

The 747-400 is entering a period of transition. Many first-tier carriers are in the process of replacing their 747-400s in preference of new, more fuel-efficient types. The market prospects of used 747-400s are considered.

Investment & used market potential of 747-400s

With newer, more fuel-efficient, large widebodied aircraft, such as the 777-300ER and the A380 being rolled out by Boeing and Airbus, the 747-400 fleet is entering a period of transition. Retirements by most passenger operators of the 747-400 have increased since 2002 as airlines update their fleets.

The best market opportunity for the 747-400 is conversion to freighter. There is no sign of a 777-300F coming available, and the A380F development is on hold. The 747-400 freighter will therefore continue to be in its own size class for the foreseeable future. Market prospects may be relatively strong.

The 747-8F and, to a lesser extent, the 777F, are in similar size categories. Boeing is producing these in large quantities, and so undermining the 747-

400 conversion market. With new factory-built freighters, however, having high acquisition and leasing costs, the 747-400F and converted 747-400s should remain popular with some freight operators for up to another 10 years.

With many 10- to 20-year-old 747-400s in operation, there is a sizeable number of aircraft at, or approaching, the prime age for freighter conversion (about 15 years old) that are likely to come available as retirements of passenger-configured aircraft continue.

The 747's size means demand for used examples in the passenger market is small.

There are still about 300 passenger-configured 747-400s in operation, and many will come onto the used market over the next 10 years. The used market options and investment potential of used 747-400s are considered here.

747-400 fleet profile

Of the total of 664 active and parked 747-400s, in differing variants, a total of 625 are still in active operational service (see table, this page). Of these, 356 are in passenger configuration, comprising 341 747-400s, six 747-400ERs, and nine 747-400Ds. A further 43 aircraft are 747-400 Combis.

226 aircraft are freighters, of which 122 are factory-built 747-400Fs, and 38 are 747-400ERFs. Bedek has converted 23 747-400BDSFs, while Boeing has converted 43 747-400BCFs.

The 747-400 fleet is sub-divided into three main engine types: the Pratt & Whitney (PW) PW4056/4062; the General Electric (GE) CF6-80C2; and the Rolls-Royce (RR) RB211-524G/H. In terms of the passenger fleet, there are

747-400 FLEET

Engine Option	747-400	747-400ER	747-400D	747-400PC	747-400F	747-400ERF	747-400BCF	747-400BDSF	Total
Active									
PW4056/62	130	0	0	7	33	14	25	9	218
CF6-80C2	119	6	9	36	72	24	14	14	294
RB211-524	92	0	0	0	17	0	4	0	113
Sub-total	341	6	9	43	122	38	43	23	625
Parked									
PW4056/62	7	0	0	0	0	0	1	0	8
CF6-80C2	21	0	1	0	1	2	0	0	25
RB211-524	6	0	0	0	0	0	0	0	6
Sub-total	34	0	1	0	1	2	1	0	39
Total Fleet	375	6	10	43	123	40	44	23	664

almost equal numbers of PW- and GE-powered aircraft still active, comprising 130 and 119 aircraft respectively. RR-powered aircraft account for 92 aircraft of the 747-400 fleet. All six of the 747-400ERs are GE powered.

The major operators of active PW4056 powered passenger 747-400s are: United Airlines (24), Korean Air (17), Delta Airlines (15), China Airlines (9), Malaysia Airlines (9), Corsairfly (6), El Al (6), Air India (5), Cathay Pacific Airways (5), and Singapore Airlines (SIA) (5). There are several other smaller fleets of GE-powered aircraft, mostly operated by smaller carriers. PW powers seven 747-400 Combis, operating for Air China (5), Cargolux (1) and the Dubai Air Wing (1).

The main fleets of active GE CF6-80C2 passenger 747-400s are operated by Lufthansa (23), Thai Airways International (18), Virgin Atlantic (12), Air France (7), Transaero Airlines (7) and KLM Royal Dutch Airlines (5). There are also several other smaller operators of GE-powered 747-400s.

All six 747-400ERs have CF6-80C2 engines and are operated by Qantas. The nine active 747-400Ds are also GE-powered, of which eight operate for All Nippon Airways (ANA). The CF6-80C2 also powers 36 of the 43 747-400 Combis. KLM operates 17 of these aircraft, followed by Lufthansa (7), Eva Air (4), Air France (3), Asiana Airlines (2), Kuwait Airways (1), United Parcel Service (UPS) (1), and the Abu Dhabi Presidential Flight (1).

The fleet of active RR-powered 747-400s is dominated by British Airways (BA) (52), followed by Qantas (19), Cathay Pacific Airways (16), Transaero Airlines (3) and Air New Zealand (2).

Freighters

The GE CF6-80C2 is the dominant engine choice for the factory-built freighters, powering 72 747-400Fs and 24 747-400ERFs. The largest fleets of GE-powered 747-400Fs are with China Airlines (19), Atlas Air (11), UPS (11), Nippon Cargo (8) and Polar Air Cargo (7). A number of smaller operators use this type with smaller fleets. The fleet of GE-powered 747-400ERFs comprises Jade Cargo International (6), AirBridge Cargo (5), Martinair (4), TNT Airways (4), Air France (3), China Cargo Airlines (2), and LoadAir Cargo (2).

PW accounts for 33 747-400Fs and 14 747-400ERFs. The largest fleets of PW-powered 747-400Fs are with SIA Cargo (11), and Korean Air (9). Several smaller fleets of this type are flying with other operators. There are only two operators of PW-powered 747-400ERFs: Korean Air (8) and Cathay Pacific Cargo (6).

RR RB211-524s power just 17 747-

747-400 & 747-400ER PASSENGER FLEET BREAKDOWN BY ENGINE TYPE & APPROXIMATE D-CHECK CYCLE

D-check interval	Age (years)	GE CF6-80C2	PW4056	RR RB211-524	TOTAL
1st - 2nd	5-11	33	10	0	43
2nd - 3rd	11-15.5	43	52	30	125
3rd - 4th	15.5-21	52	54	44	150
4th - 5th	21+	18	21	24	63
TOTAL		146	137	98	381

400Fs. The operators of these aircraft are Cargolux (10), Cathay Pacific Cargo (6) and Silk Way Airlines (1).

PW and GE match up more evenly again in terms of converted freighters, although this is to be expected as these were previously passenger aircraft. The PW 4056/4062 powers 25 of the Boeing-converted 747-400BCFs, and nine Bedek-converted 747-400BDSFs, giving a total of 34 PW-powered 747-400 converted freighters. The largest fleets of PW powered 747-400BCFs are with Cathay Pacific Cargo (7), Korean Air (7) and Air China Cargo (5). Smaller numbers of this type can also be found. The PW-powered 747-400BDSFs are flown with World Airways (4), Air Cargo Germany (2), Air China Cargo (2) and Air Atlanta Icelandic (1).

The GE CF6-80C2 powers 14 each of the 747-400BCF and 747-400BDSF. The 14 747-400BCFs are with Kalitta Air (6), Atlas Air (3), Air Atlanta Icelandic (2), Cargolux (1), National Airlines (1) and UPS (1). The 14 747-400BDSFs are with Eva Air (6), Asiana Airlines (4), Yangtze River Express (3) and ACT Airlines (1).

RR only powers four 747-400BCFs, operated by Air Hong Kong (2) and Cathay Pacific Cargo (2). It powers no 747-400BDSFs.

Parked aircraft

There are 39 parked 747-400s of all variants, passenger and freighter. Of these, 34 are regular passenger frames, so all could be considered viable contenders for freighter conversion. 15 of these aircraft were operated by Japan Airlines International (JAL). ANA, BA, United Airlines, Air New Zealand and Malaysia Airlines have all parked 747-400s in smaller numbers.

As with the active fleet, the 24 airframes aged from 11 to 21 years are the best candidates and also make up the majority of the parked aircraft. Of these 24, 14 are powered by the CF6-80C2, seven by PW4056 and just three by the RB211.

There are nine parked 747-400s aged more than 21 years. Six of these are GE-powered, and three RR-powered. The

remaining parked aircraft is 10.5 years old, and is powered by the CF6-80C2. It can be considered a strong candidate for freighter conversion.

Aircraft availability

As airlines renew their long-haul fleets, operating costs are of primary concern. The passenger 747-400 is in many cases being replaced by the 777-300ER and the A380. Many major carriers are carrying out, or have completed, the retirement of their 747-400 fleet. This has led to an oversupply of 747-400s onto the used market. This lowers market values, but means that the value of younger airframes is now low enough to make the total cost of preparing a freighter for service attractive for a larger number of operators and lessors. Older aircraft, however, could also be considered for part-out value.

The maintenance condition of an airframe is of vital consideration to a buyer of any aircraft on the used market. Market values are based not only on age, but also on half-life maintenance conditions, which is the interval remaining until next major maintenance events. Almost all 747-400s will have gone through their first D check, so the youngest possible passenger-to-freighter conversion candidates will be between their first and second D checks.

Since the current maintenance-planning document (MPD) for the 747-400 mandates that a D check is carried out every six years, airlines do not completely use this full limit, and most D checks are performed every 5-5.5 years. Most aircraft aged 5-11 years, therefore, can be assumed to be between their D1 and D2 checks. Aircraft aged between 11-15.5 years are likely to be between D2 and D3 checks, and so on, as is summarised here (*see table, this page*).

The aircraft will likely undergo the next major maintenance check required at the same time as conversion, so that upon delivery, many aircraft will not require a D check for another 5-6 years. The market or purchase value of a used 747-400 will therefore depend on not just its age, but also where it lies in terms of



its D-check interval, and other major maintenance events. This is because later D checks require more man-hours (MH) as the non-routine ratio widens, and therefore the cost of the check rises further increasing the total cost of conversion. "In general, the older the aircraft is, the higher the risk that the D check cost will escalate," says Paul Newrick, president and managing director at Guggenheim Aviation Partners.

Younger aircraft will have a lower non-routine ratio in their D checks, requiring fewer MHs, and therefore lower cost. For example, the non-routine ratio can be as low as 0.75 during the first D check, but as high as 1.2 at the fourth D check. Later D checks will also involve heavy structural inspections, such as the supplemental structural inspection program (SSIP), further adding to costs of later D checks. "Operators look at performing such D checks as an economic decision. Is it worth making such a significant investment in maintenance and continuing to operate a relatively high-cost older aircraft for the next 5-6 years?" asks Newrick.

This is a key factor in the high retirement rate of older 747s, retired at or before their sixth D check. The maintenance planning for 747-400s, however, is significantly different to that of classic 747s, and limit of validity (LOV) criteria is more important in terms of a retirement watershed. 747-400s

currently 15-20 years of age could therefore feasibly keep flying at an economically attractive rate for at least another 15 years.

This assumes that there will be demand for all aircraft available on the used market. "It is an extremely volatile and tough market," says Bert van Leeuwen, managing director of aviation research at DVB Bank. This means that parting out an old aircraft is also a viable option for many of the older 747-400s on the used market.

"Even on an older airframe, there is still a lot of value to be realised from the engines, if they are in good condition. CF6 and PW4000 engines retain a lot of their value for the continuing maintenance of the 767 fleet," adds van Leeuwen. This retention in engine value has also been aided by the delays to the 787 programme, with 767 fleets being kept in many airlines' fleets longer than originally intended.

Despite this, freighter conversion is still a viable option. Aircraft between D2 and D4 checks are still in the best zone for freighter convertibility, because: they are likely to have lower acquisition costs; the maintenance they require is not so high that it makes it unfeasible for freight operators; and the aircraft still have up to 20 years of remaining service. As the fleet profile shows (see table, page 11), there are a large number of 747-400s in this ideal zone of convertibility, with many soon to be available on the used market.

While large numbers of 747-200 freighters have been retired over the past six to seven years, there are still about 70 aircraft in service. While this represents an opportunity for 747-400 freighter conversions, the market is being curbed by weakened lease rates and a large supply of factory-built 777Fs and 747-8Fs.

In terms of the age of PW4056-powered active 747-400s, 10 aircraft are aged 5-11 years, 47 are between 11-15.5 years, 52 are 15.5-21 years old and 21 are aged 21 years or over. The middle-aged aircraft, aged from 11 to 21 years, are prime candidates for conversion. This totals 99 aircraft.

Of the active GE CF6-80C2 fleet, 32 aircraft are 5-11 years old (including the six 747-400ERs), 38 are 11-15.5 years old, 43 are 15.5-21 years old, and 12 aircraft are over 21 years old. There are therefore 81 GE CF6-80C2 747-400s aged 11 to 21 years (see table, page 11). These are the best conversion candidates.

There are no RR RB211-524-powered 747-400s aged below 11 years. 29 aircraft are 11-15.5 years old, and 42 aircraft are 15.5-21 years old. A further 21 RR-powered 747-400s are over 21 years old. This makes for 71 RR-powered 747-400s aged 11-21 years, and make for the best conversion candidates.

In total therefore, there are 251 active 747-400s from 11-21 years of age, most of which are between their D2 and D4 checks. This amounts to 72% of the active 747-400 passenger fleet currently in the ideal zone of convertibility. Add a further 24 parked aircraft, and this gives a total of 275 aircraft in this range. This means there is, and will continue to be, a plentiful supply (in relative terms) of 747-400s available on the used market for the foreseeable future.

Conversion to freighter

Conversion to freighter is a much more likely option for used market 747-400s. This means the 747-400 is likely to follow the same pattern as its older siblings, the 747 'classics'. There more than 70 'classic' 747s (-200s, and -300s) still in operation as freighters. Evergreen International, Kalitta Air, Southern Air, and Atlas Air are the largest operators of these 'classic' types. There are a number of other operators operating 747-200s and -300s in smaller numbers.

There is, therefore, potential for used 747-400s to replace these older freighters. Also, both Boeing and Airbus are predicting a rise in the demand for large freighters, thereby further increasing the

used market potential for used 747-400s. The 747-400 does, however, face competition from the 777F and 747-8F; although these aircraft do have high financing costs and are only suited to some freight operators.

There are two passenger-to-freighter programmes for the 747-400. The first is the Boeing modification programme, designated 747-400BCF. Here, the aircraft retains the maximum take-off weight (MTOW) of 870,000lbs, but the maximum zero fuel weight (MZFW) increases from 542,500lbs to 610,000lbs, and gives the 747-400BCF a structural payload of 250,700 lbs. This programme has been chosen by Atlas Air, Cargolux, Cathay Pacific Cargo, Martinair, SIA Cargo and UPS Airlines amongst others. A total of 44 aircraft have been redelivered with the 747-400BCF designation.

Second, 747-400s can be converted by Bedek Aviation, and are designated 747-400BDSF. There are three sub-variants of the 747-400BDSF. The standard variant has an MZFW of 610,000lbs, giving a structural payload of 252,000lbs. The second sub-variant increases MZFW to 630,000lbs, and thus structural payload to 272,000lbs.

Finally, Bedek offers a conversion with an MZFW of 635,000lbs and a structural payload of 277,000lbs. 23 aircraft have been redelivered after conversion by Bedek as 747-400BDSFs. Customers include Cargolux, Emirates, EVA Air, Southern Air, and World Airways, among others.

Aircraft enter the economic zone for freighter convertibility when their values are suitably low. That is, their purchase value is low enough for the total costs of providing a service-ready aircraft to be low relative to the likely lease rental that a profitable transaction will result for the lessor. While values of 747-400s have dropped in recent years, lease rentals of freighters have also fallen. Moreover, debt is less available and financing terms are more stringent.

These lower-value aircraft must also be in a good maintenance condition so the cost of conversion and overhaul is also economically attractive. As discussed previously, there are a large number of 747-400s that currently fall in this category, with a steady supply of airframes set to enter the used market in the foreseeable future.

One issue to note, however, is that with 747-400 aircraft pre-line number 727. This is primarily related to variability in wing structure, and aircraft pre-line number 727 have lower MTOWs than the standard 870,000lbs that aircraft post-line number 727 have. Aircraft up to line number 727 therefore have a limit on their MTOWs.

747-400 line number 727 was the

747-400 LEASE FINANCIAL SCENARIOS

Aircraft description	747-400	747-400
	1994	1998
	6-yr lease	6-yr lease
Current value \$	20,000,000	30,000,000
Conversion & related maintenance \$	20,000,000	20,000,000
Total investment \$	40,000,000	50,000,000
Equity %	40	30
Equity-\$	16,000,000	15,000,000
Debt \$	24,000,000	35,000,000
Debt balloon \$	3,600,000	8,000,000
Monthly debt repayment \$	354,315	466,224
Monthly lease rental \$	450,000	550,000
Monthly cashflow \$	95,685	83,776
Cashflow from lease rentals \$	6,889,320	6,031,872

eleventh -400 built and therefore was a very early production model. This means that only 11 out of the total 747-400 fleet are affected by this.

Currently, none of those aircraft pre-line number 727 has ever been converted. These aircraft may still be convertible however, subject to analysis on MTOW limitations. Values for these aircraft are likely to be significantly lower than those aircraft post-727. The cost of conversion for these early production aircraft is also likely to be significantly higher than aircraft post-727, which is likely to put off potential freight operators of these aircraft. Given the very low number of aircraft affected however, and the large number of available alternatives, this is unlikely to be a major issue in the 747-400 used market.

A further issue however is the nature of the converted large aircraft cargo market. This is a volatile market where supply-demand dynamics can drive some very high peaks and troughs in demand. The youngest factory-built freighters will more likely be leased first and assigned to the steady demand routes, while the primary role of converted aircraft will be to take up the slack in the market.

“The nose-loading capability of factory-built aircraft adds a lot of value for the operator, and means that, apart from a potentially quicker airport turnaround, these are the aircraft that will be assigned to premium outsized freight, such as oil-field equipment,” says van Leeuwen.

This means that converted aircraft are the first to suffer when the cargo market suffers a fall in demand. This is because

of the lower payloads available, nose-loading differences and lower values of the aircraft. This could reduce the demand for converted freighters in these times. There are not enough factory-built freighters, however, to satisfy demand during peak demand periods, so converted aircraft will always have a place when there is demand to provide the extra lift.

Values & lease rates

With the newest factory-built 747-400F about two years old, and the oldest passenger versions of the 747-400 now about 22 years old, the values and lease rates for 747-400s vary widely. A passenger 747-400 over 20 years old can be picked up for \$20-25 million, while a younger passenger model of 2005 vintage is likely to cost \$55-60 million.

As more 747-400s enter the used market, however, and it becomes further oversupplied, values will continue to fall. RR-powered aircraft have the lowest values, because they are less desirable, due to the smaller operator base, with most tied up between BA, Qantas and Cathay Pacific. This is particularly true for aircraft to be parted out, because there are fewer other RR RB211-powered aircraft available to support compared to the CF6 and PW4000. Therefore, PW- and GE-powered aircraft are likely to maintain similar values, dependent on their maintenance condition and vintage.

The RR engines are also heavier than the CF6-80C2 and PW4056. The RB211-524G/H also have a reputation for having higher shop visit costs.

747-400F / -400ERF / -400BCF / -400BDSF SPECIFICATION WEIGHTS

Aircraft type	747-400F	747-400ERF	747-400BCF	747-400BDSF (1)	747-400BDSF (2)	747-400BDSF (3)
MTOW (lbs)	870,000	910,000	870,000	870,000	870,000	811,000
MZFW (lbs)	635,000	611,000	610,000	610,000	630,000	635,000
OEW (lbs)	364,000	362,400	359,300	358,000	358,000	358,000
Gross structural payload (lbs)	271,000	248,600	250,700	252,000	272,000	277,000
Usable fuel (USG)	57,065	53,765	53,765	53,765	53,765	53,765

Lease rates for 747-400 freighters have also declined in recent years as more 747-400s have entered the used market. Lease rates would have been \$675,000-750,000 per month dependent on vintage and term. They are currently down to \$450,000-\$500,000 per month, depending on the quality of the aircraft and the creditworthiness of the lessee.

In terms of financing the purchase of a used 747-400, the debt/equity ratio is becoming more even. In the past, banks would regularly agree to finance 85% debt and 15% equity, but this is no longer the case. "About 40% equity is required, which is quite a barrier to entry for many," comments Newrick. This ratio largely depends on an lessor's relationship with the relevant bank and the operator's credit rating. The ratio could be 70% debt and 30% equity in some cases for better quality lessees, or as high as 45% debt and 55% equity in others. This is because there is now significant bank resistance and costs to long-term lending, particularly since the financial crisis in 2008.

If used aircraft are even considered for financing, banks will consider a wide range of factors before agreeing to lend, including the age of the aircraft, the credit of the lessee, lease term, and a conservative look at the residual value of the aircraft. Potential debt terms for a 747-400 are hard to generalise, because of the wide variety of airframes available and the wide variety of factors affecting a bank's decision to lend.

Possible debt financing structures are summarised here (see table, page 13). Here an older vintage, 1994 vintage 747-400 is first considered. As an older airframe, having accumulated more FHs and FCs, this can be acquired for lower cost than newer build airframes.

A lower grade credit lessee is unlikely to be able to afford a higher value, later vintage airframe, and therefore may be a prime customer for a circa 1994 airframe (18 years old). The all up cost of purchase and conversion costs for the airframe, under current market conditions, will be about \$40 million. As this is a lower grade credit lessee, a more even debt/equity ratio of 60% debt, 40% equity is likely to be available. The cost of

debt is likely to be high, at about 6%, with a low 15% debt balloon (\$3.6 million). This debt balloon at the end of the six-year term is expected to come from the part-out value of the aircraft. It may possibly be re-leased, in which case it could be refinanced, and the debt provided would pay the balloon.

The debt terms require a monthly debt payment by the lessor of \$354,315 per month. Given the trend of declining lease rates for the 747-400, a lower grade credit lessee could be expected to obtain a lease rate in the region of \$450,000 per month; equal to a monthly lease rate factor of 1.125%. This leaves the lessor a monthly cashflow of \$95,685 per month. This amounts to a cashflow of \$6,889,320 over the course of the 72-month debt term.

Even though a likely scrap value of a 24-year old aircraft in six years should be enough to pay the debt balloon, the cashflow from rentals of \$6.9 million clearly does not provide a sufficient return on equity invested. The financing terms and the lease rental that is likely make the transaction unsustainable.

An additional monthly cashflow of \$100,000 per month from a higher lease rental would be required for the equity invested to be covered. The transaction would only become profitable if more favourable debt terms were secured.

A second scenario involves a medium credit lessee and a later 1998 vintage airframe (see table, page 13). The all-up total cost of purchase, conversion and preparation for service is \$50 million. A medium credit lessee means that better debt terms are likely to be available from the bank. Here we assume a 70% debt, 30% equity ratio, a debt balloon of \$8 million (22.8%), a cost of debt of 5%, and a six year lease period.

Monthly debt repayments to the bank are therefore \$466,224. The lessor is likely to be able to charge a higher monthly lease rental to the lessee of about \$550,000; although this is still less than the previous levels that were as high as \$800,000 per month. The \$550,000 per month lease rental is equal to a monthly lease rate factor of 1.1%.

This generates a monthly cashflow of \$83,776 for the lessor, and over the full

72 months amounts to \$6,031,872.

A younger aircraft is more likely to be leased for a second term, and so the debt provided for this refinancing would repay the debt balloon, but is also likely to provide some return on the \$15 million equity invested. The actual refinancing available in six years will clearly depend on the demand for 747-400 freighters.

The cashflow from lease rentals is again insufficient to provide a return on equity invested, and again a higher lease rental is required.

Secondary passenger market

The secondary passenger market for the 747-400 is limited. As a large aircraft, the decision to invest in acquiring a 747-400 cannot be taken lightly. Few airlines need an aircraft this large. Because the established carriers perform most long-haul operations, the number of potential customers for a used passenger 747-400 for continued passenger use is small.

Low-cost long-haul travel is yet to find a profitable niche in the airline world, so low-cost carriers (LCCs) are not likely to enter the market for used 747-400s. The high cost of owning and operating a 747-400 is also a huge barrier to entry for start-up airlines. This is therefore another set of potential customers to which the 747-400 is unlikely to appeal.

In terms of the secondary passenger market therefore, this only leaves established legacy airlines looking to expand or replace their long-haul fleet. This has been seen in small numbers, with Thai International, Transaero Airlines and Corsairfly supplementing their long haul fleets with used 747-400s.

A more attractive market, with better returns, is parting out aircraft for engines and other rotables. PW4056 and CF6-80C2 engine values are still high, since large numbers of 767-300ERs are being supported. The re-sale value of four engines and other components should exceed the purchase value of about \$20 million of older-build 747-400s. **AC**

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