There are several issues an airline acquiring older used aircraft should consider carefully. These include access to technical manuals and the MPD, the maintenance programme the aircraft should be operated on, its maintenance status, and what major ADs and ageing programmes affect it.

Preparing technical & engineering support for older used aircraft

Acquiring sufficient engineering, technical and maintenance support is critical to ensuring the successful operation of older, used aircraft. Start-up and small airlines can often acquire used aircraft at attractive rates, but older types carry many inherent risks. These older types include aircraft such as: the A300 and A310; Fokker 50s, 70s and 100s; BAE 146 and Avro RJ; DC-8s, DC-9s, DC-10s; 737 Classics and 747 Classics. How engineering, technical and maintenance support can be acquired for older used types, and the associated risks, is examined here.

Capital costs versus risks

The rationale for acquiring used aircraft, despite their higher maintenance costs and rates of fuel burn, is that many have the same flightcrew complements of younger types, and lower capital costs. Overall they can be equally or more economic to operate than younger types in certain styles of operation. This is especially when only low rates of aircraft utilisation can be achieved. Market values and lease rates of used types adjust up or down according to the availability of all operable aircraft of all ages.

A new factor to be considered is that several countries have now imposed age limits for used aircraft being imported. A few, including Algeria and Ethiopia, have imposed a low maximum age limit of just 12 years. In fact, Algeria prefers to have new aircraft only. The countries with a 15-year limit are Mexico, Egypt, Turkey and China (although the rule is only informal in China). Brazil has a 15-year limit for passenger aircraft, and a 20-year limit for freighters. Countries with a 20-year rule are those in the Commonwealth of Independent States (CIS), Libya, Indonesia, Nigeria, Ecuador and Bolivia. In fact, Bolivia has extended the age limit upwards to 25 years, while Ecuador does not permit aircraft manufactured prior to 1990 to be imported into the country.

Once acquired, the biggest problems with used aircraft are: the ability to operate them at sustained levels of reliability; the acquisition of, and access to, technical support; and the high probability that maintenance costs may climb to levels that make continued operation unsustainable.

Engineering management

The issue of aircraft maintenance starts with engineering management.

Engineering management and technical support are of obvious importance to any operator, but certain aspects require particular consideration in the utilisation of older used aircraft.

The regulations that stipulate the minimum that airlines must have in place in terms of infrastructure, personnel and capability vary around the world but are broadly similar. Many engineering management functions can be subcontracted, but all airlines require an engineering director, a technical director and a quality director. These three share the responsibility for engineering management tasks.

Every airline is directly responsible for the airworthiness of its aircraft. The details of what this involves in a European context, for example, are laid out in EASA Part M, sub-part G, and are described as maintaining continued airworthiness of an operator's fleet.

"Continued airworthiness includes maintaining an approved maintenance programme, forecasting and keeping track of what maintenance is due on the aircraft, and monitoring the maintenance performed on the aircraft," explains Peter Cooper, planning manager at Civil Aviation Services. "An airline is therefore required to either establish its own continuous airworthiness management organisation (CAMO), or use a third party to perform its CAMO functions on its behalf. CAMO activities are predominantly related to the keeping of technical records."

Technical manuals

The engineering management functions that have to be performed start with the acquisition of all the relevant technical documents and manuals for the aircraft, its components and engines for planning and conducting maintenance. These manuals are regularly updated and revised. This is essentially a library management function.

The numerous technical manuals include the Aircraft Maintenance Manual (AMM), the Illustrated Parts Catalogue (IPC) and wiring diagrams, the Structural Repair Manual (SRM), Troubleshooting Manual (TSM), and Fault Isolation Manual (FIM).

In addition to engineering and technical manuals, there are also flight, and weight and balance manuals for use by the operations department and flightcrew. "These must be up to date before the aircraft can fly, even for a ferry flight," says Wally Andruschenko, president at The Aircraft Group.

For fleets of new aircraft delivered direct to airlines, manuals and technical documents are provided as part of the customer support package in the acquisition of the aircraft. They can be provided at zero cost in the case of some

Several older aircraft types, including the 737 Classics, MD-80 and DC-10, entered service with MSG-2 maintenance programmes. MSG-3 maintenance programmes were introduced for them later in life, but not all aircraft were transferred onto MSG-3 programmes. Careful analysis of an aircraft's past maintenance programme and probable future programme has to be made.

airlines. Revisions and updates are sent at regular intervals to airlines by the original equipment manufacturer (OEM). It is the responsibility of the airline to implement the revision and updates.

Cooper mentions that the OEMs have codes for each operator, and an aircraft's associated code is changed when an aircraft is sold or leased to another carrier. The manuals, or parts of them, are also coded to apply to specific serial numbers only. The OEM then provides regular revisions based on applicable serial numbers operated by each airline.

"The first problem with technical manuals is that OEMs provide these to aircraft owners, which these days is often a financier or lessor, rather than the operator," explains Richard Gallagher, president at The Aircraft Systems Group. "Operators of used aircraft usually have to pay to subscribe to technical manuals and the associated revision and update service. The legal issue of what manuals and documents the operator is required to use is decided by its local regulatory authority. In many cases the airline is required to use the latest manuals and apply all revisions and updates."

For Boeing and McDonnell Douglas aircraft, technical manuals and the revision service are available through Boeing's portal www.myboeingfleet.com. "Airlines have to enter a general terms agreement with Boeing and other manufacturers when acquiring used aircraft, since they have a range of technical support requirements that the OEM can offer," says Andruschenko. "These will include maintenance programme management, job and task card production, maintenance task forecasting and package planning, rotable component provisioning, issuing of service bulletins (SBs), and technical support. Technical support will include items such as modification programmes and certification of repairs."

Maintenance programme

A related function to maintaining an up-to-date technical library is keeping an approved maintenance programme (AMP). This starts with the maintenance planning document (MPD), one of the technical documents provided by the OEM.

Cooper explains that by virtue of being an operator an airline is entitled to be provided with the MPD, and a subscription to the manufacturer's revision and update service. However, if a lessor subscribes to the manuals, it is more expensive to access the data from the OEM.

The position of small airlines acquiring used aircraft is different. "An airline that has acquired used aircraft may have to pay to acquire the latest MPD for an aircraft. It has been known for up to $2,000 to be paid," says Andruschenko. "The difficulty, however, is what the airline does in terms of defining its own maintenance programme."

Lessees or owners of aircraft operated since new, will have had their own AMPs that may diverge considerably from the MPD for a number of reasons. Herein lies one of the pitfalls that a secondary operator of used aircraft will need to analyse carefully when acquiring aircraft and associated maintenance support. A small or start-up airline with used aircraft is likely to have to operate the aircraft with the MPD as its maintenance programme, or at least a programme that is close to the MPD, rather than have its own customised AMP.

Operators of used aircraft also have to acquire and implement the regular updates and revisions made to the MPD.

"What maintenance programme is actually used is down to the sophistication of the operator's regulator," says Gallagher. While an airline can theoretically just use the MPD, it is rarely this simple. All airlines will need to modify some tasks and add their own items according to their style of operation and rate of aircraft utilisation. There will almost always be some amendments and edits to be made to a maintenance programme.

"To start with, many older aircraft types' MPD documents are only available in print, or at least a higher fee has to be paid to acquire the documents in an electronic format," says Gallagher.

Even bigger issues arise with certain aircraft types when the operator has to consider whether the aircraft should be maintained on an MSG-2 or MSG-3 programme. Certain older types had their maintenance programmes converted from MSG-2 to MSG-3. The MD-80, for example, had its maintenance programme upgraded to MSG-3 in the late 1990s. The DC-10 and 737 Classics also had an upgrade to a MSG-3 programme.

Some operators stayed with MSG-2 programmes, so the fleet of each type is a mix of aircraft that have been maintained under one of the two types of programme. "Buyers of used aircraft have to be aware of what kind of maintenance programme the aircraft were operated under," says Gallagher. "An MSG-3 programme is more sophisticated, since rather than groups of tasks all being grouped into one check, airlines are free to group tasks into checks of varying intervals according to the rate of aircraft utilisation.

"An MSG-3 programme can therefore require groups of maintenance tasks to be performed at overnight, weekly and A checks that are larger than the commensurate checks in an MSG-2 programme," continues Gallagher. "The C checks in the MSG-3 programme are therefore correspondingly smaller than under the MSG-2 programme. An MSG-3 programme also has a lot of out-of-phase (OOP) tasks. An MSG-3 programme may

The 757 is one example of an aircraft that had several significant additions to its base maintenance requirements through the introduction of several major ADs and ageing programmes.

be good for an aircraft operating with a major airline at a large hub. An MSG-2 programme may be preferable, however, for an aircraft that is operating to, or from, more remote airports in a freight operation, for example."

Another issue with an MSG-3 maintenance programme is that it requires more sophisticated monitoring of tasks coming due, and their packaging into checks. This raises the issue of the operator's access to an appropriate maintenance and engineering (M&E) IT system. "One important issue with many older aircraft types is that, in addition to the main maintenance programme, there are several other groups of OOP tasks, and various ageing aircraft programmes," says Gallagher. "Ageing programmes like the corrosion prevention and control programme (CPCP) and supplemental structural inspection document (SSID) have task intervals that are in different phases to the main maintenance programme. Careful analysis is required by an operator to make a compromise between minimising downtime, and duplicating access and labour."

This is one issue of used aircraft acquisition that requires a lot of detailed analysis of documents such as the MPD and CPCP. A close look at these documents, and the aircraft's maintenance history and status, will reveal what tasks are relevant to the aircraft and when they are likely to come due in its planned operating schedule. This is one of the services offered by The Aircraft Systems Group. Gallagher makes the point that this can also show how much maintenance is required to transition the aircraft between operators. "A detailed analysis quite often reveals that the transition, and then on-going, maintenance, required on an aircraft makes its acquisition uneconomic. There are often cases where the cost of the transition maintenance exceeds the value of the aircraft," says Gallagher.

Other engineering functions

Several additional engineering functions follow from the process of maintaining technical manuals and an AMP. For some forthcoming maintenance tasks to be predicted and tracked, the engineering department has to keep track of aircraft and engine flight hours (FH), flight cycles (FC), calendar time, and technical logs. Maintaining technical logs includes the on-going engineering and line maintenance function of monitoring and managing outstanding technical defects.

The aircraft's component and engine configuration also has to be monitored. One major engineering task, which is closely related to keeping an AMP, is the monitoring of all relevant airworthiness directives (ADs) and SBs that are relevant to each aircraft in the fleet. ADs and SBs apply to specific aircraft and engine serial and line numbers.

Maintaining an approved AMP, monitoring ADs and SBs issued against all aircraft, and keeping an up-to-date set of technical documents and manuals all lead to the next main engineering task: maintenance planning. This is followed by job and task card production.

There are also several engineering functions to perform post-maintenance. These include keeping technical records, analysing and keeping reliability data, and quality management. As these functions have to be performed for both new and used aircraft, they do not represent a risk of using older, used types.

A further engineering function is the establishment of a minimum equipment list (MEL) as the first stage in generating an inventory of rotable components. An inventory of rotable components can then be acquired through various mechanisms and a number of specialist suppliers. Some of these suppliers can also provide the related logistics of managing and repairing rotable components on a fixed-rate-per-hour basis. The number of suppliers providing these services for the oldest types is limited, however. This can represent a risk and a challenge to operating the oldest types as their global fleets shrink, since it can mean operators are forced to purchase their own rotable inventories at a high capital cost.

Technical support

In addition to the engineering functions that have traditionally been performed internally by an airline's engineering department, there are several specialist engineering activities that will often require assistance from the OEMs and other outside parties. These can broadly be described as technical support functions.

These include sourcing repair schemes other than the simplest repairs documented in the SRM, and the design of modifications, which can range from the simplest installation of a new electronic device such as an electronic flight bag (EFB) to the design of a new interior configuration. These all require the use of an engineering facility that has design organisation approval (DOA). The design and approval of designs of modifications can be provided by OEMs, but many independent maintenance repair organisations (MROs) and the engineering departments of major airlines also have DOA.

Small or start-up airlines will clearly not have their own DOA within their limited engineering departments. They will therefore need access to a DOA at some stage of operating an older type. Those facilities with DOA approval for older types will diminish as a particular aircraft type ages.

There will still be a large number of facilities with DOA approval for types such as the 737 Classics and 757/767, but now a diminished number for aircraft like

the DC-8, DC-9, DC-10, 727 and A300B2/B4. This would leave the remaining, and increasingly smaller number of, operators to resort to the services of the OEM for the design of modifications.

Technical support also extends into dealing with casualty damage and aircraft-on-ground (AOG) situations. These issues, however, present no more of a challenge than they do with younger aircraft types.

Sub-contracted engineering

Once a maintenance programme is in place and the specific aircraft have been acquired, an operator will need access to a maintenance and engineering (M&E) IT system to control the various maintenance intervals and tasks. This ranges from recording FH and FC to reporting defects arising during operations and monitoring for trends. These data need to be matched to the maintenance programme to generate the content and timing of shop visits.

Increasingly, there are now well adapted IT systems such as AMOS that are commonly used by main airlines to manage the maintenance planning process. Much of this can also be outsourced to an MRO as part of a total support package. For major components such as engines, which are often enrolled in OEM power-by-the-hour programmes, this is automatically included since the OEM determines when shop visits occur according to trend monitoring inputs.

Such systems can also be used to manage line replaceable unit (LRU) inventory, and the monitoring, testing and repair of unserviceable parts. The status and embodiment of ADs and SBs can also be managed along with the associated records. Generally the system can maintain electronic records. For the moment many regulatory authorities still require that hard copy records are kept, and few operators and maintenance facilities are equipped for purely electronic maintenance. This means that manual intervention is required to ensure that electronic records are printed and signed as required. Where only paper records exist these are scanned into the electronic system in a format that can be imported.

Many other elements of engineering management can be subcontracted. Airworthiness elements, which are laid out in sub-part G, can be subcontracted to an entity approved as a CAMO. If an airline chooses to subcontract to a CAMO, that entity can perform the required functions including: operational compliance; AD and SB compliance; monitoring validity of the certificate of airworthiness (extension of Aircraft Review Certificate in an EASA Context); maintenance programme development; maintenance planning; maintenance work scope production; technical records management; and reliability performance.

If an airline subcontracts the CAMO function to a third party, it is highly unlikely the airline would do anything other than contract maintenance to a third-party facility (MRO), since it would make no sense to have maintenance in-house, but CAMO contracted out. Many MROs now also offer a CAMO capability and Andre Velda, Sales Manager of SAMCO, in Maastricht says that for start-up carriers this can be an attractive feature of any maintenance arrangements provided to the airline.

Velda explains that if a start-up carrier decides at least initially to use SAMCO as its CAMO, then it is also logical to use its maintenance planning and management systems.

Cooper adds that establishing a CAMO for a single aircraft type can cost EUR 250,000 ($350,000) per year plus the cost of a technical services manager in addition to the accountable manager and quality manager.

A start-up operator has the choice of using complete engineering management packages offered by several suppliers which are often generically referred to as 'total care' packages. A similar type of offering is now available through Boeing's Goldcare programme.

Many older used aircraft have base maintenance programmes and several ageing programmes that are all out of sync with each other. Careful analysis of all the heavy tasks that will have to be performed on aircraft must be made. Some task intervals will have to be compromised to provide the most optimised base maintenance programme.

Maintenance risks

The maintenance-related risks of older used aircraft types fall into two categories: the maintenance status of the acquired aircraft; and the possibility of the aircraft's maintenance requirements escalating after acquisition.

The first issue to be examined at acquisition is the aircraft's maintenance status, which has to be assessed through examination of technical records. This may be an easier process than it was traditionally, since many airlines have subscribed to services for scanning technical records in recent years. These scans can be read with optical character recognition (OCR) equipment. The completion of a maintenance task, AD or SB can therefore be searched for by keying in a task number into the system. Records can be accessed almost instantaneously. An extensive check of the records is vital. If any are missing or incomplete then the relevant components may need to be overhauled to allow re-certification. Currently, regulatory authorities still require that hard copy records are kept. If there are no electronic copies, it is advisable to scan the paper records so that they can be searched and integrated into a future operator's M&E system.

There are specialist advisors that search technical records for the completion of ADs and SBs. Even when sister aircraft are acquired from the same operator, the AD and SB status of each aircraft can vary. Civil Aviation Services is one company that specialises in inspecting aircraft as they come off lease or are transferred to new operators. This includes analysing maintenance records to examine the aircraft's maintenance status, AD and SB status, and time remaining on hard-time components. Cooper advises that these inspections can take three to four weeks to complete.

One particular issue will be the need to transfer the aircraft from its previous maintenance programme, the AMP of the previous operator, to a new maintenance programme. As previously mentioned, a big consideration is whether the aircraft has been maintained under an MSG-2 or MSG-3 programme.

The resulting, or more suitable, maintenance programme will depend on the sophistication of the engineering and maintenance capability of the airline.

Furthermore, the aircraft's delivery condition may be stated as being cleared to operate for a certain calendar time, or certain number of FH and FC. This may be from the perspective of the previous operator's maintenance programme, however, rather than the MPD or the new operator's AMP. The inspection will therefore need to plan ahead to see which tasks fall due during the next few years or lease term to determine if the delivery conditions are met and if bridging work is required.

Most MROs or technical services companies such as SGI, the IBA Group or others can provide comprehensive pre-purchase surveys. Velda explains that SAMCO can also manage the registration and regulatory requirements to get the aircraft onto a new AOC along with ferry flights if required. According to Cooper, a detailed inspection can take several weeks for each aircraft, but is well worth doing, particularly with reference to transferring maintenance programmes between operators.

Ageing maintenance

There is a significant risk that an aircraft's maintenance requirements will increase as it gets older.

Line maintenance will gradually increase as the rate of technical defects rises. Base maintenance requirements are the most likely to increase, however.

The first risk, or rather known, is that the number of routine inspections will increase. First, the initial inspection intervals of some structural inspections come due with increasing age. Second, repeat intervals for some inspections also reduce.

There is also the known issue of increasing rates of findings and defects with age, and so associated non-routine ratio. What is unknown, however, is the rate at which the non-routine ratio will increase in later life. One key influence in this is how well the aircraft has been maintained by its previous operator(s).

Several ageing programmes have arisen with older types after they have entered service. There is also always the risk that major ADs incurring extensive downtime and high costs will be issued against the aircraft. It is never known what additional ageing programmes and ADs will arise in the future. There are several examples of ageing programmes arising for older types.

The 737 Classic is burdened by CPCP, which was introduced after the aircraft had already entered service. Some CPCP tasks are included in the main groups of base check tasks. There are, however, about 70 separate inspections with varying intervals and levels of access required. Some are so deep that the complete interior has to be removed, and then reinstalled following the inspections *(see Assessing the 737 Classic's ageing maintenance, Aircraft Commerce, June/July 2012, page 36).*

The 737 Classic has also been subject to major ADs. These include the installation of a nitrogen-generating system, and the installation of fire-resistant insulation blankets. Major ADs involve a heavy inspection on a fuselage stringer, and one due to be released that will require the complete removal and replacement of the fuselage window belt skins.

The 757 has had some ageing aircraft maintenance programmes to contend

A careful inspection of each aircraft to determine its maintenance status is advised. A detailed analysis of the maintenance programme and the tasks that are relevant to the aircraft should be made. This can reveal if acquiring the aircraft and transferring it to a new maintenance programme will be economic.

with. The CPCP and SSID tasks were incorporated into the main MPD. The 757 has had several other ageing programmes added to its base maintenance requirements, including: the airworthiness limitation (AWL) items; the certification maintenance requirements (CMRs); the electrical wiring interconnection system (EWIS) programme; and the enhanced zonal analysis programme (EZAP) *(see Assessing the 757's ageing maintenance requirements, Aircraft Commerce, February/March 2012, page 34).*

The 757 has also had several major ADs. One in particular required the modification of the engine pylons.

The 747-400 has also been subject to several ageing aircraft maintenance programmes in recent years, including: a repair assessment programme (RAP); a SSID; a widespread fatigue damage (WFD) programme of inspections; and the EWIS and EZAP programmes that also affect several other aircraft types *(see Assessing the 747-400's ageing maintenance, Aircraft Commerce, August/September 2012, page 43).*

Reliability & control

A few operators of used aircraft believe that outsourcing maintenance poses too much risk and is actually too expensive, even for small airlines. Manfred Waeger, head of technical at Intersky Luftfahrt says that "If you operate a small fleet, and therefore do not have a spare aircraft, reliability becomes paramount. High reliability is only possible if you have a strong maintenance capability at your home base.

"If the operator is not based at a major airport then the availability of third-party support at that base is probably limited or non-existent," he adds. "Proximity to third-party support is therefore critical. High reliability is only achieved with extensive preventative maintenance conducted in small packages on an equalised basis, which could not be done by a third party in a different location."

Waeger argues that third-party maintenance is therefore not necessarily cheaper than an in-house operation. He believes the cost of monitoring and managing the third party could quickly outweigh any cost advantages of outsourcing. Furthermore, if there is a delay in turnaround time for a particular aircraft with a third party, this can rapidly end up being the most expensive maintenance.

For operators of used aircraft with bigger fleets many of the same issues still arise. Dagfinn Danielsen, director of leasing at Wideroe in Norway agrees that location is also important. Since Wideroe is based in Northern Norway, the cost of ferry flights and the logistics of transporting to an MRO for base maintenance would quickly outweigh the benefits of outsourcing.

"More importantly," says Danielsen, "as an operator of 40 aircraft from the same manufacturer you develop a huge knowledge of the aircraft that a third party could not have. This is vital for maintaining reliability of ageing aircraft operating in harsh conditions.

"For example, Wideroe has 10 specialist engineers in addition to about 200 mechanics that work on modifications to their fleet," continues Danielsen. "Many of these have to be designed and often require a supplemental type certificate (STC), which will be developed by an in-house DOA. Therefore, if most engineering and maintenance functions were outsourced to third parties, we would lose technical knowledge and control of our own product. This would also make it harder to conclude good purchase or lease agreements for additional aircraft.

Conclusion

As aircraft age, the maintenance inputs required to keep them airworthy grow substantially. The ability to acquire the necessary engineering support can diminish as fleets of a particular type decline in number, and even implode.

The process of preparing to operate an older used type starts with the airline coordinating with its regulatory authority so that what technical manuals and documents are required can be assessed. A system to acquire these, receive the regular updates and revisions, and implement and manage these revisions and manuals has to be established.

The aircraft has to be examined, in particular in relation to its maintenance status. One important issue is the maintenance programme the aircraft has been kept on, what the intended maintenance programme will be in the future, and how the aircraft can be bridged to the new programme.

All of these engineering and technical management activities, and many others, can be subcontracted to a CAMO organisation.

From this point the airline must decide how it is going to organise all relevant maintenance activities and arrange logistics relating to line maintenance and the management of rotable components. One particular issue of importance is the appreciation of what maintenance requirements the aircraft has, how they might increase during the period of planned operation, and plan maintenance events in relation to an anticipated operating schedule. AC