The large number of aircraft in storage and likely to be retired provides the opportunity for airlines to acquire green time or time-continued airframe components and material at low rates. The economics of aircraft teardown, and the market value of some components are reviewed.

The economics and process of airframe disassembly

Timing

The first issue is at what stage of a used aircraft’s life does acquiring it for disassembly and parts salvage make sense? The two used market opportunities to be explored by airlines that own aircraft and lessors with aircraft returned from lease will be: conversion to freighter; and continued passenger use, VIP, government, or specialist applications.

Asset management

The ability to dismantle an aircraft and extract all valuable items for sale differs between aircraft that are owned by airlines and those that are leased. Airlines that own aircraft have full asset and maintenance management of the aircraft. Leased aircraft are subject to maintenance reserves due to the lessor and lease return conditions.

An airline can operate an aircraft that it owns for as long as it suits its fleet planning requirements, and retire it according to its own policy of maintenance condition. Normally, a fleet type is phased out over a period of several years. Leased aircraft can be returned as agreed, and each owned aircraft retired at a time that suits the fleet plan.

Airlines can choose to swap installed engines with those that have a long, medium and short maintenance life remaining. Aircraft can also be retired just before the largest and highest-cost maintenance events come due; the most expensive being the heaviest check in a base maintenance cycle. Landing gears with a substantial or usable portion of their overhaul interval, and auxiliary power units (APUs) with ‘green time’ remaining until the next shop visit (SV) can be removed and swapped with others that are almost fully used. Most maintenance life on an airframe can therefore be fully used before retirement. This will leave engines for removal and sale, as well as the various airframe rotatable components and line replaceable units (LRUs). The aircraft can be disassembled to salvage these.

Alternatively, an owned aircraft with several years of maintenance time for the heaviest airframe check, landing gear, and APU remaining can be disassembled. This is likely to increase its sale value to a parts

Main principles

The main economic basis for tearing down an aircraft for parts is that it can usually be acquired at a minimal value, after the engines have been removed and sold. The most in-demand and high-value components are then extracted and sold at a collective total that exceeds the purchase value of the airframe, the cost of recertifying some parts and of repairing and modifying others, and the labour and overhead costs needed to dismantle and store the parts.

This is generally only feasible when narrowbodies and widebodies, without engines, can be acquired for $450,000-2.0 million. The lower sale value of the airframe is therefore only acceptable to the owner because most of the value of the complete aircraft has been realised from the sale of the engines.

The freight conversion market is the most obvious one that aircraft owners will explore. Selecting an aircraft for freight conversion depends on several factors, including being the right type and series, as well as having the right specification weights and engine variant. Some of these can be changed with upgrades, however.

Certain types and series are less favourable, or are ruled out because they do not have passenger-to-freighter (P-to-F) modification programmes available. These include the 737-600 in the 737NG family; the A319, and the 777-200, -200ER and -300 in the 777 family.

Aircraft types that have been popular freighter conversion candidates include the A310-200, 747-400, 737-800, A320 and A321, 757-200, 767-300ER, and A330.

Across many aircraft types, about 30% of a passenger fleet built will get modified to freighter. This is higher for some types.

Other factors against an individual aircraft being selected for conversion to freighter include inappropriate age, accumulated flight hours (FH) and flight cycles (FC), specification weights, and its modification status at the time it is available on the market.

Aircraft that are not selected for freighter conversion can be re-marketed or re-leased to other airlines for passenger operations. A small number of 757-200s, A340-300s, 777-200ERs and A380s have been successful in this respect. These opportunities are limited for most types, and only a small percentage of aircraft get remarkedet to passenger carriers in this way.

Once these two main aftermarket possibilities have been exhausted, sale for disassembly and teardown to salvage high-value parts is the next option for most aircraft.
salvage and disassembly specialist.

The case of leased aircraft is more straightforward from an airline’s point of view. “Airlines will have paid reserves for the heavy check, landing gear and engines to the lessor. The airline will have to ensure the aircraft meets lease return conditions in terms of the correct part numbers (P/Ns) of components installed on the aircraft, and their modification status,” says Brian Postel, senior vice president at Unical Aviation. “If the lessor does not convert the aircraft to freighter or remarket it for continued passenger operations, it will often be happy to disassemble it if it is almost or fully depreciated. This is because it holds substantial maintenance reserves, and with the sale of the engines and the airframe, it will have an attractive total.”

Economic basis

The process of tearing down and disassembling an airframe for its highest value components will be economic for most, but not all, aircraft types. Economic feasibility relies on there being strong enough demand from airlines operating an aircraft type to generate sufficient revenues from the sale of the highest-value and fastest-selling parts.

This raises the issue of why airlines decide to acquire such components, many of which do not have their full maintenance life available following extraction from the donor aircraft. They are referred to as having ‘green time’ available, and are termed used serviceable material (USM).

These components will include those that are maintained on an on-condition basis, and so have average mean-time between failure (MTBF) and mean-time between removal (MTBR). Despite this, even though the time since last repair will be known from maintenance records, the buyer will always take a risk of a shorter than average time to repair when buying this type of component. The acquisition cost amortised over a reasonably expected interval would therefore have to be overall cheaper than the repair or overhaul cost amortised over the probable interval for a component it already owns.

In the case of hard-timed or life-limited parts (LLPs), the cost of acquiring the green time component amortised over this fixed interval expressed as a rate per year or per FH or FC must also be lower than the cost of overhaul or replacement per unit of interval.

“The main reason why an airline will use extracted green-time components is that they will provide a lower cost per FH or FC overall, making them a cheaper alternative to the full SV or overhaul costs of the components already installed on its fleet,” says James Bennett, commercial director at Aerfin.

The use of cheaper material is particularly attractive to airlines that only plan to operate a fleet for a limited period of up to six years, and will phase out the existing numbers over such a period. The cheaper cost of airframe USM will help minimise component-related costs.

An example is acquiring a green-time landing gear shipset that has five years remaining to its fixed interval overhaul. This makes economic sense when its purchase cost is a fraction of the overhaul and exchange fee the airline will incur if it sends a landing gear shipset to an overhaul shop that will provide it with a fixed maintenance life of 10-12 years.

This is the same as acquiring green-time engines when the airline plans to retire aircraft after just a few years.

Following the removal and sale of engines, airframes are usually sold in the region of $450,000 to $2.0 million. It is up to dismantling experts to assess the economics of estimating the costs of recertifying or repairing every component, the costs of dismantling the aircraft, and review the likely sales value of marketable components.

The low costs of acquisition are also attractive for an airline planning to operate a used fleet for a longer period. Freight airlines acquiring converted types are good examples. The case for using USM on an old aircraft is particularly compelling when the operator expects there to be no further aftermarket opportunities for the aircraft after it has retired them. USM can therefore be used as one element of airlines minimising an aircraft’s overall maintenance costs when in the last years of its life. Such practices are particularly used by freight carriers that operate aircraft to an extended age, and in many cases operate them at lower rates of utilisation than passenger operators.

There are other reasons why USM is attractive to airlines. “One example is the case of an airline retiring a large fleet and dispersing the aircraft to smaller fleets among a range of airlines and lessors,” says Gavin Simmonds, executive director and chief operating officer at Bii. “The inventory airlines need to hold per aircraft increases as fleet size decreases, so more inventory and components will be required by each of the smaller fleets that acquire the used aircraft from the larger fleet.”

Aircraft types

Clearly the practice of disassembly for USM is most active for aircraft that have a secondary market established, while also still operating in significant numbers. The first time that USM is used instead of repairing parts for an aircraft type is when the first few aircraft in a particular fleet are disassembled by one of the industry specialists. This does not usually occur until aircraft are about 12 or 13 years old. It is therefore not possible to acquire USM for the youngest aircraft types, including the A350 and 737 MAX.

At the other extreme, disassembling aircraft is no longer viable when so many have been retired and taken out of service that the number remaining is so small that it limits demand for components.

While most aircraft types fall between these two extremes, there are still some specific types where demand for USM is weaker than for others. In the case of the A320 current engine option (ceo) family, the A320 and A321 remain popular, as is the A321, partly because of its attractiveness as a freighter.

The A319, however, is at a
disadvantage economically because of its small size, so fewer A319s have been reactivated and put back into service since the start of the Covid-19 pandemic compared to the larger A320 and A321. Several A319s have been disassembled for parts extraction, since many are common with the A320 and A321.

Demand is further driven by retirement of original A320 and A321 fleets, so aircraft are being sent into smaller fleets, raising the requirement for inventory. The prospects for continued demand for A320ceo family airframe USM are good, partly because the A321 is expected to be converted in large numbers.

The case of the 737NG family is similar. There were few 737-600s built, but they have a common engine to the other three series, while also having commonality with most of the airframe components. The 737-700 accounted for 18% of all 737NGs built, but has proved unpopular on the used market. Southwest has already retired a large number, and there is little demand for its continued use as a passenger aircraft. There is also little demand for the -700 as a freighter, even though many 737-300s, equal in fuselage size, are being converted to freighters.

The 737-800 accounted for 73% of 737NGs built, and while it continues to be popular as a passenger aircraft, it is also proving to be a favourite among freight carriers. This is likely to keep demand strong for material extracted from retired 737-600s and -700s.

The 737-900 fleet is younger than all other NG variants, so no aircraft have been disassembled yet. The -900’s fuselage length means it is also likely to be popular as a freighter, so like the -800 series will provide a strong market for airframe USM for many years.

This same factor continues to provide a market for 737 Classic material. Despite the retirement of most -300s, -400s and -500s from passenger service, there are 330 -300s and -400s in service as freighters. These will continue to provide a viable market for engine and airframe USM for another 10 years.

The popularity of the 757-200 as a freighter has had the same effect. Of 1,004 757-200s built, 320 operate as freighters; 32% of the original production run. The type will remain popular as a freighter for an extended period.

The case of the 767-300ER is similar. The 767-300ER will remain in service as a long-haul passenger aircraft for a few more years, although this depends a lot on the rate of recovery in medium- and long-haul markets after Covid-19. The type has proved popular as a freighter, with 212 factory-built and 140 converted freighters in service.

The 747-400 is another type with a large portion of the built fleet operating as freighters, and so will provide a market for airframe USM for an extended period.

In the case of Airbus widebodies, there are still 191 A300-600s in service as freighters, providing a ready market for engines and airframe components.

The A330-200 and -300 have a high degree of component and rotatable commonality with the A340-300. So while most A340-300s have been retired, and the remaining 36 passenger aircraft are likely to be retired fairly soon, the continued operation of a large number of A330s provides a market for A340-300 USM. This market will be affected, however, by how quickly traffic in the medium- and long-haul markets in the world recovers, since this will determine how many A330s get reactivated.

“The case is different for the A340-500 and -600, since few are left in operation, and the number will continue to decline,” says Postel. “Moreover, there is little or no aftermarket for aircraft that have been retired by their original operators.”

The A380 has been surprising to some, since the first one was disassembled for parts in 2018. This was an ex-Singapore Airlines aircraft retired in July 2018. The future of the remaining A380 fleet is uncertain. Of 248 aircraft built, only 39 are in active service while 203 more are in storage. A number of airlines are known to
be retiring the A380 and will not put it back into service, but Emirates could potentially return large numbers to operation, as could several other airlines.

In addition to popular passenger aircraft types, certain aircraft are operated in large numbers as freighters. Of 200 MD-11s built, 180 are in freighter configuration, and 20 are in passenger mode. There are still 109 MD-11 freighters in operation with three main users.

**Best components**

Clearly the components with the highest likely market value are those that will generate a profit for the buyer and disassembler, once all the associated costs have been incurred. “The pareto effect applies, with about 20% of the parts generating about 80% of the revenues,” says Postel. “It is not only a case of which components have the highest values, but also which ones can be sold in the shortest time following disassembly and salvage. These are ones that generally have a high turnover rate at airlines. At Unical we try to estimate which parts will sell in the first 18 months, and then 18-24 months, and 24-36 months after disassembly.

Typically, 800-1,000 parts are removed from an aircraft. “About 120 of these will be high value components,” says Bradley Gregory, managing director at Skyline Aero. “The first step after disassembly is to work out which parts are worth repairing, and which can be rectified relatively easily and cheaply.”

The most valuable items, based on typical market values, are the landing gear, APU, thrust reverser units, and the shipset of main wheels and brakes. “These heavy components can usually be sold at pro-rated values,” says Postel. “That is, their remaining life and typical cost per FC can be used as a basis to determine their value or price, although clearly airlines are looking for lower rates per FH or FC than they would achieve by using their own stocks.”

While this is the case, airlines and teardown shops prefer enhanced versions of the landing gear shipsets and APUs. “In the case of landing gears, specific landing gear sets are required for higher weight and long-range specification versions of an aircraft, and often for freighters,” says Lee Carey, vice president of asset management at EirTrade. “There may therefore be an upgrade or modification cost for some components.”

Brake discs, for example, are valued on the percentage of original brake disc thickness remaining. Many airlines will accept components with 40% or more of full maintenance life remaining. This method of valuation is used because airlines want speed and convenience when acquiring these parts. It is always worth disassembling an aircraft for components that are consumed regularly. “As an example, the four brake discs on a 737 Classic with 100% life left can be sold for $12,000-14,000 each, making $48,000-56,000 for the shipset,” says Gregory. “Wheels are also frequently changed because of tyre wear. It is convenient to buy a main 737 Classic wheel for $2,500-3,500 per wheel, making $10,000-14,000 for the shipset. Main wheels for the A320 can gain more on the used market at $10,000-12,000 each, and so $40,000-50,000 for the shipset. This is because of a higher original equipment manufacturer (OEM) price for new units.”

In addition to the four main types of heavy components, there is a range of rotatable units that it is economic to repair or recertify, and which can attract a good market value. “These include nose cowls, all avionic units and flightdeck instruments, major and complex components for the various systems, engine accessories and LRUs, and lights and electrics,” says Gregory. There is a large supply of avionic units on the market, and many tend to be reliable. The cost of repairing them following aircraft disassembly depends on their modification status. There are always some that sell at a fast rate, and these include the navigation and communications units, such as TCAS and the inertial reference unit (IRU). There are two or three IRUs on each aircraft. A typical market value for units in a serviceable condition is $9,000-14,000 per unit. Of the 100-150 avionic boxes on an aircraft, about 25% are usually sold.

A lot of interior items can also be sold relatively easily and profitably. Anything that breaks is always in demand on the used market, including many items in cabin lavatories and galleys, and various cabin furnishings, as well as cabin safety equipment, with escape slides in particular selling relatively quickly.

Some interior items are less easily sold. These include parts that are customised for individual airlines. Items that can be sold relatively easily are economy-class seats and overhead bins, since they are standardised for an aircraft type used by several different airlines. Some galley items, such as ovens, can be used.

“There are also some big structural items that airlines have a fairly good demand for,” says Jasper van den Boogard, vice president of aircraft acquisition & trading at APOC Aviation. “These include actuators, flight controls, nacelles and radomes. What does not sell fast are items like flaps and control surfaces, although it is worth having a few available, since a small number will always suffer on-ground damage.”

**Technical process**

While it is already known which parts on the aircraft are high value and are most likely to sell and generate a profit, the maintenance status and history of all parts that could possibly be sold profitably must be established.

In the case of LLPs, the date of
Avionic units are often high value items. Full paperwork of each part’s maintenance history is desirable. This will include modifications and upgrades made. Avionic units should also be assessed with respect to what modifications are available and possible for each unit.

installation and the time remaining has to be assessed. The modification and upgrade status with respect to SBs and ADs also has to be known.

Other LLPs include escape slides and other safety equipment that is likely to sell.

There are also components with hard-timed maintenance intervals, such as the aircraft’s landing gear, whose modification status and standard apply particularly to high weight variants of an aircraft. The time and FC remaining to the next overhaul are a main factor in determining the probable market value.

Most high-value parts are maintained on an on-condition basis, however. Their time on-wing, or FH and FC since installation should be considered against the P/N’s MTBF and MTBR to ascertain a likely removal interval, since potential buyers will want this information.

The modification status with respect to ADs and SBs should also be analysed for rotatable components. In addition, the series of P/Ns used for the same part installed on a particular aircraft should be examined to see if it is obsolete, can be upgraded economically, or is used in relatively large numbers across the global fleet.

“Overall, of all the components that are removed from an aircraft, 100-120 end up being sold for the whole of the aircraft project,” says Gregory. “This includes 15-20 avionic units in a typical case. The remainder are system components.”

The purchase value of airframes in the case of narrowbodies is typically less than $1 million. “An A320 with engines may have a value of about $6.5 million in the current market, but with engines removed the remaining airframe will have a value of just $0.5-1.3 million, depending on the maintenance condition of the main components; especially the aircraft line number (L/N) and the landing gear,” says Postel. “In the case of a 737NG, the value of an -800 airframe will be $1.0-1.3 million, and $0.7-1.0 million for the -700 because some of the main components and landing gear only fit the -700 and have lower specifications.”

Older aircraft with relatively few units left in service will have low airframe values. A 757-200 airframe is likely to be less than $0.5 million.

Perhaps surprisingly, widebodies have similar values. “A 767-300ER will have a market value of less than $1 million, while a type like the A340-600 which has a very limited market, will have a value of $0.5 million,” says Postel. “Despite the large number of converted freighters in operation, the hull value of a scrapped 747-400 may only be about $250,000, partly because so many have now been disassembled, and there is a large quantity of material already on the market.”

The disassembly process incurs several costs, some of which are high due to the need for access, specialised equipment, hangarage, labour and storage.

The second largest cost relates to testing, inspection, recertification, and repair and overhaul. The latter costs will only be incurred for certain components after inspection if the teardown specialist considers it economically viable.

The total cost of disassembly and putting removed components into crates for transportation to test and inspection facilities can be $80,000-150,000 for a narrowbody, and $150,000-200,000 for a widebody. The remaining airframe can then be broken up for scrap metal. The cost of sub-contracting this is about $15,000.

Component sales
The potential sales value of the main components gives an indication of the possible returns.

“A landing gear with 40% or more green time remaining can realise about $550,000 in a normal market in the case of an A321, and $850,000 for the 737-800,” says Postel. “This compares to a recertification cost for a time-continued shipset, which ranges from $50,000 to $75,000.”

A shipset of main wheels and brakes for the main narrowbody types can incur an inspection cost of $600 per wheel, and $2,000 for a shipset. Gregory says the market value of wheels varies, and ranges from $3,000 to 12,000. The corresponding market value of brake units is $5,000-18,000.

The APU SV cost is high, in the region of $250,000-350,000 for a narrowbody type, and higher $500,000-700,000 for a widebody unit. “The cost of recertification starts at about $3,000,” says Gregory. “Mid-life market values of APUs for the A320 vary from $30,000 to $200,000 depending on the model, and are about $200,000 for the A330, and about $100,000 for the 747-400.”

Avionics costs are relatively low for testing and recertification. “These start at about $500 for non-OEM tests, and $1,000 for an OEM or high-tier independent shop,” says Gregory.

Depending on the unit, the repair or overhaul could cost more than $100,000 if an upgrade or modification is made to the unit.

“A320 vary from $30,000 to $200,000 depending on the model, and are about $200,000 for the A330, and about $100,000 for the 747-400.”

Overall, the potential sales value of components can be $250,000-300,000 for a 737 Classic, and range from $400,000 to more than $1.0 million for an A320.