737CLs are a good candidate for replacing ageing 727Fs and 737-200Fs. With a surplus of narrowbody aircraft on the market, 737CLs are available at low values. Before selecting airframes for conversion there are a number of key criteria to consider. These include structure related ADs, fleet commonality and airframe maintenance status.

Cherry picking 737 Classics for conversion to freighter

At the start of 2013 there were still about 1,200 737-300/-400/-500s in active passenger or freight service. About 300 others were parked. 737 Classics (CLs) are being replaced in increasing numbers by 737NG and A320 family aircraft, and a surplus excess of narrowbodies means the values of 737CLs have dropped to unprecedented levels. This makes 737CLs more attractive options for passenger-to-freighter (P-to-F) conversion, particularly as replacements for less efficient 737-200s and 727s.

Despite low market values, there are a number of potentially costly maintenance requirements for 737CLs *(see Assessing the 737 Classic's ageing maintenance, Aircraft Commerce Issue 82, June/July 2012, page 36)*. These present potential pitfalls for operators and lessors. This article will identify the most suitable airframes for conversion based on future maintenance needs and marketability.

Freight conversion options

Only the 737-300 and -400 series have been converted to freighters. The fuselage of the -500 is shorter and therefore not conducive to conversion.

The first 737-300, line number (L/N) 1,001, was built in 1985. A total of 1,113 were built, and the last aircraft was L/N 3,130, built in 1999. A total of 486 737-400s were built: L/N 1,487, built in 1989, to L/N 3,132, which is the very last 737 Classic, built in 2000.

"Operators are now buying 737-500s as engine donors for use on -300 or -400 converted freighters" says Robert Convey, vice president of sales and marketing at Aeronautical Engineers Inc (AEI).

Various freighter configuration options are available for 737CLs. For the -300 there are full freighter, quick change (QC) or combi programmes. For the -400 there are full freighter and combi options.

At the end of February 2013 there were 167 737CLs in various freighter configurations. Only five of these were parked. The main operators of 737CL freighters are China Postal Airlines, Europe Airpost and TNT Airways.

Of the 167 freight-configured aircraft, 126 are -300s, of which 88 of are full freighter and 38 are QC variants. The remaining 44 are -400s, with 36 in a full freighter and eight in a combi layout.

There are three main providers of 737CL freight conversion programmes: AEI, IAI Bedek and Pemco *(see The used market prospects for 737 classics, Aircraft Commerce, Issue 67 December 2009/January 2010, page 7)*.

There are several unit load device (ULD) main deck containers that 737 freighters can use. The ULD with the largest internal volume, and used here, is the AAA. This has a 88-inch depth, a 125-inch base width, and a 80- or 82-inch height. It has an internal useable freight volume of 420 cubic feet (cu ft).

AEI

AEI offers nine- and 10-pallet full freighter conversion options for the 737-300SF. The nine-pallet option allows for nine unit loading devices (ULDs) or nine netted pallets. If using ULDs it is possible to load eight 88-inch X 125-inch X 82-inch AAA containers, and one 88-inch X 125-inch X 64-inch. This offers a main deck usage volume of 3,853 cubic feet (cu ft) *(see table, page 65)*.

The 10-pallet 737-300SF (special freighter) conversion can hold eight 88-inch X 125-inch X 82-inch containers, and two half-containers. This provides a total ULD volume of 3,860 cu ft *(see table, page 65)*.

AEI also offers an 11 pallet 737-400SF conversion. This can carry 10 88-inch X 125-inch X 82-inch ULDs, and one smaller ULD providing a total usage volume of 4,572 cu ft *(see table, page 65)*.

Alternatively, AEI's conversion allows for 10 netted pallets, and one 88-inch X 53-inch X 64-inch ULD which gives a volume of 4,416 cu ft.

Only AEI can offer a 737-400SF conversion with the capacity to accommodate 10 full-height AAA containers, due to the positioning of the installed main deck cargo door. All AEI conversions include the installation of an 86-inch X 140-inch main deck cargo door on the left side of the fuselage.

"The nine-pallet 737-300SF conversion costs $2.45 million, while the 10 pallet option is a little over $2.535 million," says Convey. "The 11-pallet 737-400SF conversion costs $2.75 million. All of AEI's 737 conversion programmes are based on a turnaround time of 90 days. With these prices, you are probably looking at a total build cost of $8-9 million to buy, convert, service and paint a 737-400SF at today's values," adds Convey.

PAYLOAD SPECIFICATIONS OF AEI, IAI BEDEK & PEMCO 737-300/-400 PASSENGER-TO-FREIGHTER MODIFICATIONS

Aircraft type	737-300 AEI	737-300 AEI	737-300 IAI Bedek	737-300 Pemco
MZFW lbs	109,000	109,000	109,600	109,600
OEW lbs	62,000	62,000	66,500/67,300	65,965/66,400
Gross structural payload lbs	44,000	44,000	43,100/42,300	43,635/43,200
Main deck ULD containers:				
ULD containers:	8 X 88/125/82 plus 1 X 88/125/64	8 X 88/125/82 plus two 1/2 ULDs	8 X 88/125/82	8 X 88/125/82 plus 1 X 60/96
ULD volume-cu ft:	3,853	3,860	3,628	up to 3,592
Aircraft type	**737-400 AEI**	**737-400 IAI Bedek**	**737-400 Pemco**	**737-400 Pemco**
MZFW lbs	113,000/117,000	114,000/117,000	117,000	117,000
OEW lbs	67,000/68,000	69,800	69,860	69,860
Gross structural payload lbs	46,000/49,000	44,200/47,200	47,140	47,140
Main deck ULD containers:				
ULD containers:	10 X 88/125/82 plus small ULD	9 X 88/125/82 plus 88/125/79	10 X 88/125/82 plus 1 X HAZMAT	8 X 96/125/82 plus 1 X 88/125/82
ULD volume-cu ft:	4,572	3,997	up to 4,600	up to 3,900

IAI Bedek

IAI (Israel Aerospace Industries) has full freight and QC conversions for 737-300s. The full freight option permits various configurations of ULDs and netted pallets. It can hold up to eight 88-inch X 125-inch X 82-inch ULDs, the last position filled by a netted pallet. Typical main deck useable volume is 3,628 cu ft *(see table, this page)*. IAI also offers a full freighter conversion programme for the 737-400. This holds nine 88-inch X 125-inch X 82-inch ULDs, plus a netted 88-inch X 125-inch X 79-inch pallet. Typical main deck usable volume is 3,997 cu ft.

Pemco

Pemco provides full freight, QC and combi conversion programmes for 737-300s. The full freight option holds eight full-size containers, and one smaller ULD to provide a main deck cargo volume of 3,592 cu ft *(see table, this page)*.

The QC can fit eight ULDs, offering a volume of 2,920 cu ft, or it can carry up to 147 passengers. The combi carries 66 passengers and three full-size containers at the same time. These ULDs provide a main deck cargo volume of 1,320 cu ft.

For the -400 variant, Pemco offers an 11-position, high-yield freight conversion and a nine-position, high-density option. It also offers a combi conversion for the -400. The 11-position freighter allows a main deck cargo volume of 4,600 cu ft. The combi can fly 72 passengers and four ULDs on the main deck. This provides a main deck cargo volume of 1,680 cu ft.

Airframe selection

Ireland-based Aergo Capital Ltd has decided to invest in 737CLs for conversion to freighter. It recently announced a deal with PEMCO to convert as many as 20 737-400s to full freight configuration. The first three conversions are already in progress.

Aergo has six 737CLs in its portfolio: five -400s and one -300. "We focus on extracting maximum value from older aircraft like 737CLs and MD-80s," explains Michael Moore, head of commercial operations at Aergo Group. "The 737-400s being converted by PEMCO will be available for sale or finance leases. Our current focus is on converting 737-400s, but we would consider the -300 if there were interested parties," he adds. "The 737-400 is an ideal candidate to replace ageing 737-200s and 727s in the freight role."

Structural ADs

When identifying suitable aircraft for conversion, Moore says there are a number of key issues to consider: "We aim to avoid aircraft approaching the number of cycles where issues such as the structural lap joint repairs become a factor. Ideally we look for airframes with adequate D-check life remaining."

Service bulletins (SBs) and airworthiness directives (ADs) relating to structural issues are one of the most important considerations for continued operations with 737-300/-400s. Some ADs and SBs that affect the aircraft have resulted in or could result in a high cost for compliance.

Four ADs are issued against SB 53A1177 Revision 6. Three of these concern 737-300s and -400s.

AD 2002-07-08 requires lapjoint and window corner inspections and repair instructions along the window belts on the side of the fuselage. These repairs and inspections have to be made by 50,000 flight cycles (FC). This AD applied to Classics up to L/N 2,565, which was manufactured in February 1994.

AD 2002-07-10 relates to determining whether previously made lap joint repairs are obsolescent, and so need replacing.

The third is AD 2003-08-15, which mandates an inspection detailed in SB 737-53A1255. This involves detecting cracks along stringer number 4, which is along the top of the fuselage, and stringers number 10 and 14, which run along the top and bottom of the passenger windows. This is between body stations 540 and 727, which is the central section of the fuselage, adjacent to the wing. This has a compliance limit of 50,000 FC (flight cycles). If cracks are found, the AD requires modifications to be completed by 45,000 FC. Estimates are compliance could cost as much as $1 million. Later-built aircraft, from L/N 2,553 to the last 737 Classic, L/N 3,132, were exempt from this AD. L/N 3,132 was built in January 1994.

The 737 Classic is also affected by several other major structural ADs. This includes AD 2004-18-06, which resulted from fatigue cracking of skin panels.

A seventh revision of SB 53A1177 is

There are several passenger-to-freighter conversion programmes available for 737-300s and -400s. The most important aircraft selection criteria include structure-related ADs, airframe maintenance status, accumulated FC, and fleet commonality.

expected soon. It is expected to provide an alternative method of compliance (AMOC) for up to seven ADs, including those outlined.

Like revision 6, the first issue of revision 7 to SB 53A1177 will probably apply up to L/N 2,565. It is therefore possible that all 737-300s and -400s from L/N 2,566 to L/N 3,132 will be unaffected.

The main expection of revision 7 to SB 53A1177 is that it will first require an eddy current inspection of the areas of fuselage affected by the ADs described. One such inspection would be an external LFEC of all crown skin lap joints at a maximum limit of 40,000EFC. These inspections are likely to result in findings of delamination, corrosion and other problems. This would then require new, and probably expensive, repairs.

Another expectation is that the need to comply with all the ADs would involve completely replacing the window skin belts. The limit for this is expected to be 50,000FC. Costs for this would be high, since the aircraft would have to be jacked up and completely stripped, and window belt skins removed and replaced. In fact the cost could be so high as to represent a retirement watershed for the aircraft.

Potential suitors of 737CLs for P-to-F conversion are unlikely to want the cost and inconvenience associated with aircraft approaching the new inspection thresholds of revision 7 to SB 53A1177. That is, the probable LFEC inspection at 40,000FC is likely to reveal the need for expensive modifications. This utilisation limit is therefore a retirement threshold for the 737 Classic. Potential operators of 737 Classic freighters should use this as an upper age limit when selecting aircraft that are up to L/N 2,565. Any additional utilisation achievable above this 40,000FC limit could be regarded as a bonus in terms of operating life.

If revision 7 to SB 53A1177 does not affect aircraft from L/N 2,566, as expected, then these younger aircraft will be less of a risk to potential freight operators, and be more attractive. They will also have accumulated fewer FCs than aircraft pre- L/N 2,566, and so be more desirable candidates for conversion.

Fleet commonality

Fleet commonality involves selecting aircraft with the same component, engine, modification, configuration, and AD and SB status. This usually means that those aircraft that have been with the same operator make more attractive conversion candidates. The longer that aircraft have been in service with one airline -- sisterships -- the greater the chances of commonality.

Expressing his own personal views, Jacob Netz, senior consultant at Seattle-based Air Cargo Management Group (ACMG), comments that: "There is no doubt that all parties prefer commonality and sistership aircraft." Having aircraft in a similar configuration with the same modifications makes maintenance, conversion and future operation easier.

"It is important to be sure that the previous operator has properly maintained the aircraft," says Craig Papayanis, managing director at BCI Aircraft Leasing Inc. "We prefer to take an aircraft that has been with a single operator for the longest period. Although we would not rule out taking aircraft from a specific country or region, there might be secondary airlines in certain of these markets that we would avoid."

Parts manufacturer approval (PMA) parts could also be a stumbling block for some lessors and future operators. "Anything that could potentially limit the future marketability of an aircraft would be a concern," explains Moore. "We try to avoid aircraft with PMA parts unless a specific customer wants to take it."

Engine type

All 737CL aircraft are fitted with one of three versions of the CFM56-3. The CFM56-3B1 is the lowest rated -3 series variant, has a rating of up to 20,000 lbs thrust, and equips the 737-300. The CFM56-3B2 and -3C1 engines power both the -300 and -400, and have thrust ratings of up to 22,000lbs and up to 23,500 lbs.

The CFM56-3 variant powering a 737CL is not a critical deciding factor in terms of airframe selection for Aergo. "The engine thrust rating can always be upgraded at a later date by simply adjusting the full authority digital engine control," according to Moore. "The most important issue is to have sufficient life remaining on an engine's life limited parts (LLPs). We would consider sourcing airframes and engines separately."

"The significance of the engine type will depend on the proposed operator's geographical region," says Papayanis. "Some operators flying from hot-and-high locations may have a greater need for higher thrust powerplants."

Aircraft weight

Gross weight is a consideration for Aergo. "Aircraft with higher gross weights are more marketable, since they provide more options to meet a wider range of operational needs," says Moore.

But Netz does not see a 737CL's certified weight as a key factor when choosing airframes for cargo conversion. "Most leasing companies want the maximum certified weight available, because it makes the aircraft more flexible for future customers," says Netz. "Most of the time, increasing the certified weight only involves a paperwork amendment, however. It does not require any physical modifications. Aircraft owners could just make this alteration when they have a particular operator that requires it.

"At the same time it is worth identifying the niche in which a lot of

737-300/-400 freighters are operated," continues Netz. "Most are used by integrators, either directly or by sub-contractors. In integrator operations the required freight volume is filled before reaching the maximum payload of these aircraft. The key term is packing density, or weight per unit of volume. A fully-loaded 737-300 has a maximum structural payload of 43,000 lbs, and the available volume allows a packing density of up to about 9.1 lbs per cu ft. Typical integrator operations have a packing density of about 7 lbs per cu ft or less, so the payload will not exceed more than about 33,000 lbs when all available main and lower deck volume is used, and so will cube out," explains Netz.

Suitable airframes

By analysing fleet data it is possible to identify the most suitable 737-300/-400s conversion candidates. This article has identified that the most important selection criteria in order of priority are: structurally-related ADs and SBs; followed by fleet commonality; and, depending upon the area of operation, engine type. There is also the issue of maintenance status.

As described, the seventh revision to SB 53A1177 will probably require low frequency eddy current (LFEC) inspections on aircraft at 40,000 FC relating to the lower row of crown skin lap joints for aircraft up to L/N 2,565. Potential operators will want to avoid the related inspection and repair costs that are likely to follow.

"737-300s and -400s operating in a freight configuration will typically have a low utilisation of 600-1,000 FH per year or maybe two FC per day," explains Netz. Based on this average utilisation, a converted 737CL freighter might perform 730 FC per year. Potential owners might look for 10 years of operational life following conversion, and possibly up to 12 or 15 years. Working on the specified average utilisation, an aircraft would operate up to 10,000-11,000 FC over a 15-year period. To avoid the potential of costly AD and SB issues arising from 40,000 FC onwards, lessors and freighter operators should therefore consider airframes that have accumulated 30,000 FC or less as conversion candidates in order to realise an economic life limit.

Because aircraft from L/N 2,566, which was built in February 1994, are not affected by revision 6 to SB 53A1177, and will probably not be affected by revision 7 either, these aircraft provide lower risk conversion candidates, since they do not have a retirement limit of 40,000 FC, and so have a longer potential operating life. The number of FC they have accumulated at time of conversion would therefore be less

737-300/-400 PASSENGER-CONFIGURED FLEET

Status	737-300	737-400
Aircraft up to L/N 2,564		
Active - less than 30,000FC	47	68
Parked - less than 30,000FC	27	25
Total	**74**	**93**
Active - more than 30,000FC	182	143
Parked - more than 30,000FC	102	53
Total	**284**	**196**
Aircraft from L/N 2,565		
Active - less than 30,000FC	85	77
Parked - less than 30,000FC	40	12
Total	**125**	**89**
Active - more than 30,000FC	126	19
Parked - more than 30,000FC	8	4
Total	**134**	**23**

critical.

At the end of February 2013 there were 229 active 737-300s and 211 active 737-400s in passenger configuration that were up to L/N 2,564 *(see table, page this page)*. Of these, 182 -300s and 143 -400s had accumulated 30,000 FC or more, and so are not suitable conversion candidates. These fleets included large numbers of -300s that are operated by Comair, JAT, Jet2.com, Lufthansa, Southwest Airlines, and VivaAerobus; as well as large numbers of -400s that are operated by Alaska Airlines, British Airways (BA), Comair, Malaysian Airlines, Qantas, Turkish, and US Airways.

There were 47 active passenger 737-300s and 68 active 737-400s that have accumulated less than 30,000 FC. These -300s include aircraft that are operated by Air China and China Southern Airlines; and groups of three or four -400s that are operated by airlines that include BA and Malaysian Airlines. All of the -400s are equipped with -3C1 engines, while the -300 fleet has a mix of the engine variants.

There were also 129 parked 737-300s and 78 parked -400s. Of these, 27 parked -300s and 25 parked -400s have accumulated less than 30,000 FC. These aircraft are owned by a variety of lessors and financial institutions. Like the active fleet, virtually all -400s are powered by -3C1 engines.

There are, therefore, 74 active and parked 737-300s and 93 active and parked -400s that are up to L/N 2,564 and have accumulated less than 30,000 FC.

The younger portion of the fleet, with aircraft from L/N 2,565, provides more promising conversion candidates. There are 85 active 737-300s and 77 active -400s that have accumulated less than 30,000 FC. Not only are these aircraft unlikely to be affected by the major ADs and SBs described, but the majority have -3C1 engines. The largest groups of -300s are operated by Air New Zealand, Air Baltic, China Southern Airlines, Kenya Airways, and Ukraine International Airlines. The largest groups of -400s are operated by Alaska Airlines, Japan Transocean Air, Solaseed Air, and UTAir.

There are also groups of -300 sisterships operated by Air New Zealand, China Eastern, Yunnan, Norwegian, and Shandong Airlines, and VivaAerobus that have accumulated 30,000-35,000 FC. Many of these have -3C1 engines.

There are also 40 parked -300s and 12 parked -400s with less than 30,000FC. The largest groups of sisterships have been operated by bmibay and webjet.

Maintenance status

The fourth main selection criterion will be the maintenance status of a potential freight conversion candidate. Two main items have to be considered. These are airframe maintenance status, engine maintenance status, and the status of landing gear.

The 737-300/-400 maintenance programme is complicated by the fact that maintenance planners have to combine C and D check tasks with a

There are several airlines flying 10 or more 737CLs that they have operated since new, and many of which have accumulated less than 30,000FC. Alaska Airlines is once such example.

separate group of 70 corrosion prevention and control programme (CPCP) tasks *(see Assessing the 737 Classic's ageing maintenance, Aircraft Commerce, June/July 2012, page 36).* These CPCP tasks can be sub-divided according to their intervals and the area of the aircraft to which they relate. The tasks that will have the largest effect on the on-going maintenance costs of the aircraft, and an aircraft's potential as a conversion candidate, are the upper and lower lobe fuselage inspections, keel beam inspections, galleys and lavatory inspections, wing-body fairing inspections, and centre and outboard fuel tanks. These all require deep access, and so result in large numbers of MH being used. The upper and lower lobe fuselage inspections require the complete removal, and re-installation, of the aircraft's interior. They also have repeat intervals of six to 10 years.

The deep access required to perform these means they are best combined with the heavier C4 checks and the C6/D check to minimise MH consumption. These have an interval of 16,000 FH and 24,000 FH.

Two issues have to be considered with airframe maintenance status. The first is maintenance status at conversion; the second is maintenance status following conversion and in operation.

Of the aircraft in the fleet with the most desirable characteristics, the selection can be further filtered by choosing those aircraft that are close to requiring a C6/D check, and the deepest CPCP tasks. The deepest CPCP tasks are the upper and lower lobe fuselage inspections, which have repeat intervals of six and eight years *(see Assessing the 737 Classic's ageing maintenance, Aircraft Commerce, June/July 2012, page 36).* The optimum conversion process would be to combine the conversion with the C6/D check, the deepest CPCP tasks, and as many of the other CPCP tasks as possible. These would leave the aircraft free of deep and heavy maintenance for six years. All three conversion providers also have heavy maintenance capability and facilities.

Following conversion the aircraft are likely to operate at 1,000-1,500 FH per year. C check intervals are in multiples of 4,000 FH for aircraft operated at regular rates of utilisation.

The heaviest and deepest CPCP tasks of the upper and lower lobe inspections have a repeat interval of eight years. This means that if these tasks were performed during conversion, then operators could operate the aircraft for eight years, be prepared to incur the cost of a heavy maintenance that included the deep CPCP tasks, and then operate for a further eight years, and subsequently retire the aircraft just as the tasks are coming due again. This would therefore provide an aircraft with an operating life of eight or up to 16 years. The decision to retire would be driven by other maintenance requirements, overall operating costs, and the availability of alternative aircraft types at the time the heavy checks come due.

The second issue of maintenance status is engines. The value of 737-300s/-400s is little more than the value of their installed engines. Engine values are determined by their maintenance status. This is most influenced by remaining life of life limited parts (LLPs). Modules can be exchanged for time-continued modules to minimise outlay for shop visits and LLPs.

Potential competition

Another factor that potential 737CL freight operators may need to consider is competition from the MD-80. AEI received a supplemental type certificate (STC) to convert these aircraft in February 2013. AEI is the only company that offers a certified conversion programme for the type.

The MD-80SF can hold 12 88-inch X 108-inch X 78-inch ULDs, providing a useable main deck cargo volume of 4,416 cu ft, similar to the 737-400F.

"The MD-80SF will most likely halve the market share of converted 737CL freighters," says Convey. "To buy an MD-80, convert and service and have it ready to go, will cost about $4 million, half the cost of a 737CL. Additionally the MD-80SF does not have any structural AD issues to contend with."

Fleet commonality issues mean it is unlikely, however, that operators already using the 737CL will take the MD-80.

Summary

Structure-related ADs, fleet commonality and maintenance status are the most important considerations when selecting 737CLs for conversion. These ADs divide the active passenger fleet in two. Aircraft from L/N 2,565, which are 14-19 years old, are the lowest risk and best conversion candidates.

Ideally aircraft should not have accumulated more than 30,000 FC. There are 381 active passenger aircraft that meet these criteria, including 182 -400s. Most are equipped with -3C1 engines.

Aircraft that have recently had D checks and the deepest CPCP tasks, or are due these tasks in a few years, will have the longest periods free of heavy maintenance and can potentially operate for up to another 16 years. This would coincide well with the time that aircraft are likely to reach the 40,000 FC limit, when LFEC inspections relating to structural ADs and SBs come due.

There is also the potential to source a common fleet, with several operators still flying 10 or more aircraft that they have operated since new. AC