Two solutions for A320 and A321 freighter conversions have been announced. The main criteria operators need to consider when selecting feedstock for conversion include the model series, weight specifications, accumulated FH and FC and the presence or absence of Sharklets.

Cherry picking A320s & A321s for P-to-F conversion

Since it entered service in 1988, the A320 family has dominated the narrowbody passenger segment, alongside the 737. More than 6,150 A320 family aircraft are in passenger service, but there are no A320 family members operating as freighters. The narrowbody freighter market is dominated by Boeing types, including the 737 Classics and 757-200.

Boeing's dominance of the narrowbody freighter market, however, will soon be challenged for the first time. Since late 2014, two passenger-to-freighter (P-to-F) conversion options have been announced for the A320 family.

The most suitable A320 family candidates for P-to-F conversion are identified here.

Conversion options

The four A320 family variants are the A318, A319, A320 and A321. "Only the A320 and A321 will be considered for conversion," explains Jacob Netz, senior analyst at the Air Cargo Management Group, expressing his own opinion. The shorter fuselages of the A318 and A319 mean they offer little cargo volume, so they are not suitable for conversion.

"The A320 will compete with the 737 Classic and Next Generation (NG) variants in the narrowbody cargo market," continues Netz. "The A321 is clearly the closest sized in-production aircraft to the 757-200. Since 1988, more than 4,000 A320s have been delivered. The A321 entered service in 1994, and more than 1,100 have been delivered."

There are 3,662 A320s and 1,120 A321s in active passenger service. A further 82 A320s and 21 A321s are parked in passenger configuration.

"Given their age and market values, many A320s and some A321s are in the 'window of conversion'," claims Netz.

The typical age-range for P-to-F feedstock aircraft is 15-20 years. It is generally at this age that their market values have declined to a level that makes P-to-F conversion economically viable.

Two different conversion programmes have been launched for A320s and A321s. These take a different approach to the provision of converted freighters.

A320/A321 P2F

Airbus, EFW and ST Aerospace launched a collaborative P-to-F conversion programme for A320s and A321s in June 2015. Converted aircraft will be designated with the P2F suffix, so a converted A320 becomes an A320P2F, and a converted A321 an A321P2F.

The programme will convert aircraft owned by third parties, including airlines or lessors.

ST Aerospace will develop the supplemental type certificate (STC). Once it has been granted, ownership of the STC will pass to EFW. Conversion work will be performed at both EFW and ST Aerospace's facilities. EFW will provide marketing and sales activities, while Airbus will offer original equipment manufacturer (OEM) data support.

The target for maximum structural payload is up to 21 metric tonnes (t) for an A320P2F, and 27t for an A321P2F, equivalent to 46,297lbs and 59,525lbs respectively *(see table, page 72)*.

The first A321P2F conversion is expected to take place in 2018, with the prototype aircraft entering service later the same year. It is expected that the first A320P2F conversion will begin in late 2018, and enter service in 2019.

A320/A321 Freighter LITE

PACAVI Group announced plans to convert A320s and A321s into freighters in September 2014. It has taken a different approach to traditional P-to-F conversion programmes.

Rather than focus on converting third-party aircraft, PACAVI, together with its partners, AeroTurbine, GAMECO and HAITEC, will source its own A320 and A321 feedstock, convert the aircraft into freighters and perform any required maintenance, before offering the aircraft for sale or lease.

PACAVI will also offer STC kits for operators that want to convert their own aircraft.

PACAVI will develop the STCs and kits for conversion and be responsible for marketing and on-going maintenance. The conversions will be performed by AeroTurbine in the USA, GAMECO in China, and HAITEC in Germany.

An aircraft converted under this programme will be designated as an A320 Freighter LITE or an A321 Freighter LITE.

Maximum structural payloads could be up to 21t for an A320 Freighter LITE and 25t for an A321 Freighter LITE. This is equivalent to 46,297lbs and 55,116lbs respectively *(see table, page 72)*.

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

Cargo configurations

The P2F and Freighter LITE conversion programmes will both involve the installation of a large cargo door on the left-hand side of the fuselage, forward of the wing. They will include the installation of a partially reinforced floor, a Class E cargo interior, a 9G barrier and a manual cargo loading system.

A typical configuration would see the A320 freighters accommodate up to 10 88-inch X 125-inch X 82-inch unit load devices (ULDs) or pallets, and one

A320-200 & A321-200 FREIGHTER SPECIFICATIONS

Aircraft	A320-200P2F	A320-200 Freighter LITE	A321-200P2F	A321-200 Freighter LITE
Weight Variant	12	12	11	11
MTOW (lbs)	169,753	169,753	206,129	206,129
MZFW (lbs)	137,787	137,787	162,698	162,698
Max structural payload (lbs)	up to 46,297	up to 46,297	up to 59,525	up to 55,116
Max structural payload (Metric tonnes)	up to 21	up to 21	up to 27	up to 25

Notes:
1). Specifications based on stated weight variants. Other weight variants are available and could result in lower MTOW, MZFW and max structural payload.
2). Max structural payload figures are estimates. These could vary slightly by aircraft owing to different OEWs.
3). A320-200P2F & A321-200P2F max structural payload does not account for weight of cargo loading system. CLS weight is assumed to be 1,764lbs for A320-200P2F and 1,874lbs for A321-200P2F.

smaller container or pallet, on the main deck *(see A320 family P-to-F conversion programmes, Aircraft Commerce, June/July 2015, page 60)*. This would result in a main deck cargo volume of about 4,539 cubic feet (cu ft). This compares to 4,977 cu ft for a 737-800BDSF.

The A320 family can accommodate containerised freight in the aircraft's belly holds. This will be a unique capability among competing narrowbody freighters. "The A320 and A321 can carry unique LD-3-45W containers in the belly," explains Netz. These are reduced height variants of a typical LD-3 ULD.

"Using containers in the belly hold can be useful in an operation that needs interlining," says Netz. "The narrowbody freighter segment is dominated by express package or integrator operators, however, and they tend not to need interlining."

An A320 freighter will accommodate up to seven LD-3-45W ULDs in its belly hold, plus an additional 208 cu ft of bulk freight. This would provide a total lower deck cargo volume of about 1,125 cu ft.

A typical configuration might see the A321 freighters accommodate up to 13 88-inch X 125-inch X 82-inch ULDs or pallets, and an additional reduced size container or pallet, on their main decks. This would provide a main deck cargo volume of about 5,853, cu ft. This compares to 6,600 cu for a 15-position 757-200PCF.

In addition, the A321s could accommodate up to 10 LD-3-45W ULDs in their belly holds plus an additional 208 cu ft of bulk freight. This would provide a total belly hold volume of 1,518 cu ft.

Airframe selection

There are a number of important criteria for potential operators to consider when selecting A320 and A321 feedstock for P-to-F conversion. These include: the model series: weight specifications: accumulated flight hours (FH) and flight cycles (FC); the presence or absence of wing tip Sharklets; the engine type; fleet commonality; and maintenance status.

The aircraft's age is also a crucial factor. Most P-to-F conversions will take place when the aircraft is 15-20 years of age, although accumulated FH and FC are an important consideration. This analysis identifies aircraft of suitable feedstock age, but does not prioritise this criteria. In focusing on non-age-specific selection criteria it can provide a more inclusive guide for future conversions.

Model series

Two different model series of the A320 and A321 have been produced. Early examples of each variant were designated as -100 series aircraft.

There are no A320-100s and only 63 A321-100s remaining in a passenger configuration. Three of these aircraft are parked, but 60 are still active.

The -100 series aircraft were superseded by A320-200s and A321-200s. These have superior weight specification options. The -200 series aircraft account for most of the combined A320 and A321 passenger fleet.

Only -200 series A320s and A321s will be converted into freighters under the P2F and Freighter LITE proposals.

"Converting both -100 and -200 series aircraft would have required development of two different STCs," explains Andreas Mayer, head of aircraft conversion sales at EFW. "It was not economically viable to develop an STC for the conversion of -100 series aircraft due to the limited and ageing feedstock."

Weight specification

There are many weight specifications, or weight variants (WV) available for the A320-200 and A321-200.

The specifications for the A320P2F programme are based on WV12 *(see table, this page)*. With a maximum take-off weight (MTOW) of up to 169,753lbs and a maximum zero fuel weight (MZFW) of up to 137,787lbs, this offers a better combination of range and structural payload than most of the other WV options.

The A320s that can be modified to WV12 are therefore considered the best candidates for conversion. This includes all A320s manufactured from line number (L/N) 1,081 onwards. L/N 1,081 was manufactured in 1999. Some of these aircraft may already be certified at WV12, while others will need modifications. The extent of any required modifications could vary by aircraft, and operators and lessors should check with Airbus for specific instructions.

The specifications for the A321P2F are based on WV11 which offers an MTOW of up to 206,129lbs and an MZFW of up to 162,698lbs. It therefore has the best range and structural payload capability *(see table, this page)*. A321P2Fs that can be certified to WV11 are therefore considered to be the best candidates for conversion. Qualifying airframes that can be modified to WV11 include L/N 1,794 and all A321-200s from L/N 1,878 onwards. L/N 1,794 was manufactured in 2002 while L/N 1,878 was built in 2003. Some of these aircraft may already be certified at WV11. Others may need modifications and operators should check with Airbus for specific requirements.

Utilisation

The A320 and A321 have a design service goal (DSG) of up to 60,000FH or 48,000FC. Operators can choose to extend the life of their aircraft by implementing the intermediate service goal (ISG) of 80,000FH or 37,500FC, or the extended service goal (ESG) of up to 120,000FH or 60,000FC.

Operators will need to consult Airbus on the work and associated costs required to implement the ISG or ESG.

Implementing the ISG is likely to be a paperwork exercise. Some aircraft may need structural modifications for the ESG to be applied, in which case they could be carried out during the conversion process to minimise additional downtime and airframe access requirements.

"The A320 and A321 will be part of the small/medium freighter segment,"

Excluding aircraft age, the four main selection criteria for A320/321 feedstock are the model series, weight specifications, accumulated FH and FC, and the presence or absence of Sharklets.

says Netz. "These aircraft tend to have a low utilisation of 600-1,200FH per year. Operators would expect to achieve 15-20 years' operation with an A320 family freighter following its conversion."

EFW estimates that the average FH:FC ratio for an A320P2F or A321P2F will be 1.25:1. This analysis assumes that a converted A320 or A321 freighter may have to operate up to 1,200FC per year for 20 years with an FH/FC ratio of 1.25:1. This would be equal to 1,500FH per year and a total time of 30,000FH and 24,000FC following conversion.

Taking the limits of the current ESG into account, operators that need 20 years' service should only consider feedstock aircraft that have accumulated a maximum of 90,000FH and 36,000FC.

Sharklets

Airbus describes Sharklets as 2.4-meter-tall wingtip devices. They are designed to improve an aircraft's aerodynamic efficiency, and are offered as an option for new-build A320s and A321s. The first new-build A320 to be fitted with Sharklets was delivered in 2012, followed by the first A321 in 2013. A320. There is also a Sharklet retrofit option for A320s.

Airbus claims that Sharklets can reduce fuel burn by up to 4%, and give an A320 or A321 operator a payload increase of up to 450kg (992lbs), or another 100 nautical miles (nm) of range.

Sharklets may not necessarily have benefits for freighter operations, however. "Operators will only start to benefit from the impact of Sharklets when a sector is longer than 1.5 FH," claims Joshua Long, structural engineer at PACAVI.

It is unlikely that the average sectors operated by converted A320s or A321s will regularly exceed 1.5FH, so they will not benefit from having Sharklets.

The P2F programme will not initially convert Sharklet-equipped aircraft. "Sharklets do not make sense for the short sectors that most A320P2F and A321P2F operators are likely to fly," says Mayer. "We do not expect to see many Sharklet-equipped aircraft coming available in the typical conversion age-range for the next 15 years."

PACAVI says that its STC will cover the conversion of aircraft with Sharklets.

A320-200s and A321-200s without Sharklets are considered the most suitable candidates for conversion in the near-to-medium term. Sharklets are unlikely to provide significant benefits for a typical freighter operation, and there will be more conversion programmes available for aircraft without them.

Engines

There are two engine families available for A320-200 and A321-200 aircraft: the CFM56-5 and V2500.

There will be a slight difference in weight between the two engine types. This will result in a small variation in the aircraft's operating empty weight (OEW) and therefore its maximum structural payload, depending on which engines it has. *Aircraft Commerce* has been unable to identify the exact weight of CFM56-5 or V2500 series engines. It is assumed that the weight difference between the two engine types will be too small to lead to a significant variation in structural payload, so it should not influence the feedstock selection process.

Another consideration is the difference in shape between the two engine types and the potential impact on cargo-loading capability.

"The V2500 and CFM56-5 have different contours," explains Mayer. "The V2500 protrudes out further at the front. On a converted A320 freighter this will result in V2500-powered aircraft suffering from a relatively small cargo loading clearance between the large freight door and the front of the engine cowl.

"The International Civil Aviation Organisation (ICAO) recommends a minimum engine clearance of 50cm (20 inches) for cargo loading," continues Mayer. "The P2F programme has developed a cargo layout for the A320 that allows a loading clearance of 85-95cm (34-38 inches). The engine type will therefore not influence feedstock selection, unless an operator specifically requires loading clearance of one metre (40 inches) or more."

Engine clearance for cargo loading is not a factor on the A321 due to its longer fuselage.

The engine type is not considered to be a defining factor in the feedstock selection process, but some operators may opt for a certain engine family based on specific cargo loading, operational or fleet commonality preferences.

Fleet commonality

An operator looking to build a fleet of A320 or A321 freighters may place a high priority on commonality during the feedstock selection process.

This could involve a preference for 'sisterships'. These are groups of aircraft that have been operated by the same airline, and so are more likely to have the same engines, components, modifications and configuration. They will also have been flown under the same operating and maintenance procedures.

Sourcing a fleet of sisterships can avoid costs associated with multiple spares inventories, maintenance programme complexities, and extra training for flight crew and maintenance personnel.

Maintenance condition

An aircraft's maintenance condition

ESTIMATED ACQUISITION COSTS FOR A320-200 & A321-200 AIRCRAFT

Aircraft Type	MTOW (lbs)	Current Value (US$-millions) 15-year-old	20-year-old	2018 value est (US$-millions) 15-year-old	20-year-old
A320-200	169,753	11.0	8.0	13.42	8.74
A321-200	206,129	13.25	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

will be an important consideration in the feedstock selection process.

Most operators combine the conversion process with a heavy maintenance check to optimise aircraft downtime.

A heavy C check normally includes deep structural inspection tasks. A high proportion of the man-hours (MH) assigned to these tasks will be required to remove and reinstall aircraft interior items to open and close access to the aircraft's structure. The P-to-F conversion process will need similar levels of access. It is therefore logical to combine the conversion process with a heavy check to avoid the needless and costly duplication of access MH and aircraft downtime.

The A320 and A321 initially had maintenance programmes designed around a base cycle of eight C checks and two sets of structural tasks. The intervals for the structural tasks corresponded with those for the fourth (C4) and eighth (C8) checks, making them the largest in the base check cycle.

The A320 family's maintenance planning document (MPD) was subsequently revised. Some inspection intervals have been extended and each task is assigned individual interval thresholds, rather than being grouped into letter checks. Some tasks are assigned a combination of two or three interval criteria; including FH, FC and calendar time. This is designed to help operators plan their maintenance according to their specific operation and levels of utilisation. It might be possible to plan some C check tasks into smaller line checks.

Some operators still refer to C checks and plan large numbers of tasks with similar intervals into a single check. With the increase in certain inspection intervals, some A320 and A321 operators have devised a base cycle consisting of six checks, with the third and sixth checks forming the structural tasks.

Operators could benefit from carrying out A320 or A321 P-to-F conversions as a candidate aircraft approaches its next heavy maintenance visit, featuring structural inspections. This might be the C4 or C8 check under the original MPD philosophy, or the C3 or C6 check for aircraft maintained under the revised MSG 3 principles.

The downtime needed for the conversion process could be an ideal opportunity for any avionics upgrades.

Any outstanding airworthiness directives (ADs) or service bulletins (SBs) relating to A320s or A321s will need to be considered during the feedstock selection process.

Mayer highlights a number of other potential maintenance issues that operators may need to be aware of when selecting conversion candidates.

"The P2F conversion for the A320 involves relocating an angle-of-attack (AOA) sensor," explains Mayer. "On some older A320s this may require replacing air data initial reference unit (ADIRU) hardware, but only on aircraft equipped with ADIRUs manufactured by Litton. Replacing the ADIRU hardware could cost $500,000-900,000, so operators may consider aircraft with the Litton hardware to be unsuitable conversion candidates."

The AOA sensor relocation is not required for A321s.

"Another consideration is the solid state flight data recorder," continues Mayer. "This must now be capable of recording 256 words. Some aircraft may still have older variants that cannot be upgraded, so these need to be replaced."

Costs

The on-ramp costs will also be an important factor in the feedstock selection process. That is the total cost to acquire an aircraft, perform any required maintenance, and convert it.

Current market values for 15-year-old A320s and A321s in half-life maintenance condition with half-life engines are estimated to be $11.0 million and $13.25 million *(see table, this page)*. By 2018, when the first conversions are likely to be under way or close to entering production, the values of 15-year old A320s and A321s are predicted to be $13.42 million and $15.27 million.

Costs of conversion are not clear. The standard price for the PACAVI Freighter LITE is believed to be about $3 million. The cost of the EFW conversion can be expected to be higher.

Suitable aircraft

The four initial selection criteria to be applied when selecting A320 and A321 airframes for P-to-F conversion are the model series, weight specifications, accumulated FH and FC, and the presence or absence of winglets. Once these filters have been applied, the engine variant and fleet commonality could also be important factors for those looking to acquire a fleet of multiple aircraft.

Only -200 series models of the A320 and A321 will be converted.

These aircraft need to be filtered to identify which will offer the best potential weight specifications. The most suitable A320-200s for conversion are those from L/N 1,081 (built 1999) onwards. The most suitable A321-200s are L/N 1,794 (built 2002) and all those aircraft from L/N 1,878 (built 2003) onwards.

The appropriate L/N candidates need to be filtered by their accumulated FH and FC. A320-200s and A321-200s that have accumulated a maximum of 90,000FH and 36,000FC will be the best candidates for conversion. At typical rates of utilisation these aircraft will provide up to 20 years of service following P-to-F conversion.

The final filter considers the presence or absence of Sharklets. A320-200s and A321-200s without Sharklets are considered the best candidates, since more conversion programmes will be available for these aircraft.

Aircraft Commerce has applied these selection criteria to the current fleet of A320s and A321s.

The analysis identifies which aircraft will be suitable conversion candidates by the end of 2018. It is assumed that operators are more likely to be actively seeking feedstock aircraft by this time, since the conversion programmes will be under way or about to enter production.

Each aircraft's average utilisation was used to estimate the current fleet's accumulated FH and FC by the end of 2018.

FH and FC data were not available for the entire A320 and A321 fleet. The data were, however, only missing for aircraft aged about five years or younger. These aircraft should be suitable, since

A320-200 & A321-200 SUITABLE FUTURE CONVERSION CANDIDATES

Aircraft variant	CFM56-5 series engines	V2500 series engines	Total
A320-200			
Active	1,401	1,043	2,444
Parked	16	8	24
Total	**1,417**	**1,051**	**2,468**
A321-200			
Active	185	444	629
Parked	5	1	6
Total	**190**	**445**	**635**
All Aircraft			
Active total	1,586	1,487	3,073
Parked total	21	9	30
Total	**1,607**	**1,496**	**3,103**

Notes:
1). Fleet data correct as of October 2015.
2). A320-200 figures refer to all aircraft from L/N 1,081 onwards
3). A321-200 figures refer to L/N 1,794 & all aircraft from L/N 1,878 onwards.
4). All A320-200 & A321-200 figures relate to aircraft without Sharklets and with estimated accumlated utilisation of 90,000 FH and 36,000 FC or less by end 2018

they are too young to exceed the FH and FC thresholds by 2018.

The most suitable conversion candidates are split into A320-200 and A321-200 fleets to help operators identify the aircraft that best suit their specific operations. Each fleet is grouped by operator and engine variant to help identify the potential for commonality.

The analysis identifies the largest groups of A320-200s and A321-200s that will be within the typical feedstock age range by the end of 2018.

Younger aircraft are also considered, since they could be potential future conversion candidates.

A320-200 candidates

There are 2,468 active and parked, passenger-configured A320s that meet the four main feedstock selection criteria discussed here *(see table, this page)*.

The largest operators of these A320-200s are jetBlue Airways (122), China Southern Airlines (97), China Eastern Airlines (92), IndiGo (69), TAM Linhas Aereas (64), Shenzen Airlines (63), Vueling Airlines (61), Air Asia (54), British Airways (BA) (50), United Airlines (45) and easyJet (44).

The 2,468 future conversion candidates include 1,417 aircraft with CFM56-5 engines and 1,051 with V2500-A5 engines *(see table, this page)*.

The jetBlue, Indigo, BA and United aircraft all have V2500-A5 series engines. The Air Asia and easyJet aircraft are all powered by CFM56-5 series engines.

The other large fleets include a mix of the two engine variants. China Southern Airlines' A320-200 fleet includes 58 aircraft with V2500-A5 and 39 with CFM56-5 series engines. The China Eastern, TAM Linhas Aereas, Shenzen Airlines, and Vueling Airlines fleets respectively include 52, 39, 36 and 50 aircraft with CFM56-5 series engines, plus 40, 25, 27 and 11 aircraft with V2500-A5 series engines.

The main lessors of the most suitable conversion candidates are GECAS (190) and AerCap (141).

There will be about 448 suitable aircraft within the typical feedstock age range by the end of 2018. The largest common fleets of A320-200s that will be of conversion age by the end of 2018 are currently operated by United Airlines (45), jetBlue Airways (41), BA (27) and American Airlines (25).

The United, jetBlue and BA aircraft all have V2500-A5s. American Airlines' fleet is split between aircraft with V2500-A5s (14) and CFM56-5s (11). China Eastern Airlines (17) and Austrian Airlines (13) operate the largest fleets of CFM56-5-powered A320-200s that will fall within the feedstock age range by the end of 2018.

A321-200 candidates

There are 635 active and parked, passenger-configured A321s that meet the four main feedstock selection criteria *(see table, this page)*.

The largest operators of these A321-200s are American Airlines (93), China Southern Airlines (73), Vietnam Airlines (49), Air China (45), Lufthansa (38), Turkish Airlines (34), Aeroflot (26), China Eastern Airlines (26), Air India (20) and Asiana Airlines (20).

Of the 635 conversion candidates, 445 have V2500 and 190 CFM56-5B engines. The V2500-powered fleet has 14 aircraft with V2500-A1s and 431 with V2500-A5s *(see table, this page)*.

The Vietnam Airlines, Lufthansa, Turkish Airlines and Asiana Airlines aircraft all have V2500-A5 engines, while the Aeroflot and Air India aircraft have CFM56-5Bs. The other large fleets have a mix of both engine variants. The fleets of American Airlines, China Southern, Air China and China Eastern respectively have 82, 68, 13 and 17 aircraft with V2500 family engines and 11, five, 32 and nine with CFM56-5B engines. The V2500-powered fleets operated by China Southern and China Eastern respectively include 13 and one aircraft with V2500-A1s. The main lessors for suitable conversion airframes are AerCap (39) and Vietnam Aircraft Leasing Co (19).

About 33 suitable A321-200s will enter the typical feedstock age range by the end of 2018. The largest common fleets of these aircraft are operated by Thomas Cook Airlines (5), airberlin (4) and Air Busan (3). The Thomas Cook and airberlin aircraft have CFM56-5Bs, while Air Busan's airframes have V2500-A5 engines. The rate of suitable A321-200 conversion candidates entering the feedstock age range will increase after 2018. About 200 aircraft will pass the 15-year age threshold in 2019-2023. AC