

Used opportunities for narrowbody aircraft include passenger charter, freighter conversion and tear down. Engine shop availability and a ready supply of components and parts is essential to operators by allowing the fine tuning of maintenance status to aircraft utilisation rate.

Markets for used narrowbody assets

Depressed passenger traffic has led many operators to re-align their fleets, resulting in a large number of used narrowbodies becoming available. Older aircraft are typically the first to be withdrawn from passenger service in an industry downturn, while younger aircraft are prioritised to operate airlines' reduced schedules and stabilise cashflow.

Despite growing interest in 737 MAX and A320neos, these new generation types still represent a small percentage of the narrowbody fleet. Many operators and start-ups must rely on used legacy types that require a supply of parts and material to optimise their remaining life.

Start-up airlines

The ability to finance aircraft is important to investors, and new generation aircraft are fundamentally easier to finance than older ones. Timeframes for operators looking to acquire aircraft at short notice can be problematic because of the time taken between making an initial order and final delivery date. "Stable reliability is also important, especially if an airline wants to operate with short turnaround times and little margin for delays," explains Oriel senior ISTAT appraiser, Olga Razzhivina. "Fuel will become a more important part of the equation, however, especially in a competitive sector because an airline will not have the opportunity to pass the cost on to the passenger."

Whether a used narrowbody remains in passenger service, is converted to freighter, or is scrapped for parts typically depends on the scenario. First the investor must look at the aircraft's maintenance condition and calculate the cost of the larger upcoming maintenance events. A part-out scenario could be best for an aircraft with low remaining maintenance life compared to the investment needed to convert it into a

freighter or to reconfigure the cabin for passenger use.

"If the aircraft has good remaining maintenance life and a relatively standard interior, it is worth keeping it in passenger service and trying to maximise lucrative short-term summer season opportunities. In Europe a notable amount of charter services are being commissioned for major airlines, which represents a good opportunity," says Razzhivina. "Longer-term leases are possible, maybe with second tier airlines, but now there is a strong emphasis on an airline's credit, partly because the industry has become far more indebted during the Covid crisis."

Sales incentives offered by aircraft manufacturers to airlines can include maintenance and software support packages and warranties. New aircraft can be attractive to airlines as they are typically a 'turn-key' solution that will not require large maintenance events in the near term.

Lessening government intervention has put greater pressure on the lessor to assess more carefully an airline's ability to survive.

Lease

A decision must be made to acquire an aircraft with or without an active lease attached.

According to Maurick Groeneveld, managing director of AvSkills BV: "Then the question must be, 'how good is the lease'? If the lease was brokered pre-Covid with minimal restructuring during the crisis, then the lease will probably have a good rental and return. Another factor is the lease duration, since aircraft with longer leases are more favourable."

There comes a point at which it is not possible to yield much benefit from an asset attached to a short lease, whereby it will be returned by the airline after just a few months. Remarketing aircraft

requires investment, including a risk of the aircraft being parked if a new operator cannot be immediately found.

Poor lease conditions may have been negotiated between the airline and the previous lessor regarding modification and maintenance commitments. These could include a long-term power-by-the-hour (PBH) deal, for example, with minimal return conditions. The PBH deal is intended to prevent lessee defaults and airline insolvencies at times of low passenger demand.

Under the typical PBH agreement, the airline will pay for all fixed costs including storage, line-maintenance and insurance, and only pay rent when the aircraft is operated. PBH arrangements will not be favourable to a lessor if the operator does not use the aircraft enough to yield significant lease returns. "The issue with the PBH deal for investors is that the airline ultimately chooses whether or not to use the aircraft. If it chooses not to, then the aircraft costs it less, and the lessor will probably not yield all the funds to cover large scheduled maintenance events in the future," explains Groeneveld.

Airlines will typically seek a number of maintenance obligations from PBH leases because they are looking to recover and avoid large cash outgoings. In this case, many of the costs must be absorbed in part or in full by the lessor. In a soft market an investor will prefer not to put the aircraft on a short lease because lease rental must be lowered to appeal to cash-strapped carriers. If the market is good on the other hand, lease rentals can be increased, and lessors can insist on a longer lease duration.

Maintenance

Another factor influencing lease duration is the aircraft's maintenance condition. Lessors will typically include a return clause in the lease agreement that



stipulates that the aircraft is handed back in a particular maintenance condition. This means the operator is responsible for completing scheduled heavy maintenance visits (HMF), including D and C Checks, before the handover.

Primarily a D or heavy C Check is the most comprehensive inspection in terms of aircraft checks and repairs. During the HMF, the entire aircraft is stripped down and equipment is removed, including engines. The HMF can take six to eight weeks, uses about 50,000 man-hours (MH), and can cost \$2 million or more for a narrowbody. Typical heavy check intervals vary between aircraft types, but on average are six to 12 years, or 24,000-40,000 flight hours (FH).

The intermediate six-year visit on an A320 family type is less rigorous than the D check at 12 years. D1 and D2 checks are likely to be completed, and the aircraft withdrawn before the D3 check comes due. The only exception is if the aircraft is converted to freighter. A smaller C Check is performed every 20-24 months.

"If an aircraft is considered for a short lease to an operator and during such lease the operator is also required to put aircraft through an HMF, this will make the aircraft difficult to re-market to an airline," explains Groeneveld. "An airline will not want to take an aircraft if the undercarriage and engines must be removed and replaced for periodic inspection and overhaul in the near future. Therefore, the investor will want to consider timing the major maintenance events at the optimum time to broker a new lease or a renewal."

Assuming a typical first narrowbody lease is eight years, then two years will have elapsed since its first intermediate

check, and the D check will be due in about four years' time.

Essentially the older an aircraft is the greater the number of repair tasks and airworthiness directives (AD), including service bulletins (SB) that have to be addressed. Maintenance costs generally increase with aircraft age, devaluing older assets approaching large maintenance events. The aircraft's value is adjusted by considering its maintenance condition.

According to Groeneveld, the owner needs to justify the investment needed for an HMF and an engine shop visit (SV), especially if it is unlikely that the aircraft will be used for the full maintenance interval. "It always boils down to the total cost that needs to be invested compared to the potential benefit of the investment. Clearly it is uneconomic to finance costly maintenance and zero-time the engines if the plan is to operate the asset for just one or two years," adds Groeneveld.

It is possible that an aircraft stored since the start of the Covid crisis will require the renewal of 'hard-time' components, such as the landing gear just because of the laps in calendar time.

737 Classics & NGs

The 737-300/-400/-500 Classic (CL) family was in production from 1984 to 2000, and powered by the CFM56-3B/-3C engine. At the start of 2022 there were 232 737 CLs in passenger service, and almost 100 of these were 737-300s.

"The current market value (CMV) for the 737 Classics is low. This is helping to generate demand for the type from operators outside Europe and North America, and typically for feedstock to be converted into freighters, despite large

The 737 Classic freighter fleet has been extremely active during the pandemic, meaning many CFM56-3 series of engines have required maintenance. The volume of readily available engine material has declined over the past five years, but active trading programmes are allowing 737 Classic carriers to remain operational.

numbers of cargo operators migrating to the newer 737NG," says Groeneveld.

Active passenger freighter conversion programmes are available for the -300/-400 through Aeronautical Engineering Inc (AEI), and Pemco Conversions. A P-to-F supplemental type certificate (STC) has not been developed for the -500.

The conversion costs \$2.5-2.8 million, and typical lease rates for the freighter are between \$100,000 and \$130,000. To yield the longest possible return from this investment, it makes sense to put the aircraft through a D check during conversion so that it can remain in service for as long as possible. If the aircraft is to remain in passenger service, it could make sense to fly all the remaining life out of the aircraft and scrap it just as it is due its next HMF.

"Older assets tend to have less demanding leases," says Groeneveld, "It depends on what the business model is, but cargo operators will typically operate the aircraft at a low utilisation rate compared to a passenger aircraft. Because of this it is not as imperative to have an asset with many flight cycles (FCs) remaining in terms of engine life limited parts (LLPs)."

The 737NG is powered by the CFM56-7B series of engine that is rated at 19,500-27,300 lbs of thrust.

737-800 P-to-F conversion providers include AEI, Boeing and Israel Aerospace Industries (IAI), and a combined output of about 44 conversions in 2021 makes it one of the most prolific programmes in recent years. Conversion cost for the 737-800 is about \$5 million and typical monthly lease rates are \$160,000 and \$180,000. IAI provides P-to-F conversion STCs for the 737-800 and the shorter 737-700.

EirTrade Aviation is a Dublin-based global technical assets services and trading company that has been operating for almost 12 years. The company specialises in aircraft and engine teardown, aircraft material sales and asset management. "We tear down three engine types at the moment inhouse including the CFM56-5A, -5B and 7B, and the evolution variation of the -7B," explains EirTrade vice president Lee Carey. "In the future we will probably look to expand our inhouse engine capabilities by adding other engine types. Both our airframe & engine disassembly facilities offer these services to the market



in addition to catering for our owned & managed assets”

757-200

The 757-200 was in production from 1983 to 2005. Depending on the variant, it has a maximum take-off weight (MTOW) ranging from 255,000lbs to 273,000lbs, and is the heaviest narrowbody. Comprising 163 -200s and 44 -300s, the 757 passenger fleet is considered diminished by 2022.

The 757's operating economics mean it is falling out of favour with passenger operators, despite long-range capability and ideal passenger capacity for many routes. Because of this, younger 757-200s on the market are most likely to be converted to freighters.

Precision Aircraft Solutions provides the only active 757-200 P-to-F conversion, with 19 aircraft converted in 2021, and at least 15 scheduled for 2022. According to Zach Young, director of sales and marketing: “We have set the standard with the 757-200PCF, and the product can clearly stand the test of time. No other narrowbody type is as capable in terms of payload, volume, and range.”

To date there are about 320 757-200F in active service

The 757-200 conversion costs about \$5.2 million, and typical lease rates for a converted freighter are between \$205,000 and \$240,000 per month. The aircraft is powered by either the Pratt and Whitney PW2000 series or the Rolls-Royce RB211-535E4. Due to the 757-200's popularity, there is high demand for many engine components.

“EirTrade will be receiving its first PW2000 engine for teardown in a month's time, and we have already had a

lot of interest,” says Carey. “Last year we opened an office and warehouse facility in Dallas, and members of the team have much experience with that engine. The RB211 market has picked up in terms of supply of material in the last couple of years, and there is still a strong demand driven by many freight operators.”

The only available P-to-F conversion programme is for the -200, although there are 44 active 757-300s in passenger service that were built from 1999 to 2005. The -300 is a larger stretched version with a greater MTOW, allowing it to have a higher volumetric and gross payload than the 757-200.

The youngest 757 is now 17 years old, and the oldest active passenger aircraft was delivered in 1983.

A320 family

A320 P-to-F conversion providers include Elbe Flugzeugwerke (EFW), which has A320-P2F and A321-P2F conversion STCs, and 321 Precision Conversions with its A321-PCF. Other A320 family cargo conversions are being developed by Sine Draco, and C Cubed Aerospace. Output from the fledgling conversion programmes is currently low and there are few operational A321Fs, redeliveries are expected to increase.

The current engine option (ceo) A320 family of aircraft is powered by CFM56-5B engine and the IAE V2500-A5.

Engines

Aero Norway provides maintenance solutions for the CFM56 family, including the -3, -5 and -7 series that power all 737 and the majority of A320 family aircraft. Based in Stavanger, the

In normal operation, carriers require upwards of 4000EFC remaining for a CFM56-3B engine, and between 10,000EFC and 12,000EFC remaining for younger CFM56-5B and -7B engines used on A320 and 737NG family of aircraft. Typically, operators want to extract the maximum life out of engine LLPs by matching remaining EFCs to the operational life of the airframe.

facility will introduce phase one light maintenance worksopes for the CFM LEAP 1A and 1B series of engine in the fourth quarter of 2023.

According to Aero Norway chief executive officer Glenford Marston, sourcing some of the parts for the CFM56-3 series of engine can be testing at times. Aero Norway, however, has an active trading programme that includes the buying and selling of used material and the teardown of engines for parts. “The volume of material for the CFM56-3 engine has fallen over the past five years, yet in 2021 Aero Norway completed worksopes on more than 40 CFM56-3 engines, which was about half of the company's productivity that year,” adds Marston.

Before the Covid crisis, it was believed that the number of CFM56-3s passing through the facility would decline as the impetus moved towards the CFM56-5B and -7B series. However, a significant uptick in utilisation rates by many 737 CL freighter operators translated to an urgent requirement for the completion of maintenance events on the legacy engine type.

New LLPs with 25,000EFC remaining will have far too much life if it is only planned to fly the asset for five more years, before parking and dismantling it for parts.

“Aero Norway completes LLP replacement worksopes, but when we talk about the 737 Classic and the CFM56-3s, the workscope is typically much lighter. Much of the time it is possible to add some life to the engine without replacing a large number of LLPs,” says Marston. “If an operator wants to fly an engine for five to six years, then maybe only one or two LLPs with stub life will be need replacing.”

In a normal operation operators want 4,000EFC and upwards remaining for a -3B engine. For newer -5B and -7B engines, it is usual to return them to at least half-life condition following an SV, with at least 10,000 EFC and 12,000EFC remaining. This means some LLPs will need replacing.

Exhaust gas temperature

Key reasons to put an engine through an SV are to replace LLPs that have run out of EFCs or are showing loss of

performance, or because of an unplanned event such as a bird strike, high pressure turbine (HPT) failure, or high vibration. Exhaust gas temperature (EGT), and exhaust gas temperature margin (EGTm), is the indicator typically used to determine the on-wing health of an engine. As EFC accumulate, the EGT rises and so reduces the available EGTm until the point where the absolute EGT temperature limit is reached.

“The rate of EGTm deterioration is elevated for engines with high thrust ratings. It is possible to operate a CFM56-3C1 engine at 18,000lbs of thrust all the way up to 23,500lbs. It is possible to get more life out of an engine by reducing its thrust rating,” adds Marston. “An engine with insufficient thrust for a 737-400/-800 or A321 can still give the correct amount of performance for the 737-300/-700 or a A318/319/321. This is one way to defer large maintenance events.”

A V2533-A5 S1 rated to 33,000lbs of thrust will remain on wing for between 8,500EFC and 9,500EFC. At 24,000lbs of thrust, the V2524-A5 S1 will usually remain on-wing for longer at 15,500-16,500EFC before requiring a performance restoration. A CFM56-7B27 with 27,300lbs of thrust will need to be refreshed at between 10,000EFC and 12,000EFC, compared to 16,000EFC to

17,000EFC for a CMF56-7B24 rated at 24,000lbs.

If the engine is not removed for an SV, then material in the hot section will start to degrade and parts will be damaged beyond repair, costing more in the long term. The subsequent second and mature runs will be shorter than the first. A CFM56-5B6/3, for example, will typically achieve a maximum of 17,000EFC on its first run, and 13,000EFC during a mature run.

Other influences detrimental to EGTm are high FC:FH ratio, and operating environment. It might not be feasible for carriers operating at high utilisation rates and high MTOW, and in a region with high outside air temperature (OAT), to reduce the available thrust rating. Then an engine with diminished EGTm will typically require a core performance restoration.

“Many customers do not want to pay for a full performance restoration,” says Marston. “Aero Norway can improve EGTm without the need to complete a core performance restoration. If an operator wants to fly out the remaining LLP life but needs to improve EGTm then we can tighten up engine tolerances and gain enough positive EGTm to fly out its remaining LLP EFCs.”

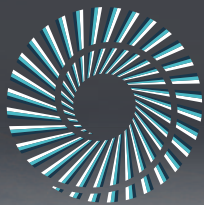
“The engine’s maintenance condition can be customised to the required rate of

utilisation,” adds Marston. “It is pointless completing a core performance restoration unless the operator needs 9,000EFCs or more. It is possible to perform a modular inspection and make sure everything is serviceable, and EGTm will be fundamentally improved.”

It is advisable on an engine with 9,000EFC remaining to complete a core performance restoration, partly because much of its market value will relate to the maintenance condition. Doing so will typically take the engine to the end of its LLP life. Engines capable of comparatively high thrust ratings, however, could run out their LLP life of 20,000EFC without the need of an SV if they are re-rated to a low thrust rating.

For 2022 Aero Norway is focusing on CFM56-5B/-7B engines. This is driven in part by the high number of upcoming A321 and 737-800 P-to-F conversions. The 737 MAX delay has also meant that many -5B/-7B engines have remained on-wing for a longer period of time than planned and will soon require an SV.

It is possible to part-exchange engines that are LLP- or performance-limited for a fresh SV engine with several thousand EFCs remaining, and sufficient to match airline strategy and aircraft utilisation rate. It is, however, possible to optimise available EFCs on the CFM56 by switching modules.



**AERO
NORWAY**
Quality Engines

Visit us at
MRO Americas 2022
April 26-28, Dallas, Booth 3735

unequivocal precision
assured engine performance

Aero Norway is an independent engine MRO delivering high performance CFM56-3C/5B/7B series engines, recognised globally for flexibility and quality.

**It's precisely why operators
choose Aero Norway.**

aeronorway.no



The HPC and HPT LLPs in most -5B and -7B engines are limited to 20,000EFC. The LPT is limited to 25,000EFCs while the fan and LPC have lives of 30,000EFC. After the HPT is run out, it is possible to refit the LPT to a second core and run out the remaining 5,000EFC. Once the LPT has run out of life at 25,000EFC, there is life remaining in the LPC fan disk, fan shaft and booster spool.

It is possible to match available EFC for different sections of the engine with green time of LLP and maintenance life remaining to extract the maximum operational life from the engine.

V2500

LLP life in the V2500 is 20,000EFC for all modules. “The V2500 is at the end of its life and production has stopped,” says Gerd Ockerman, programme manager at Jet Engine Management Limited. “Covid, rising fuel prices and increasing environmental scrutiny mean that more legacy engines will be phased out and retired. This means that there will be a healthy market for USM going forward.”

Recent leases are often shorter than 10 years meaning engines will come off lease with LLP life remaining.

During the Covid crisis there was a significant downturn in V2500 SVs and a subsequent fall in demand for parts. According to David Hobbs, customer account manager at AerFin: “We did not see an uptick in demand for V2500 material until the end of 2021, when an increased number of engines started going into the shop.”

Many MROs pre-purchase parts and core material and have sufficient LLPs in

advance for SVs that were pushed back over a year, and only recently have shops been drawing on these resources. The V2500 market has been slightly slower than the CFM-5B/-7B that recovered quickly. “Aero Capital Solutions (ACS) specialise in ‘green-time’ leases and are looking to acquire a V2500 with 2,500EFC remaining as a spare engine. “This engine is being purchased because the company owns aircraft. When those engines fall due for maintenance, ACS has a pool of available substitute engines, so in essence the company is leasing thrust rather than a particular serial number,” explains Simon Mermod, director at Jet Eng Man.

When modules are split it is typical to find damaged items that must be repaired and replaced. To reduce turnaround time damaged components may be exchanged with USM material to reduce the time off-wing.

“After the first run the V2500 will require a combustion chamber overhaul, turbine blades and turbine nozzle overhaul to restore performance. The compressor gets a level 2.3 check and repair. If there is some damage then the check and repair could equate to more work, but in theory it could be left,” says Mermod. “In theory it is a performance restoration, but in practice it is a hot section restoration.”

During the pandemic, lessors became more reliant on exchanging engines to save costs, so there has since been an increase in SV demand.

“Most of the V2500 engines are covered by IAE and on a PBH program including a SV. Therefore, there is limited amount of demand for used material. We support operators that are out of the IAE contract and putting their engines into

Delays in the MAX entry into service has caused many 737NG operators to extend their leases, which has impacted the availability of used serviceable material. On the other hand, there is a good supply of A320 family material. This includes landing gear and safety equipment such as slides.

the MROs and a third party works scope,” says Hobbs.

New engine

EirTrade supplies CFM56-5B/-7B LLPs and material sourced by tearing down zero-timed engines that have never been operated and put on wing. The advantage of this is that tearing down a new engine mitigates against scrap material that is damaged beyond repair.

“When evaluating a used engine you must try and forecast the amount of scrap material you are likely to get,” explains Carey. “Acquiring a used CFM56-7B engine with 80 HPT blades does not mean it will yield 80 HPT blades back from the repair shop. Depending on the operational history of the aircraft, you may only have 20 or 30 that are within limits for repair.”

It is possible to borescope the engine and reference its operational history, maintenance status, and status of any active ADs to forecast what USM could be monetised. Tearing down a new engine removes the unknown.

“Generally, there is 100% yield, and there are no issues about the items being delayed in a repair facility,” adds Carey.

If an operator or asset owner needs to put an engine through an SV for a new lease or to achieve a number of EFC, then USM represents a saving compared to the component list price (CLP).

Consignment

By completing airframe and engine teardowns in-house, EirTrade can start assessing inventory and preparing parts for repair immediately. Valuable airframe components, such as landing gear, avionics, and system components are salvaged and placed into storage. Some of these components will require additional investment for repair and overhaul before they are authorised for release.

“If somebody wants to sell the airframe in its entirety without engines, then to sell it whole it must be marketed at a low price,” explains Groeneveld. “This is to enable the consignment company to sell the components at a profit, so that they cover overhead costs such as warehouse space and the effort needed to extract the components from the airframe. Furthermore, there is an element of risk.”

During the health crisis many repair shops downsized and have since been struggling to ramp up activity and support the volume of material that is coming to the repair shops. “Component overhaul times are doubling and tripling, and this is having a huge adverse impact on project timing, and also means you must plan ahead when making a commitment to an asset owner for a maintenance event” explains Carey.

In terms of major component availability more A320 family material is available than for the 737NG. One reason is the delay in the MAX, which caused many operators to extend leases. There have been fewer retirements for the 737NG, and there is the uptake from the booming 737-800 P-to-F programme.

“We have seen good demand for 737NG APU and landing gear. However, on the A320 family there is a lot of interchangeability between the A319/320/321, including a lot of A319 retirements, especially in Europe,” explains Carey. “Depending on the MSN, many A319s have enhanced landing gears, which are effectively the same gear on the A320.

The landing gear is not interchangeable between the 737-700 and the -800, meaning anticipated 737-700 retirements will not increase supply, yet many smaller items including engine

components are interchangeable between the two series.

EirTrade can exchange landing gear with a replacement item with enough remaining life to match aircraft utilisation levels. There is a 10-year interval on A320 landing gear overhaul, which makes it difficult to manage when operating older aircraft in the short term. “We can offer an affordable solution that is cheaper than investing in an overhaul,” says Carey. “Many aircraft that we are tearing down have ‘green time’ remaining on the landing gear. We ship the landing gear to a shop for a continued time inspection and complete necessary minor repairs, enabling the new operator to run out the remaining life.”

According to Carey, EirTrade can supply landing gear with three to nine years of outstanding life left and adding the much needed flexibility when running the life out of an aircraft. The same methodology can be applied to APU exchange. APUs have LLPs installed and have a FC limit, yet many retired aircraft that have been parted out can have APUs that have recently had a SV.

Apart from landing gear, the most valuable controlled calendar time components include safety equipment such as slides.

“Slides typically have a 15-year ultimate life and are always in high

demand and probably one of the most regularly turning parts,” says Mark Shimizu, head of sales inventory, AerFin Limited. “The unit we have in stock could be a 2020 day of manufacture unit and the customer item is a 2015. When the units are exchanged a differential fee is applied that is based on a pro rata price when item was new.”

Low utilisation caused by the pandemic is also lowering the demand for many parts as typical failure rates per calendar month improve.

“It must be remembered that if the design of the original aircraft is sound, then there is a large number of parts and components that do not wear out as quickly as others,” explains Groeneveld. “If a part is much more durable than others, then the high number of aircraft being parted out over time will result in surplus material. Basically, there will always be ‘fast-running’ parts, and others that are difficult to sell.”

Parts that have not been overhauled and are listed as ‘as removed’ and needing an SV may not be desirable. They will lose their competitive advantage when urgently needed to solve an aircraft-on-ground (AOG) situation. **AC**

To download more than 1,200 articles like this, visit:
www.aircraft-commerce.com



**Integrated disassembly
maximises aircraft
asset values**

**Comprehensive engine and
airframe disassembly solutions**

Complementing its established aircraft teardown activities, EirTrade offers disassembly services for CFM56-3, CFM56-5A, CFM56-5B & CFM56-7B engines at its NEW facility in Dublin, Ireland.

EirTrade's AFRA accredited teardown facility in Knock, Ireland West, can complete a narrowbody disassembly in 15 days. With a 95% recycle rate, it is ISO EQA 9001 2015 & EU333/2011 certified.

EirTrade Aviation

AFRA
AIRCRAFT FLEET RECYCLING ASSOCIATION

eirtradeaviation.com
Call: +353 1401 6080
assetmanagement@eirtradeaviation.com

Dublin | Knock | Dallas | Barcelona | Beijing