

Coronavirus has created a large pool of feedstock examples suitable for narrowbody freighter conversions. In terms of engine type, weight variant and age, the better 737-800, 757-200 and A321 feedstock potential candidates are evaluated.

Identifying the best narrowbody conversion candidates

From May 2020 to February 2021, the narrowbody freighter fleet grew by about 60 aircraft. Today there are no factory-built narrowbody freighters with a 20-35 tonne payload available on the market, so all additions to this fleet are passenger to freighter (P-to-F) conversions.

The narrowbody freighter fleet accounts for about 625 active aircraft of a total freighter fleet of about 750 aircraft with more than 90 operators worldwide, this number includes 757-200 (298), 737-800 (51) and Airbus A321-200 (3). Before the pandemic, feedstock availability was low, and initial acquisition prices were high. Today investors are looking at placing increasing numbers of parked aircraft into P-to-F programmes so they can generate yields from the flourishing freight industry.

Aldav Engineering has experience with airlines, manufacturing and leasing companies for asset management, including sourcing aircraft feedstock and cargo conversion management. According to managing director, Moshe Haimovich, Aldav Engineering:

“More lessors are looking towards the air freight sector and are evaluating the possibility of converting their parked assets into freighter aircraft. There are also new-entrant investors who are looking for alternative investment in buying feedstock for cargo conversion. Some will want to sell the converted freighter at a profit, or to generate income by leasing it.”

The number of aircraft that has been grounded by the pandemic means there is an abundance of feedstock aircraft available. In this market of opportunity, and with potentially thousands of narrowbody aircraft to choose from, which A321, 737-800 and 757-200 are the ideal candidates for freighter conversion?

Investors

Today many aircraft owners are reluctant to sell aircraft at rates that are way below book value. Investors have to acquire the feedstock for the lowest value possible to allow them to produce an aircraft that can be leased competitively within the marketplace.

Dan Watson, chief commercial officer at Aero Capital Solutions (ACS), says: “The market has been more patient than we anticipated. The feedstock is available, but not at ‘fire-sale’ prices, and there is still a competitive market for passenger aircraft. The economics for a freighter are less compelling than for a passenger aircraft. This is because passenger aircraft do not need to be grounded for six to eight months and invest \$4.6-5.6 million as you need to do with a conversion. I think that some of these owners will be well served to be patient and wait and see if they can eventually place assets on a passenger lease.”

Post-pandemic travel demand could mean that many major airlines may be under capacity in 2022 and 2023, especially if they reject new deliveries and reduce capital expenditure. It is believed that many passenger airlines are preparing for additional lease support and aircrew, maintenance and insurance (ACMI) support for 2022 and 2023.

ACS is a rapidly growing middle-life aircraft lessor, and has a typical focus on aircraft that are 10 years old and older. The lessor has deployed more than \$750 million into aircraft sale, leaseback and acquisitions over the course of 2020, and has grown during the pandemic. Expanding its portfolio of 737-800 P-to-F converted aircraft, ACS is continuing its investment into narrowbodies in conjunction with its engine leasing activity.

“We have taken a large position in the 737-800 converted freighter market. We have also watched the A321 conversion development closely. Through our engine leasing and aircraft sales we have supported some of the A321 conversion activity, but the bulk of the investment is with the 737-800,” says Watson.

A factor for investing in narrowbody converted freighters is the availability of feedstock aircraft. There are 4,770 737-800s currently in service and in storage, 1,650 A321-200s, and 350 757-200s. Not all of these aircraft will be converted, because some will be considered too old, while most 737-800 and A321-200s will be too young.

Growth market

It has been estimated that market demand for 737-800s could be 2.5 and 3.5 times higher than the A321 over a 20-year term. The key driver to this may be the high number of 737-800s in the fleet.

According to Watson not all cargo operators will have the dense cargo route networks that are suitable for widebodies and large narrowbodies, such as the 757 and A321. This is also driving the appetite for a large number of 737-800 conversions.

Long-term air-cargo capacity growth rates have been forecast to be 4% to 5%. Part of the market growth is linked to increasing integration in the Asia Pacific in regard to trade. China is developing a large number of new regional freighter hubs, while similar developments are occurring in UAE, Qatar, Turkey and across many other Middle Eastern countries, Europe and North America. Narrowbody freighters will be a key component for all of these hubs, and they will be required in increasing numbers.

737-800 PASSENGER FLEET AGE & ENGINE PROFILE

Build year	CFM56 -7B24	CFM56 -7B24/3	CFM56 -7B24E	CFM56 -7B26	CFM56 -7B26/2	CFM56 -7B26/3	CFM56 -7B26E	CFM56 -7B27	CFM56 -7B27/B1	CFM56 -7B27/B1	Grand Total
1997								1			1
1998				39			1	4	2		46
1999	8			95		1	4	6			114
2000	15			119	2	4		25	3	1	169
2001	15			105		2	4	26	5		157
2002	7	2	3	78		1	7	13	6		117
2003	1			56		2		8	2		69
2004	10			61		1	1	1			76
2005	18			73			2	8			1003
Grand total	74	2	7	626	2	11	19	92	18	1	852

737-800

Before the pandemic, the ideal candidate age for 737-800 conversion was considered to be 20 years old. Unique circumstances of high availability and limited passenger demand mean that some lessors are considering aircraft built in 2009, 2010 and 2011. Yet in many cases, the most viable aircraft for conversion is going to be 2005 and older.

The 737-400 high gross weight (HGW) is a competitive aircraft versus the -800, but ultimately there will be a point in time where increasing maintenance costs become a negative return of investment (ROI). Combined with increasing environmental restrictions and noise restrictions, especially in Europe, this means the fleet will naturally evolve away from the Classic to the -800 series.

A total of 852 737-800s were built from 1997 to 2005. Of this number, 487 were built before 2002. The lease rate for the 737-800 converted freighter is \$180,000-205,000 per month.

The initial acquisition price for a 2011 aircraft is higher than for a 2005, yet monthly lease rates will be similar for both aircraft. Paying an additional \$5-10 million for a younger aircraft does not necessarily translate to a higher lease rate.

There are some higher lease rates to be yielded for younger aircraft from operators that value lower maintenance spending and the operational security, but there is a ceiling on the rental cost they are willing to bear.

In addition to aircraft vintage, a significant factor in choosing suitable feedstock candidates is the maintenance condition of the engines. Engines account for about 80% of the aircraft value, and when evaluating a conversion candidate, investors will put a high emphasis on its historic pedigree. This includes the operator, how many operators it has been through, and the maintenance status and condition of the airframe and engines.

Many life limited parts (LLP) in the CFM56-7B are rated to 20,000 engine flight cycles (EFC) before they must be replaced. The resulting shop visit (SV) will cost \$5 million, excluding LLP replacements. Engines that have recently been through an SV will have too many EFC remaining, so they will be considered too expensive for low utilisation rates of narrowbody freighters.

Engines that have 5,000EFC life remaining are considered to be ideal for narrowbody freighter operators. Flying at a low utilisation rate of 700-1,000 flight cycles (FC) per year will equate to a five-to-seven year on-wing life.

“Aero Capital Solutions has a robust engine-leasing platform and a pool of available engines, making it possible to match the engine maintenance condition to the aircraft lease term and the operator’s utilisation rate,” says Watson. “Operators with a long lease term that are flying a high number of short-haul flights will require a lot of remaining EFCs. For short lease terms at low utilisation rates, it is possible to install engines with 2,500-3,500 remaining EFCs.”

It is possible to have a dramatic variation in remaining EFCs to optimise the aircraft to freighter leasing. “The point is not to ‘run out’ the engine, but to offer it at a cost and condition that are best suited to the individual lessee,” adds Watson.

The Federal Aviation Administration (FAA) has published rules that limit the commercial usage of ageing airframes as the onset of widespread fatigue damage (WFD) increases with age. The limit of validity (LOV) for a 737-800 must not exceed 100,000FC and 125,000 flight hours (FH). As the number of accumulated FC and FH increase, so do the number of scheduled maintenance tasks and inspections, impacting operational cost and dispatch reliability.

“The 737-800 addresses the large number of AD issues with the Classic. The structural issues of the -400 have been

addressed with a better design,” says Robert T. Convey, senior vice president of sales and marketing at AEI. “Total FC are not an issue, unless they are very high. FH are often low because of the low FH to FC ratio. Typically I am seeing 2:1 FH:FC on the Classics, and the -800s are a little higher because of their range capability. But Southwest Airlines and Ryanair fly many one-hour operations.”

The average number of FC for 737-800s, built from 1997 to 2005, is typically 8,500FC for a 22-year-old EL AL MSN 29958; and 41,250FC for a 22-year-old Anadolu Jet MSN 29769. The number of FC depends on the aircraft’s age and utilisation rate.

737-800 weights

The greater the difference between the aircraft operating empty weight (OEW) and maximum zero fuel weight (MZFW), the greater its gross structural payload. The OEW will be similar for aircraft converted under the same supplemental type certificate (STC); and higher MZFW are typically preferred by operators to enable them to carry greater payloads.

“The structural weight specifications from aircraft that have been operated by low-cost carriers (LCC) are typically low. It is possible, however, to upgrade structural weights with Boeing before the conversion,” explains Convey.

737-800 feedstock is available with a number of certified MZFWs. The lowest MZFWs are 120,500lbs and 121,700lbs, on a total of 96 aircraft built from 2015 to 2018. Most of these aircraft are operated by Southwest Airlines and Xiamen Airlines, and are considered too young for conversion.

The main MZFW variants are certified at 136,000lbs and 138,300lbs. For aircraft built from 1997 to 2005, 564 are certified at 138,000lbs HGW) and 288 are certified at 136,000lbs low gross weight (LGW). Exclusive operators of LGW-certified



aircraft include Delta Airlines (71), Ryanair (42) and KLM (13).

Sole operators of HGW aircraft include United Airlines (99 aircraft, aged 16 years and above), American Airlines (64), Sun Country (16) and the Turkish operator Anadolu Jet (18). South African-based Mango Jet has 12 early-production aircraft built in 2000 and 2001.

Qantas operates 26 HGW aircraft of this vintage, but MSN 33993, 33994 and 33995 are certified at LGW. Jet2.com operates 17 HGW and 13 LGW aircraft that were built from 1998 to 2005.

"Sometimes it will make sense to acquire an LGW aircraft and upgrade the weights with Boeing," says Watson. "However, if additional investment is needed to upgrade the engine thrust rating from 24,000lbs to 26,000lbs, then the aircraft could be at a point where the economics to convert it are not sensible."

CFM56-7B thrust rating

Traditional freight carriers typically require 26,000lbs of thrust, although some express and eCommerce carriers can operate with 24,000lbs. Bill Kmietek, director, BlackRock Aviation Holdings says: "If I get a 27,000lbs engine I will typically derate it to 26,000lbs so it will last longer on the wing. Building a conversion with 24,000lbs is likely to limit the available market."

The CFM56-7B is available with three thrust ratings: CFM56-7B24 at 24,000lbs, CFM56-7B26 at 26,000lbs, and the CFM56-7B27 at 27,000lbs. The -7B26 has the market share (626) of aircraft built from 1997 to 2005. Next is the -7B27 (92), followed by -7B24 (74).

Unless the operator needs the extra performance to lift heavy payloads from

restricted airports, it is unlikely they will require the -7B27. The -7B24 is least desirable for 737-800 P-to-F conversions because of its low thrust rating. The -7B26 is considered to have the optimum thrust rating for P-to-F candidates.

56 LGW and 17 HGW aircraft are equipped with -7B24 engines. The LGW aircraft with low thrust ratings include KLM (13), Air Algerie (8), Garuda Indonesia (3) and Qantas (3). HGW aircraft with low thrust ratings include Qantas (7).

HGW aircraft with -7B26 (423) built from 1998 to 2005 include Air China (7), American Airlines (76), Jet2.Com (10), Royal Air Maroc (9) and United (94).

The high number of American Airlines and United Airlines aircraft will make good candidates for conversion.

LGW candidates with -7B26 (203) engines include Delta Airlines (70), Ryanair (42), China Southern (14) and Sun Express (5).

There are 75 HGW candidates with -7B27 engines built from 1998 to 2005, including Mango Airlines (12), Safair (7), Sun Country Airlines (8) and El Al (5).

Having gone through maintenance, some base engines have upgraded part numbers and could even have some hot-section modifications. Many freight operators are unwilling to pay more for such modifications. Unique circumstances that allow lessors to add value to non-baseline engines such as /3 or E variants include operating long flight sectors and having long lease terms.

Pedigree & sisterships

Many aircraft operated by the same passenger airline ordered from the same batch are furnished with identical avionics

The 757-200 was produced until 2005 and there is still a plentiful supply of suitable 757-200 feedstock aircraft available to convert, satisfying demand for cargo conversions of the type.

and minimum equipment lists (MEL). Sisterships are beneficial from a configuration standpoint for operators, and typically have a lower on-ramp cost. The fact that two aircraft are released from the same operator does not always translate to commonality in configuration.

"Prior pedigree is important with sisterships, and two aircraft of similar age that have been with the same operator since birth are ideal. It is possible to have two aircraft coming out of an airline that have been through a number of prior operators," says Watson.

Sisterships are ideal when creating a fleet and some carriers, like ASL, are focusing on ex-Ryanair aircraft. This makes sense in terms of maintenance and stocking rotatable and support components.

Sisterships are less of a concern for operators interested in one or two aircraft for initiating freighter programmes, fleet growth or to replace existing fleets.

Often lessors can address cockpit configuration issues and work with lessees and operators to address commonality issues. It is useful to have prior agreement before getting the aircraft converted speculatively.

Aircraft operated in areas with high pollution cause excessive wear on the engines, making them less desirable, as opposed to aircraft based in northern Europe and America. It is possible to put an exhaust gas temperature (EGT) margin penalty on engines that have been operating in India and China, reducing the time on wing.

Countries such as China and South Korea set maximum age restrictions on imported aircraft. Many experts believe that the quality of the aircraft and its maintenance is more important.

A321-200 freighter

Air Transport Services Group (ATSG) is a leading provider of aircraft leasing and cargo transportation, and has an inventory that includes 777, 767 and 757 freighters. It is part of a joint venture (JV) with A321 Precision Conversions to develop an A321 P-to-F STC. Together with 321 Precision Conversions, ATSG plans to use its conversion facility, PEMCO Conversions, to convert A321 passenger aircraft.

"The A321 P-to-F conversion is ideal for operators that want to up-scale from

the 737 family freighter to 757-200 capacity. The A321 has the potential to achieve a greater yield on peak-time, high-density routes," says Haimovich. "The A321's high volumetric payload makes it ideal for the express and eCommerce market. SmartLynx Malta has inducted the prototype 321 Precision conversion into its fleet and has plans to take redeliveries of Elbe Flugzwerke (EFW) converted aircraft. So far there are two EFW A321-P2F aircraft in service, one with Qantas Australian Airfreight and one with Titan."

It is expected that the A321 freighter will be popular in many regions that operate large numbers of A320 family aircraft, such as Europe, the Middle East and the Far East. A321 operators in these regions will have sufficient access to feedstock numbers. Aircraft registered in the same jurisdiction are unlikely to require system modifications and MEL upgrades to satisfy national aviation authority (NAA) requirements, and maximum age restrictions are less likely to apply.

Including ATSG 321 Precision and EFW, Sine Draco is developing a conversion STC for A321-200 aircraft that will have 14 main-deck positions.

"The aircraft is entering a heavy maintenance check starting in late June. Then in the third quarter of 2021 it will be inducted into the conversion facility and rolled out by the fourth quarter," says Senior director of sales and marketing, Sine Draco Chris Stafford adding. "Flight testing will start early 2022 and it is forecasted that the STC will be awarded in the second quarter of 2022."

Many investors see the A321 P-to-F conversion programme as a replacement to the 757 conversion programmes because of similarities in their volumetric payload and the maturity of the 757-200 programme. Yet increasing cargo demand and high feedstock availability have significantly driven demand for 757 conversions.

Lease rates for the A321-P2F/PCF range from \$228,000 to \$258,000 per month. This is about \$30,000 more than a 757F. The 757-200's fuel, maintenance and environmental costs will be fundamentally higher than the A321's.

"Many 757 freighter operators such as FedEx (PF) and UPS (P-to-F) will continue to operate these aircraft for the long term," explains Haimovich. "However, taking into account the fact that the successor of the B757 freighter is the A321-200 freighter, North American operators will most likely consider the A321-200 in the future for fleet growth and replacement. New entrant such as Global Crossing Airlines intends to build a fleet of A321-200 freighters and it will be interesting to see if Amazon Prime will add the A321 to their fleet in ACMI or CMI operation. The A321 has an initial foothold in Europe but it will not be too long to see the A321 in Southeast Asia and China."

Vintage

The ideal vintage for A321-200 feedstock are aircraft built from 2000 to 2005. Early A321-100 aircraft should be avoided, since there is no conversion STC available for them, and they lack the necessary weight to achieve a meaningful gross structural payload. All 44 A321-100 aircraft are more than 20 years of age, are operated by Air France, Alitalia, Lufthansa and Swiss and are typically in storage.

Another important consideration is not acquiring aircraft with sharklets. In 2013 Airbus introduced the sharklet option into its portfolio. The oldest sharklet-equipped aircraft is eight years old, and is considered too young for P-to-F conversion.

There are currently 1,650 A321s in the fleet. Of these, 756 were built before 2014, and do not have sharklets. Half the aircraft built in 2013 have sharklets.

There are 184 aircraft built from 2000

to 2005. It is likely that younger aircraft will return to passenger service, although some could soon be retired once airlines introduce new engine option (neo) aircraft.

Flight cycles & flight hours

The A321's design service goal (DSG) is 48,000FC or 60,000FH. It is possible to extend the DSG with an extended service goal one (ESG1) and ESG2. The ESG1 will increase the DSG to 96,000FH; and the ESG2 will increase DSG life to 60,000FC and 120,000FH. The number of structural modifications and their high cost make the ESG2 uneconomic for conversion candidates.

Air France MSN 0777 at 23.3 years has achieved 37,500FC and one of the highest accumulated FC in the A321-200 fleet. MSN 0792 built in the same year has as few as 26,500FC. 18-year-old examples will typically have accumulated 16,000-



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CFM56-5B-POWERED A321-200 PASSENGER FLEET AGE & ENGINE PROFILE

Build year	CFM56 -5B1/3	CFM56 -5B1/P	CFM56 -5B2/3	CFM56 -5B2/3 PIP	CFM56 -5B2/P	CFM56 -5B3/2P	CFM56 -5B3/3	CFM56 -5B3/3 PIP	CFM56 -5B3/3B1	CFM56 -5B3/P	Grand Total
1998	1	2			2	2			5	12	
1999		5			2	2			4	13	
2000					1	2			6	9	
2001		1			1				35	37	
2002		3			1				13	17	
2003		1				1			14	16	
2004		1			1	1			7	10	
2005					3				4	7	
2006		2							8	10	
2007		1	2				3		12	18	
2008	3	1	8				14		3	29	
2009		1	9				17		2	29	
2010		1	8				12			21	
2011						8	3			11	
2012								13		13	
2013		1		3				31		35	
Grand total	4	20	27	3	11	8	54	47	5	108	287

24,000FCs, and 15-year-old examples 13,000-24,000FCs; 10-year-old examples will have accumulated 7,000-15,0000FC.

A321-200 weight variant

It is important to choose the correct A321-200 weight variant (WV) when considering feedstock candidates and ensure it is the optimum WV for the conversion STC.

There are 12 available WVs for A321-200 aircraft, ranging from WV000 to WV011. These include different MZFW and maximum take-off weight (MTOW). The larger the difference between OEW and MZFW, the greater the gross structural payload.

Three MZFWs are available: 162,701lbs (73,800Kg), 157,630lbs (71,500Kg) and 153,221lbs (69,500kg). There are no A321-200s certified at WV007, WV008 and WV009 with an MZFW of 153,221lbs (69,500kg) in the fleet.

Of 765 aircraft built before 2014, 320 are certified at 162,701lbs (73,800kg) MZFW, and 436 are certified at 157,630lbs (71,500kg). The certified MTOW is also a consideration to determine the WV of these aircraft. The greater the difference between MZFW and MTOW, the greater the aircraft range. Feedstock candidates rated with the lowest MTOW (WV006) are optimised to fly shorter sectors and can have a higher FC:FH ratio.

There are nine available MTOW options that can be combined with three available MZFW options to form WV000

to WV011. The predominant combinations of MZFW and MTOW for pre-2014 aircraft are: WV000 (347), WV001 (208), WV002 (66), WV005 (14), WV006 (34) and WV011 (40).

Engine choices for pre-2014 A321-200 are the Pratt and Whitney V2500 series (478) and CFM International CFM56-5B (287) series. Popular pre-2014 A321-200 engine models include the V2530-A5 (15) with a thrust rating of 29,000lbs and the V2533-A5 (207) with a thrust rating of 32,000lbs. The CFM56-5B3 (222) series has a thrust rating of 33,000lbs, the -5B2 (41) 31,000 lbs, and -5B1 (24) 30,000lbs.

Since the programmes are new, data relating to the optimal thrust rating for A321 operations is limited. All conversion STCs will have the ability to convert both CFM56-5B and V2500s.

There are 207 aircraft powered by the V2533-A5 baseline engine, and in 2008 the upgraded V2533-A5 Select One (242) was introduced. The CFM56-5B3/P (108) was installed on aircraft up to 2007, when it was replaced by the CFM56-5B3/3 (54) and then in 2011 with the CFM56-5B3/3PIP (47).

Once the programme matures, younger aircraft with modified sub-series engines will become candidates for conversion feedstock.

Most pre-2014 WV000s (347) are powered by V2533-A5 engines (117). CFM56-5B3/P (45) was superseded by CFM56-5B2/3 (27) and CFM56-5B3/3 (30) in 2006. After 2008 the most numerous engine type for the WV000 is the V2533-A5 Select One, with 90 aircraft.

The WV000 is best suited to the ATSG

321 Precision Conversion.

The 321 Precision modification makes it possible to convert any of the high number of WV000s available without the need for an expensive MZFW or MTOW weight upgrade.

"To upgrade the weight from a WV000 to a WV001 or WV002 requires a repair damage assessment report (RDASS) to be completed on the aircraft. This means that all previous repairs must be inspected by Airbus to ensure that the work is satisfactory. Unacceptable repairs must be recompleted, which can be very expensive," says Zach Young, director of sales at Precision Aircraft Solutions.

According to Young, at an 80% load factor and 27-tonne gross payload the 321-200PCF will have a packing density of 8.8 lbs per cu ft. Designing its payload to be greater than 27 tonnes will negatively impact aircraft OEW, resulting in only incremental gains in gross structural payload.

There are 89 WV000s ranging in age from 15 to 21 years; and 54 of these have V2533-A5 engines. Air China Southern owns 10 and leases seven, and is the largest V2500 operator in this age and WV category. British Airways has three V2500s in storage. Air Busan currently leases eight V2500 aircraft. Cathay Pacific and Vietnam Airlines each own two aircraft.

There are 29 CFM56-5B3/P WV000s ranging in age from 15 to 21 years. China Eastern (6) is the largest operator in the category, followed by TAP Air Portugal (2), Ural Airlines (2) and Nordwind Airlines (2). It is worth noting that Air India has six -5B3/3 and three -5B3/P

aircraft from 2007 and 2008 build years.

The EFW STC is optimised for feedstock with a high MZFW, and it considers the ideal to be the WV001. Close ties with Airbus mean the EFW STC is considered by many investors to be the original equipment manufacturer (OEM) solution. The high MZFW and MTOW of the WV001 enable the A321-200P2F to achieve a gross structural payload of up to 32 tonnes, and its design allows it to carry a 14th AAA/AAY container in the aft-most main-deck cargo position.

Most WV001s from 2009 and later are powered by the V2533-A5 Select One (107). Older aircraft are mainly powered by (35) CFM56-5B3/P, 25 of which are installed on 2001-vintage aircraft. The V2533-A5 is installed on 33 pre-2010 aircraft. Other engine options for younger non-sharklet WV001s include the CFM56-5B3/3 (13) and -5B3/3PIP (25).

There are 50 WV001 aircraft built from 2000 to 2006, of which 35 have CFM56-5B3/P engines and 15 have the V2533-A5. American Airlines operates 28 -5B3/P-equipped aircraft; of these it owns 16. All these American Airlines aircraft were built from 2001 to 2002. The remaining aircraft in this category are lessor-owned, and two 2003 aircraft are operated by Eurowings.

The V2500 WV001s built from 2000 to 2006 are all owned by lessors. Operators include Aegean Airlines (3), Red Wings Airlines (5) and Ural Airlines (2).

There are limited numbers of CFM56-5B3/P (6) and V2530-A5 (2).

"The Sine Draco STC will initially address WV000 and WV002 aircraft. At the customer's request, Sine Draco can amend its STC to account for the higher MTOW. From an operational perspective, only very high payload and longer segments would require this MTOW. The market is indicating this may not be needed for a package freighter operating a two-hour mission," says Stafford. "The simplest solution for WV001 feedstock is to assess if a lower MTOW would suffice. Reducing the MTOW from spec WV001 to WV002 is straightforward."

There are 10 WV002 aircraft built from 2000 to 2006, and 29 from 2000 to 2008. Of these aircraft, four have -5B3/P engines and six have V2500 engines. Two V2530-A5 aircraft are owned by SAS; they are 18 and 19 years of age and are in storage. JetStar has a 21-year-old, Qantas-owned V2533-A5 Select One aircraft in storage. Other aircraft in this category are owned by lessors such as AerCap and Aero Capital Solutions (ACS).

Noise restrictions

Some CFM-56-3B engines do not meet Chapter 4 and Stage 4 noise regulations, and are certified to Stage 3 noise regulations only. Many airports in Europe require

V2500-POWERED A321-200 PASSENGER FLEET AGE & ENGINE PROFILE

Build year	V2530-A5	V2530-A5 SelectOne	V2533-A5	V2533-A5 SelectOne	V2533-A5 SelectTwo	Grand total
1998	3		6			9
1999			11			11
2000	1		11	1		13
2001	4		7			11
2002	5		13			18
2003			15			15
2004			22			22
2005			10			10
2006	1		19			20
2007	1		32			33
2008			30	7		37
2009			19	39		58
2010			2	27		29
2001		6	10	39		55
2012		6		65		71
2013				64	2	66
Grand total	15	12	207	242	2	478

visiting aircraft to be Stage 4 compliant, and have introduced a number of restrictions preventing Stage 3 aircraft from performing operations at night. This can impact some freight carriers.

"The V2500 engines are Stage-4-compliant. We have received positive feedback that Sine Draco must address this engine type first," says Stafford. "Certain WVVs of some CFM-powered aircraft require significant upgrades to make them Stage-4-compliant. Typically, if a high thrust rating is combined with an HGW aircraft, the higher is the chance that it will be only Stage-3-compliant."

To modify a Stage 3 engine to be Stage-4-compliant depends on its serial number and existing parts. Upgrades can include improved fan frame forward panels, enhanced acoustic thrust reverser and core chevron nozzle.

Noise improvement modifications can be quite extensive and can cost \$800,000 to \$1 million per engine.

757-200

The most mature narrowbody P-to-F conversion programme belongs to the 757-200 airframe. The first 757 freighter was a production freighter (PF) that first entered service with UPS in 1987. It was not before 2001 that Boeing introduced a P-to-F conversion variant called the 757-200SF.

The Precision Converted Freighter (PCF) was developed by Precision Engineering, and was first certified in 2005. The PCF is the only available conversion programme STC available for the 757-200.

High volumetric payload, gross structural payload and range mean the 757 is a capable freighter and its typical monthly lease rate ranges from \$150,000 to \$225,000. Feedstock values are \$10 to \$14 million, added to a conversion list

price of \$5.2 million, meaning the return on investment is attractive for investors.

"Many marketing efforts are trying to kill off the 757-200PCF, by saying it is too old and there is not enough feedstock. The reality is that there are more than 100 good conversion candidates left," explains Young. "Precision will induct its 145th 757-200 P-to-F conversion later this year, and its 150th by January 2022. It has converted many different vintages, operating weights and configurations."

According to Young, 757 sceptics put the aircraft in the same category as the 737 Classic. The 757-200 production run is longer than the Classic and the airframe is more robust and not subject to a high number of expensive airworthiness directives (ADs) and repetitive inspections.

Additionally, the 757 typically operates long sectors, so it does not accumulate the high number of FC compared to a 737 Classics.

"We have four 757s that we will be converting this year and next," explains Kmiotek. "Recently we acquired a factory-built 757-200 freighter. It was an ex-ASL aircraft that was returned to a lessor, and we bought it on spec. We acquired a 757-passenger aircraft with good engines and swapped one of them with the freighter, significantly increasing the latter's value. Then we sold the freighter to a lessor who leased it immediately."

According to Kmiotek, even though the freighter was a 1990-build, it had accumulated a low number of FCs and was well maintained by ASL. Because of the strong interest in the 757F, BlackRock decided to convert the 757-200 it initially acquired as an engine donor.

Strong demand for the 757F means that BlackRock does not have any concerns placing its P-to-F converted aircraft on spec, and has four conversion

757-200 PASSENGER FLEET AGE & ENGINE PROFILE

Build year	PW2037	PW2040	RB211-535E4	RB211-535E4B	Grand total
1995	5		7	9	21
1996	14	2	8	4	28
1997	12	1	2	5	20
1998	14	1	4	10	29
1999	20	1	9	9	39
2000	13		11	7	31
2001	8	2	5	16	31
2002	4	1		4	9
2004	3				3
2005	2				2
Grand total	95	8	46	64	213

slots booked. "We have just agreed the purchase of three more Rolls-Royce-powered 757-200s, and we intend to convert them next year when they come off lease," says Kmiotek.

"We like to choose late-1990s vintage feedstock; the oldest we are considering is 1995," adds Kmiotek. "Slot availability is at a premium at the moment, so you must acquire the asset and park it until it can be inducted into a four-month conversion programme. From start to finish, the whole process can take over 12 months, although during that time it is possible to lease the engines."

High FH:FC ratios mean many 757-200s have accumulated a low number of FC, despite their age. The LOV for the 757-200 is 75,000FC and 150,000FH. Built in 2001, MSN 30044 Azur Air Russia, has accumulated 6,517FC and has had nine previous owners. With 7,083FC is Azur Air Russia, MSN 29382, which was built in 2002 and has had two previous owners.

Delta Airlines' older aircraft have accumulated some of the highest FC numbers in the fleet, ranging from 37,000FC to 41,000FC. The ideal number of FC for conversion candidates is 18,000-25,000FC. There are 125 aircraft that meet these criteria in the fleet.

Weights

The 757-200PCF can carry a gross payload 68,000lbs from a base level Rolls-Royce aircraft with an OEW of 116,000lbs and MZFW of 184,000lbs. There are 52 passenger aircraft left in this category.

There are 58 RB-211 candidates with a certified MZFW of 188,000lbs, and they can achieve a gross structural payload of 72,000lbs. Precision offers an MZFW upgrade to 200,000lbs, enabling the 757-200PCF to achieve a gross structural payload of 84,000lbs.

There are two MZFWs for PW2000-

powered aircraft: 184,000lbs (62); and 186,000lbs (41).

The Precision modification upgrades the MZFW to 198,000lbs. 110 of the PW-equipped aircraft are operated by Delta Airlines. The US carrier has recently invested in new 757 interiors, and it is unlikely to want to sell these aircraft in the foreseeable future.

"Over the past year we have completed more MZFW upgrades than any other year. This is surprising because the recent focus is on eCommerce cargo and generally low packing densities. The 84,000lbs payload is equal to 37.5 tons and more than 37 tonnes. This is 10 tonnes more than the A321," says Young.

Before Precision can upgrade the MZFW to 200,000lbs, aircraft must be certified at the highest MZFW. The maximum landing weight (MLW) must be upgraded from 198,000lbs to 210,000lbs, before Precision can upgrade the MZFW to 200,000lbs.

One factor explaining the high number of MZFW upgrades is that many lessors are converting 757-200s on speculation. For a lessor the high gross structural payload will increase aircraft marketability and make it easier to place.

Engine options for the 757-200 are Rolls Royce RB-211-535E4 and -535E4B and PW2037 and PW2040

Good EGT margins mean the RB211 engine can remain on-wing for a long time, and are often only removed for LLP replacement. Since all 757 P-to-F conversions are the same and all recently converted aircraft have had a fresh C check, lessors sometimes want the best available engines to help differentiate them in a homogeneous marketplace. Many 757F operators will typically fly at an average FC time of 3-5FH.

Of the 168 passenger aircraft left that were built from 1995 to 2000, there are 78 PW2037-powered, five PW2040-powered, 44 RB211-535E4-powered, and 41

RB211-535E4B-powered.

There are also 45 aircraft left that were built from 2001 to 2005, split between 20 aircraft equipped with the RB211-535E4B, five with the RB211-535E4, 17 with the PW2037, and three with the PW2040 (*see table, this page*).

"The RB211 is the most popular choice for freighter operators. We are now considering aircraft with the PW2000 family of engines, and are seeing more released onto the market. FedEx operates aircraft with both engine types in large quantities, so it is possible to operate both together, and the Rolls-Royce versus Pratt situation is now driven by feedstock availability," says Kmiotek.

Rolls-Royce RB211s that have had a restoration level four SV are typically trading for \$6 million. Yet it is considered that these engines could have too many remaining EFC for freighter operations.

There are 64 remaining RB211-535E4B-powered aircraft built from 1995 to 2005 operated by airlines including American Airlines (14), United Airlines (29) and Iceland Air (1). AerSale has 12 aircraft pending conversion in this category that it purchased from American Airlines in December 2020. These aircraft have 16,300-19,400 FC.

There are 46 RB211-535E4-equipped aircraft in the same category. These include Icelandair (10), Tui (4), American Airlines (3) and Turkmenistan (4). AerSale has three ex-American Airlines aircraft pending conversion. Most of the -535E4-equipped aircraft have a 188,000lbs MZFW, compared to the -535E4B's 184,000lbs MZFW.

PW2037 (95) is the most numerous engine type. Delta Airlines operates 77 of these aircraft built from 1995 to 2005. Remaining operators include United Airlines (6), built from 1997 to 1999, and Uzbekistan Airways (5), built in 1999.

There are eight PW2040-powered aircraft, operating with Azur Air Russia (4) and Fly Persia (1).

Finals

"EFW is converting the prototype A320-200 with STC anticipated next year. In my opinion the A320-200 freighter will compete well in the market with the B737-800, also taking into account that there is a significant difference of about \$2.0M between the same vintage feedstock A320-200 and B737-800 in half life. In the long term I foresee operators with a mixed fleet of A320 and A321 freighters. The narrowbody freighter market, which was dominated for many years by Boeing is now facing competition from Airbus," says Haimovich. **AC**

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