**Two A320 family conversion programmes have been announced, providing competition to Boeing in the narrowbody freighter market. Payload and range specifications of potential A320 and A321 freighters are compared to 737 solutions.**

# A320 family P-to-F conversion programmes

There are no new-build narrowbody freighters, so cargo operators rely on passenger-to-freighter (P-to-F) conversions to replace or grow their fleets.

In the past this would have involved a straight choice between Boeing types, such as the 727, 737 and 757, or to a lesser extent DC-9s and MD-80s.

In the next few years, however, narrowbody freighter operators will be able to choose between Boeing and Airbus platforms for the first time. Two A320 family P-to-F conversion programmes have been announced.

Potential demand, payload specifications, and options for A320 family freighters are examined here.

## A320 family

The A320 family entered service in 1988. There are about 5,955 A320 family aircraft in active passenger service.

The A320 family was the first commercial aircraft family to introduce fly-by-wire controls. Due to cockpit commonality, a single type rating covers all four members of the A320 family, so that a pilot qualified on one variant can fly all of them: the A318, A319, A320 and A321.

Their size means that no A318s or A319s are likely to be converted.

The A320, the first family member to enter service, has a fuselage length of about 123 feet and is popular, with 3,540 A320s in active passenger service.

Two A320 series have been produced. There are no -100s in service, so the -200 is the sole A320 conversion candidate.

The A321 is the largest member of the A320 family, with a fuselage length of about 146 feet. The current A321 fleet is split between 62 -100s and 979 -200s. The -200 series is the most likely candidate for conversion.

The A320 and A321 are the most likely variants to be converted into freighters. There are two engine families available for both aircraft: the CFM56-5 series and V2500 series.

## P-to-F conversion options

P-to-F conversion programmes have been announced for A320s and A321s. There will be two competing solutions, offered by: EFW and ST Aerospace; and PACAVI. The two programmes will bring contrasting approaches to the market.

## EFW/ST Aerospace

In collaboration with Airbus, EFW and ST Aerospace launched a P-to-F conversion programme for A320s and A321s in June 2015.

ST Aerospace will carry out the supplemental type certificate (STC) development work and the conversions. Once STCs have been awarded, ownership will pass to EFW. EFW will also convert aircraft and provide marketing and sales activities.

Airbus will provide original equipment manufacturer (OEM) data support where required. The three organisations have established a similar relationship on the A330P2F programme. ST Aerospace will increase its share in EFW from 35% to 55% as part of the agreement, with Airbus owning 45%.

Aircraft converted by EFW and ST Aerospace will be designated A320P2Fs and A321P2Fs.

EFW and ST Aerospace will only develop STCs for the conversion of A320-200 and A321-200 series aircraft. The -200 series aircraft are newer and more numerous, and have superior weight specifications. For both variants, P2F conversions will involve installing a large cargo door on the left-hand side of the fuselage forward of the wing. They will also provide a Class E cabin, a 9G barrier, a manual cargo loading system, and a partially reinforced floor.

### A320P2F

The maximum take-off weight (MTOW) of an A320P2F could be up to 169,756lbs *(see table, page 66)*.

The maximum structural payload will be up to 21 metric tonnes (t), equivalent to about 46,297lbs.

An A320P2F will be able to hold up to 10 88-inch X 125-inch unit load devices (ULDs) or pallets, and a smaller container or pallet on its main deck.

In a containerised configuration an A320P2F could hold up to 10 AAY ULDs and an extra LD-3, AEP or AEH container on its main deck. An AAY ULD is a prime example of a ULD with base dimensions of 88 inches X 125 inches *(see table, page 66)*.

The A320P2F will also be able to accommodate ULDs in its lower deck hold. "The A320 family is the only single-aisle aircraft family that can accommodate LD3-45W containers in the lower hold," explains Andreas Mayer, head of aircraft conversion sales at EFW. "This provides operators additional flexibility in terms of interlining."

LD-3-45W containers have the same base dimensions as standard LD-3s but are reduced in height *(see table, page 61)*. An A320P2F can accommodate seven LD-3-45Ws split between two lower deck holds, and arranged in single rows. It will also have an additional bulk hold that can accommodate up to 208 cubic feet (cu ft) of freight.

Narrowbody freighter operators have traditionally bulk-loaded freight in the lower deck. EFW believes the A320's and A321's ability to containerise cargo in their lower decks will bring advantages.

"Containerised cargo makes more use of lower deck volume, since it provides higher packing densities," claims Mayer. "It could also lead to shorter turnaround times, since fewer people are required to unload cargo. In addition, the ULDs provide more protection from damage

and weather. We believe the introduction of the A320P2F and A321P2F will change the common practice of bulk loading lower deck cargo in the narrowbody freighter segment."

### A321P2F

The MTOW of an A321P2F could be up to 206,132lbs *(see table, page 66)* and maximum structural payload will be up to 27t. This is equal to about 59,525lbs.

On its main deck an A321P2F will accommodate up to 13 88-inch X 125-inch ULDs or pallets, plus a reduced-size container or pallet.

In a containerised configuration, an A321P2F will accommodate up to 13 AAY ULDs, plus a further LD-3, AEP or AEH container on its main deck. It will also be able to hold up to 10 LD-3-45W containers in its lower deck. The A321P2F has the same 208 cu ft bulk hold as the A320P2F.

### Programme status

EFW and ST Aerospace will first pursue an STC for A321 conversions. "This is because the certification process for the A321 conversion is less complicated than that for the A320," explains Mayer.

"The first A321P2F conversion will take place in Dresden in 2018 with the prototype aircraft expected to enter service later the same year," adds Mayer. "The prototype A320P2F conversion will begin at the end of 2018, with the aircraft expected to enter service in 2019."

There are currently no launch customers for the A320P2F or A321P2F. "We formally launched the programme at the Paris Air Show, and received authorisation to offer conversions to the market," explains Mayer. "We are now starting to engage with potential customers."

EFW and ST Aerospace's combined experience includes both widebody and narrowbody P-to-F conversions. They are already collaborating on the A330P2F programme. In addition, EFW has previously converted A300s and A310s, while ST Aerospace has converted 767s for Boeing. ST Aerospace currently has an active 757-200 P-to-F programme, for which it has developed its own STC.

## PACAVI

The PACAVI Group launched a programme for A320 and A321 P-to-F conversions in September 2014.

It does not plan to offer a traditional approach to P-to-F conversions. "The conversion market today is a service market where customers take their aircraft to a provider for the necessary engineering and conversion work," explains Stephan Hollmann, chief executive officer at the PACAVI Group. "This is not PACAVI's primary approach.

"Instead of just converting customer-owned assets, we will acquire and convert feedstock aircraft before offering the complete package for sale or lease."

PACAVI will work with a number of partners to bring converted A320 and A321 freighters to the market including AeroTurbine, GAMECO, and HAITEC.

PACAVI is carrying out the necessary research and development and will be responsible for obtaining the STCs for conversion. It will also manage any on-going maintenance requirements. Physical conversion work will be carried out by AeroTurbine in the USA, GAMECO in China, and HAITEC in Germany.

An aircraft converted under PACAVI's P-to-F programme would be designated as an A320 Freighter LITE or an A321 Freighter LITE. PACAVI's A320 and A321 STCs will cover -200 series aircraft.

Conversions will involve installing a 140-inch-wide cargo door on the left-hand side of the fuselage forward of the wing. They will also provide a Class E cabin, a 9G barrier, a manual cargo loading system, and a partially reinforced floor.

### A320 Freighter LITE

An A320 Freighter LITE could have an MTOW of up to 169,756lbs *(see table, page 66)*. It would have a maximum structural payload of up to 21 metric tonnes, equivalent to 46,297lbs.

An A320 Freighter LITE will be able to accommodate the same container or pallet configurations as an A320P2F. This means it could hold up to 10 88-inch x 125-inch ULDs or pallets, plus an additional reduced-size container or pallet on its main deck.

In a containerised configuration an A320 Freighter LITE could accommodate up to 10 AAY ULDs, and an additional LD-3, AEP or AEH container on its main deck. It could also hold up to seven LD-3-45W ULDs on its lower deck. There is also a 208 cu ft bulk cargo hold.

**NARROWBODY FREIGHTER ULD SPEC ASSUMPTIONS**

| Container | Volume (cu ft) | Tare weight (lbs) |
|---|---|---|
| 88"x125"x82" (AAY) | 438 | 507 |
| 88"x53"x63.5" (AEP) | 152 | 284 |
| 80"x43"x57" (AYK) | 103 | 220 |
| 88"x78.9"x62.5" (AYF) | 193 | 270 |
| 88"x125"x79" | 390 | 450 |
| 60.4"x61.5"x64" (LD3) | 159 | 168 |
| 60.4"x61.5"x45" (LD3-45) | 131 | 176 |

### A321 Freighter LITE

An A321 Freighter LITE could have an MTOW of up to 206,132lbs *(see table, page 66)*, with a maximum structural payload of up to 25 metric tonnes, equivalent to about 55,116lbs.

An A321 Freighter LITE will accommodate the same container or pallet configurations as an A321P2F. It could, therefore, hold up to 13 88-inch x 125-inch ULDs or pallets on its main deck, plus an extra, reduced-size container or pallet. In a containerised configuration, an A321 Freighter LITE could accommodate up to 13 AAY ULDs on its main deck, plus an additional LD3, AEP or AEH container. It could also accommodate up to 10 LD-3-45W ULDs on its lower deck. The aircraft would also have a 208 cu ft bulk cargo hold.

### Programme status

PACAVI hopes to simultaneously offer A320 and A321 Freighter LITEs for sale or lease by 2017.

"We have already received 37 orders for sale or lease, most of which have been for A320 Freighter LITEs," claims Hollmann.

PACAVI, which has no plans to convert A318s or A319s, has not identified launch customers.

## Market for A320 family freighters

A320 and A321 freighters are most likely to compete with 737s and 757s for a share of the narrowbody cargo market. They might be used for express package or general freight operations. They might also be used for mail services.

### Position in market

A converted A320 would offer similar maximum structural payloads and main deck loading configurations to a high gross weight (HGW) 737-400 freighter *(see table, page 62)*. An A320 freighter would offer a similar structural payload

**NARROWBODY FREIGHTER MARKET**

| Aircraft Type | Max structural payload | Main deck container/pallet positions |
|---|---|---|
| MD-82/88SF | 46,600 | 12 x (88"x108") |
| MD-83SF | 45,100 | 12 X (88"x108") |
| 737-300 | 42,900-43,100 | Up to 8 (88"x125") plus one or two reduced-size or up to 9 x (88"x125") with final position restricted to height of 64" |
| 737-700BDSF | 45,500 | 8 x (88"x125") plus two reduced-size |
| 727-100 | 43,000 | 9 x (88"x125") |
| SGW 737-400 | 43,100-44,000 | Up to 10 x (88"x125") plus one reduced-size |
| A320P2F/Freighter LITE | 46,297 | 10 x (88"x125") plus one reduced-size |
| HGW 737-400 | 46,100-48,000 | Up to 10 x (88"x125") plus one reduced-size |
| 737-800 | 50,300-57,980 | 11 x (88"x125") plus one reduced-size |
| 727-200 | 59,000 | 12 x (88"x125") |
| A321P2F/Freighter LITE | 55,116-59,525 | 13 x (88"x125") plus one reduced-size |
| 757-200PCF | Up to 84,000 | 15 x (88"x125") |

Notes:
1). 757-200 specs based on aircraft converted by Precision Aircraft Solutions with no winglets and RB211 engines.
2). 737 Classic conversions are provided by AEI, IAI and PEMCO. Exact specs depend upon conversion provider.

to a 737-700BDSF, but the A320 can hold two more 88-inch X 125-inch main deck ULD positions than the 737.

The A320 would, however, offer one fewer main deck ULD position, and a lower maximum structural payload than a 737-800 freighter.

An A321 freighter could offer a higher maximum structural payload and larger main deck volume than any narrowbody freighter currently available, with the exception of the 757.

It will accommodate 13 full-height 88-inch X 125-inch containers, which is two more than the 737-800.

An A321 freighter will offer a similar maximum structural payload to a 727-200, but can accommodate one extra 88-inch X 125-inch ULD on its main deck. It will be the closest competing narrowbody freighter to the 757, but will provide less structural payload and main deck cargo volume than the Boeing aircraft *(see table, this page)*.

EFW and PACAVI both believe that their A320 and A321 freighters will compete with 737NGs as replacement candidates for 737 Classics and 757s.

"The A321 Freighter LITE is not 100% equivalent to a 757 freighter," admits Hollmann. "The 757 is larger and more powerful, but there is probably only enough 757 feedstock remaining for 100-150 more conversions. After that the A321 will be the closest-sized option."

## Types of freight

Express or integrator operations move small packages in ULDs at relatively low packing densities, typically about 6.5lbs per cubic foot (lbs/cu ft).

Due to these low packing densities, aircraft on express or integrator operations can 'cube' or 'bulk' out. This is where the aircraft reaches its volumetric capacity before using the full available net structural payload.

Integrator operations, such as DHL, FedEx and UPS, are normally based on hub-and-spoke networks.

General freight operations involve the carriage of heavier and bulkier items, usually on pallets rather than in ULDs.

General freight is usually packed at higher densities, typically between 7.0lbs and 9.0lbs per cu ft.

These higher packing densities mean that an aircraft operating general freight services could 'gross' out, reaching its net structural payload limit before using all of the available volume.

EFW and PACAVI are mainly targeting their A320 and A321 freighter solutions at the integrator market. They believe they could also appeal to some general freight operators.

The current P2F programme is not the first time Airbus and EFW have investigated potential A320 family conversions. In 2007 they launched the Airbus Freighter Conversion (AFC) programme for A320s and A321s in association with Unit Aircraft Corporation (UAC) of Russia, but the programme was cancelled in 2011.

"The AFC programme was cancelled due to a combination of market forces and engineering complications," explains Mayer. "The AFC conversion tried to appeal to all areas of the air freight market, including both integrator and general freight operators. This resulted in main deck position weights of up to 3.8t. The cargo door was positioned in the rear of the fuselage on the left-hand side. This required structurally reinforcing the rear of the fuselage, which increased weight and decreased the available payload. At the same time airlines were keeping A320 family aircraft in their fleets for longer than expected, due to demand, so residual values did not drop as low as expected."

The new A320P2F and A321P2F programme is very different. "The P2F specifications are focused on the integrator segment," explains Mayer. "Integrators account for 90% of demand in the narrowbody freighter market."

The aircraft do not require the same level of structural reinforcement because of the lighter loads associated with express freight. The highest main deck position weights on the A320P2F and A321P2F will be up to 2.5t. The cargo door has also been moved to a position in front of the wing. Both of these factors mean the A320P2F and A321P2F will be quicker and cheaper to certify.

## Regional demand

EFW and PACAVI both expect the Asia Pacific, and specifically China, to demonstrate the strongest growth in demand for narrowbody freighters in the A320 and A321 size category.

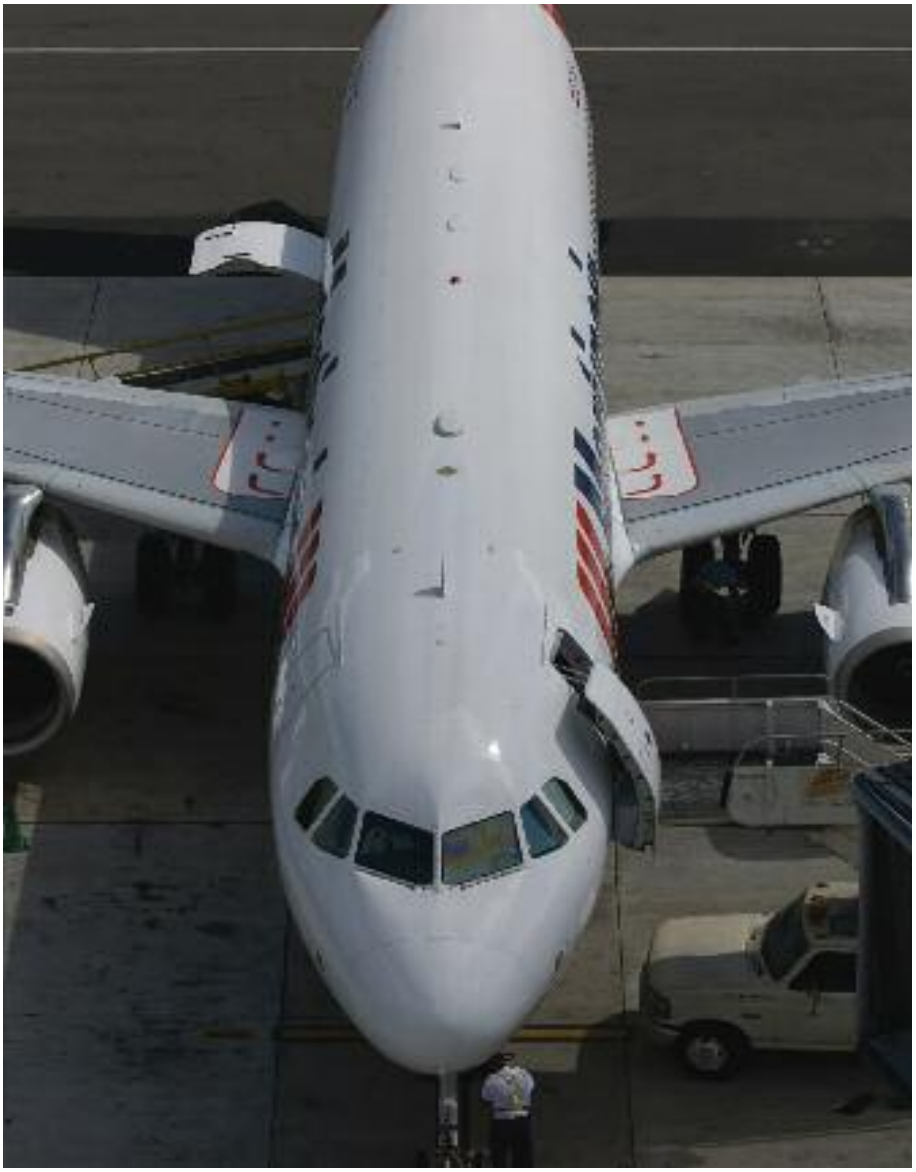
EFW also believes that the USA and Europe will require a large volume of narrowbody freighter replacements.

## A320/321 freighter payload & range

Preliminary specifications have been provided for the A320/321P2F and A320/321 Freighter LITE programmes.

The potential net structural payloads of these aircraft are identified here, along with their volumetric capacities at different packing densities.

The potential payload characteristics of the A320 and A321 freighters are compared to those of HGW 737-400s,



*A320s and A321s could compete with 737NGs and 757-200s for future narrowbody freighter conversion orders. The A320 family is able to accommodate reduced height LD-3 ULDs in its lower deck. Boeing narrowbodies have freight loaded only as bulk on their lower decks.*

and 737NG freighters that are likely to represent some of the main competition.

## Assumptions

Results of this analysis should only be considered within the context of a certain set of assumptions. The aircraft are compared in a containerised configuration because the A320 and A321 freighters are targeting the integrator market, which packs freight in ULDs rather than on pallets.

Multiple main deck ULD configurations are possible for all aircraft in this analysis. Only one configuration has been used for each aircraft, although these should provide some of the highest possible cargo volumes.

In this scenario the A320 and A321 freighters accommodate ULDs in their lower cargo holds. Operators will have the option to bulk load freight in the lower decks, resulting in a lower tare weight and higher net structural payloads for the A320 and A321 freighters than those stated in this analysis. None of the 737s can accommodate lower deck containers, so it is assumed that cargo is bulk loaded in their lower decks.

The precise contour, volume and tare weight of a ULD can vary. The ULD specification assumptions used in this analysis have been summarised *(see, table, page 61)*. These are based on actual examples and should give a realistic idea of the potential total freight volume and ULD tare weight on a loaded aircraft. It cannot, however, be guaranteed that containers matching these exact specifications will be compatible with all the analysed aircraft.

It has been assumed that 100% of the internal ULD volume can be used for loading cargo; it is more likely that about 85% of the volume would be utilised.

The MTOW, maximum zero fuel weight (MZFW) and maximum structural payload figures used in this analysis are the highest achievable for each aircraft type. Some feedstock aircraft may have lower specifications.

The maximum structural payload figures are preliminary estimates that are subject to change. In reality they will vary by individual aircraft owing to differences in operating empty weight (OEW). The stated maximum structural payload figures are based on aircraft that are not equipped with Sharklets.

The maximum structural payload figures for the A320P2F and A321P2F do not account for the weight of the proposed cargo loading system (CLS). In addition to the container tare weights, the estimated weight of the CLS has been subtracted from the maximum structural payload to calculate the net structural payload for these aircraft.

Preliminary specifications for A320 and A321 freighters do not account for weight difference between aircraft with CFM56-5 and V2500 series engines. In reality there will be a slight difference in weight between the two engine variants, but this is unlikely to result in significant differences in structural payload.

The maximum structural payload used for the 737-800BCF is the typical, rather than the highest potential, value.

On some occasions an aircraft's maximum structural payload can exceed its main-deck payload limit. This analysis assumes that any payload exceeding main-deck limits could be accommodated in the lower deck.

## Payload analysis

Net structural payload is an important measure of cargo-carrying capacity. It is the actual weight of freight that can be carried, once tare weight of containers or pallets has been considered.

Net structural payload is calculated by subtracting the tare weight of containers or pallets from the maximum structural payload. The A320P2F's and A321P2F's net structural payload has been calculated by removing container tare weight and the CLS's estimated weight from the stated maximum structural payload. This is because the CLS is not accounted for in the P2F maximum structural payload figures.

The A321P2F would provide the highest net structural payload of any of the narrowbody freighters being analysed *(see table, page 66)*. Its net structural payload of 49,132lbs would be slightly higher than the 737-800BDSF's.

The A321 Freighter LITE would provide the third-highest net structural payload of about 46,597lbs.

The A320P2F would offer the lowest net structural payload of any of the narrowbody freighters in this analysis. The A320 Freighter LITE would provide

## PAYLOAD CHARACTERISTICS OF A320 & 737 FAMILY FREIGHTERS

| Aircraft Type | 737-300BDSF | 737-300SF 10 Position | 737-400BDSF HGW | 737-400SF HGW |
|---|---|---|---|---|
| MTOW (lbs) | Up to 139,500 | Up to 139,500 | Up to 150,000 | Up to 150,000 |
| MZFW (lbs) | Up to 109,600 | Up to 109,600 | Up to 117,000 | Up to 117,000 |
| Max structural payload (lbs) | 43,100 | 42,900 | 48,000 | 46,100 |
| Main deck ULDs | 8 x AAY + 1 LD3 | 8 x AAY + 1 AEP + 1 LD3 | 9 x AAY + 1 88/125/79 | 10 x AAY + 1 LD3 |
| Main deck freight volume (cu ft) | 3,663 | 3,815 | 4,332 | 4,539 |
| Tare Weight (lbs) | 4,224 | 4,508 | 5,013 | 5,238 |
| Lower deck volume (cu ft) | 1,068 | 973 | 1,373 | 1,256 |
| Total volume (cu ft) | 4,731 | 4,788 | 5,705 | 5,795 |
| Total tare weight (lbs) | 4,224 | 4,508 | 5,013 | 5,238 |
| Net structural payload (lbs) | 38,876 | 38,392 | 42,987 | 40,862 |
| Max packing density (lbs/cu ft) | 8.22 | 8.02 | 7.53 | 7.05 |
| Volumetric payload @ 6.5lbs/cu ft | 30,752 | 31,122 | 37,083 | 37,668 |
| Volumetric payload @ 7.5lbs/cu ft | 35,483 | 35,910 | 42,788 | 40,862 |
| Volumetric payload @ 8.5lbs/cu ft | 38,876 | 38,392 | 42,987 | 40,862 |

| Aircraft Type | 737-700BDSF | 737-800BDSF | 737-800SF | 737-800BCF |
|---|---|---|---|---|
| MTOW (lbs) | Up to 154,500 | Up to 174,200 | Up to 174,200 | Up to 174,200 |
| MZFW (lbs) | Up to 121,000 | Up to 138,300 | Up to 138,300 | Up to 138,300 |
| Max structural payload (lbs) | 45,500 | 54,800 | 52,000 | 50,300 |
| Main deck ULDs | 8 x AAY + 1 AYK + 1AYF | 11 x AAY +1 LD3 | 11 x AAY + 1 LD3 | 11 x AAY + 1 LD3 |
| Main deck freight volume (cu ft) | 3,800 | 4,977 | 4,977 | 4,977 |
| Tare Weight (lbs) | 4,546 | 5,745 | 5,745 | 5,745 |
| Lower deck volume (cu ft) | 964 | 1,555 | 1,555 | 1,555 |
| Total volume (cu ft) | 4,764 | 6,532 | 6,532 | 6,532 |
| Total tare weight (lbs) | 4,546 | 5,745 | 5,745 | 5,745 |
| Net structural payload (lbs) | 40,954 | 49,055 | 46,255 | 44,555 |
| Max packing density (lbs/cu ft) | 8.60 | 7.51 | 7.08 | 6.82 |
| Volumetric payload @ 6.5lbs/cu ft | 30,966 | 42,458 | 42,458 | 42,458 |
| Volumetric payload @ 7.5lbs/cu ft | 35,730 | 48,990 | 46,255 | 44,555 |
| Volumetric payload @ 8.5lbs/cu ft | 40,494 | 49,055 | 46,255 | 44,555 |

| Aircraft Type | A320P2F | A320 Freighter LITE | A321P2F | A321 Freighter LITE |
|---|---|---|---|---|
| MTOW (lbs) | Up to 169,756 | Up to 169,756 | Up to 206,132 | Up to 206,132 |
| MZFW (lbs) | Up to 137,789 | Up to 137,789 | Up to 162,701 | Up to 162,701 |
| Max structural payload (lbs) | 46,297 | 46,297 | 59,525 | 55,116 |
| Main deck ULDs | 10 x AAY + 1 LD3 | 10 x AAY + 1 LD3 | 13 x AAY + 1 LD3 | 13 x AAY + 1 LD3 |
| Main deck freight volume (cu ft) | 4,539 | 4,539 | 5,853 | 5,853 |
| MD tare Weight (lbs) | 5,238 | 5,238 | 6,759 | 6,759 |
| Lower deck ULDs | 7 x LD3-45 | 7 x LD3-45 | 10 x LD3-45 | 10 x LD3-45 |
| Lower deck volume inc bulk (cu ft) | 1,125 | 1,125 | 1,518 | 1,518 |
| LD tare weight (lbs) | 1,232 | 1,232 | 1,760 | 1,760 |
| Total volume (cu ft) | 5,664 | 5,664 | 7,371 | 7,371 |
| Total tare weight (lbs) | 6,470 | 6,470 | 8,519 | 8,519 |
| Net structural payload (lbs) | 38,063 | 39,827 | 49,132 | 46,597 |
| Max packing density (lbs/cu ft) | 6.72 | 7.03 | 6.67 | 6.32 |
| Volumetric payload @ 6.5lbs/cu ft | 36,816 | 36,816 | 47,912 | 46,597 |
| Volumetric payload @ 7.5lbs/cu ft | 38,063 | 39,827 | 49,132 | 46,597 |
| Volumetric payload @ 8.5lbs/cu ft | 38,063 | 39,827 | 49,132 | 46,597 |

Notes:
1). Stated max structural payloads are estimates of max potential. Actual payload will vary by individual aircraft due to differences in OEW.
2). Stated max structural payload of 737-800BCF is typical value. Max payload of 57,980lbs is possible.
3). 737-700BDSF has main deck payload limit of 45,000lbs
4). 737-800BDSF and -800SF have main deck payload limit of 52,000lbs.
5). A320 & 321P2F max structural payload does not include CLS. CLS weight assumed to be 1,764lbs for A320P2F and 1,874lbs for A321P2F. This has been subtracted along with tare weight to calculate net structural payload for these aircraft.

a higher net structural payload than the A320P2F and the 737-300s, but it would be lower than that offered by the HGW 737-400, 737NG and A321 freighters.

The A320 and A321 freighters would have higher net structural payloads if cargo were bulk loaded rather than containerised on their lower decks.

Maximum packing densities of the A320 and A321 freighters are lower than those offered by most of the 737 variants, but should be generally satisfactory for express package operations.

Maximum packing density is calculated by dividing the aircraft's net structural payload by the available volume. It is the maximum density at which cargo can be packed to make optimum use of the aircraft's available payload and volume.

The two A320 freighters have maximum packing densities ranging from 6.67 to 6.72lbs/cu ft *(see table, page 66)*. The A321 freighters have maximum packing densities ranging from 6.32 to 7.03lbs/cu ft.

The volumetric payloads of various A320 and 737 family freighters have been compared at different packing densities.

## 6.5lbs per cu ft

With the exception of the A321 Freighter LITE, all the A320 and 737 freighters would cube out at a typical express packing density of 6.5lbs/cu ft. The A321 Freighter LITE would gross out, reaching its payload limit before making use of all of the available volume.

The two A321 freighters offer the highest volumetric payloads at this packing density *(see table, page 66)*. The A321P2F and A321 Freighter LITE offer volumetric payloads of 47,912lbs and 46,597lbs. The next highest volumetric payloads are provided by the 737-800 freighters, at 42,458lbs. The A320P2F and A320 Freighter LITE provide a volumetric payload of 36,816lbs. This is higher than that of the 737-300 and 737-700BDSF freighters, but marginally less than that offered by the HGW 737-400s.

The A321 Freighter LITE uses all of its available structural payload at this packing density, while the A321P2F uses about 98%, and the A320P2F and A320 Freighter LITE would use 97% and 92% respectively.

## 7.5lbs per cu ft

A packing density of 7.5lbs/cu ft would be relatively high for express freight, and quite low for general freight.

At this density all of the A320 family freighters and some 737 variants will gross out. The 737-300s, HGW 737-400BDSF, 737-700BDSF and 737-800BDSF will all cube out.

The A321P2F provides the highest volumetric payload at this packing density *(see table, page 66)*. Its volumetric payload of 49,132lbs marginally exceeds the 48,990lbs offered by the 737-800BDSF. The A321 Freighter LITE provides the third-highest volumetric payload of 46,597lbs, compared to volumetric payloads of 46,255lbs and 44,555lbs for the 737-800SF and 737-800BCF.

The A320P2F and A320 Freighter LITE provide volumetric payloads of 38,063lbs and 39,827lbs, higher than those provided by the 737-300s and the 737-700BDSF, but lower than those of the HGW 737-400s.

## 8.5lbs per cu ft

At a packing density of 8.5lbs/cu ft, all of the aircraft would gross out, with the exception of the 737-700BDSF.

This density is more likely to apply to general freight than express operations.

**ESTIMATED ACQUISITION COSTS FOR A320 AND 737 FAMILY AIRCRAFT**

| Aircraft Type | MTOW (lbs) | Current Value (US$-millions) 15-year-old | 20-year-old | 2017 value est (US$-millions) 15-year-old | 20-year-old |
|---|---|---|---|---|---|
| HGW 737-400 | 150,000 | 4.64 | 3.5 | n/a | 2.37 |
| 737-700 | 154,500 | 10.5 | n/a | 10.6 | 7.73 |
| 737-800 | 174,200 | 17.05 | n/a | 15.79 | 12.13 |
| A320-200 | 169,776 | 11.8 | 8.0 | 13.42 | 8.74 |
| A321-200 | 206,132 | 15.64 | n/a | 15.27 | 10.3 |

Source: Oriel

Oriel current market values and future base values, assuming 1.5% inflation. All values are for aircraft in half-life maintenance condition

The A321P2F's volumetric payload of 49,132lbs is the highest at this packing density, but would only be about 80lbs more than that offered by the 737-800BDSF *(see table, page 66)*. The A321 Freighter LITE has a volumetric payload of 46,597lbs, exceeding the 46,255lbs and 44,555lbs offered by the 737-800SF and 737-800BCF.

The A320P2F offers a volumetric payload of 38,063lbs, the lowest of any of the 737 and A320 family freighters at this packing density.

The A320 Freighter LITE's volumetric payload of 39,827lbs exceeds those offered by the two 737-300 freighters, but is less than that of the 737-700BDSF and the HGW 737-400s.

### Payload range

The following payload-range comparisons are based on the particular aircraft specifications used in this analysis. Different weight specifications could lead to different results.

The A320P2F and A320 Freighter LITE are expected to have a range of 2,100nm and 2,000nm at maximum payload. The A321P2F and A321 Freighter LITE will have a range of 1,900nm and 2,000nm at maximum payload. Converted A320s and A321s will have superior range to 737 Classic freighters, and similar capabilities to 737NG freighters *(see 737NG P-to-F conversion programmes, Aircraft Commerce, April/May 2015, page 74)*.

An A320 freighter would have a range advantage of 250-350nm over a HGW 737-400, but its maximum structural payload could vary from 1,703lbs less to 197lbs more than the 737's. The A320 would have 100-200nm less range than a 737-700BDSF, but its maximum structural payload would be 797lbs higher.

In comparison to the 737-800s used in this analysis, an A320 freighter could have up to 100nm more range, but the A320's maximum structural payload would be 4,003-8,503lbs less.

An A321 freighter would have a range advantage of 150-250nm and a maximum structural payload advantage of 7,116-13,425lbs compared to a HGW 737-400. The A321 would have 200-300nm shorter range than a 737-700BDSF, but a payload advantage of 9,616-14,025lbs.

The A321 could have 100nm less range than the 737-800 freighters used in this analysis but its maximum structural payload will be 316-9,225lbs higher.

## Aircraft financing

The typical feedstock age-range for P-to-F conversions is 15-20 years.

Passenger-configured A320s and A321s can be acquired for less than 737-800s *(see table, this page)*. The A320 and A321 would, however, require more investment than a HGW 737-400 or a 737-700.

The current values for 15-year-old A320s and A321s in half-life maintenance condition, and with half-life engines, are estimated to be $11.8 million and $15.64 million *(see table, this page)*. This compares to $17.05 million for a 737-800, $10.5 million for a 737-700, and $4.64 million for a HGW 737-400.

Both A320 family programmes could be converting aircraft by 2018. Estimated 2018 values for 15-year-old A320s and A321s in half-life maintenance condition, with half-life engines, are $13.42 million and $15.27 million, compared to $15.79 million for the 737-800 and $10.6 million for the 737-700. The gap in acquisition costs between 15-year-old 737-800s, and similar vintage A320s and A321s, is, therefore, expected to shrink.

Acquisition cost is not the only consideration for narrowbody freighter operators. The on-ramp cost of a narrowbody freighter also includes maintenance and conversion costs. PACAVI plans to bundle these and provide aircraft for sale or lease.

It was not possible to provide an on-ramp cost comparison of the various 737 and A320 family freighter options, since conversions costs were not available for all programmes, and PACAVI does not advertise its sale and lease costs.

## Summary

P-to-F conversion programmes have been announced for A320s and A321s but are unlikely for A318s or A319s.

EFW and ST Aerospace will offer a traditional approach to converting customer-owned aircraft. PACAVI's main focus will be to source its own feedstock, before offering freighters for sale or lease.

A320 and A321 freighters may be required for growth and replacement, most likely to replace 737 Classics. The A321 is the closest narrowbody replacement for the 757 freighter.

A321 freighters will offer higher maximum payloads and cargo volume than any of the 737 specifications considered here.

The A321P2F offers higher net structural payloads and volumetric capacities than all of the other aircraft, at the packing densities used in this analysis.

It should be noted that the highest weight specification 737-800BCF was not considered. This could provide a higher net structural payload than the A321P2F, but would still offer less volume.

A320 freighters will offer more cargo volume than any of the 737 variants. They will provide maximum structural payloads similar to those of HGW 737-400s. This is higher than those of 737-300s or the 737-700BDSF, but less than those of 737-800s and A321s.

The net structural payloads of A320 freighters will be similar to those of 737-300s. At certain packing densities, the A320 freighter provides higher volumetric payloads than 737-300s and the 737-700BDSF. The A320 freighter's volumetric payload will still be inferior, however, to that offered by HGW 737-400, 737-800 and A321 freighters. AC