Operators looking to add widebody freighters may need to select between new-build and converted aircraft. Converted freighters can have lower payloads and higher fuel and maintenance costs, but have competitive costs per freight lb due to lower lease rates.

The economics of converted versus new-build freighters

Identifying the most economic freighters for a particular operation can include selecting between new-build and converted aircraft.

Aircraft Commerce has analysed the comparative benefits of new-build and similar-sized converted freighters to establish which options may provide the most economic solutions for different operators. This is in a trip cost and cost per lb of available freight basis.

Widebody freighters

The choice of new-build and converted aircraft is only available for widebodies. There are no new-build narrowbody freighters.

"The main reason why there are no new-build narrowbody freighter programmes is that all narrowbody freighter operators have low levels of utilisation," explains Robert Convey, senior vice president of sales and marketing at Aeronautical Engineers Inc (AEI). "Narrowbody freighter operators only use their aircraft for three or four flight hours (FH) a day, and five or six days a week on average. This low rate of utilisation drives them to acquire the aircraft at the lowest possible on-ramp price. In contrast, widebody freighters can fly in excess of 15FH per day on long-haul routes. This allows operators to amortise their higher acquisition or purchase costs over more FH and flight cycles (FC)."

Boeing classifies medium widebody freighters as those with a revenue payload of 40-80 metric tonnes (t). It categorises large freighters as aircraft with a payload of 80t or more.

Medium-widebody freighters

The in-service medium-widebody freighter fleet currently consists of 481 aircraft. There are a further 59 in storage.

The in-service fleet includes 195 767s and 179 A300s, 170 of which are the -600 variant. Others include DC-10s (53), A330-200Fs (33), and A310s (21).

The largest in-service fleets of medium-widebody freighters are operated by FedEx (160) and UPS (111), both of which operate A300-600Fs and 767-300ERFs. FedEx also operates DC-10s and a declining fleet of A310 freighters.

Several new-build freighter programmes are available in the medium-widebody market, as are active conversion programmes. All of these options are focused on the 767 and A330 families *(see table, page 75)*.

There are two new-build options: the 767-300PF and the A330-200F.

Boeing offers its 767-300BCF cargo conversion for passenger configured 767-300ERs. IAI Bedek offers its 767-300BDSF conversion.

IAI Bedek also offers conversions for the -200ER, and non-ER -300 variants of the 767, although these are not expected to see significant levels of demand.

The A330P2F conversion programme is the only one available for the A330 family. It is a joint undertaking between EFW, ST Aerospace and Airbus. It offers passenger-to-freighter conversions for the A330-200 and A330-300. A launch customer for the A330P2F programme was announced in December 2014 and the prototype A330-300P2F is expected to enter service in 2017, followed by the first A330-200P2F in 2018.

The current in-service fleet of 767 freighters includes 195 aircraft split between 59 converted -200/-200ERs, 108 new-build 767-300Fs, and 28 converted 767-300ERs.

The entire fleet of in-service A330-200 freighters are new-build aircraft, since the A330P2F programme is yet to complete its first conversion.

Large-widebody freighters

The in-service large widebody freighter fleet comprises 531 aircraft, with a further 101 in storage.

The in-service fleet includes 283 747 freighters, 130 MD-11 freighters and 118 777 freighters. The 747 freighter fleet is dominated by variants of the 747-400 (201) and the 747-8 (63).

The largest fleets of large widebody freighters are operated by FedEx (84) and UPS (51). Both integrators still have large numbers of MD-11s. FedEx has been adding 777Fs to its fleet, while UPS also operates 747-400Fs.

There are two new-build options in the large widebody freighter market, both of which are provided by Boeing. These are the 777F and 747-8F.

Boeing and IAI Bedek also offer two conversion programmes available in the large widebody market, both of which are for the 747-400 *(see table, page 75)*. Converted aircraft are respectively designated 747-400BCFs or 747-400BDSFs.

The active fleet of 747-400 freighters is split between 149 new-build and 52 converted aircraft.

IAI Bedek is evaluating the development of a conversion programme for the 777-200ER and 777-300ER.

Current trends

"The widebody freighter fleet is changing," claims Stephen Fortune, principal at Fortune Aviation services. "Widebody freighter conversions outpaced production freighter deliveries by almost 50% from 1990 to 2007. Since 2008, production freighter deliveries were more than double the number of conversions completed."

Fortune believes this trend is unlikely to change in the near future. "Regional widebody conversions will remain low, with only one potential conversion candidate until the A330-200/-300 conversion is certified in a few years' time. With more than 30 747-400 freighters in storage there is no need for additional 747 freighter conversions. Integrator demand has shifted from converted widebodies to production freighters," continues Fortune. "FedEx has seen an significant improvement in operating costs and reliability after replacing MD-11s with 777Fs. The 767-300F has also been an excellent replacement for the MD-10 for FedEx."

"Declining yields mean that the future of traditional pure freighter operations will be challenging," claims retired Air Cargo executive Ram Menen. "Freighters will work better either in a supplementary role alongside a passenger fleet, or with large integrator fleets."

Boeing expects that most of the large freighter market will be made up of new-build aircraft.

IAI Bedek and EFW both believe there will be demand for their widebody conversions.

"We are already facing significant demand for 767-300ER conversions and expect this to continue for at least the next three to five years, along with maybe a few additional 747-400 conversions," explains Moshe Haimovich, director of marketing and business development at IAI Bedek. "747-400 conversions slowed down after 2011 due to the high cost of fuel. With fuel prices now lower, however, it is possible there might be some demand for 747 freighters.

"There are a number of parked, mostly converted, 747-400 freighters, but many are very old," continues Haimovich. "In some cases it might be difficult to justify the investment required to bring them back to service. This might lead to limited requirements for new conversions."

"In the medium-widebody freighter segment the high capital cost of new-build aircraft is weighted against the slightly higher cash operating cost of converted aircraft," says Thomas Centner, director sales aircraft conversion and technical marketing at EFW. "The key is availability of enough attractively priced, suitable aircraft for conversion.

"The new generation A330P2F is coming soon, and we expect the availability of used A330s will improve once the A330neo and A350 enter the market in numbers," adds Centner. "We believe there is a market for 150-200 converted A330s in the next 15 years, depending on the feedstock situation. Demand is likely to increase once the aircraft become available in large numbers from 2018 onwards. This will correspond with the replacement wave of A300 and 767 freighter fleets, and emerging express freight companies in China, which will need widebody aircraft to operate a hub-and-spoke system."

WIDEBODY FREIGHTER MARKET

Aircraft type	New-build	Conversion
Medium-widebody		
767-200ER	None	IAI Bedek
767-300	None	IAI Bedek
767-300ER	Boeing	Boeing /IAI Bedek
A330-200	Airbus	EFW, ST Aerospace, Airbus
A330-300	None	EFW, ST Aerospace, Airbus
Large-widebody		
777-200ER	Boeing	None
747-400	No longer in production	Boeing /IAI Bedek
747-8F	Boeing	None

Freighter economics

The following analysis summarises the potential payload performance and trip costs of widebody freighters to give an indication of the comparative economics of converted and new-build aircraft.

The results of the analysis are given in the context of a number of assumptions, which will be stated throughout.

Boeing's BCF specifications will be used as representative of 767-300 and 747-400 converted freighters. It should be noted that IAI Bedek also provides conversions for these aircraft.

Payload performance

Some of the more important indicators of a freighter's payload capability are its net structural payload, maximum packing density and volumetric payload at a given packing density.

The net structural payload is the payload available for freight after the tare weight of cargo containers or pallets has been accounted for. It is sometimes referred to as the revenue payload and is calculated by subtracting container and pallet tare weight from the aircraft's available structural payload.

The maximum packing density is that at which cargo can be packed to make full use of the available revenue payload and volume. It is calculated by dividing the net structural payload by the available volume.

The volumetric payload indicates the actual cargo payload that can be carried at a given packing density.

A freighter's net structural payload, maximum packing density and volumetric payload will depend on whether it is configured for express package or general freight operations.

Express package or integrator operations are usually based on hub-and-spoke networks. They transport small packages and parcels in unit load devices (ULDs) or containers at relatively low packing densities, typically about 6.5lbs per cubic foot (cu/ft). The low packing densities mean an aircraft configured for express package operations can reach its volumetric capacity before using the full available net structural payload. This is known as 'cubing' or 'bulking' out.

General freight operations tend to involve more point-to-point services, the carriage of heavy and bulkier items at higher packing densities, and the use of pallets rather than containers. Typical packing densities might range from 7.0 to 9.0lbs per cu/ft. These higher packing densities make it more likely that an aircraft carrying general freight will reach its net structural payload before all of the available volume has been used. This is referred to as 'grossing' out.

A freighter might have a higher net structural payload and maximum packing density when configured for general freight operations, since pallets have lower tare weights than ULDs.

The following payload analysis assumes that aircraft are configured with pallets on the main deck, and in the lower hold where possible, although some ULDs are used on certain variants.

The volume and tare weight assumptions used for the pallets and ULDs in this analysis should be realistic. However, pallet and ULD volumes and tare weights can vary by manufacturer. The volume and tare weight offered by different pallets with the same base dimensions can vary depending on the thickness of the base and the fuselage contour of the aircraft that they are loaded on. The total volume of the aircraft used in this analysis includes bulk volume.

WIDEBODY CONVERTED & NEW-BUILD FREIGHTER SPECIFICATIONS

Medium-widebody	A330-200F	767-300F	A330-200P2F	A330-300P2F HGW	767-300BCF
MTOW (lbs)	500,449	412,000	513,677	513,677	412,000
MZFW (lbs)	392,423	309,000	374,786	385,809	309,000
Gross Payload (lbs)	154,324	126,250	130,073	134,482	125,380
Total volume (cu ft)	16,969	15,467	16,969	20,046	15,710
Total tare weight (lbs)	7,582	6,887	7,582	8,941	7,988
Net structural payload (lbs)	146,742	119,363	122,491	125,541	117,392
Max packing density (lbs/cu ft)	8.65	7.72	7.22	6.26	7.47
Volumetric payload @ 7.0lbs/cu ft	118,783	108,269	118,783	125,541	109,970
Volumetric payload @ 8.0lbs/cu ft	135,752	119,363	122,491	125,541	117,392

Large-widebody	777-200F	747-400F	747-8F	747-400BCF
MTOW (lbs)	766,800	811,000-875,000	987,000	870,000
MZFW (lbs)	547,000	635,000-610,000	727,000	610,000
Gross Payload (lbs)	228,700	283,056-258,056	292,400	249,360
Total volume (cu ft)	23,051	26,063	30,284	25,097
Total tare weight (lbs)	8,325	9,103	10,678	8,775
Net structural payload (lbs)	220,375	273,953-248,953	281,722	240,585
Max packing density (lbs/cu ft)	9.56	10.51-9.55	9.30	9.59
Volumetric payload @ 7.0lbs/cu ft	161,357	182,441	211,988	175,679
Volumetric payload @ 8.0lbs/cu ft	184,408	208,504	242,272	200,776

Notes:
Available payload/volumetric capacity assumes no payload/range restriction

The gross structural payload figures used here are based on estimated operating empty weights (OEWs). OEW will vary by individual aircraft.

Medium widebody

In the medium widebody category it is possible to compare the potential payload capacity of the 767-300F and A330-200F to converted 767-300ERs and the proposed A330-200 and -300P2F.

A 767-300BCF could offer 15,710 cu ft of cargo volume, which is potentially slightly more than the 767-300F *(see table, this page)*. Both aircraft would have the same main deck and bulk cargo volumes. The difference is due to lower deck loading configurations. Unlike the production freighter, the 767-300BCF is unable to load 96-inch X 125-inch pallets in the aft lower hold, due to the size of the cargo door. It accommodates 14 LD-2 containers in this section.

A 767-300BCF could offer the same maximum take-off weight (MTOW) and maximum zero fuel weight (MZFW) as a production freighter *(see table, this page)*. The 767-300F has a slightly lower OEW which translates to a higher gross structural payload. When this is combined with the 767-300BCF's higher tare weight, the production freighter has a net structural payload advantage of about 2,000lbs. Assuming that there are no payload/range restrictions, the 767-300BCF would have a volumetric payload advantage over the -300F of 1,700lbs at a packing density of 7.0lbs per cubic feet (lbs/cu ft). At a packing density of 8.0lbs/cu ft the 767-300F would have a volumetric payload advantage of 2,000lbs, due to its higher maximum packing density, although both aircraft would gross out.

An A330-200P2F will provide a total cargo volume of 16,969 cu ft, the same total as the A330-200F production freighter. An A330-300P2F will provide more volume due to its longer fuselage. Based on the assumptions used in this analysis, the larger aircraft could provide about 3,000 cu ft of additional cargo volume *(see table, this page)*.

The A330-200F features the option to trade MTOW for an increased MZFW and therefore a higher gross structural payload. This analysis assumes the production freighter is operated with the highest available MZFW. This results in the A330-200F having a lower MTOW than a typical A330-200P2F, but a net structural payload advantage of 24,000lbs *(see table, this page)*. The A330-200F and -200P2F would offer the same volumetric payload at a packing density of 7.0lbs/cu ft. The production freighter would have a volumetric payload advantage of 13,000lbs at a packing density of 8.0lbs/cu ft due to a higher maximum packing density.

The payload performance of an A330-300P2F will vary depending on whether it is a low gross weight (LGW) or high gross weight (HGW) aircraft (see *Cherry-picking A330s for conversion to freighters, Aircraft Commerce, October/November 2014, page 59*).

A HGW A330-300P2F will have a lower net structural payload than an A330-200F configured with the highest available MZFW *(see table, this page)*. The A330-300P2F would have a higher volumetric payload than the production freighter at a packing density of 7.0lbs/cu ft. At a packing density of 8.0lbs/cu ft the A330-200F would have a volumetric payload advantage of 10,000lbs.

The A330-200F offers the highest net structural payload in the medium-widebody freighter segment. Based on the configurations used in this analysis, it would provide the highest volumetric payloads at packing densities in excess of 7.40lbs/cu ft.

Large widebody

In the large widebody category it is possible to compare the payload capacity of the 747-8F, 747-400F and 777F to that of the 747-400BCF. The 747-400F is included, despite no longer being in production, since it is assumed that there will be relatively young used airframes available for lease, and that these will provide a legitimate alternative to converted aircraft.

Not surprisingly the 747-8F offers the most volume, the highest net structural payload and the highest volumetric payloads at packing densities of 7.0 and 8.0lbs/cu ft *(see table, this page)*.

The 777F has the lowest volume, net

structural payload and volumetric payloads in this category.

The 747-400BCF offers 25,000 cu ft of cargo volume, which is 1,000 cu ft less than the 747-400F *(see table, page 76)*. The 747-400F does not have the extended upper deck of the passenger variant, so the upper deck floor does not extend as far back over the main deck on the production freighter as it does on converted aircraft. A 747-400BCF has a longer section at the front of the main deck where pallets or ULDs have to be contoured to a lower height and subsequently provide less volume.

Another difference between converted 747-400s and production aircraft is that the new-build airframe has a hinged nose door, which allows the loading of outsized and, in particular, long items of cargo. The 747-8F also has a nose cargo door.

The 747-400F has a dynamic payload capability whereby it can trade MTOW for an increase in MZFW and a higher payload. This analysis assumes the 747-400F has an OEW of 351,944lbs. Its net structural payload would therefore vary from 248,953lbs to 273,953lbs depending on the chosen configuration *(see table, page 76)*. This analysis assumes the 747-400F is operating with a net structural payload of 256,953lbs. This is an advantage of 16,368lbs over the 747-400BCF, and leads to a maximum packing density of 9.86lbs/cu ft, which is higher than the 747-400BCF's maximum packing density of 9.59lbs/cu ft.

The 747-400F provides higher volumetric payloads than a 747-400BCF at all packing densities.

Trip costs

To provide a more detailed economic comparison between new-build and converted freighters, trip costs have been estimated for those types that are currently in service.

In the medium widebody segment the 767-300F and A330-200F are compared to the 767-300BCF.

In the large widebody market the 777-200F, 747-400F and 747-8F are compared to the 747-400BCF.

For the large widebody freighters, trip costs were generated on two realistic sectors representing an East-to-West trade route between Shanghai (PVG) and Chicago O'Hare (ORD), with a technical stop at Anchorage (ANC).

PVG-ANC has an assumed equivalent still air distance (ESAD) of 3,832 nautical miles (nm). The ESAD takes account of the tracked distance and the prevailing wind speed and direction. ANC-ORD has an assumed ESAD of 2,443nm. An average annual utilisation of 4,500 flight hours (FH) was assumed for all of the aircraft on both sectors.

The ESAD and assumed utilisation used for PVG-ANC and ANC-ORD were also used to compare the long-range trip costs of the medium-widebody freighters, although it is unlikely these aircraft would be used on these specific city pairs.

An additional theoretical sector of 1,000nm was included for the medium-widebody freighter analysis, in order to account for the fact that some operators will use these aircraft on shorter regional routes. The assumed annual utilisation of aircraft operating this sector was 2,600FH.

Trip costs are expressed in cents per available freight lb for each sector. The costs are calculated at packing densities of 7.0 and 8.0lbs/cu ft. A packing density of 7.0lbs/cu ft would be high for express package and low for general freight cargo.

The total assumed trip costs were made up of a number of fixed fleet and variable costs.

The fixed costs include those related

MEDIUM WIDEBODY FREIGHTER TRIP COSTS

1,000nm sector	A330-200F	767-300F	767-300BCF
Available payload @ 7.0lbs/cu ft	118,783	108,269	109,970
Available payload @ 8.0lbs/cu ft	135,752	119,363	117,392
Total sector costs ($)	31,720	26,703	25,359
Cost per lb @ 7.0lbs/cu ft (cents)	27	25	23
Cost per lb @ 8.0lbs/cu ft (cents)	23	22	22
2,443nm sector	**A330-200F**	**767-300F**	**767-300BCF**
Available payload @ 7.0lbs/cu ft	118,783	108,269	109,970
Available payload @ 8.0lbs/cu ft	135,752	119,363	117,392
Total sector costs ($)	49,511	43,225	41,433
Cost per lb @ 7.0lbs/cu ft (cents)	42	40	38
Cost per lb @ 8.0lbs/cu ft (cents)	36	36	35
3,832nm sector	**A330-200F**	**767-300F**	**767-300BCF**
Available payload @ 7.0lbs/cu ft	118,783	101,688	99,839
Available payload @ 8.0lbs/cu ft	131,310	101,688	99,839
Total sector costs ($)	65,452	57,187	54,505
Cost per lb @ 7.0lbs/cu ft (cents)	55	56	55
Cost per lb @ 8.0lbs/cu ft (cents)	50	56	55

Notes: Available payload takes account of any payload/range restrictions

to aircraft finance, crew, maintenance and insurance. There will be a variable element to maintenance costs.

The variable costs include fuel, landing, handling and international navigation costs.

Converted freighters tend to be older than production freighters, resulting in slightly higher fuel and maintenance costs, although these are offset by the converted aircraft's lower acquisition costs.

"New purpose-built freighters are usually deployed on high-utilisation, long-haul operations," says Centner. "It is more difficult to justify the investment in a new freighter if it is only being operated regionally and with low levels of utilisation. A brand new aircraft will benefit from a honeymoon phase with fewer maintenance requirements in the first years after entering service. The low acquisition costs of used converted aircraft will, however, offset their slightly higher direct operating costs. The reliability of older converted aircraft can be maintained to almost the same level as a new freighter, since their low rates of utilisation provide more time to perform line maintenance or potential repairs."

"The ageing maintenance requirements of older converted freighters means they accrue higher maintenance costs than a new-build freighter," says Haimovich. "The low acquisition cost of the converted aircraft will compensate for this, however, and will favour the converted freighters at the bottom line."

This analysis assumes that the freighters are leased rather than owned and depreciated.

In the medium widebody segment the assumed monthly lease costs are $350,000 for a 767-300BCF, $450,000 for a 767-300F and $675,000 for an A330-200F.

In the large widebody freighter market the assumed monthly lease rentals are $275,000 for a 747-400BCF, $450,000 for a 747-400F, $900,000 for a 777-200F and $1,150,000 for a 747-8F.

The cost of fuel can vary according to region. A fuel cost of $1.18 per US Gallon (USG) is assumed for the ANC-ORD and 1,000nm sectors. A cost of $0.98 per USG is assumed for PVG-ANC. The fuel burn figures include assumptions that the aircraft are operated at long-range-cruise speed and that there will be a taxi time of 30 minutes for each sector.

Some of the aircraft types under analysis have multiple engine options. For the purposes of this exercise it is assumed that the 747 and 767 aircraft are powered by CF6 engines, and the A330-200F are powered by Trent engines.

The assumed landing fees and international route charges are based on international averages and a function of each aircraft's MTOW. The handling fees are based on a function of the aircraft's revenue payload.

The crew costs include per diems or allowances, and the aircraft/crew ratio is based on a sliding scale related to utilisation.

The maintenance costs include cost per FH for elements of line and ramp maintenance, A Checks, C Checks, heavy components, line replaceable unit (LRU) rotable support, engine performance restoration and LLPs.

Medium widebody

The A330-200F's and 767-300F's estimated trip costs were compared to the 767-300BCF's at two different packing densities across three different sectors, with ESADs ranging from 1,000-3,832nm.

Despite the A330-200F's dynamic payload capability the assumption is made here that the aircraft was operated at the maximum MZFW configuration on all three sectors.

The 767-300BCF demonstrated the lowest total trip costs on all three sectors *(see table, this page)*. Its trip costs ranged from $25,359 on the 1,000nm sector to $54,505 on the 3,832nm sector. The A330-200F had the highest total trip costs on all three routes. These varied from $31,720 on the 1,000nm sector to $65,452 on the 3,832nm route. The 767-300BCF's trip costs were 4.1-5.0% lower than those of the 767-300F and 16.3-20.0% lower than those of the A330-200F across the three sectors. In both cases, its largest advantage came on the shortest sector and the smallest difference was experienced on the 2,443nm sector.

The 767-300F and -300BCF had similar fuel, maintenance, crew, landing, handling and en-route navigation costs on all three sectors. Higher lease costs were the main factor behind the 767-300F's higher trip costs. It also had slightly higher insurance costs than the converted freighter.

The differences in trip costs between the 767-300BCF and the A330-200F are due in large part to the A330's higher lease rates. The A330-200F's assumed lease costs are 88% higher than those of the 767-300BCF on all three sectors. They account for 21.4-24.8% of the A330-200F's total trip costs. In contrast lease costs only account for 13.6-16.5% of the 767-300BCF's total trip costs.

The A330-200F also burns more block fuel and incurs higher fuel costs than the 767-300BCF. The A330-200F burns 7.8-9.2% more fuel than the 767-300BCF across the three sectors.

The A330-200F's higher weights are a contributing factor to its greater fuel burn. Its higher MTOW and available payloads also contributed to the Airbus incurring greater landing, en-route navigation and handling fees than the 767-300BCF on all three sectors.

A more useful economic comparison can be drawn from each aircraft's costs per available freight pound (lb). In some cases the production freighters erode the trip cost advantage of the 767-300BCF due superior payload performance.

The 767-300ER is available as a new-build or converted freighter. Conversions are offered by Boeing and IAI Bedek. Based on the assumptions used in this analysis a 767-300BCF would provide the lowest trip costs and competitive costs per lb or freight when compared to new-build medium widebody freighters.

Cost per lb @ 7.0lbs/cu ft

At a packing density of 7.0lbs/cu ft the 767-300BCF has trip costs of 23-cents per lb on the 1,000nm sector, 38 cents per lb on the 2,443nm sector, and 55 cents per lb on the 3,832nm route *(see, table, page 78)*. It has the lowest or equally lowest costs per available lb on all three sectors at this packing density.

The 767-300BCF's costs per lb are 1.8-8.0% lower than the 767-300F's across the three routes, with the advantage decreasing with longer routes. The 767-300BCF also has lower costs per lb than the A330-200F on the two shortest routes. Its costs per lb are 14.8% lower on the 1,000nm sector and 9.5% lower on the 2,443nm route.

On the longest sector, however, the A330-200F's costs per lb are equal to the 767-300BCF.

The A330-200F's superior payload-range capability is emphasised on the longest sector where it only suffers a 10% payload restriction, compared to a 14% restriction for the 767 freighters.

Cost per lb – 8.0lbs/cu ft

The 767-300BCF has trip costs of 22-55 cents across the three sectors at 8.0lbs per cu ft *(see table, page 78)*.

Its costs per lb are equal to the 767-300F's on the 1,000nm sector, but the converted aircraft has 2.8% and 1.8% lower costs over its production rival on the 2,443nm and 3,832nm sectors.

The 767-300BCF has 4.3% lower costs per lb than the A330-200F on the 1,000nm sector and 2.7% lower costs on the 2,443nm route. On the 3,832nm sector the A330-200F's superior payload range performance means it would offer the lowest costs per lb. The A330-200F's cost per lb would be 9.1% lower than the 767-300BCF's on this sector at a packing density of 8.0lbs/cu ft.

Large widebody

The estimated trip costs of the 777-200F, 747-400F and 747-8F were compared to those of the 747-400BCF at two different packing densities on the PVG-ANC and ANC-ORD sectors.

The 747-400F's dynamic payload capability was taken into account. The aircraft is operated with a gross structural payload of 266,056lbs on both sectors giving it an advantage of 16,696lbs over the 747-400BCF.

The 747-400BCF's trip costs are $84,289 on PVG-ANC and $64,837 on ANC-ORD *(see table, page 80)*. It has the lowest trip costs on PVG-ANC and the second lowest on ANC-ORD behind the 777-200F. The 747-8F demonstrated the highest trip costs on both sectors.

On PVG-ANC, the 747-400BCF's trip costs are 2.5% lower than the 777-200F's, 5.0% lower than the 747-400F's and 21.5% lower than the 747-8F's.

On ANC-ORD, the 747-400BCF's trip costs are 4.5% lower than the 747-400F's and 20.0% lower than the 747-8F's. The 777-200F had a marginal 0.11% advantage in trip costs over the 747-400BCF on this sector.

The 747-400BCF and 747-400F have similar fuel, maintenance, crew, landing and international route charges on both sectors. Higher lease rates are the main contributing factor to the production freighter's higher trip costs.

The 747-400BCF has higher maintenance costs than the 747-8F. The two aircraft have similar crew and fuel costs. The biggest factor in the 747-8F's higher trip costs are its more expensive lease rates. These account for 21.5-24.6% of the 747-8F's total trip costs across both sectors. In addition, the 747-8F has higher insurance costs than the 747-400BCF. The 747-8F also has higher landing, handling and international route charges because of its higher weight.

The 747-400BCF and 777-200F demonstrated very similar total trip costs on both sectors. The 747-400BCF has higher fuel and maintenance costs. The 777-200F, however, burns the least block fuel of the four large widebody freighters on both sectors. This is to be expected, since it is competing with three four-engine aircraft. The 777-200F burns 28.6% less fuel than the 747-400BCF on PVG-ANC and 31.3% less on ANC-ORD. The 747-400BCF also has slightly higher landing, handling and international route charges than the 777-200F due to its higher weight specifications. All of these variables are, however, offset by the 777-200F's higher lease rates which account for 21.3% to 24.2% of the aircraft's total trip costs across the two sectors.

Cost per lb – 7.0lbs/cu ft

The 747-400BCF has the lowest or equally lowest costs per lb on both sectors at a packing density of 7.0lbs per cu ft. Its costs per lb are 48 cents on PVG-ANC and 37 cents on ANC-ORD. The 777-200F has the highest costs per lb on both sectors.

The 747-400BCF's cost per lb are 11.1% and 7.5% lower than the 777-200F's, and 5.9% and 2.6% lower than the 747-8F's on PVG-ANC and ANC-ORD. The 747-400BCF's costs per lb are 2.0% less than the 747-400F's on PVG-ANC. The two 747-400 freighters demonstrated the same costs per lb on ANC-ORD.

Cost per lb – 8.0lbs/cu ft

The 747-400BCF has the lowest costs per lb on both sectors at a packing density of 8.0lbs/cu ft. It has costs per lb of 42 cents on PVG-ANC and 32 cents on ANC-ORD. The smallest 777-200F again demonstrates the highest costs per lb on both routes.

The 747-400BCF's costs per lb are

LARGE WIDEBODY FREIGHTER TRIP COSTS

PVG-ANC 3,832nm	777-200F	747-400F	747-8F	747-400BCF
Available payload @ 7.0lbs/cu ft	161,357	182,441	211,988	175,679
Available payload @ 8.0lbs/cu ft	184,408	208,504	242,272	200,776
Total sector costs ($)	86,414	88,768	107,334	84,289
Cost per lb @ 7.0lbs/cu ft (cents)	54	49	51	48
Cost per lb @ 8.0lbs/cu ft (cents)	47	43	44	42

ANC-ORD 2,443nm	777-200F	747-400F	747-8F	747-400BCF
Available payload @ 7.0lbs/cu ft	161,357	182,441	211,988	175,679
Available payload @ 8.0lbs/cu ft	184,408	208,504	242,272	200,776
Total sector costs ($)	64,766	67,915	81,009	64,837
Cost per lb @ 7.0lbs/cu ft (cents)	40	37	38	37
Cost per lb @ 8.0lbs/cu ft (cents)	35	33	33	32

10.6% and 8.6% less than the 777-200F's, 4.5% and 3.0% less than the 747-8F's, and 2.3% and 3.0% less than the 747-400F's on PVG-ANC and ANC-ORD.

The 747-400F's costs per lb are similar to those of the 747-400BCF on both sectors at both packing densities, because its higher trip costs are offset by its higher available payload.

The 777-200F has the highest costs per lb on both sectors at both packing densities despite having a significantly superior fuel burn performance and lower landing, handling and international route charges than the three 747 freighters. This is mainly due to its lower available payload and its higher lease costs in comparison to the 747-400 variants.

The two 747-400 variants maintain the lowest costs per lb and remain closely matched at higher packing densities.

The 747-400BCF would have costs per pound of 37 cents on PVG-ANC and 29 cents on ANC-ORD at a packing density of 9.0lbs/cu ft. This compares to costs of 38 cents and 29 cents per lb for the 747-400F.

The two 747-400 variants have equal costs of 35 cents per lb on PVG-ANC at a packing density of 10.0lbs/cu ft. The 747-400F has the lowest costs at 26 cents per lb compared to 27 cents for the -400BCF on ANC-ORD. This is due to the combination of the production freighter's extra volume and higher maximum packing density.

LCF concept

Low Cost Freighter Conversions (LCF) Ltd, part of the Eolia Group, is marketing an alternative to conventional new-build and converted freighters.

The LCF concept would convert third-generation, passenger-configured widebodies and is targeted at the A330, A340 and 777-200ER. It could even be applied to the A380 (see *The belly capacity of widebody passenger aircraft, Aircraft Commerce December 2014/January 2015, page 52*).

Its unique selling point would be price. An aircraft could be modified to LCF status at a fraction of the cost required for a conventional conversion, or that required to source a new-build aircraft.

An LCF modification does not involve the same level of structural work required for a conventional conversion, and does not change the range of certified limits of the feedstock passenger aircraft. An LCF aircraft would not have a large cargo door installed. As an alternative it would have two lift platforms fitted in the lower cargo hold. All freight would then be loaded through the lower hold cargo doors, with cargo being raised to the main deck via the lifts.

One potential restriction of the LCF concept is the size of pallets or containers it could accommodate. This would be limited by the size of the lower deck doors. This means that an LCF aircraft would offer less cargo volume than a conventional freighter. It has been argued, however, that an LCF aircraft could cater for more than 90% of cargo traffic because 90% of cargo can physically fit in lower deck ULDs. LCF also argues that for payloads with typical industry packing densities of around 7.0lbs/cu ft, there is effectively no loss of volume for an LCF aircraft.

"Going forward the industry needs to recognise that the business model for the widebody freighter market has changed," claims Cliff Duke, chief executive officer at the Eolia Group. "The size of the potential widebody conversion market will be less than half what it was over the past two decades. There have been virtually no conversions in the over 80t segment since 2011. This is in part due to the decline in appeal of the 747, but also due to the fact that the widebody freighter market has consolidated and is now dominated by the large integrators which account for 70% of the fleet. These operators can afford to buy new aircraft.

"In the medium widebody market you are probably looking at $12-15 million for a 767-300ER conversion and $15-20 million for an A330 conversion," continues Duke. "There is not much appetite for that level of investment in a 20-year-old aircraft. Importantly, there are no conventional conversion programmes yet for the 777.

"We believe there is a niche for the LCF concept of a cheap and flexible cabin modification, adds Duke. "The low cost would allow operators to make a return on investment over a shorter period of time."

Summary

The choice between converted and new build freighters is only available in the widebody market where the main conversion options in the near-term will be for 767-300ERs, A330s and 747-400s.

Converted freighters can have slightly higher fuel and maintenance costs than comparable new build freighters. They will generally offer similar levels of volume, but may have slightly lower payloads.

Based on the assumptions used in this analysis converted freighters are competitive and sometimes cheaper to operate than new aircraft at a cost-per-unit of freight level due to their lower lease rates. This could make them appealing to independent general freight operators. Large integrators are still likely to be attracted to new-build aircraft since they are able to finance the higher acquisition costs and may perceive that the new aircraft have higher levels of reliability better suited to their operation and levels of utilisation. AC