P-to-F conversion programmes for the A321 and A320 are due to enter production in 2018 and 2019. A321 freighters will see long-term demand as 757-200 replacements. The A320 and A321 could see short-term demand as freighters for start-up operators and combination carriers.

The market for A320 and A321 freighters

The narrowbody freighter segment has historically relied on various Boeing aircraft types for capacity, including the 727 family and 737-200, and in more recent years, 737-300s, 737-400s and 757-200s.

The first passenger-to-freighter (P-to-F) conversion programme for an Airbus narrowbody, the A321-200, will enter production in 2018, followed by an A320-200 P-to-F conversion line in 2019.

The potential markets for A320 and A321 converted freighters are considered here. The types they are most likely to replace and compete with are identified, based on a comparison of cargo volume and payload specifications, and potential acquisition and conversion costs. Some potential A320 and A321 freighter operators are highlighted.

A320/A321 P-to-F programmes

Two separate A320 family conversion programmes have been launched in recent years. In 2014 PACAVI Group announced plans to develop supplemental type certificates (STCs) for A320 and A321 freighter conversions. In 2015, the experienced Airbus widebody conversion provider EFW announced plans to offer P-to-F conversions for A320s and A321s, in association with its two controlling shareholders, ST Aerospace and Airbus.

PACAVI planned to develop STCs for its A320/321 Freighter Lite conversions before acquiring, converting and leasing or selling ready-made freighters. A recent communication from PACAVI explained that, following a change in investors, the group is being restructured so STC development for the P-to-F modifications will now be outsourced. It is not yet clear which entity will continue developing the STCs, or when this will be announced.

This feature will focus on EFW's A320P2F and A321P2F programmes, both of which are in development.

A320P2F

The A320P2F programme will focus on A320-200 series airframes, and is expected to enter production in 2019.

An A320P2F could have a maximum take-off weight (MTOW) of up to 171,958lbs (78 metric tonnes), a maximum zero fuel weight (MZFW) of up to 137,789lbs (62.5t) and a gross structural payload of up to 46,297lbs (21t) *(see table, page 75)*.

Any A320-200 can be converted. Aircraft from line number (L/N) 1081 (manufactured in 1999) onwards can be certified at the highest MZFW specified here. Most feedstock aircraft are likely to qualify for these weight specifications since L/N 1081 will be 20 years old in 2019, and the typical age range for P-to-F conversions is 15-20 years.

Some aircraft may require more modifications than others to be certified at the highest possible weights after conversion. This depends on the certified weight variant (WV) of the incoming feedstock. Modifications could range from a simple paperwork exercise to the need for structural changes. EFW and Airbus should be consulted for technical details and related costs.

An A320P2F will accommodate up to 10 88-inch X 125-inch unit load devices (ULDs), plus a further reduced-size ULD on its main deck, and seven LD3-45W ULDs, plus 208 cubic feet (cu ft) of bulk freight in its lower hold. Alternatively, entirely bulk loading the lower hold will give a bulk cargo capacity of 1,322 cu ft.

In a typical loading configuration an A320P2F will offer a containerised main deck cargo volume of up to 4,539 cu ft *(see table, page 75)*. This assumes that the main deck is loaded with 10 AAY ULDs and a single LD-3. If the lower hold is also loaded with containers, an A320P2F freighter may offer a containerised volume of up to 5,456 cu ft.

A321P2F

The A321P2F programme will focus on converting A321-200 series airframes, because there are only 50 -100 series aircraft left, and the -200 series has higher certified weights. EFW notes that A321-100 series aircraft can be upgraded to -200 status before a P-to-F conversion, through specification weight upgrades. Interested parties should consult Airbus or EFW for details.

An A321P2F could offer an MTOW of up to 206,129lbs (93.5t), an MZFW of up to 162,701lbs (73.8t) and a gross structural payload of up to 59,525lbs (27t) *(see table, page 75)*. Any A321-200 could be converted to A321P2F status.

A321-200 L/N 1,794, an improved weight variant, was built in 2002, and all aircraft above this L/N benefit from the best achieveable MTOW, which offers a potential minimal range advantage. Aircraft qualifying for the maximum post-conversion weight specifications will therefore be entering the 15-20 year feedstock age range when the A321P2F programme enters production in 2018.

Like the A320-200 fleet, some A321-200 feedstock may need more modifications to be certified at the highest possible post-conversion weights. EFW and Airbus should be consulted for technical details and related costs.

An A321P2F will accommodate up to 13 88-inch X 125-inch ULDs, plus one reduced-size ULD on its main deck. It can take up to 10 LD3-45W ULDs and offer 208 cu ft of bulk cargo in its lower hold. Alternatively it could take up to 1,829 cu ft of bulk cargo in the lower hold.

If an A321P2F is configured with 13 AAY ULDs and one LD-3 on its main deck and 10 LD3-45W ULDs in its lower hold, it could offer a containerised main deck cargo volume of 5,853 cu ft and a total containerised volume of 7,163 cu ft *(see table, page 75)*.

NARROWBODY FREIGHTER ULD SPEC ASSUMPTIONS

Container	Internal Volume (cu ft)
88" x 108" x 78"	368
88" x 125" x 82" (AAY)	438
88" x 53" x 63.5" (AEP)	152
80" x 43" x 57" (AYK)	103
88" x 78.9" x 62.5" (AYF)	193
88" x 125" x 79"	390
88" x 125" x 80"	436
88" x 125" x 64" (LD9)	364
60.4" x 61.5" x 64" (LD3)	159
60.4" x 61.5" x 45" (LD3-45)	131
27" x 125" x 80"	156

Potential demand

There are no new-build options available in the narrowbody freighter market, so the A320P2F and A321P2F will be competing solely with alternative conversion options. There are currently active P-to-F conversion programmes for the MD-80, 737-300, 737-400 and 757-200. A conversion programme for the 737-700 will enter production in the near future, followed by multiple programmes for the 737-800 in 2017 and 2018.

"The Airbus market forecast is that 1,000 narrowbody freighter conversions will be needed over the next 20 years," explains Thomas Centner, director sales aircraft conversion, Asia Pacific at EFW. "The market success of the A320 family in the passenger role convinces us that it is possible to achieve reasonable market shares in the freighter segment."

Jacob Netz, senior analyst at the Air Cargo Management Group (ACMG), expressed his own opinions to *Aircraft Commerce* on potential demand for A320 and A321 freighters. "Today's narrowbody freighter fleets are dominated by Boeings, such as 737 Classics and 757-200s. If I had to predict the make-up of the fleet 10 years from now, I would guess that for every Airbus narrowbody there will be three or four Boeing freighters," says Netz.

"EFW cannot predict market shares upfront, but we are obviously aiming to become a significant player in the future narrowbody freighter segment," says Centner. "We trust that the market share earned by A320P2Fs and A321P2Fs will develop strongly in the years to come."

Airbus advantages

Centner believes that a number of factors will help the A320P2F and A321P2F make inroads into a narrowbody freighter segment currently dominated by Boeing types. These include fuel and maintenance cost performance, a developed support network and the ability to accommodate containerised freight in the lower hold.

"The A320P2F and A321P2F will offer better operating performance in terms of lower combined fuel and maintenance costs than existing similar-sized solutions, such as 737 Classics and 757-200s," claims Centner. "Their operating performance will be very competitive against that of the 737-800.

"The A3120's basic design is 20 years younger than that of the 737 and 757," continues Centner. "This means the A320 family has been certified under much stricter damage tolerance criteria. Full-scale fatigue testing of the A320 family was state of the art 20 years after the original 737 entered service.

"The A320P2F and A321P2F offer the best ratios of containerised cargo volume to external dimensions," adds Centner. "Their ability to accommodate lower deck ULDs is unique among narrowbody freighters, and optimises the entire available volume with comparably small ramp space requirements.

"The A320 family also accounts for about half of the worldwide narrowbody passenger fleet," says Centner. "This has led to an extensive network of trained flightcrews and maintenance personnel, and a large and liquid spares pool. This means the A320P2F and A321P2F are known, easy to acquire and operate, and represent a low risk from the beginning."

Netz cautions that some of the advantages of the A320 and A321 may not translate to cargo operations. "The A320 and A321 are excellent passenger aircraft with some advantages over the 737 and 757," says Netz. "However, these will not necessarily apply when the aircraft are flying as freighters.

"Fuel burn is a significant element of operating costs, so it is a major factor in an airline's overall profitability," adds Netz. "The A320 has lower fuel consumption than the 737-400, and the A321 has lower consumption than the 757-200. This is highly significant for passenger airlines with an annual utilisation of 3,000-4,000 flight hours (FH) per aircraft, but less so for narrowbody freighter operators. Many narrowbody freighters are operated for or by major integrators. Average annual utilisation is typically 650-1,200 FH per aircraft, so small differences in fuel consumption, and other cash operating costs, are not as influential in the fleet selection process for narrowbody freighter operators as they are for passenger airlines. For the freighter operator, acquisition cost and dispatch reliability are higher priorities.

"It should be noted that narrowbody freighters with older technology will need more maintenance,' continues Netz. "Unlike passenger aircraft, however, the freighter is on the ground for most of the day leaving more time for maintenance."

In theory this means that older 737 Classics and 757 freighters will have similar dispatch reliability to younger A320 and A321 freighters, even though the Boeing aircraft may need more maintenance, due to the amount of time available to clear defects. However, this assumes that spares are equally available for all types and does not account for any differences in maintenance costs.

Netz also questions the value of the A320's and A321's ability to accommodate containers in their lower cargo holds. "The A320 and A321 can carry unique LD3-45W belly containers that can be useful in an operation requiring interlining. These unique containers cannot be fitted in the belly of a 737 or 757 freighter, and would be impractical to load in widebodies since they would leave too much unused volume. Interlining with these containers might not offer a great deal of benefit, depending on the fleet being operated."

Competition

The proposed specifications for the A320P2F and A321P2F are analysed here to identify which types they are most likely to compete with or replace. The specifications for in-service narrowbody freighters have been summarised *(see table, page 76)*. The proposed specifications for those narrowbody conversions still in development are also summarised *(see table, page 75)*.

The volume figures stated here are only based on one potential loading configuration for each aircraft type. Other loading configurations or ULD positions might be available.

The specifications are also based on certain assumptions regarding internal ULD volumes *(see table, this page)*. It is possible that the loading configuration and internal ULD volume will vary depending on the conversion provider,

NARROWBODY FREIGHTER SPECIFICATIONS - PROGRAMMES IN DEVELOPMENT

Aircraft Type	A320P2F	A321P2F
Engines	CFM56-5/V2500	CFM56-5/V2500
Conversion provider	EFW	EFW
MTOW (lbs)	up to 171,958	up to 206,129
MZFW (lbs)	up to 137,789	up to 162,701
Gross structural payload (lbs)	up to 46,297	up to 59,525
Gross structural payload (Metric Tonnes)	up to 21	up to 27
Main deck positions	10 (88" x 125") + 1 LD3	13 (88" x 125") + 1 LD3
Lower deck positions	7 x LD3-45 + 208 cu ft bulk or 1,322 cu ft bulk	10 x LD3-45 +208 cu ft bulk or 1,829 cu ft bulk
Main deck volume (cu ft)	4,539	5,853
Total containerised volume (cu ft)	5,456	7,163
Total volume if LD bulk loaded (cu ft)	5,861	7,682

Aircraft Type	737-700BDSF	737-800BDSF	737-800SF	737-800BCF
Engines	CFM56-7B	CFM56-7B	CFM56-7B	CFM56-7B
Conversion provider	IAI Bedek	IAI Bedek	AEI	Boeing
MTOW (lbs)	up to 154,500	up to 174,200	up to 174,200	up to 174,200
MZFW (lbs)	up to 121,700	up to 138,300	up to 138,300	up to 138,300
Gross structural payload (lbs)	up to 45,000	up to 52,000	up to 52,000	up to 52,800
Main deck positions	8 (88" X 125') + 1 AYK + 1 AYF	11 (88" X 125") + 1 LD3	11 (88" X 125") + 1 LD3	11 (88" X 125") + 1 LD3
Lower deck positions	Bulk only (964 cu ft)	Bulk Only (1,555 cu ft)	Bulk Only (1,555 cu ft)	Bulk only (1,555 cu ft)
Main deck volume (cu ft)	3,800	4,977	4,977	4,977
Total containerised volume (cu ft)	3,800	4,977	4,977	4,977
Total volume if LD bulk loaded (cu ft)	4,764	6,532	6,532	6,532

Notes:
1), Gross structural payload refers to payload available for ULDs and cargo.
2).Gross structural payloads are estimates. These will vary by individual aircraft due to differences in OEW.
3). Specifications assume 737NGs are equipped with blended winglets but that A320 and A321 do not have Sharklets.

operator and ULD manufacturer.

The stated MTOW and gross payload figures generally assume that all aircraft are certified at their optimum potential post-conversion weights. Several weight options are included for the 757-200 freighters due to differences between aircraft with and without winglets, and in the MZFW upgrades available. In some cases converted aircraft may be certified at lower weights than those stated in this analysis, and will therefore have lower gross payloads.

Potential narrowbody acquisition and conversion costs were summarised in a recent *Aircraft Commerce* feature and are also considered here *(see Narrowbody freighter build costs, Aircraft Commerce, October/November 2016, page 82)*. The costs exported for use in this analysis are based on specific engine variants and MTOWs. They also assume the feedstock would need a heavy maintenance visit, since most operators take the opportunity to put an aircraft through a base check at the time of conversion.

Some caution should be taken when comparing these combined acquisition and conversion costs, since the dates from which the estimated feedstock values are derived are inconsistent. Some estimates are based on current market values (CMVs), while others are based on future base values (FBVs) for conversions not yet in production. In some cases the aircraft vintages being compared are also inconsistent, although the vintages used should be accurate for typical feedstock for each aircraft variant. Conversions usually occur when the feedstock is 15-20 years old, but for some older variants this age limit can increase to 25 years.

The full 'on-ramp' costs required to bring a converted freighter into service also include any maintenance requirements. Potential maintenance costs for all types are not included here, since data is unavailable for A320 and 737NG family freighters.

A320 freighter market

"The A320P2F could compete with 737-300, 737-400, 737-700, 737-800 and MD-80 freighters based on proposed cargo volume and payload specifications," says Netz.

The A320P2F will offer two more full-height 88-inch X 125-inch main deck loading positions than a 737-300 or 737-700 freighter. The A320P2F could also offer 671-876 cu ft of additional, containerised, main deck volume compared to 737-300 freighters and 739 cu ft more than a 737-700BDSF *(see table, this page and page 76)*. An A320P2F might provide 3,197-3,397lbs of additional gross payload compared to 737-300 freighters, and 1,297lbs more payload than a 737-700BDSF.

An MD-80 freighter offers more main deck loading positions than the proposed A320P2F, but these are for 88-inch X 108-inch containers, whereas the Airbus accommodates larger 88-inch X 125-inch ULDs. An A320P2F would therefore offer 100lbs of additional containerised main deck cargo volume compared to an MD80. An A320P2F's gross payload would be 1,200lbs higher than that of an MD-83SF, but 300lbs less than an MD-82 or MD-88 freighter.

The A320P2F will offer similar main deck loading options to 737-400 freighter solutions and therefore similar main deck containerised cargo volumes.

"The A320P2F offers the same main deck capacity and is the primary replacement candidate for the ageing 737-400," says Centner.

"Size-wise, an A320 freighter offers 10 main deck loading positions, just like the 737-400," explains Kevin Casey, president of Spectre Cargo Solutions, the freighter aircraft and engine solution specialist arm of Spectre Air Capital.

The main deck loading options for 737-400 freighters and their subsequent cargo volumes vary slightly by conversion provider *(see table, page 76)*. In general a 737-400 freighter can accommodate up to 10 88-inch X 125-inch ULDs. AEI's conversion offers 10 88-inch X 125-inch positions plus room for an additional half-size container, such as an LD-3.

"The main competition for the A320P2F will come from 737NG conversions," speculates Centner. "The A320P2F will directly compete against the 737-700, but its ability to accommodate lower hold containers means it could uplift more containerised volume than a 737-800 freighter, even though it has one fewer main deck

NARROWBODY FREIGHTER SPECIFICATIONS - IN PRODUCTION PROGRAMMES

Aircraft Type	MD-82/-88SF	MD-83SF
Engines	JT8D	JT8D
Conversion provider	AEI	AEI
MTOW (lbs)	up to 149,500	up to 160,000
MZFW (lbs)	up to 122,000	up to 122,000
Gross structural payload (lbs)	up to 46,600	up to 45,100
Main deck positions	12 (88" x 108")	12 (88" x 108")
Lower deck positions	Bulk only (1,253 cu ft)	Bulk only (1,013 cu ft)
Main deck volume (cu ft)	4,416	4,416
Total volume inc LD bulk (cu ft)	5,669	5,429

Aircraft Type	737-300SF 9-position	737-300SF 10-position	737-300BDSF	737-300F
Engines	CFM56-3	CFM56-3	CFM56-3	CFM56-3
Conversion provider	AEI	AEI	IAI Bedek	PEMCO
MTOW (lbs)	up to 139,500	up to 139,500	up to 139,500	up to 139,500
MZFW (lbs)	up to 109,600	up to 109,600	up to 109,600	up to 109,600
Gross structural payload (lbs)	42,900	42,900	43,100	43,100
Main deck positions	8 (88"x125") + 1LD9	8 (88" x 125") + 1AEP + 1LD3	8 (88"x125") + 1LD3	8 (88"x125") + 1LD3
Lower deck positions	Bulk only (973 cu ft)	Bulk only (973 cu ft)	Bulk only (1,068 cu ft)	Bulk only (1,068 cu ft)
Main deck volume (cu ft)	3,868	3,815	3,663	3,663
Total volume inc LD bulk (cu ft)	4,841	4,788	4,731	4,731

Aircraft Type	737-400SF SGW	737-400BDSF SGW	737-400F SGW
Engines	CFM56-3	CFM56-3	CFM56-3
Conversion provider	AEI	IAI Bedek	PEMCO
MTOW (lbs)	up to 143,500	up to 143,500	up to 143,500
MZFW (lbs)	up to 113,000	up to 113,000	up to 113,000
Gross structural payload (lbs)	43,100	44,000	45,750
Main deck positions	10 (88" x 125") + 1 LD3	10 (88" X 125")*	1 (27" x 125") + 10 (88" X 125")*
Lower deck positions	Bulk only (1,256 cu ft)	Bulk only (1,373 cu ft)	Bulk only (1,373 cu ft)
Main deck volume (cu ft)	4,539	4,332	4,534
Total volume inc LD bulk (cu ft)	5,795	5,705	5,907

Aircraft Type	737-400SF HGW	737-400BDSF HGW	737-400F HGW
Engines	CFM56-3	CFM56-3	CFM56-3
Conversion provider	AEI	IAI Bedek	PEMCO
MTOW (lbs)	up to 150,000	up to 150,000	up to 150,000
MZFW (lbs)	up to 117,000	up to 117,000	up to 117,000
Gross structural payload (lbs)	47,100	48,000	47,890
Main deck positions	10 (88" x 125") + 1 LD3	10 (88" X 125")*	1 (27" x 125") + 10 (88" X 125")*
Lower deck positions	Bulk only (1,256 cu ft)	Bulk only (1,373 cu ft)	Bulk only (1,373 cu ft)
Main deck volume (cu ft)	4,539	4,332	4,534
Total volume inc LD bulk (cu ft)	5,795	5,705	5,907

Aircraft Type	757-200PCF Standard MZFW	757-200PCF OEM Upgrade	757-200PCF Precision Upgrade	757-200SF Standard MZFW	757-200SF OEM Upgrade
Engines	RB211-535/PW2000	RB211-535/PW2000	RB211-535/PW2000	RB211-535/PW2000	RB211-535/PW2000
Conversion provider	Precision	Precision	Precision	ST Aerospace	ST Aerospace
Winglets	No	No	No	No	No
MTOW (lbs)	250,000	250,000	250,000	250,000	250,000
MZFW (lbs)	184,000	188,000/186,000	200,000/198,000	184,000	188,000/186,000
Gross structural payload (lbs)	68,000/68,350	72,000/70,350	84,000/82,350	66,000	70,000/68,000
Main deck positions	15 (88" x 125")	15 (88" x 125")	15 (88" x 125")	15 (88" x 125")	15 (88" x 125")
Lower deck positions	Bulk only (1,790 cu ft)	Bulk only (1,790 cu ft)	Bulk only (1,790 cu ft)	Bulk only (1,790 cu ft)	Bulk only (1,790 cu ft)
Main deck volume (cu ft)	6,570	6,570	6,570	6,570	6,570
Total volume inc LD bulk (cu ft)	8,360	8,360	8,360	8,360	8,360

Aircraft Type	757-200PCF Standard MZFW	757-200PCF OEM Upgrade	757-200PCF Precision Upgrade	757-200SF Standard MZFW	757-200SF OEM Upgrade
Engines	RB211-535/PW2000	RB211-535/PW2000	RB211-535/PW2000	RB211-535/PW2000	RB211-535/PW2000
Conversion provider	Precision	Precision	Precision	ST Aerospace	ST Aerospace
Winglets	Yes	Yes	Yes	Yes	Yes
MTOW (lbs)	250,000	250,000	250,000	250,000	250,000
MZFW (lbs)	185,400	189,400/187,400	200,000/198,000	185,400	189,400/187,400
Gross structural payload (lbs)	68,000/68,350	72,000/70,350	82,600/80,950	70,000/68,000	70,000/68,000
Main deck positions	15 (88" x 125")	15 (88" x 125")	15 (88" x 125")	15 (88" x 125")	15 (88" x 125")
Lower deck positions	Bulk only (1,790 cu ft)	Bulk only (1,790 cu ft)	Bulk only (1,790 cu ft)	Bulk only (1,790 cu ft)	Bulk only (1,790 cu ft)
Main deck volume (cu ft)	6,570	6,570	6,570	6,570	6,570
Total volume inc LD bulk (cu ft)	8,360	8,360	8,360	8,360	8,360

Notes:

1). Gross structural payload refers to payload available for ULDs and cargo. These are estimates. Payload will vary slightly by individual aircraft owing to differences in OEWs.

2). 737 Classic conversions based on aircraft without winglets

3). Final 88" x 125" main deck positions of IAI Bedek 737-400BDSF and PEMCO 737-400F conversions limited to 79-inches and 80-inches in height respectively.

loading position."

Despite offering similar main deck volume to a 737-400 and 400 cu ft less than that of a 737-800, an A320P2F will accommodate more overall containerised cargo than both Boeing variants by using its lower hold. If the A320P2F uses its lower hold capacity in addition to the main deck, it could offer 917-1,124 cu ft more containerised volume than a 737-400 and nearly 479 cu ft more than a 737-800 freighter. The A320P2F would offer a gross payload advantage of 547-3,197lbs compared to a standard gross weight (SGW) 737-400, but 803-1,703lbs lower payloads than a high gross weight (HGW) 737-400 and 5,703-6,503lbs lower payloads than a 737-800 freighter.

The use of the lower deck would further extend the A320P2F's advantage in containerised volume over the smaller 737-300, 737-700 and MD-80 freighters to 1,588-1,793 cu ft, 1,656 cu ft, and 1,040 cu ft respectively.

"While containerised volume in the lower deck has its advantages there are drawbacks," claims Casey. "737 Classic and 757 freighter operators that bulk load the belly holds of their aircraft enjoy 20% greater lower hold volumetric capacity than A320s and A321s configured with LD3-45W ULDs. They also achieve higher revenue payloads by avoiding the tare weight penalty associated with the belly containers. Large integrators may think twice about using lower deck containers, since their sort facilities are optimised around traditional full-size ULDs. Adding a small capacity container into the mix could affect their efficiency," concludes Casey.

If all the aircraft were loaded with main deck containers, but bulk loaded in the lower hold, an A320P2F would provide a total cargo capacity of 5,861 cu ft. This is 192-432 cu ft more than MD-80 freighters, 1,020-1,130 cu ft more than 737-300 freighters and 1,097 cu ft more than 737-700 freighters. It would offer similar total volumes to 737-400 freighters but 671 cu ft less than a converted 737-800.

"For many narrowbody freighter operators the acquisition price is highly sensitive and cash flow reduction may be a priority," claims Netz. "In countries without aircraft age restrictions some of the main competition for the A320P2F may come from older types with very low acquisition costs, like the MD-80 family."

The A320P2F conversion programme is not expected to enter the production phase until 2019, when the combined acquisition and conversion costs for typical A320 freighter feedstock could be $11.50-16.55 million depending on the aircraft vintage and engine type. A 737-700 in similar condition is expected to have total acquisition and conversion costs of $10.25-13.00 million, and the range for 737-800s is forecast to be $14.70-19.80 million. The 737 costs are based on 2017 and 2018 estimates respectively since this is when conversion programmes for each type are expected to enter the production phase.

At the end of 2016, estimated acquisition and conversion costs for in-service narrowbody freighters were $2.95-3.20 million for MD-80s, $3.55-5.40 million for 737-300s, $5.25-7.05 million for SGW 737-400s and $5.25-7.10 million for HGW 737-400s.

Comparing these costs can provide a rough guide to the A320P2F's potential position in the market, although the costs associated with heavy maintenance visits also need to be considered. In terms of the acquisition and conversion cost, there could be some overlap between the A320P2F and 737-700BDSF and 737-800 freighters depending on the vintage. All three younger generation types will be more expensive to source as freighters

NARROWBODY FREIGHTERS - MARKET POSITIONING

Aircraft Type	Max structural payload (lbs)	Main deck containerised volume (cu ft)	Total containerised volume (cu ft)
737-300	42,900-43,100	3,663-3,868	3,663-3,868
737-700	45,000	3,800	3,800
MD-82/88	46,600	4,416	4,416
MD-83	45,100	4,416	4,416
SGW 737-400	43,100-45,750	4,332-4,539	4,332-4,539
HGW 737-400	47,100-48,000	4,332-4,539	4,332-4,539
A320-200	46,297	4,539	5,456
737-800	52,000-52,800	4,977	4,977
A321-200	59,525	5,853	7,163
757-200	66,000-84,000	6,570	6,570

Notes:
1). Aircraft listed in ascending order according to main deck containerised volume (cu ft).

than existing 737-300, 737-400 and MD-80 solutions. By the time the A320P2F enters service however, remaining feedstock for some cheaper, older types might be limited. MD-80 freighters are unlikely to be significant competition for the A320P2F in the integrator market despite having the lowest acquisition and conversion cost in the segment. This is because MD-80s cannot accommodate the 88-inch X 125-inch ULDs that these express operators use as standard.

A321 freighter market

The A321P2F will be the closest replacement option available for 757-200 freighters.

"We believe that the A321P2F will take over the role of the 757 rather than compete with it," says Centner. "The 757 fleet is ageing and EFW does not anticipate serious direct conversion competition from this platform by the time the first A321P2F enters service."

"When feedstock for 757 conversions runs out, and the fleet begins to age, the P-to-F conversion of A321s might be the only option to replace them," adds Netz.

"The most natural fit for the A321P2F is as a replacement for 757 freighters and the few remaining 727 freighters," says Casey. "757 freighters represent nearly half of the narrowbody freighter fleet in operation today, but there are only a few years' supply of good convertible feedstock remaining."

The A321P2F will offer lower gross payloads and less main deck volume than a 757-200 freighter. The A321P2F's gross payload could be 6,475-24,475lbs lower than that of a 757-200. The A321P2F will offer 13 88-inch X 125-inch loading positions, plus a further reduced size position on its main deck. In comparison, a 757-200 freighter can accommodate up to 15 88-inch X 125-inch ULDs. A 757 freighter will therefore offer up to 717 cu ft of additional containerised main deck volume; about 12% more than an A321P2F.

"The average main deck freighter flies at 70% of capacity, so the A321P2F will be able to operate most of the routes flown by 757 freighters today using its main deck alone," says Casey.

In addition, an A321P2F will be able to offer a higher total containerised volume than a 757-200 if ULDs are loaded in its lower hold. The A321P2F will accommodate up to 10 LD3-45W containers in the lower hold. When added to the main deck volume, this will offer a total containerised cargo volume of 7,163 cu ft. In this configuration, the A321P2F will offer 593 cu ft or 9% more containerised volume than a 757-200.

Some believe the A321P2F will face competition from 737-800 freighters. "We can expect the 11.5 position 737-800 and 13.5 position A321 to split the market for future 757-size freighter growth opportunities," claims Casey.

The 737-800 will accommodate two fewer 88-inch X 125-inch ULDs than the A321P2F on its main deck. The A321P2F will offer 876 cu ft of additional containerised main deck volume. The A321P2F's total containerised volume advantage over the 737-800 could be up to 2,186 cu ft if it is loaded with lower deck ULDs. This is equivalent to 44% of additional containerised volume.

If all the aircraft were loaded with main deck containers, but bulk loaded in the lower hold, an A321P2F would provide a total cargo capacity of 7,682 cu ft. This is 1,150 cu ft more than a 737-800 freighter, but 678 cu ft less than a converted 757-200.

"Strong established conversion providers like EFW and ST Aerospace bring credibility and competition-induced market-bearing economics to the A321 freighter concept," says Casey. "Market values for the oldest A321 airframes, which have already dropped below $10 million, will help bring future freighter costs in line with today's 757 solutions. The A321 freighter's revenue tonne kilometre (RTK) and trip costs should prove competitive and compelling. Its two-position main deck loading advantage over the 737-800 also adds to its attractiveness, particularly to efficiency-sensitive integrators."

The A321P2F programme is expected to enter the production phase in 2018, by which time the combined acquisition and conversion costs for typical feedstock aircraft are forecast to be $13.50-18.60 million. In comparison, late 2016 cost estimates to acquire and convert 757-200s were $7.95-16.72 million. The forecast 2018 acquisition and conversion costs for typical 737-800 feedstock are $14.70-19.80 million as previously stated. The A321P2F could therefore be competitively priced against its main rivals, depending on their vintage and specifications.

Potential A320/321 operators

There are several different types of air cargo operations including integrator or express package, and general freight services. Airmail operations have similar dynamics to express package services.

Express package or integrator operators typically establish hub-and-spoke networks with aircraft flying single scheduled return sectors five or six days per week. These sectors are often flown by the integrator's own aircraft, but there is also a large market for third-party carriers to provide capacity on the integrator's behalf. These third-party aircraft often operate in the integrator's livery. Express cargo typically comprises small parcels or packages, including e-commerce goods that are loaded in containers. The nature of the freight means that express cargo often has relatively low packing densities of 6.5lbs per cu ft. "For integrators, an aircraft's cargo volume is more important than its

The A320P2F and A321P2F will be the only narrowbody freighters capable of accommodating lower deck containers. When loaded with LD3-45W ULDs, the A320P2F and A321P2F will provide more containerised volume than 737-800 and 757-200 freighters respectively.

payload capability," explains Netz. "In most cases the available volume is used up before the maximum payload has been reached. This is known as 'cubing out'."

General freight services normally involve the point-to-point carriage of heavier bulkier items with packing densities usually in excess of 9.0lbs per cu ft. General freight payloads are often loaded on pallets rather than in containers, due to their dimensions. The nature of these cargoes means that general freight services may not be as regularly scheduled as express package operations. A general freight shipment might involve an urgent requirement for specialist machinery that will lead to a one-off charter. An aircraft carrying general freight is likely to reach its gross payload limit before using all the available cargo volume. This is known as 'grossing out'.

"Most narrowbody freighter operators are in the integrator sector," explains Netz. "Express package services account for the largest portion of the narrowbody freighter market," agrees Centner. The three largest integrators are FedEx, UPS and DHL.

"The A320P2F's volumetric capacity, including the volume provided by its seven lower deck positions, makes it an ideal express package aircraft," claims Centner. "The A320P2F's target payload and volume, along with its operating performance and fuel and maintenance costs, make it ideal for typical express utilisation. In addition, the A320P2F's large cargo door could make it interesting for bulkier general cargo. Its take-off performance will make it an appealing option in hot-and-high environments.

"We expect the main market for the A321P2F to be integrators and operators that are sub-contracted by integrators," says Centner.

Replacement market

On a like-for-like basis the A320P2F is most suited to replacing ageing 737-300 and 737-400 freighters. Centner believes the A321P2F will be used to replace 757-200 freighters, and increase capacity for 737 Classic operators. "The A321P2F is the natural successor to ageing 757 freighters and the perfect growth platform from 737 Classics." It has also been suggested that the A321P2F could replace old 727 freighters.

There are 210 737 Classic freighters in service, including 108 737-300s and 102 737-400s. The largest 737 Classic freighter fleets are based in China and Europe. They are operated by China Postal Airlines (22 aircraft), ASL Airlines Belgium (17), SF Airlines (15), Yangtze River Express (15) and West Atlantic (11). ASL Aviation Group includes six European airline subsidiaries, three of which operate 28 737 Classic freighters between them: ASL Airlines Belgium (formerly TNT Airways), ASL Airlines France and ASL Airlines Hungary.

Although none of the three large integrators operates 737 Classics directly, some are used on express package services flown by contracted third parties. 737 Classic freighters are also extensively used on overnight domestic mail routes.

There are 283 757-200 freighters in service. The largest operators are FedEx (107), UPS Airlines (75) and DHL (44). Together they account for 80% of the active 757 freighter fleet. DHL's fleet is split across several operating subsidiaries: DHL Air (25), European Air Transport (12), DHL Aero Expreso (4) and DHL International Aviation (3). Other significant 757 freighter operators include SF Airlines (16), Blue Dart Aviation (6) and Morningstar Air Express (6).

Only 60 727 freighters remain in service, including six 727-100s and 54 727-200s. The largest 727 operators are Kalitta Charters (6), Cargojet Airways (5), Serve Air (5) and Total Linhas Aereas (5). "Some operators may choose efficiency over up-gauging," suggests Casey. "Some 727 freighter operators have replaced their aircraft with 737 Classics."

Several factors could influence the extent to which the A320P2F and A321P2F are successful as near-term replacement candidates for the current narrowbody freighter fleet. One challenge facing the A321P2F is that several large integrators have only recently expanded or modernised their 757 freighter fleets. This could reduce near-term replacement demand for A321P2Fs although these operators may have some medium-term replacement or growth demand.

The appeal of commonality in the fleet selection process could also affect the ability of A320 and A321 platforms to gain market share in the narrowbody freighter segment. "Current Boeing narrowbody freighter operators, in particular those with 737 Classics, could favour 737NG replacements for logistical reasons," claims Netz. "These operators will already have a relationship with Boeing, technicians with 737 experience, common tools and equipment, and pilots that can easily transition from one generation of 737 to the next."

"For the immediate future, Boeing narrowbody freighter operators seem predisposed to continue operating Boeing types," says Casey. "The STCs for the proposed 737NG conversions are in most cases derivatives of proven 737 Classic freighters and the STC holders are proven. The acquisition and conversion economics are understood and acceptable and all pilots in this segment are trained and certified on Boeing equipment."

Despite these challenges, Centner says that EFW is confident it can convince many operators to select its Airbus narrowbody products.

The A321 freighter platform should see long-term demand as a 757 replacement. It will be the only option close to the 757's capacity class when

The strongest short-term demand for A320P2Fs and A321P2Fs could come from start-up operators or established combination carriers. Turkish Airlines already operates Airbus widebody freighters and uses A320s and A321s in passenger service.

suitable feedstock for the Boeing aircraft diminishes and current fleets begin to age.

Netz believes some smaller operators could be persuaded to swap Boeing for Airbus. "In China there are some express airlines that strive to be the local FedEx. They operate a variety of Boeing types but in quite small numbers. They could be candidates for swapping to Airbus types due to their relatively small fleets."

Combination carriers

With near-term replacement opportunities potentially limited, there are suggestions that some of the strongest initial demand for A320 and A321 freighters could come from expanded services by combination carriers. These are airlines with established passenger fleets that also operate dedicated freighters. Combination carriers are most likely to use freighters to carry general freight but might also carry some express package cargo.

"The A320P2F would be suited to combination carriers with a footprint in regional cargo," claims Centner. "Ideally these carriers would also be Airbus widebody freighter operators."

"Airbus widebody freighter operators might prefer the A320P2F and A321P2F to Boeing narrowbody freighters for a number of reasons," explains Netz. "These include the availability of fly-by-wire qualified pilots that are positioned for an easy transition between the A320 and A330 families, common tools, and an existing relationship with Airbus."

Casey believes that A320 and A321 freighters could appeal to combination carriers that also operate the types in passenger service. "In the Middle East and South-East Asia there are combination carriers with aspirations, and retiring A320 fleets with limited market appeal." Casey believes that the P-to-F option for these aircraft could be an economic solution to impending passenger fleet retirements.

The active fleet of Airbus widebody freighters consists of 186 A300s, including 174 A300-600s, 12 A310-300s and 35 A330-200Fs.

Combination carriers that operate Airbus widebody freighters include Turkish Airlines, Qatar Airways, Hong Kong Airlines, Avianca, Etihad Airways, Egyptair, Malaysia Airlines, Afriqiyah Airways and Royal Jordanian. With the exception of Malaysia Airlines all of these carriers also operate passenger-configured A320s or A321s, or both. Turkish Airlines and Qatar Airways operate the largest Airbus widebody freighter fleets with 11 and eight aircraft respectively, while Egyptair is the launch customer for EFW's A330-200P2F conversion programme.

Netz also identifies dedicated cargo carriers with Airbus widebody freighters as potential candidates for the A320P2F and A321P2F. "Several cargo airlines are operating medium-size operations in Turkey with A300s and A310s. These operators may want to diversify into more local operations with smaller types from the same OEM." MNG is one such A300 operator, with a fleet of five A300-600 freighters and a single A330-200F.

Start-up candidates

A320 and A321 freighters may appeal to new entrants in the cargo market.

"Start-up airlines may be attracted to the A320P2F because it offers the best residual aircraft values of all the new generation narrowbody conversion solutions," claims Centner. "It also has excellent MRO, spares, crew and services networks."

"Start-up airlines may become good candidates for A320 and A321 freighters," adds Netz. "These carriers are most likely to begin operations in emerging economies. India, Indonesia and Vietnam are good candidates for start-up carriers since they are emerging economies with no dominant cargo airlines. It is also worth noting that the passenger variant of the A320 is very popular in these three countries."

Summary

EFW's A321P2F and A320P2F conversion lines are expected to enter production in 2018 and 2019 respectively.

The A320P2F is most likely to compete with 737-300s, 737-400, 737-700 and 737-800 freighters when it enters the market. Its potential as a replacement for the current Boeing narrowbody fleet could be limited by a preference for commonality. Existing 737 freighter operators may opt for 737NG conversion solutions due to perceived logistical commonalities with their current fleets.

The A321P2F is most likely to compete with 757-200 freighters when it enters the market. The A321P2F may struggle to gain market share as a replacement candidate in the short term, since there has been some recent 757 fleet addition and replacement activity among the large integrators. The A321P2F should however carve out a substantial share of the market in the medium to long term as 757-200 freighters begin to age, and the available feedstock for additional conversions diminishes. It could face some competition from 737-800 freighters in this part of the market.

The strongest initial demand for the A320P2F and A321P2F could come from start-up cargo operators in emerging economies, and combination carriers that already operate Airbus aircraft and want to expand into more regional freighter services. *-NMP* AC