The 15-20 ton freight fleet is forecast to grow from its current fleet of 381 aircraft. Predictions are that up to 750 conversions of different 737 variants will be required over the next 20 years. The best variants for freighter modification and conversion programmes are examined.

The status of 737 freighter programmes

The world freighter fleet is forecast to increase by 70% as air cargo is anticipated to more than double in the next 20 years.

Growing trade from e-commerce markets and fast developing economies is driving this expected growth. With 2,650 new freighters needed in the next two decades, it is predicted that 63% of demand will be satisfied by passenger-to-freighter (P-to-F) conversions, and 750 aircraft will be converted 737s.

The 15-20 ton short- and mid-range narrowbody cargo fleet is dominated by the 737 aircraft family.

About 10,500 737s have been delivered, and 90 Next Generation (NG) aircraft are on order. A combination of age, accumulated flight hours (FH) and flight cycles (FC), and sufficiently low market values to make conversion economic will determine when passenger aircraft are converted to freighter. Low values are caused by the introduction of new generation, more efficient aircraft.

As fleets mature, initial purchases are generally made by the teardown market, where valuable parts are salvaged and put onto the aftermarket. Aircraft values are initially too high to economically justify conversion to freighter.

Once the initial teardown market has increased component supply, and when passenger airlines have retired and off-loaded large numbers of a type, market values fall to a level economic for freighter conversion. The type's lease rates also fall.

This will often provide enough good quality, usable aircraft with sufficiently low FH and FC - prime candidates for P-to-F conversion.

Other freighter fleets, and conversion modifications, exist for the MD-80 and BAE146. Of the comparable short- to medium-range freighter fleet of 381 aircraft, 299 are 737s. All of these aircraft are non-original equipment manufacturer (OEM) P-to-F conversions. Apart from re-delivering 737 Boeing Converted Freighters (BCF) from a feedstock of passenger aircraft, Boeing has yet to commission any factory-built 737 freighters, as it has done with some larger types.

A 2018 Boeing forecast predicts that freight revenue ton kilometres (RTKs) will grow at an average annual rate of 4%.

Major lessors have started to expand freighter portfolios by commissioning P-to-F conversions.

It is expected that 50% of the predicted freighter fleet growth will be narrowbodies. Demand for 737 conversions is expected to be robust. Built from 1985, some converted mature -300s have now reached over 44,000FC and 70,000FH. These aircraft remain operational because of low annual utilisation. The scenario for the -400 is similar, with early-built examples entering service 30 years ago. High-time aircraft have reached 32,000FC and 63,000FH, with lower utilisation rates.

Analysing utilisation of the 737-300 fleet over the past year indicates that the 20 most utilised aircraft in terms of FH are operated in China, with an average annual utilisation of 2,845FH.

The top 20 737-400s in terms of annual utilisation averaged 2,762FH. These aircraft are operated across Europe, the Asia Pacific, North America and Latin America.

Retirement predictions

Freighter fleet data show the 737's dominance, and highlights that most of the 737 fleet comprises ageing 737-300s and -400s, a number of which are reaching the end of useful life.

Of the 299 737Fs in service, 135 are -300s and 148 are -400s, from a passenger fleet production run of 1,988 aircraft. More -300s and -400s are due to be converted, although the amount of quality feedstock is diminishing.

Just 16 of the aircraft are recently converted NGs: eight -700s and eight -800s. Boeing has manufactured 6,982 737NG airframes. The number of NG freighters is expected to grow as the first aircraft are converted.

One issue is the number of 737-300s and -400s that are expected to be retired in the next five years. The average age of retirement from service is 31 years. The youngest converted -300 was built in 1999, so it can be expected that all 135 737-300Fs will have retired by 2030. Overlaying this data across the 15-20 ton fleet means that by 2030.

The situation of 737-300Fs retirements becomes more acute over the near term. Of the current fleet, 85 converted aircraft are 26-34 years old. This suggests that 28% of the 737-300F fleet will retire over the next five years.

All converted 737-400Fs are in service. The oldest cargo variant was built in 1988, and the -400F fleet is 19-31 years old. It can be assumed that most or all -400Fs will have also retired or be close to retirement by 2031. This means that all 737 Classic freighters will no longer be in service.

Over the next five years to 2024, 80 aircraft of the current -400F fleet, built from 1988 to 1993, are likely to retire, representing 28% of all 737 freighters.

It is possible that 42% of operational 737 freighters will retire within the next five years.

San Francisco-based cargo aircraft manager and lessor Vx Capital Partners tapped the securitisation market in late 2018 with a deal collateralised with a portfolio of 737 freighters having an average age of 23.1 years. The portfolio comprises 35 aircraft that are 18 years old or older. The portfolio breakdown is

Most retired 737-300s and -400s have market values less than $3 million, and make economic conversion candidates. With more than 30 aircraft being converted each year, supply of appropriate-quality airframes is running low.

33 737-400Fs and two 737-300Fs.

Kroll Bond Rating Agency (KBRA) predicts that in four to five years, 54% of the aircraft in the Vx Capital portfolio will be retired, increasing to 100% in eight to nine years.

Aircraft appraiser Oriel predicts that operators can expect up to 15 years' service from a 737 Classic after conversion, although many lessors may not be comfortable offering a lease for more than five or 10 years.

That is not to say that demand for 737 Classic P-to-F conversions has stopped. Kevin Casey, chief executive officer at Spectre Cargo Solutions, says that demand from operators for Classic conversions remains strong, and estimates that 30 737 Classics were converted in 2018 alone.

KBRA reports that the 737 Classic has become one of the most in-demand aircraft types for new P-to-F conversions. This requirement is expected to evolve into a large demand for NG conversions as Classic feedstock diminishes. The first NG redelivery was a -700 series acquired by Alaska Airlines in 2016.

Redelivery of four 737-800 Boeing Converted Freighters (BCF) to West Atlantic Airlines IN 2018 was followed by two aircraft to ASL Airlines Belgium. An additional two -800 Aeronautical Engineers Inc (AEI) conversions are due to be redelivered to Ethiopian Airlines in early 2019.

GE Capital Aviation Services (GECAS) is converting 20 737-800NGs. Atran Airlines, part of the Volga-Dnepr Group, signed an operating lease for two aircraft to be used on express cargo services in the growing e-commerce sector.

Market

A thriving Chinese economy has underpinned the air cargo market in recent years. There has been a 40% rise in China's e-commerce sales over the past five years.

China, along with Japan and South Korea, make the Asia Pacific region the largest e-commerce market in the world, surpassing the US. Online retail giant Amazon accounts for almost half of the US e-commerce sector. Indonesia is predicted to break $200 billion in e-commerce sales by 2025.

Since freight operators do not identify e-commerce shipments separately, it is hard to quantify the exact impact of e-commerce on global freight. It has, however, translated into growth in air cargo.

It is expected that most 737 freighters will be used to satisfy demand on express carrier routes. China will develop networks as it moves to a consumer-driven economy. The size of China's e-commerce market is expected to surpass a combined US, UK, Japan, Germany and France market by 2020.

The global e-commerce market was estimated to be worth $2.8 trillion in 2018, and is forecast to rise by 41% to $4.8 trillion in the next three years.

With previous annual growth rates of 2.6%, 2018 saw world air cargo traffic grow by 4.2%. Forecasts are for annual growth rates of 4.7% for East Asia and North America. The annual growth rates are expected to reach 5.8% for intra-Asia, and 6.3% for intra-China.

National aircraft age limits

China and Indonesia have recently imposed maximum age limits of 15 years for freighter aircraft at registration and importation.

South Korea and Saudi Arabia have limited aircraft import age to 20 years, while Thailand has limited it to 18 years. Yet aircraft age restrictions have not been set within the US, Canada, Europe or Australia.

While countries like Thailand are vigorously policing aircraft age restrictions, China has a more flexible approach, dealing with individual cases, assessing an aircraft's previous operator, accumulated FC and general condition along with age.

There is a drive by some individual civil aviation authorities to push down the average age of their country's fleet. Most Classic series aircraft are beyond the age threshold that can be accepted by new operators in these countries. While these regulations are restricting development of new markets for converted 737-300s and -400s, age restrictions are expediting the introduction of 737NG conversions.

Indonesia, for example, has decreed a maximum 30-year operational age from the date of first registration for all aircraft.

Leasing

According to Casey, monthly lease rate factors for a 737NGs are 1.0-1.1%, which can translate to over $200,000 per month for a 737-800F, and slightly less for a 737-700F.

While these lower than the 1.5-1.7% rate factors that are expected for older 737-300s/-400Fs, the monthly rent for a NG freighter is still higher than for the Classic. The NG's lower fuel burn and lower maintenance costs offset higher lease rentals. These benefits are improved with higher rates of utilisation. "The NGs also have a higher payload and longer range," says Casey. "It is easy to see why the 737NG freighter is expected to

experience strong demand."

Casey adds that the -800's continuing popularity in passenger service means that airframe feedstock is still limited and so costly.

The market value of a Classic is $1.5-2.2 million, compared to $20 million for an NG series aircraft. Values of -800s will fall, which will then drive demand for operators' fleet expansion. Market values of -700s are starting to fall as operators offload this type, and bulk retirements are expected to relieve the low availability of CFM56-7B engines.

Feedstock

Rafi Matalon, aviation group marketing vice president at Israel Aircraft Industries, says that 737-700 owners will need to invest a significant amount in updating and changing the interiors to extend leases. "We believe that a better solution is a freighter conversion, since lessors need to invest less and they will get an aircraft that will be operational for another 15-20 years."

Converting -700s is a good solution, since their market values are dropping. "This is yet to happen for the -800, so we see converting the -700 as a great solution for the narrowbody market," continues Matalon. "We are noticing a demand for the -700, and we are in talks with some of the big lessors about the -800 and we have plans to release the first converted aircraft. The conversion programme will be launched in 2020," continues Matalon. "We expect a lot of -700 feedstock to be available as big batches of aircraft get phased out."

Matalon expects that no 737 Classics will be left for conversion in two years, due to age restrictions and maintenance costs. The older high-FC aircraft will need a level of maintenance that is likely to become uneconomic in the long run.

"The -700 is a similar size to the -300, but the -700 has more efficient engines," comments Matalon.

According to Robert Convey, senior vice president of sales and marketing at AEI, the 737 Classic has not aged particularly well. Its 1980s design and longevity of service mean that it is subject to a large number of evolving and costly fuselage Airworthiness Directives (ADs) and Service Bulletins (SBs).

Agreeing with Casey, Convey says that demand for Classic conversions remains buoyant because of low feedstock values. "The Classic is a bargain. All you need to do is find a decent -400 with the right number of FC left, and you are looking at sub-$9 million for a service-ready aircraft," says Convey. "This compares to $20 million for a service-ready converted NG. There is at least a $10 million difference just for the ability to carry one more container."

"You will get 10 years' service out of a new Classic conversion, and if you get the right feedstock you can expect 10-15 years," continues Convey. "The problem with the Classic is that there are lots of ADs and SBs. At AEI, we terminate all the ADs around the cargo door area by performing all the required modifications. Yet you encounter lots of problems that arise in the heavy maintenance phase of the aircraft's life at about 50,000FC."

He adds that with low utilisation rates, the low acquisition cost of up to $3 million for an aircraft with 50,000FC can make it viable. "If you find scribe line damage, this could mean a $1 million repair bill. The operator has to decide whether to invest in this and add it to the conversion cost, or to move on to the NG," says Convey.

Convey notes that the pool of quality Classic airframes is drying up. "It is becoming harder to find unpicked Classics at 30,000FC, but there are many good NGs on the market that will make excellent conversions."

ULD SPECIFICATIONS

	Volume cu ft	Tare lbs	Base width	Depth	Height
AAA	436/400	424/504	125	88	80
AAY	438	507	125	88	80.75
AAK/LD7	340	463	125	88	64
AAP/LD9	370	459/514	125	88	64
AEP	152	284	53	88	82
AYF	193	270	78.9	88	62.5
AYK	103	220	80	43	57
LD3	159	168	61.5	60.4	64
P6P	415	264	125	96	64
88" x 125" x 79"	390	450	125	88	79

Notes: ULD specifications will vary by manufacturer

737 ADs & SBs

AD 2002-07-08 required lapjoint and window corner inspections, as well as repair instructions along the window belts on the side of the fuselage. Repairs and inspections are required by 50,000FC for Classics up to line number (L/N) 2,565, an aircraft that was built in 1994.

Now superseded by 2015-21-06, revision 7 of SB 53A1177, the later AD contains instructions for replacing rather than repairing the belts. Previously, airlines were required to use structural repair manuals/Boeing Repair Schemes. Within the superseded document, the AD allocates 4,650 man-hours (MH) to complete a 'retained lap joint modification,' adding a parts cost of $204,000 and cost per product of $599,250.

AD 2002-07-10 relates to determining whether previously made lap joint repairs need to be replaced. The AD applies to Classics with L/Ns 292 through to 2,565.

AD 2003-08-15, which involved detecting cracks along stringer number 4 along the top of the fuselage, and stringers 10 and 14 along the top and bottom of the passenger windows between body stations 540 and 727 adjacent to the wing, has been superseded by 2013-09-01. This was prompted by reports of cracking of the lap-joint lower row, which, if not repaired, could result in sudden decompression of the aircraft. With a compliance limit of 50,000FC, the estimated cost of such repairs is more than $1 million.

AD 2004-18-06, now superseded by 2013-18-08 and also linking to AD 2013-09-01, for an alternative method of compliance (AMOC), was updated, adding new inspections for the cracking of the fuselage skin along certain chem-milled lines, and corrective actions if necessary.

A later AD of relevance is 2017-10-08, which is an updated version of AD 2009-21-01 for the -300/-400 series. The newer communication adds fuselage inspections, repairs and replacement items, plus investigative and corrective actions, while removing some aircraft from applicability. The main issues addressed by the AD concern the unsafe condition of the aft fuselage skin that is subject to widespread fatigue damage and reports of cracking.

Evolving from the 737 Classic, the NG features design improvements that render the aircraft less susceptible to widespread fatigue damage. Inspections are being mandated with the introduction of recent ADs because airframes are ageing.

AD 2008-12-04 details 737-600/-700/-800/-900 variations and requires various repetitive inspections to detect cracks along the chem-milled steps of the fuselage skin as well as loose fasteners.

For most of the narrowbody fleet, the Maintenance Planning Documents (MPD) are either based on MSG-2 (Maintenance Steering Group) or later MSG-3 maintenance principles.

As a general overview, the MSG-2 MPDs contain inspection requirements that could be grouped into a series of numbered 'C' checks to annotate when the task was due in a cycle of checks. These were derived from groups of C check tasks: the 1C, 2C, and 4C tasks.

Within the MSG-2 maintenance programme, it is common to see Corrosion Prevention and Control Program (CPCP) calendar-driven tasks controlled on separate thresholds and repeat intervals to those of the C check or FH-driven structural inspection tasks.

MSG-3 MPDs do not have one single A or C threshold parameter, but incorporate FH, FC or calendar backstops to each task to cover the varied aircraft utilisations. The term C check, however, is still used to refer to grouping of these check requirements.

In MSG-3 MPDs, the CPCP programme of inspections was absorbed/aligned with other zonal and structural inspection tasks for greater maintenance efficiencies.

There is the option to bridge from an MSG-2 to an MSG-3 programme.

Packing densities

A typical packing density for express freight and integrator operations with small packages is 6.5lbs per cubic foot (lbs/cu ft). The relatively low density of this freight means an aircraft will often 'bulk out' by reaching volumetric capacity before reaching full net structural payload.

General freight usually has a higher packing density. An aircraft can commonly reach full net structural payload, and 'gross-out' before volumetric capacity is reached. Packing densities for these operations are 7.0-9.0lbs per cu ft.

Main-deck ULDs

The standard unit load device (ULD) often used by the 737 on the main deck is the AAA/AAC/AAY. This is a full-width contoured container with a base width of 125 inches, a depth of 88 inches and a height of 80.75 inches *(see table, this page)*. Tare weights of the same container can vary slightly among manufacturers. SATCO specifies a tare weight of 545lbs.

LD-7 and LD-9 containers have the same dimensions as widebody belly compartment ULDs. They have a height of 64 inches and a curved profile that allows them to be used on the main deck of narrowbody aircraft.

There are many contoured ULDs with dimensions and profiles closely designed to match the 737 fuselage. The standard base width of these is 125 inches, with a standard depth of 88 inches. FedEx has developed its own 'demi' containers that have a profile of half the full-width ULD and are, therefore, loaded two-abreast.

Unlike the A320/A321, freight is loaded in bulk in the lower cargo compartments on the 737.

All of 737 P-to-F conversions bulk out or cube out at the lower end of the packing density scale of 6.5-7.5lbs per cu ft *(see table, page 70)*. The 737-800Fs offer the highest volumetric payload, with the IAI's -800BDSF conversion being able to lift 48,990lbs, while the AEI conversion -800SF is at 46,995 lbs *(see table, page 70)*.

The IAI 737-700BDSF has a net structural payload of 40,954lbs, and is the only NG conversion that neither bulks nor grosses out with the highest max packing density of the group at 8.6lbs per cu ft *(see table, page 70)*.

Even the 7.5lbs per cu ft average weight density is more analogous to low-end general freight than express. At this packing density, the IAI -400BDSF standard gross weight (SGW), the AEI -400SF SGW, the AEI -400SF high gross weight (HGW), and the AEI -800SF all gross out at low packing densities. That is, they reach their net structural payload limits before using all available volume.

With the maximum packing density of 8.22lbs per cu ft, the -300BDSF grosses out at a high packing density of 8.5lbs per cu ft.

At 40,954lbs, the -700BDSF has a higher net structural payload than the AEI -300SF and -300BDSF variants. The -400SF HGW, with the ability to carry 10 AAYs and a single LD-3, has a small volume advantage over the against the -400BDSF's nine AAYs plus a single 88/125/79 container*(see table, page 70)*.

The AEI 737-800SF has a 6,093-9,093lbs higher net structural payload compared to a -400SF HGW. Similarly, the IAI 737-800BDSF has a 6,068-8,101lbs higher net structural payload than its -400BDSF variants.

The 737-300 freighters have the lowest volumetric payloads across all packing density ranges.

Converted 737-700s and -800s will have range advantages over 737 Classic freighters when operating with a maximum payload.

At maximum payload, the 737-700BDSF has a range advantage of 500nm over a 737-300SF freighter, and a 2,078-2,573lbs higher maximum structural payload. The aircraft also has a range advantage of 750nm over a HGW 737-400F, but its structural payload is slightly lower.

AEI conversions

AEI has converted more than 490 aircraft of varying types and developed more than 128 US Federal Aviation Administration (FAA)-approved Supplemental Type Certificates (STCs). AEI is also a Boeing-licensed third-party STC, and is able to perform freighter conversions for 737 Classics and NGs.

"We have four GECAS 737-800 P-to-F conversions, with two due to be delivered to Ethiopian Airlines," says Convey. "We expect to complete 8-10 737-400 conversions this year, but feedstock will be a problem by the end of the year. The good news is that large numbers of NGs are coming available as operators are starting to retire them."

The AEI 737-300SF has a gross structural payload of 42,900lbs *(see table, page 70)*. There are two main-deck loading configurations: a nine- and 10-position configuration. Floor beams have been reinforced to allow higher ULD or pallet position weights of 4,000-8,000lbs.

AEI uses Ancra International for the loading system, which is included in the conversion price.

The nine-position configuration carries AAA, AAC or AAY ULDs in positions P1 to P8. Position P9 is a single 88-inch X 125-inch X 64-inch LD-9, AAK or AAP ULD. Using eight AAYs and an AAK provides a main-deck volume of 3,844 cu ft, and a total volume of 4,817 cu ft *(see table, page 70)*. Deducting tare weight of 4,519lbs, provides a net structural payload of 38,381lbs to give a maximum packing density of 7.97lbs per cu ft *(see table, page 70)*.

The AEI 737-300SF 10-pallet configuration carries eight AAA, AAC or AAY ULDs in positions P2 to P9. Position P10 accommodates a single LD3, AEP or AEH. Position P1 accommodates an AEP or AEH.

Using eight AAYs, an AEP and LD3 provides a main deck volume of 3,815 cu ft, and a total volume of 4,788 cu ft (*see table page 70)*. Deducting tare weight of 4,508lbs provides a net structural payload of 38,392lbs. This aircraft will have a maximum packing density of 8.02lbs per cu ft. (*see table, page 70)*.

The AEI 737-400SF is available in SGW trim with a gross structural payload of 43,100lbs or 46,100lbs in HGW trim. Both have an 11-pallet configuration and carry 10 AAYs, plus a single LD3 *(see table this page 70)*.

PAYLOAD CHARACTERISTICS OF 737 CLASSIC & 737NG FREIGHTERS

Aircraft type	AEI 737-300SF SGW	AEI 737-300SF HGW	AEI 737-400SF SGW	AEI 737-400SF HGW	AEI 737-800SF
MTOW - lbs	139,500	139,500	143,500	150,500	174,200
MZFW - lbs	109,600	109,600	113,000	117,000	138,300
OEW - lbs	66,700	66,700	69,900	70,900	85,600
Max structural payload - lbs	42,900	42,900	43,100	46,100	52,700
ULDs	8 AAY + 1 AAK	8 AAY + 1 AEP + 1 LD-3	10 AAY + 1 LD-3	10 AAY + 1 LD-3	11 AAY + 1 LD-3
Main deck freight volume - cu ft	3,844	3,815	4,539	4,539	4,997
Tare weight - lbs	4,519	4,508	5,238	5,238	5,745
Lower deck - cu ft	973	973	1,256	1,256	1,555
Total volume - cu ft	4,817	4,788	5,795	5,795	6,532
Total tare weight - lbs	4,519	4,508	5,238	5,238	5,745
Net stuctural payload - lbs	38,381	38,392	37,862	40,862	46,955
Max Packing Density - lbs per cu ft	7.97	8.02	6.53	7.05	7.18
Volumetric payload @6.5lbs/cu ft	31,311	31,122	37,668	37,668	42,458
Volumetric payload @7.5lbs / cu ft	36,128	35,910	37,862	40,862	46,955
Volumetric payload @8.0lbs / cu ft	38,381	38,392	37,862	40,862	46,955

Aircraft type	IAI 737-300BDSF	IAI 737-400BDSF SGW	IAI 737-400BDSF HGW	IAI 737-700BDSF	AEI 737-800BDSF
MTOW - lbs	139,500	143,500	150,000	154,500	174,200
MZFW - lbs	109,600	114,000	117,000	121,000	138,300
OEW - lbs	66,500	69,000	69,000	75,500	83,500
Max structural payload - lbs	43,100	45,000	48,000	45,500	54,800
ULDs	8 x AAY + LD-3	9 x AAY +1 88X125X79	9 x AAY +1 88/125/79	8 x AAY +1 AYK + 1 AYF	11 x AAY +1 LD-3
Main deck freight volume - cu ft	3,663	4,332	4,332	3,800	4,977
Tare weight - lbs	4,224	5,013	5,013	4,546	5,745
Lower deck - cu ft	1,068	1,373	1,373	964	1,555
Total volume - cu ft	4,731	5,705	5,705	4,764	6,532
Total tare weight - lbs	4,224	5,013	5,013	4,546	5,745
Net stuctural payload - lbs	38,876	39,987	42,987	40,954	49,055
Max Packing Density - lbs per cu ft	8.22	7.01	7.53	8.60	7.51
Volumetric payload @6.5lbs/cu ft	30,752	37,083	37,083	30,966	42,458
Volumetric payload @7.5lbs / cu ft	35,483	39,987	42,788	35,730	48,990
Volumetric payload @8.0lbs / cu ft	38,876	38,987	42,987	40,494	48,990

Using 10 AAY and a LD3, the aircraft provides a main-deck volume of 4,539 cu.ft and a total volume of 5,795 cu ft *(see table, this page).*

Deducting tare weight of 5,238lbs, provides net structural payloads of 37,862lbs and 40,862lbs. These aircraft have a maximum packing densities of 6.53lbs per cu ft and 7.05lbs per cu ft *(see table, this page.)*

Floor beams have been reinforced to allow weights of 4,000-8,000lbs.

The AEI 737-800SF has a gross structural payload of 52,700lbs *(see table, this page).* The main deck loading configuration can accommodate 12 positions. Floor beams have been reinforced to allow higher ULD or pallet position weights of 5,700-8,000lbs. AEI uses Ancra International for the loading system, which is included in the conversion price.

The 12-position configuration carries AAA, AAC or AAY ULDs in positions P1 to P11. Position P12 is a single 53-inch X 88-inch X 64-inch LD-3, AEP or AEH ULD. Using 11 AAYs and a single LD3 provides a main deck volume of 4,997 cu ft, and a total volume of 6,532 cu ft *(see table, this page).*

Deducting tare weight of 5,745lbs provides a net structural payload of 46,955lbs. This aircraft will therefore have a maximum packing density of 7.18bs per cu ft and a volumetric payload of up to 46,955lbs *(see table, this page).*

Engineers installing the door surround structure that will accommodate the man deck cargo door for a new 737-700 P-to-F conversion. Later the windows will be plugged, and a main deck cargo loading system (CLS) will be installed.

IAI Bedek

IAI has STCs for the Bedek Special Freighter (BDSF) conversions on the -300, -400, -700 and -800 series, as well as a Bedek Quick Change (BDQC) conversion that is exclusive to the -300.

Bedek Aviation has 40 years of experience, completing more than 200 conversions. IAI claims that with more than two million flying hours it has not incurred a single AD relating to any of their conversions.

Indian low-cost carrier SpiceJet recently took delivery of its 737-700BDSF. Matalon says Bedek sees big demand with the 737NG, adding that IAI no longer converts Classics, focusing instead on newer aircraft.

"We took this decision partly because of the age restrictions that many countries have," says Matalon. "We are focusing on the NG, especially the -700. We have already converted eight aircraft. There is a noticeable demand for the aircraft, and I think that the supply of aircraft will start flowing in second half of 2019 as aircraft finish lease contracts.

"We have two sites in China, and we are establishing a remote site in Mexico in addition to the existing 767 line," continues Matalon. "We are operating three sites because we are reacting to current market demands.

"I believe that more countries will introduce minimum age restrictions for importing aircraft," adds Matalon. "However, I do not think it will happen in Europe or North America because aviation authorities there monitor maintenance more tightly."

The 737-300BDSF holds three STCs for Special Freighter (SF), Ridged Barrier (RB), and Quick Change (QC).

IAI's 737-300BDSF has a maximum structural payload of 43,100lbs. Its total volume of 4,731 cu ft and main-deck volume of 3,663 cu ft, allow the aircraft to carry eight AAA, AAC or AAY ULDs, in addition to a single LD-3 *(see table page 70)*. Deducting tare weight of 4,224lbs provides a net structural payload of 38,876lbs. This means the 737-300BDSF will have a maximum packing density of 8.22lbs per cu ft (*see table, page 70).*

The IAI 737-400BDSF is available in SGW trim with a gross structural payload of 45,000lbs and 48,000lbs in HGW trim. Both have a 10-pallet configuration and can carry nine AAA, AAC or AAY ULDs in positions P1 to P9, and a single 88-inch x 125-inch x 79-inch pallet in P10.

In this configuration, the aircraft provides a main deck volume of 4,332 cu ft and a total volume of 5,705 cu ft (*see table, page 70).*

Deducting tare weight of 5,013lbs provides a net structural payload of 39,987lbs (SGW) and 42,987lbs (HGW). This aircraft will have a maximum packing density of 7.01lbs per cu ft (SGW) and 7.53lbs (HGW) *(see table, page 70).*

The 737-700BDSF has four main-deck loading configurations, a maximum structural payload of 45,500lbs, total volume of 4,764 cu ft and a main-deck cargo volume of 3,800 cu ft.

Configuration A has provision for eight AAA, AAC or AAY ULDs in positions P2 to P-9, an AYK ULD in P1, and an AYF ULD in P10 *(see table, page 70).*

Configuration B has provision for nine ULDs: seven ULDs in P2 to P8, plus a single AKY ULD, and an AYF or AYG ULD in P9.

Configuration C has provision for seven positions plus an engine pallet: five AAA, AAC or AAY ULDs in P2 to P6, plus a single 96-inch X 125-inch engine pallet, plus a single AYK ULD, and an AYF ULD in P7.

Configuration D has provision for seven positions plus a 13,000lbs pallet: five AAA, AAC or AAY ULDs in P2 to P6, plus a single tiedown-restrained 125 X 96 ULD (up to 13,500lbs), one AYK ULD in P1, and an AYF ULD in P7.

Using configuration A, deducting tare weight of 4,546lbs provides a net structural payload of 40,954lbs. This aircraft will have a maximum packing density of 8.60lbs per cu ft (*see table, page 70).*

The 737-800BDSF has a total cargo volume of 6,532 cu ft and a main deck volume of 4,977 cu ft. This gives it a maximum structural payload of 54,800lbs *(see table, page 70)*. It will provide up to 12 loading positions in four main deck configurations.

Configuration A accommodates 12 pallets: AAA, AAC or AAY in positions P1 to P11 and an LD-3 in P12. Using this configuration and deducting a tare weight of 5,745lbs gives a net structural payload of 49,055lbs. This aircraft will have a maximum packing density of 7.51lbs per cu ft *(see table, page 70).*

Configuration B has provision for 11 positions: P1 to P10 accommodating 10 P6P ULDs with a single AKE in the P11.

Configuration C has 10 positions plus an engine pallet. P1 to P4 and P7 to P11 accommodate nine AAA,AAC or AAY. P12 is a single AKE, and the P5 to P6 positions are 96-inch X 125-inch engine pallets.

Configuration D takes nine AAA, AAC or AAY ULDs in P1 to P4 and P7 to P11. P12 takes a single AKE, with P5 and P6 accommodating a 125-inch x 96-inch 13,500LB, CLS or tie-down restrained pallet.

Pemco

Tampa-based conversion facility Pemco offers 737 P-to-F conversions for 737 Classics and NGs. The company also offers a Flexicombi version of the -700 that offers a 24-seat passenger cabin and 2,640 cu ft of cargo for up six pallets, among other permutations.

A recently converted 737-800SF S/N 29121 ready for redelivery. The conversion process takes approximately 100 days to complete and will eliminate SBs around the cargo door area.

Pemco has performed over 135 737-300 and -400 P-to-F conversions.

The 737-300F offers nine pallet positions, including eight full-size ULDs or pallets, and one smaller container or pallet.

The 737-300QC allows for eight full-size ULDs due to retention of the aft galley/lavatory complex. It can be configured to seat up to 147 passengers in a 30-minute turnaround.

With its 48,000lbs payload and 4,600 cu ft main deck volume, Pemco's 737-400F High Yield Freighter (HYF) can carry 11 AAA/AAC/AAY ULDs and use a variety of different pallets, such as the LD-9, demi LD-3 and AEH.

The 737-400F nine-position Alternate High Density (AHD) can be loaded with eight 96 X 125 pallet positions, plus one AAA/AAC/AAY ULD. Supplementary floor reinforcements allow the variant to carry higher density cargo.

The 737-400 Combi 400C configuration has space for four ULDs in the forward cargo area for a 25,000lbs payload, plus seating for 66-72 passengers. The Pemco conversion is the only -400 Combi and, if needed, the cargo area has the volumetric capacity to ship a CFM56 aircraft engine.

The 737-700F has nine pallet positions, and has a gross payload of 45,000lbs. It has a main cargo deck of 3,844 cu ft. The aircraft can accommodate eight AAA/AAC/AAY plus a smaller ninth pallet.

Pemco is the first company to offer a 737-700 Flexicombi model that can have both passenger and freight permutations. These are as follows:

A: a 24-seat passenger cabin aft of a 2,640-cubic-foot cargo deck holding up to 30,000 lbs of payload in six pallet positions.

B: This is configured to include a 3,005 cu ft cargo deck with an available 35,000lbs of payload on seven pallet positions, with a 12-seat passenger compartment aft.

C: As a full freighter variant with the capability to lift six AAA/AAC/AAY ULDs and two smaller pallets on a 3,370 cu ft cargo deck to a maximum payload of 40,000 lbs.

Competition

"I believe that the A321 is a good competitor for the 737-800 because the A321 has more volume. Do not forget that with Airbus there is a major issue for the converted aircraft, because they are still not in the market," says Matalon.

"Converting an aircraft is a major structural modification, and there are big differences between the structure of an Airbus and a Boeing. An additional concern is feedstock price, which is still high for the A321. I do not see the A320 as a good alternative because the 737-700 and the -800 are so established it does not make sense," continues Matalon. "Also, I do not see growth or demand for the A320, and I think its conversion price is more expensive than for the 737."

A320 and A321 P-to-F conversions are being developed by Elbe Flugzeugwerke (EFW), the joint venture between ST Aerospace and Airbus, and an A321 conversion is being developed by Precision Aircraft Solutions. With a 5,603 cu ft containerised volume and a structural payload of 48,280lbs, the EFW A320 can lift 10 AAA/AAC/AAY ULDs and a single PAG on the main deck, plus seven LD-3s in the lower hold.

The A320 is likely to benefit from the increasing demand to move e-commerce by air. With this in mind, the A320 is likely to make an appropriate sister-ship for an A321 P-to-F operator.

The A320, accommodating 10 88 X 125 ULDs plus the additional smaller container, will have more main deck cargo volume than a 737-700, but slightly less than a 737-800. The A321 with a main-deck capacity of 13 88 X 25 ULDs and the additional smaller pallet, however, will have more cargo volume than the 737-800.

Summary

For freighters in this class, 737 variants clearly dominate in terms of number of aircraft converted and in operation.

There is established technical support and component availability, leading to lower operating costs and commonality.

Feedstock of Classic conversion candidates will dictate the future of these conversions. Its low market value means a low-time FC Classic is still a viable proposition for operators with low utilisation rates that operate in jurisdictions without age restrictions.

Market values of -800 feedstock are high, while the lower valued and readily available -700 makes an alternative for operators, especially those affected by aircraft age restrictions. The -700 features the benefits of the -800 in terms of range and fuel efficiency at the expense of one ULD and a 6,461lbs lower net structural payload.

"It is too early to arrange an STC for the -900, but there are no obstacles from our side to develop a conversion," says Matalon. "The -900 is an excellent aircraft with a long fuselage and more volume. Feedstock is still expensive. We do not have any problems creating the STC. We do everything well, and we know how to reverse engineer. We shall bring a product in time with the market, and the market is not yet right for the 737-900 at this time." AC