter removal intervals of 3,500-3,800EFC means that LLPs could remain in the engine for a fifth removal interval, but would then force a heavier shop visit when a core heavy maintenance is likely to be required. This would, however, allow most of the LLP lives to be used and overall achieve the lowest possible cost per EFC.

LLPs are therefore likely to be replaced after 18,000-19,000EFC. This would result in reserves of $180-190 per EFC.

The total cost of the two shop visits is $5.0-5.2 million. For the PW4152, this is equal to a reserve of about $278 per EFH for engines operating at 2.0EFH, $215 per EFH for engines operating at 3.0EFH, and $180 per EFH for engines operating at 4.0EFH.

For the PW4158, this is equal to a reserve of $520 per EFH for engines operating at 1.0EFH, $350 per EFH for engines operating at 2.0EFH, and $245 per EFH for engines operating at 3.0EFH.

A third element of engine maintenance reserves is for quick engine change (QEC). This is $15-20 per EFH.

When combined with reserves for LLPs adjusted for EFC time, total reserves vary with average EFH:EFC ratio. For the PW4152 powering the A310, total reserves are $388 per EFH for engines operated at an EFC time of 2.0EFH, $290 per EFH for engines operated at 3.0EFH, and $245 per EFH for engines operated at 4.0EFH *(see second table, page 27)*.

In the case of the PW4158 powering the A300-600R, reserves are about $730 per EFH for engines operating at 1.0EFH, $460 per EFH for engines operated at 2.0EFH, and $320 per EFH for engines operated at 3.0EFH *(see tables, page 27)*.

CF6-80C2

The CF6-80C2 has four thrust ratings for the A300-600R: the -80C2A1 at 59,000lbs thrust; the -A8 at 59,000lbs thrust; the -A3 at 60,200lbs thrust; and the -A5 rated at 61,300lbs thrust. The CF6-80C2 has two ratings for the A310-300: the -A2 rated at 53,500lbs, and the -A8 that is also used for the A300-600R.

The first three variants for the A300-600R are flat rated at 30 degrees centigrade, meaning that thrust reduces from its maximum level when outside air temperature is higher than this. The -A8 is flat rated at 35 degrees, while the -A2 is flat rated at 44 degrees. This gives operators more ability to operate in hot climates without suffering loss of operating performance.

The CF6-80C2 freighter has power management controls (PMC) or a full authority digital engine control (FADEC) system. Engines with FADEC controls tend to have better performance retention.

The majority of CF6-80C2s powering the A300-600 and A310 are mature, and have been through their first shop visit. EGT margins are less than for new engines, and are generally higher for the block 3 engines that were the last batch to be manufactured. Earlier block 1 engines have been improved, however, with better blades and vanes. This means that the mature EGT margins of the three production groups are similar.

EGT margins are 35-50 degrees, depending on the exact variant and previous shop visit workscope. EGT margin erosion rates are the highest for engines operating on short cycle times.

Engines operating on the A300-600 with short FC times of about 1.0FH can lose 14 degrees of EGT margin in the first 2,000EFH/2,000EFC, and lose four degrees per 1,000EFH thereafter. Engines in this style of operation typically remain on wing for about 5,000EFH and 5,000EFC.

Engines on the A300-600 operating longer cycles of about 2.0FH lose eight degrees of EGT margin in the first 1,000EFH on wing, and then about three degrees per 1,000EFH thereafter. These engines have on-wing intervals of about 4,500EFC and 9,000EFH.

Engines used on the A300-600 at FC times of 3.0FH have lower EGT margin loss rates of 7-10 degrees in the first 2,000EFH, and then 2-3 degrees per 1,000EFH. This would allow a total on-wing interval of about 4,000EFC and 12,000EFH. Longer cycle times of about

The cycle of eight base checks on the A300-600 and A310 is completed about every nine years. Most aircraft in the fleet will have been through one or two base maintenance cycles.

4.0EFH are rare, but intervals of 12,000EFH can be expected, equal to 3,000EFC.

Most A310-300 operations operate at medium-haul cycle times of about 3.0EFH, and -A2 engines can typically achieve intervals of about 5,000EFC and 15,000EFH. This is a 1,000EFC longer interval compared to higher thrust engines used on the A300-600.

Engines used on long-haul operations can enjoy long removal intervals due to the relatively high EGT margin, and hardware deterioration is the main cause for removals. Older engines with PMC controls do, however, experience more removals due to performance loss than engines with FADEC controls.

The CF6-80C2 has several ADs that can force removals. The first of these is AD 2006-16-06, which requires the reworking of the dovetail slots on the first stage HPT blades. This requires an inspection every 3,000EFC, and so will limit removal intervals for engines on medium- and long-haul operations. The slots eventually have to be reworked after an accumulated 10,000-14,000EFC, and the LLP concerning these slots will eventually be replaced.

AD 2002-25-08 affects another LLP, the HPC stage 3-9 spool. It also requires an inspection every 2,000-3,500EFC. This can be avoided by replacing the LLP at a cost of about $250,000.

AD 2004-22-07 requires an inspection of the stage 2 nozzle guide vanes (NGVs) initially after 1,600EFC. This therefore forces an early removal. A new set of NGVs has a list price of about $290,000.

Removal intervals also have to be managed around LLPs. The CF6-80C2 has 20 LLPs: four in the fan and booster module; six on the HPC; four in the HPT; and six in the LPT. The prices of these four groups of parts are $950,000, $950,000, $620,000 and $865,000 respectively, taking the cost of a shipset to about $3.4 million.

There are several part numbers for each part, but many of the latest part numbers have the full lives of 15,000EFC or 20,000EFC. Most variants have LLPs with lives of 20,000EFC in the fan/booster, HPC and LPT modules. The HPT modules have lives of about 15,000EFC.

Unless parts have restricted lives shorter than 15,000 EFC, this allows engine maintenance management to be relatively simple. That is, the typical range of removal intervals of 4,000-8,000EFC allow replacement of LLPs with lives of 20,000EFC every two to five shop visit removals, and replacement of LLPs with lives of 15,000EFC every two or three shop visits. This can be achieved while leaving only short stub lives of LLPs in most cases.

In the case of engines powering the A300-600R, the removal intervals provide convenient LLP replacement timings for engines operated at 1.0EFH cycle lengths. Most parts could be replaced every third or fourth shop visit, depending on their lives. This would result in reserves of about $180 per EFC.

Engines on cycle times of 2.0EFH will still have their LLPs replaced every third and fourth shop visit, but the LLPs will be replaced with more stub life remaining because the EFC removal intervals are shorter than for engines operated at EFC times of 1.0EFH. These longer cycle engines will have LLPs of about $200 per EFC.

Engines operated at 3.0EFH per cycle and with removals of about 4,000EFC will have their LLPs replaced every third and fifth shop visit. The LLPs with lives of 20,000EFC have little or no stub life in this case. This results in LLP reserves of $190 per EFC.

Lower rated engines on the A310-300, which are operated at EFC times of 3.0EFH and achieve longer intervals of 5,000EFC between removals, have LLPs replaced at third and fourth shop visits, with little or no stub life remaining. LLP reserves are therefore about $180 per EFC.

The probable removal intervals will affect shop visit workscopes and workscope patterns. The HPT and HPC will require a heavy scope or overhaul every removal. The two low pressure modules will follow an alternating pattern of light and heavy or overhaul workscopes at a high EFC interval of 1.0EFH.

A similar pattern of module workscopes will be followed by engines operated at longer EFC times of 2.0EFH and 3.0EFH, although workscopes on average will be lighter as cycle times. This will consequently reduce the labour, material and parts inputs required for the workscopes.

The lower rated engines operated on the A310-300 will also follow a similar shop visit workscope pattern when used at EFC times of 3.0EFH.

A light workscope or performance restoration on the HPT and HPC will use about 4,000MH in labour, $1.0 million in parts and materials, and $250,000 in sub-contract repairs. A generic labour rate for engine maintenance of $70 per MH will take this to a total of $1.6 million.

A heavier performance restoration or light overhaul will require about 500MH more labour, $300,000 more in parts and about $50,000 more in sub-contract repairs. This will take the total to $1.8 million.

A heavy overhaul will use about 5,000MH of labour, $1.6 million in parts and materials, and about $300,000 in sub-contract repairs. This will take the total to about $2.3 million.

A light LPT workscope uses about 700MH, requires about $120,000 of parts and materials, and $50,000 in sub-contract repairs, resulting in a total of about $200,000. A heavier LPT workscope will cost a total of $300,000.

A fan and booster overhaul will cost in the region of $250,000.

Total shop visit costs for the complete engine will therefore vary according to average EFC length and particular removal interval. High-rated engines for the A300-600 operated at 1.0EFH will have total shop visit costs of $2.3-2.7 million, while those operated at 2.0EFH will cost $1.9-2.6 million. Engines used at higher cycle times of 3.0EFH will have total costs of $2.0-2.3 million.

A third element of QEC costs at a rate of $15-20 per EFH should be added.

Once LLP reserves are added, this will take total reserves to $700 per EFH and EFC for the -80C2A8 powering the A300-600/-600R operated at 1.0EFH, to $375 per EFH when operated at 2.0EFH, and $265 per EFH when operated at 3.0EFH *(see tables, this page)*.

Shop visit costs for lower rated -80CA2 engines powering the A310-300 will be $2.2-2.6 million, and total reserves for an EFC time of 3.0EFH, including LLPs, will be $240 per EFH *(see second table, this page)*.

Reserves for the JT9D-7R4H1 and CF6-80A3 powering earlier examples of the A300-600 and A310-300 are high by comparison. The JT9D-7R4H1, for example, has reserves in the region of $470 per EFH when operating at an average EFC time of 2.0EFH, about $410 per EFH at an average EFC time of 3.0EFH, and $355 per EFH at an average EFC time of 4.0EFH.

The CF6-80A3 powering lighter examples of the A310-300 has reserves of about $400 per EFH when operating an average EFC time of 3.0EFH.

Maintenance cost summary

The difference between short- and medium-haul operations is clearly illustrated by the total costs per FH. Aircraft operating on an average FC time of 1.2FH have about 60% higher costs. Most of this difference is accounted for by engine maintenance.

As with all aircraft types, engine reserves follow an asymptotic relationship with increasing EFC times. Reserves for the CF6-80C2A8, for example, are about $700 per EFH at 1.2EFH per EFC and $265 per EFH at 3.0EFH.

The result is that total maintenance costs for the A300-600 on short-haul operations are $2,600-2,800 per FH, with engine reserves accounting for 55-60% of this *(see first table, this page)*.

Reserves for the A300-600R operated at 2.8FH per FC are $1,490-1,600 per FH. Engine reserves account for about 35% of the total *(see second table, this page)*.

Total maintenance costs for the smaller A310-300 operated at the same flight cycle time of 2.8FH are $1,345-1,445 per FH *(see second table, this page)*.

There is a smaller difference between the reserves for airframe maintenance and costs associated with heavy components and rotables for aircraft operated on short- and medium-haul missions. AC

MAINTENANCE COSTS FOR PASSENGER-CONFIGURED A300-600

Maintenance Item	Cycle cost $	Cycle interval	Cost per FC-$	Cost per FH-$
Line & ramp checks	490,000	1 year		155-165
A check	66,000-70,000	350-500FH		140-190
Base checks	6,850,000	22,500		310
Heavy components:			455	380
LRU component support				225-240
Total airframe & component maintenance				**1,205-1,315**
Engine maintenance:				
2 X PW4158: 2 X $730 per EFH				1,460
2 X CF6-80C2A8: 2 X $700 per EFH				1,400
Total direct maintenance costs:				**2,600-2,800**

Annual utilisation:
2,500FH
2,000FC
FH:FC ratio of 1.2:1.0

MAINTENANCE COSTS FOR PASSENGER-CONFIGURED A300-600R & A310-300

Maintenance Item	Cycle cost $	Cycle interval	Cost per FC-$	Cost per FH-$
Line & ramp checks	355,000-390,000	1 year		105-115
A check	66,000-70,000	350-500FH		140-190
Base checks - A310-300	6,800,000	30,500		220
Base checks - A300-600R	7,400,000	30,500		240
Heavy components:			485	175
LRU component support				225-240
Total airframe & component maintenance: A310-300				**865**
Total airframe & component maintenance: A300-600R				**960**
Engine maintenance A310-300:				
2 X PW4152: 2 X $290 per EFH				580
2 X CF6-80C2A2: 2 X $240 per EFH				480
Total direct maintenance costs A310-300:				**1,345-1,445**
Engine maintenance A300-600:				
2 X PW4158: 2 X $320 per EFH				640
2 X CF6-80C2A8: 2 X $265 per EFH				530
Total direct maintenance costs A300-600R:				**1,490-1,600**

Annual utilisation:
3,400FH
1,200FC
FH:FC ratio of 2.8:1.0