Converted freighters offer lower capital costs than new-build aircraft. The total costs to bring a converted freighter into service are considered here. These include acquisition, conversion and maintenance costs.

Narrowbody & widebody converted freighter build costs

Airlines looking to expand their freighter fleets or replace ageing aircraft have two main options. They can buy new-build factory freighters from the original equipment manufacturer (OEM), or perform passenger-to-freighter (P-to-F) conversions of used aircraft.

Factory-built freighters will offer the lowest cash operating cost per available ton-mile (ATM) in their size category.

The older technology of converted aircraft may have higher cash operating cost, but will have the advantage of lower capital investment.

The full costs to prepare a converted freighter for service are considered here. These include the initial acquisition of a used passenger aircraft, the cost to convert the aircraft to a freighter and to install a cargo loading system (CLS), and the cost of any required maintenance to prepare the aircraft for service. These costs are considered for narrowbodies and widebodies that are the most likely conversion candidates in the near future.

Air cargo market & conversion trends

The global economic downturn led to a year-on-year reduction in the freight tonnes carried by airlines in 2008 and 2009. Despite an upturn in 2010, growth was again static from 2011 to 2012. There were signs of growth in 2013, but this appears to have been followed by another slow-down.

"Trading conditions for air freight are difficult," says Tony Tyler, the International Air Transport Association's (IATA's) director general and chief executive officer. "Overall, business activity and trade have shifted down a gear after a strong end to 2013."

"The air cargo market has changed significantly since 2008," explains Stephen Fortune, principal at Fortune Aviation. "Shippers have become smarter about saving money. For non-time-critical goods they have realised that they can afford longer transit times. There has also been a shift in modes of transport from air, to rail and sea."

In terms of conversion trends, narrowbody aircraft are being converted in larger numbers than widebody types.

"The widebody conversion market has collapsed," claims Fortune. "In 2007 there were 65 widebody conversions. In 2013 there were eight."

The economic downturn and a growing trend for carrying cargo in the lower holds of passenger aircraft has reduced demand for widebody freighters. "An increase in the levels of belly cargo flown by widebody aircraft, and primarily the 777, has taken traffic away from dedicated main-deck freighters,' says Fortune. "This is particularly apparent on trans-Pacific routes. A 777-300ER can accommodate up to 70,000lbs of freight in the belly hold on top of its standard passenger payload. Airlines are willing to charge marginal costs for belly freight so this method can be cheaper than using conventional freighters."

In the widebody market new freighters have been delivered in greater numbers than converted aircraft in recent years.

One reason for this is that above a certain level of utilisation, the efficiency of cash operating costs become more important than initial capital cost and monthly lease rentals. Only widebody freighters are likely to achieve sufficient levels of utilisation where cash operating cost efficiency is the most important.

Cliff Duke, chief executive officer at the Eolia Group, believes that the widebody freighter segment can be split between medium widebodies with a payload of 40-80 tons, and large widebodies with payloads in excess of 80 tons. Duke believes that most of the movement in the large widebody category will be for factory-built freighters, rather than converted aircraft.

Duke sees more conversion potential in the medium widebody category. "Medium widebody freighters are mainly used on low-utilisation, regional routes that do not require the aircraft's full range capability," explains Duke. "This low utilisation adds extra significance to the importance of acquisition, conversion and overall capital expenditure costs."

To address this issue, the Eolia Group has formed LCF Conversions to provide a low-cost freight-conversion option for medium widebody freighters including the A340, A330 and 777.

P-to-F conversion options

The acquisition and conversion costs, and basic payload specifications for the most likely P-to-F conversion candidates are considered here. Aircraft are divided between narrowbodies and widebodies.

The stated weight specifications of these aircraft are generally the highest available, or among those options most likely to be chosen for freighter conversion.

The acquisition costs are intended to offer a guide and are based on specific engine and maximum take-off weight (MTOW) variants. There may be some variation in price for different engines and MTOWs.

The estimated acquisition costs are for aircraft in half-life maintenance condition with half-life engines. In reality operators of converted freighters may look to acquire aircraft in a lower

There are two conversion programmes for the 757-200. These are offered by Precision Aircraft Solutions and ST Aerospace. The cost for the standard Precision conversion is $4.65 million.

maintenance condition, since this will reduce capital expenditure.

In general, aircraft are considered suitable feedstock for freight conversion when they reach 15-20 years of age. At this age their market values have normally dropped to levels that make acquisition and conversion an economic option. In this analysis the acquisition costs are based on 15-year old aircraft, with the exception of the 737 Classics and MD-80s. Since few of these types were manufactured in 1997-1999, a value range for 15-20-year old aircraft is given.

Narrowbody freighters

The narrowbody aircraft with active conversion programmes are the 737 Classic series, the MD-80 series and the 757.

In March 2014 Aeronautical Engineers Inc (AEI) launched a conversion programme for the 737-800, but development and certification of the supplementary type certificate (STC) is expected to take two to three years.

737 Classics

The 737 Classic series includes the 737-300, -400 and -500. There are conversion programmes for the -300 and -400, but not the -500, which is too short to be economically viable as a freighter.

The only engine family available for the 737-300 and -400 is the CFM56-3.

Current market values for 15-20-year-old, passenger-configured aircraft are $1.90-3.06 million for a -300 and $3.40-4.36 million for a -400 *(see table, page 67)*.

Aeronautical Engineers Inc (AEI), IAI Bedek and Pemco World Air Services all offer freight conversion options for the 737-300 and -400. IAI Bedek and Pemco also offer quick-change (QC) conversions for 737-300s.

A typical converted 737-300 freighter would have a gross structural payload of 42,400-43,100lbs depending upon the internal configuration and conversion option selected *(see table, page 62)*.

AEI, IAI Bedek and Pemco all offer 9-position freighter conversions for 737-300s. These can accommodate up to eight 85-inch X 125-inch X 82-inch (AAA/AAY) containers or 88-inch X 125-inch pallets, plus an additional reduced size container or pallet. AEI's conversion can alternatively hold up to nine 88-inch X 125-inch pallets.

AEI also offers a 10-position 737-300 freighter that can accommodate up to eight AAA/AAY containers or 88-inch X 125-inch pallets plus two additional reduced-size containers or pallets.

There are standard gross weight (SGW) and high gross weight (HGW) variants of the 737-400 *(see table, page 62)*. Typical gross structural payloads would be 42,600-44,000lbs for an SGW freighter and 45,000-47,830lbs for a converted HGW aircraft, depending on the selected configuration and conversion programme.

AEI and Pemco both offer 11-position configurations for converted 737-400s.

AEI's conversion accommodates up to 10 AAA/AAY containers or 88-inch X 125-inch pallets, plus an additional reduced-size container or pallet.

Pemco's 11-position high yield 737-400 configuration can accommodate up to 10 AAA/AAY containers or 88-inch X 125-inch pallets, plus an additional reduced-size ULD or pallet. Pemco also offers a 9-position configuration that can hold up to nine 96-inch X 125-inch pallets.

IAI Bedek offers a 10-position 737-400 freighter configuration that can accommodate up to nine AAA/AAY ULDs, or 88-inch X 125-inch pallets plus an additional 88-inch X 125-inch pallet with a reduced height of 79-inches.

The cost of an AEI 737-300 freight conversion is $2.535 million. The cost of PEMCO conversion is $2.58 million *(see table, page 67)*. All conversion prices generally include provision for a standard cargo loading system (CLS).

The price for an AEI 737-400 freight conversion is $2.75 million. The cost for a PEMCO conversion is $2.85 million. Both conversions include provision of a standard CLS.

MD-80

The MD-80 family includes the MD-81, -82, -83, -87 and -88. AEI is the only conversion provider for this aircraft family. Its conversion programme covers all variants except the shorter MD-87.

There is very little MD-81 feedstock available, while most MD-88s look likely to remain in service with Delta for some years. The MD-82 and -83 are therefore the most likely conversion candidates.

The only engine family available for MD-80s is the JT8D-200 series.

The current market value for 15-20-year-old, passenger-configured MD-80s is about $1.00 million *(see table, page 67)*.

The MD-80 does not suffer from any of the ageing structural maintenance issues affecting the 737 Classics, but it does have a narrower fuselage, so it cannot accommodate the standard AAA/AAY containers preferred by integrators. It is therefore most likely to be used in a general freight role.

An MD-82 or -83 converted by AEI could accommodate up to 12 88-inch X 108-inch ULDs or pallets. These aircraft could also hold up to eight 88-inch X 125-inch pallets loaded longitudinally. The typical gross structural payload of the converted freighters would be about 46,100lbs for an MD-82 and 44,600lbs for an MD-83 *(see table, page 62)*.

AEI's P-to-F conversion price for MD-80s is $2.35 million, including the provision of a CLS *(see table, page 67)*.

757

The 757 family comprises the 757-200 and the stretched -300. Only 757-200s can currently be converted into freighters.

The passenger-configured fleet of 757-200s is split almost equally between those powered by the PW2000 series and the RB211-535 series.

The current market value for 15-year-old passenger-configured 757-200s is about $13.13 million *(see table, page 62)*.

The most suitable 757-200 airframes for conversion are those manufactured from L/N 210 and above, and with less than 30,000 accumulated flight cycles (FC) *(see Cherry-picking 757-200s for conversion to freighter, Aircraft Commerce, February/March 2014, page 60)*.

L/N 210 was manufactured in 1988 and delivered in 1989. Aircraft from L/N 210 onwards offer the highest potential maximum zero fuel weights (MZFWs) through a series of OEM and proprietary third-party weight upgrades. This offers greater payload capability.

At typical freighter utilisation rates, aircraft with fewer than 30,000FC would offer at least 20 years' service before reaching a maintenance-critical threshold at 50,000FC. This is the threshold at which a group of structural inspections is needed, the extent of which could represent a retirement watershed for the aircraft *(see Assessing the 757's ageing maintenance requirements, Aircraft Commerce, February/March 2012, page 35)*.

There are two providers of 757-200 P-to-F conversions: Precision Aircraft Solutions (formerly Precision Conversions) and ST Aerospace.

ST Aerospace currently offers 14 and 14½-position 757-200 freighter conversion configurations that can accommodate AAA/AAY ULDs or 88-inch X 125-inch pallets. It is developing a 15-position configuration, for which it hopes to secure a supplemental type certificate (STC) in the third quarter of 2014.

Precision Aircraft Solutions offers a 15-position 757-200 freighter configuration. It can accommodate up to 15 AAA/AAY ULDs or 88-inch X 125-inch pallets. Alternatively it can hold 13 96-inch X 125-inch containers or pallets. Precision is currently the only organisation with the relevant approval to convert winglet-equipped 757-200s.

For aircraft without winglets and from L/N 210 and above the standard MZFW of a 757-200 is 184,000lbs *(see table, page 62)*. This can be increased to 188,000lbs for RB211-535-powered and 186,000lbs for PW2000-powered aircraft by means of an OEM weight upgrade. Precision offers an additional 8,000lbs upgrade taking the MZFW to 196,000lbs for RB211-535-powered, and to 194,000lbs for PW2000-powered aircraft. The Precision upgrade is conditional on the aircraft having already received the OEM MZFW modification.

The range of MZFWs for aircraft without winglets and from L/N 210 and above results in a potential gross structural payload of 68,000lbs-80,000lbs for Precision-converted 757-200s powered by RB211-535 engines. The potential gross structural payload of a PW2000-powered aircraft would be 68,350lbs-78,350lbs.

The installation of winglets can improve fuel burn, but adds about 1,320lbs to a 757-200's MZFW and operating empty weight (OEW).

For aircraft with winglets and from L/N 210 and above, the standard MZFW is 185,320lbs. The MZFWs of aircraft that have received the OEM weight upgrade would be 189,320lbs for RB211-535-powered and 187,320lbs for PW2000-powered aircraft. Precision's proprietary 8,000lbs MZFW upgrade is not currently available for aircraft with winglets. It hopes to gain approval to offer this upgrade for winglet-equipped aircraft during 2014.

The range of available MZFWs for

BASIC SPECIFICATIONS FOR CONVERTED NARROWBODY FREIGHTERS

Aircraft Type	MD-82/-88	MD-83	737-300	737-400 SGW	737-400 HGW
Engines	PW	PW	CFM	CFM	CFM
Conversion provider	AEI	AEI	AEI/IAI/PEMCO	AEI/IAI/PEMCO	AEI/IAI/PEMCO
MTOW (lbs)	149,500	160,000	up to 139,500	up to 143,500	up to 150,000
MZFW (lbs)	122,000	122,000	109,600	113,000	117,000
OEW (lbs)	75,900	77,400	66,500-67,200	69,000-70,400	69,000-71,400
Gross structural payload (lbs)	46,100	44,600	42,400-43,100	42,600-44,000	45,000-47,830

Aircraft Type	757-200 (Standard)	757-200 (OEM upgrade)	757-200 (Precision upgrade)	757-200 (Standard)	757-200 (OEM upgrade)
Engines	RR/PW	RR/PW	RR/PW	RR/PW	RR/PW
Conversion provider	Precision	Precision	Precision	Precision	Precision
Winglets	No	No	No	Yes	Yes
MTOW (lbs)	250,000	250,000	250,000	250,000	250,000
MZFW (lbs)	184,000	188,000/186,000	196,000/194,000	185,320	189,320/187,320
OEW (lbs)	116,000/115,650	116,000/115,650	116,000/115,650	117,320/116,970	117,320/116,970
Gross structural payload (lbs)	68,000/68,350	72,000/70,350	80,000/78,350	68,000/68,350	72,000/70,350

Notes:
1) Stated OEWs are estimates. Actual OEW will vary by individual aircraft.
2). ST Aerospace also provides 757-200 conversions but weight specifications were not available.
3). Precision 757-200 MZFW upgrades require OEM MZFW to be carried out first. Precision upgrades add extra cost to standard conversion price.
4). 757 specifications refer to post L/N 210 aircraft only.

aircraft with winglets and from L/N 210 and above results in a potential gross structural payload of 68,000-72,000lbs for Precision-converted 757-200s powered by RB211-535 engines. For PW2000-powered aircraft the gross structural payload would be 68,350-70,350lbs.

MTOW and maximum landing weight (MLW) restrictions apply to certain MZFWs for 757-200s. MZFW is limited to 186,000lbs for aircraft with an MTOW of 255,500lbs. The highest potential MZFWs utilising Precision's proprietary 8,000lbs upgrade can be applied to aircraft with an MTOW of 250,000lbs and MLW of 210,000lbs.

The cost of Precision's 757-200 P-to-F conversion is $4.65 million including a CLS *(see table, page 67)*. The OEM MZFW is available from Boeing and will add extra cost. Precision's 8,000lbs MZFW upgrade would add $256,000 to the standard conversion price.

Widebody freighters

The widebody aircraft types with P-to-F conversion options include the 767, A330, A340 and 747-400.

The A300-600R is not included here, since it is unlikely to be converted in significant numbers in the future.

767

The 767 family comprises the 767-200, -300 and -400. Conversion programmes are available for the -200 and -300 series.

"I do not see many more 767-200s being converted," says David Bucher, chief operating officer at Cargo Aircraft Management Inc. "Although the majority of previous conversions were for -200s, the 767-300ER has taken over the market in the past five years."

This analysis will concentrate on the 767-300ER, since this is the most likely variant to be converted in the future.

The -300ER is a higher weight aircraft than the standard -300 which means it can carry a larger payload over a longer range. "The general rule of thumb is that freight operators tend to go for higher gross weight aircraft," says Bucher.

"Most converted 767s have been powered by the CF6," says Bucher. This may be more to do with a larger feedstock of aircraft with GE engines, rather than a conscious choice between engine types.

The active and parked passenger-configured fleet of 767-300ERs is dominated by CF6-80C2-powered aircraft (330). There are a further 169 with PW4000 and 28 with RB211-524 series engines.

Bucher suggests that there is a preference among 767 freighter operators to select aircraft that have engines with full authority digital engine control (FADEC). It is understood that FADEC can provide fuel burn savings of up to 3%.

Typical market values for 15-year-old, passenger-configured 767-300ERs are $13.01-16.01 million, depending on the engine variant *(see table, page 67)*.

767-300ER freight conversions are offered by Boeing and IAI Bedek, and are given the designations -300BCF and -300BDSF. Boeing only accepts increased gross weight (IGW) airframes for conversion. These have MTOWs of 408,000lbs or 412,000lbs.

Converted 767-300ERs, with the highest weight specifications, would have a typical gross structural payload of 125,100-126,500lbs *(see table, page 64)*.

A 767-300ER converted by Boeing or IAI Bedek could accommodate up to 24 AAA/AAY containers, or 88 X 125-inch pallets on its main deck. In the lower deck the aircraft could accommodate up to 14 LD-2 containers plus four 96-inch X 125-inch pallets.

As with the 737-300 and 757-200, winglets are available as a retrofit solution for the 767-300ER to help improve fuel efficiency and range. Boeing can convert 767-300ERs with or without winglets. If the aircraft inducted for conversion does not have winglets, but the operator would like to add them, Boeing can retrofit them during the freight conversion process.

The list price for a 767-300BCF conversion is about $18 million, including provision of a CLS. The price for a 767-300BDSF conversion is estimated to be $13-14 million, including a CLS *(see table, page 67)*.

BASIC SPECIFICATIONS FOR CONVERTED WIDEBODY FREIGHTERS

Aircraft Type	A330-200P2F	A330-300P2F HGW	A330-200LCF	A330-300LCF HGW	A340-300 HGW
Engines	-	-	-RR	RR	CFM
Conversion provider	EADS EFW	EADS EFW	LCF	LCF	LCF
Weight variant	022	052	022	052	026
MTOW (lbs)	513,677	513,677	513,677	513,677	606,271
MZFW (lbs)	374,786	385,809	374,786	385,809	399,037
OEW (lbs)	244,713	251,327	235,544	240,216	250,840
Gross structural payload (lbs)	up to 130,073	up to 134,482	139,242	145,593	148,197
Aircraft Type	**767-300BCF**	**767-300BDSF**	**747-400BCF**	**747-400BDSF**	**747-400BDSF**
Engines	GE or PW	GE/PW	GE	GE	GE
Conversion provider	Boeing	IAI Bedek	Boeing	IAI Bedek	IAI Bedek
MTOW (lbs)	408,000-412,000	412,000	870,000	870,000	875,000
MZFW (lbs)	295,000-309,000	309,000/303,000	610,000	610,000	610,000
OEW (lbs)	183,900	182,500/183,500	360,640	357,000	357,000
Gross structural payload (lbs)	111,100-125,100	126,500/119,500	249,360	253,000	253,000

Notes:
1) Stated OEWs are estimates only - actual OEW will vary by individual aircraft.
2). OEW estimate for A330LCF conversions based on aircraft with RR Trent engines.
3). OEW estimate for A330P2F based on post-conversion aircraft and target payloads. Final payloads to be confirmed following completion of conversion and final weighting.
4). OEWs for 747-400s based on GE-powered aircraft.

A330

The A330 family consists of the A330-200 and the larger -300. No A330s have been converted so far, but there are P-to-F modification programmes available for both variants.

The A330-300s with the best potential performance characteristics are those from L/N 256 onwards which were manufactured from 1999 onwards. These HGW aircraft have higher weight specification options than earlier examples and can therefore offer greater range and marginally larger gross structural payloads.

Aircraft below L/N 256 are low gross weight (LGW) airframes. These have similar MZFWs to HGW aircraft, but they have lower MTOWs, which limits their range. LGW A330-300s may still be attractive for regional integrator operations.

There is no distinction between LGW and HGW aircraft in the A330-200 fleet.

The passenger-configured fleet of A330-200s and -300s is split between those powered by PW4000-100 series, Trent 700 series and CF6-80E1 series engines.

Typical market values for 15-year-old passenger-configured A330-200s range from $25.62 million to $26.62 million, depending on the engine variant *(see table, page 67)*. Values for a typical 15-year old HGW A330-300 would be $32-33 million, depending on the engine variant.

EADS EFW and LCF Conversions are marketing competing conversion solutions for the A330-200 and -300.

EADS EFW is developing the A330P2F conversion programme in conjunction with Airbus and ST Aerospace. It expects to finish the prototype A330-300P2F by 2017, and the prototype A330-200P2F in 2018. The A330P2F is a traditional freighter conversion that incorporates a large cargo door and powered CLS. A manual system for low-density operations may become available on request.

In contrast, LCF Conversions has designed a concept that avoids the need for a large cargo door by loading freight though the aircraft's existing lower deck cargo doors. A pair of internal lifts, situated by the forward and aft cargo doors, are then used to raise ULDs or pallets to the main deck. The LCF conversion would also include a lightweight CLS.

The main advantage of the LCF option is its cost. Because it does not require the installation of a large cargo door or reinforcement of the main-deck floor, conversion costs less than the A330P2F programme.

The A330P2F concept, however, has the advantage of a greater total cargo volume. The A330P2F's large cargo door and reinforced main-deck floor would allow larger containers and higher stacked pallets to be loaded on the main deck than the LCF version. It would also provide greater flexibility for accommodating outsized loads.

On its main deck, an A330-200P2F could accommodate up to 22 96-inch X 125-inch X 96-inch pallets, or 23 containers. These would consist of 18 96-inch X 125-inch X 96-inch (AMV) ULDs, and five 88-inch X 125-inch X 93-inch (AAX) containers. This configuration would provide the maximum containerised volume. By comparison, the -200LCF could accommodate 23 height-restricted 96-inch X 125-inch X 64-inch pallets or ULDs.

An A330-300P2F can carry up to 26 96-inch X 125-inch X 96-inch pallets or 26 ULDs on its main deck. The maximum containerised volume would include 22 AMV and four AAX ULDs. The -300LCF can accommodate 25 96-inch X 125-inch X 64-inch pallets or ULDs.

Both conversion options would offer the same lower deck capacity for converted A330-200 and -300s. One potential lower deck configuration would see a converted A330-200 accommodate up to eight 96-inch X 125-inch X 64-inch pallets or AMF ULDs, plus two 60.4-inch X 61.5-inch X 64-inch (LD3/AKE) containers. Alternatively it could accommodate up to 26 LD3 containers.

The larger -300 could accommodate

The 767-300ER is the most likely 767 variant to be converted in the future. 767 conversions are offered by Boeing and IAI Bedek. The total cost to bring a converted 767 into service could be $27-35 million.

up to nine 96-inch X 125-inch X 64-inch pallets or 10 AMF ULDs, plus two LD3 containers in its lower deck. An alternative configuration would see the aircraft accommodate up to 32 LD3 ULDs.

An A330-200P2F would offer a typical gross structural payload of up to 59 tonnes or 130,073lbs. An HGW A330-300P2F would provide a gross structural payload of up to 61 tonnes or 134,482lbs. An LGW A330-300P2F would provide a gross structural payload of up to 60 tonnes or 132,277lbs.

An A330-200LCF, based on weight variant 022, would offer a typical gross structural payload of 139,242lbs. An HGW A330-300LCF, based on weight variant 052, would provide a gross structural payload of 145,593lbs.

The price for an LCF conversion of an A330-200 or -300 is $6.5 million including the CLS.

The current price for an A330P2F conversion is not available. Based on previous indications it could be more than two-and-a-half times the cost of an LCF conversion.

A340

The A340 family includes the A340-200, -300, -500 and -600. There is no large cargo-door conversion option for the A340 family. LCF Conversions provides a P-to-F modification option for the -300, -500 and -600. Based on age profile and size of fleet, the -300 is the most likely conversion candidate in the near term.

Like the A330-300 fleet, there is a split between early production lower weight A340-300s and later-production higher weight aircraft. For the purposes of this analysis, aircraft within the weight variant series 000-004 are considered LGW A340-300s, while those in higher weight variant series are considered HGW examples.

The only engine family available for A340-300s is the CFM56-5C series.

The current market value for 15-year-old, passenger-configured HGW A340-300s is $9.00 million *(see table, page 67)*.

The A340-300LCF conversion would involve the same modifications as the A330LCF. Internal lifts would again be used to raise freight to the main deck after loading via the existing lower-deck cargo doors.

The A340-300LCF can accommodate three standard and 22 contoured 96-inch X 125-inch X 64-inch pallets, or similarly configured ULDs on its main deck. In the lower deck it could hold up to 10 AMF and two LD3 containers, or nine 96-inch x 125-inch pallets plus a further two 88-inch x 125-inch pallets.

A typical HGW A340-300 would offer a gross structural payload of 148,197lbs.

The price for an A340-300LCF conversion is $6.5 million, including the CLS *(see table, page 67)*.

747-400

The 747-400 series includes the standard -400 and -400ER variants. There are no conversion options for the ER variant. There are two conversion programmes on offer for standard 747-400s, provided by Boeing and IAI Bedek.

There are three engine options for the 747-400: the CF6-80C2, the PW4056/62 and the RB211-524G/H. In general aircraft with the GE and PW engines have a lower hull weight than those with RR engines, sometimes by up to 2,000lbs. The resulting gross payload advantage would probably make the GE and PW-powered aircraft more attractive conversion candidates.

The current market value for 15-year-old 747-400s in passenger-configuration is $16.50-18.50 million, depending on the engine variant. This would be for an aircraft with an MTOW of 875,000lbs. Boeing only converts 747-400s with MTOWs of up to 870,000lbs, so it is possible the acquisition cost of these will be lower. Nevertheless, the cost provided here offers a guide to the maximum an airline could expect to pay for a 15-year-old aircraft.

Converted 747-400s do not have hinged-nose cargo doors like the factory freighter variants. They do, however, have large cargo doors installed at the rear left side of the fuselage.

Aircraft converted by Boeing or IAI Bedek would offer the same internal volume. On the main deck a converted 747-400 freighter could accommodate 21 96-inch X 125-inch X 118-inch contoured pallets or containers, plus seven square profiled 96-inch X 125-inch X 96-inch pallets or ULDs, with a further two specially contoured smaller containers or pallets at the very front.

In the lower deck the use of LD-1 containers would offer the most containerised volume. These generally measure 60.4-inches X 61.5-inches X 64-inches. A converted 747-400 can accommodate up to 32 LD-1s.

The standard MTOW for 747-400s is 870,000lbs, although an upgrade to 875,000lbs is available. A small number of early-built 747-400s have lower MTOWs, and are unlikely to be considered for freighter conversion. This only affects aircraft up to L/N 727 which was manufactured in 1989. Only seven active aircraft fall into this category.

The Boeing conversion programme is available for aircraft with MTOWs of 870,000lbs. The IAI Bedek conversion is available for aircraft with MTOWs of 870,000lbs and 875,000lbs.

The typical gross structural payload of a converted 747-400 freighter with CF6-80C2 engines is 249,360-253,000lbs.

The price for a 747-400BCF conversion is $34 million, including provision of a CLS. The price for a 747-

The main narrowbody types with active conversion programmes are the 737-300 and -400, MD-80 and 757-200. AEI is developing a conversion for the 737-800, but this will not be available for several years.

400BDSF conversion is about $25 million including the CLS *(see table, page 67)*.

Maintenance costs

A rough guide to the potential base maintenance costs for aircraft acquired for freight conversion is provided here.

The conversion process offers a good opportunity to carry out heavy and structural maintenance. In base maintenance checks, there are often a large number of structural inspections that require deep airframe access. This may include the removal and reinstallation of some or all of the aircraft's interior so that the airframe is stripped down to its basic structure. This can consume several hundred or even thousands of man-hours (MH).

To avoid duplicating MH, it makes sense to combine the aircraft's next heavy maintenance check with the conversion process. Conversion requires a similar level of access to remove the passenger interior and install a new cargo door, a reinforced floor, and several associated systems. This therefore has the potential to save the several hundred or even thousands of MH used to completely remove and later reinstall the aircraft's entire interior. This a process that would normally be required during a routine heavy maintenance visit.

In this analysis it is therefore assumed that the acquired aircraft will be put through a D check, or the heaviest base check in its current maintenance cycle. This will realise some of the largest possible savings.

The cost of labour and materials for interior refurbishment is one element of regular base maintenance for passenger aircraft that can be subtracted from the total base check cost. This is because the passenger cabin will be replaced by a cargo interior during conversion.

Aircraft preparation is another element of passenger aircraft base maintenance that would already be included in the conversion process. This involves docking, the removal of fuel and oil and disconnecting power. This represents another saving in regular maintenance costs.

The conversion would also involve the removal of interior fixtures and fittings to gain airframe access to make conversion possible. This would result in a reduction of any MH related to access or routine tasks that would normally be used in the base checks of passenger-configured aircraft.

It is possible that combining the base check with the conversion process would also lead to a reduction in non-routine MH that would otherwise be used in regular maintenance.

The maintenance performed in conversion would also realise savings in materials and parts related to the passenger cabin that are normally consumed in base maintenance. Passenger oxygen bottles and galley ovens are examples of rotables that would not require replacing when converting an aircraft to a freighter.

The potential cost savings associated with a reduction in routine and non-routine MH and materials vary, and depend on factors including the aircraft type and check cycle.

For the purposes of this analysis it has been assumed that combining a D check with the freight conversion process. This will save the equivalent of about one third of the normal cost of a heavy maintenance visit that an aircraft would incur in passenger configuration.

The D check cost assumptions used in the following summary are based on previous *Aircraft Commerce* analysis of each aircraft type in a passenger configuration. The costs have been reduced by a third as per the assumptions mentioned. The base check labour rate is assumed to be $75 per MH.

Narrowbody maintenance costs

It is assumed that a 15-year-old 737 Classic would be in its second base check cycle. Its next D check would therefore be the D2 check, that normally comes due at an age of about 16 years *(see Assessing the 737 classic's ageing maintenance, Aircraft Commerce, June/July 2012, page 36)*.

The estimated cost of this check reduced by a third is $1.67 million. A 20-year old 737 Classic is assumed to be in its third check cycle. The estimated costs of the D3 check are about $1.20 million.

There are a number of corrosion prevention and control programme (CPCP) tasks for the 737 Classic that require a lot of MH, including for deep access. Many of these are related to structural inspections. CPCP tasks can be out-of-phase with base checks. Operators should take the opportunity of deep access provided by the conversion process to carry out these inspections.

A 15-20-year-old MD-80 is assumed to have a D check cost of $1.00-1.40 million.

It is assumed that a 15-year-old 757-200 would be towards the end of its third base check cycle. Its next D check would therefore be the D3 check, normally due at age of about 15 years *(see Assessing the 757's ageing maintenance requirements, Aircraft Commerce, February/March 2012, page 34)*. The estimated cost of this check is about $1.81 million.

Widebody maintenance costs

Like the 757-200, a 15-year-old 767-300ER is assumed to be towards the end of its third base check cycle and approaching its D3 check *(see Assessing the 767's ageing maintenance, Aircraft*

ESTIMATED ACQUISITION, CONVERSION AND MAINTENANCE COSTS

Aircraft Type	Weight (lbs)	Engine Type	Acquisition cost ($-millions)	Conversion cost ($-millions)	Maintenance cost ($-millions)	Total cost ($-millions)
Narrowbody						
737-300	139,500	CFM56-3C1	1.9 - 3.06	2.535 - 2.58	1.20 - 1.67	5.64 - 7.31
737-400	143,500	CFM56-3C1	3.4 - 4.36	2.75 - 2.85	1.20 - 1.67	7.35 - 8.88
737-400	150,000	CFM56-3C1	3.4 - 4.36	2.75 - 2.85	1.20 - 1.67	7.35 - 8.88
MD-82/-83/-88	149,500	JT8D-219	1.00	2.35	1.00-1.40	4.35-4.75
757-200	250,000	RB211-535E4	13.13	4.65	1.81	19.59
757-200	250,000	PW2040	13.13	4.65	1.81	19.59
Widebody						
767-300ER	412,000	CF6-80C2B6F	16.01	13.00 - 18.00	1.72	30.73 - 35.73
767-300ER	412,000	PW4060	16.01	13.00 - 18.00	1.72	30.73 - 35.73
767-300ER	412,000	RB211-524H	13.01	13.00 - 18.00	1.72	27.73 - 32.73
A330-200	513,677	Trent 700	26.62	6.50	2.59	35.71
A330-200	513,677	CF6-80E1A4	25.85	6.50	2.59	34.94
A330-200	513,677	PW4168A	25.62	6.50	2.59	34.71
A330-300	513,677	Trent 700	32.62	6.50	2.59	41.71
A330-300	513,677	CF680E1A4	31.85	6.50	2.59	40.94
A330-300	513,677	PW4168A	31.62	6.50	2.59	40.71
A340-300	609,578	CFM56-5C4/P	9.00	6.50	2.08	17.58
747-400	875,000	CF6-80C2B1F	18.50	25.00 - 34.00	4.52	48.02 - 57.02
747-400	875,000	RB211-524H-T	16.50	25.00 - 34.00	4.52	46.02 - 55.02
747-400	875,000	PW4056	17.50	25.00 - 34.00	4.52	47.02 - 56.02

Acquisition Cost Source: Oriel

Notes

1). Acquisition costs for half-life aircraft with half-life engines and based on 15-20-year old aircraft for 737 classics & MD80 and 15-year-old aircraft for all other types.

2). 737 classic conversion costs based on AEI and PEMCO prices. IAI Bedek prices are not included here.

3). 757-200 conversion costs for Precision Aircraft Solutions conversion only. There will be extra charge of $256,000 for full Precision MZFW upgrades. ST Aerospace conversion costs were not available.

4). A330/A340 conversion costs are for LCF conversion. EADS EFW conversion costs for A330P2F were not available.

5). Maintenance costs only include estimated D check costs. Other costs may need to be considered.

Commerce, April/May 2012, page 38). The estimated cost of this check, is about $1.72 million.

A340-300s, A330-200 and -300s are all assumed to be in their second base check cycles when they reach 15 years of age *(See A330 family 1st & 2nd base airframe check cost analysis, Aircraft Commerce, June/July 2011, page 34; and Budgeting for the cost of materials & parts in widebody base checks, Aircraft Commerce, February/March 2013, page 27).* The C8 check at the end of the second cycle, excluding interior refurbishment, is estimated to cost about $2.59 million for A330-200s and -300s.

The A340-300's estimated check cost is about $2.08 million.

A 15-year-old 747-400 is estimated to be in its second base check cycle and therefore approaching its C8/D2 check *(see Assessing the 747-400's ageing maintenance, Aircraft Commerce, August/September 2012, page 43).* The estimated cost of this check excluding interior refurbishment is $4.52 million.

SBs/ADs

Operators will need to be aware of any outstanding Service Bulletins (SBs) or Airworthiness Directives (ADs) for their preferred aircraft type. These can result in mandatory inspections or repairs that can be costly in terms of MH and materials. In some cases they may represent a retirement watershed for the aircraft.

A number of SBs and ADs related to structural issues have been issued for the 737 Classic family. One particular issue is the potential for cracks around the fuselage window skin belts. A revised SB has recently been issued for this *(see 737 Classic window belt skin replacement modification, Aircraft Commerce October/November 2013, page 56).*

There is an important modification to consider for PW-powered 757-200s before they can operate as converted freighters. To comply with aerodynamic instability margins, aircraft with this engine family will require an engine mount replacement during the conversion process *(see Cherry picking 757-200s for conversion to freighter, Aircraft Commerce February/March 2014, page 60).* It is estimated that this could cost up to $250,000. This would need to be added to the total cost of bringing a PW-powered converted freighter into service.

Additional maintenance considerations

In addition to a base check, some aircraft might be acquired with engines that require shop visits. This analysis does not attempt to estimate engine shop visit costs, because it is assumed that most freight operators would acquire aircraft with life remaining on their engines.

The same assumption applies to the landing gear. Rather than acquiring an aircraft that needs an immediate and costly landing gear overhaul, operators are likely to source one with sufficient life remaining on the landing gear.

Thrust reversers are another maintenance consideration. The potential

AEI, IAI Bedek and Pemco offer conversions for 737-300s and -400s. 737 Classics can accommodate AAA/AAY containers, which makes them more appealing to integrators than the MD-80, which has a narrower fuselage.

cost of a thrust reverser shop visit is not included in the total cost in this analysis. It is estimated that average shop-visit costs for a thrust reverser shipset would be $125,000 for narrowbody engines and $200,000 for widebody types *(see Thrust reverser repair process & economics, Aircraft Commerce, February/March 2014, page 48)*.

Although they are not included in this analysis, wheel and brake maintenance costs may also need to be considered. It is possible that an operator may fit new tyres, or overhaul brakes before putting a converted freighter into service. Aircraft Commerce has previously analysed these costs *(see Wheels, tyres & brakes maintenance & repair costs, Aircraft Commerce August/September 2011, page 25)*.

Operators will also need to be aware of the potential requirement for avionics upgrades to be carried out during the conversion process.

Lease rates

Olga Razzhivina, senior ISTAT appraiser at Oriel, provided estimated lease rates for all of the converted freighter types, except the A330 and A340 because these are yet to enter service.

Razzhivina estimates that lease rates for the 737 Classic freighters would be $70,000-125,000 per month for a -300, and $130,000-150,000 per month for a -400.

Lease rates for a converted MD-80 freighter are estimated to be $100,000 per month.

For a converted 757-200 freighter monthly lease rates are estimated to be $85,000-240,000, while they could vary from $250,000 to $330,000 for a converted 767-300ER.

Lease rates for a converted 747-400 are estimated to be $300,000 per month.

Total costs

The total costs to put converted freighters into service based on acquisition, conversion and estimated base maintenance costs are summarised here.

There is potential for additional costs associated with engine, landing gear, thrust reverser and wheel and brake maintenance. The level of additional maintenance required will be reflected in the aircraft acquisition cost. The aircraft value will be lower for those airframes in need of more maintenance.

Freight airlines can pick and choose the most suitable airframes for conversion based on performance and maintenance condition.

Narrowbody costs

The total cost of bringing a converted 737 Classic freighter into service based on the assumptions in this analysis is $5.64-7.31 million for a -300, and $7.35-8.88 million for a -400 *(see table, page 67)*.

This compares to an estimated total cost of $4.35-4.75 million for a converted MD-80.

Excluding OEM MZFW upgrades and the engine pylon modification required for aircraft with PW engines, it would cost up to $19.59 million to put a converted 757-200 into service. This could potentially rise to $19.85 million if the additional Precision-supplied MZFW upgrades are carried out.

Widebody costs

The total cost of bringing a converted 767-300ER freighter into service would be $27.73-35.73 million.

This compares to $34.71-35.71 million for an LCF-converted A330-200, and $40.71-41.71 for an LCF-converted HGW A330-300.

The current costs for the A330P2F conversion were not available, but based on previous indications the total cost for A330-200 and -300P2Fs could be as much as 25% higher than the equivalent LCF options.

An LCF-converted A340-300 would offer the lowest total cost in the widebody market. The estimated acquisition, conversion and maintenance price would be $17.58 million.

It would cost $46.02-57.02 million to put a converted 747-400 into service.

OEM support fees

In addition to the total costs summarised in this analysis, operators may be required to pay a fee for technical support from the OEM for their converted aircraft.

Airlines that select Boeing conversions receive similar customer and technical support that they would expect for a new aircraft.

Those Boeing aircraft converted by non-OEM conversion houses will be subject to an access fee for Boeing technical support.

Provided the third-party conversion is licensed by Boeing, the fee is $50,000 per year for each aircraft, and applies up to the first four aircraft in a converted fleet. The maximum annual fee is therefore up to $200,000, regardless of fleet size *(see Customer & technical support & avionics standards of passenger-to-freighter conversion programmes, Aircraft Commerce, June/July 2012, page 61)*.

It is understood that there is no equivalent support fee for converted Airbus aircraft. AC