Growth in long-term engine leasing means airlines and lessors both have to be aware of all issues relating to long-term lease management. The core of this is predicting the cost of maintenance time used during the lease and agreeing how this should be paid for by the lessee.

Considerations in long-term engine lease management

With more airlines using long-term engine leasing to support their inventory requirements, both lessors and airlines need to be aware of the pitfalls of long-term engine lease management. Besides regular lease rentals, the key issues are asset management and maintenance condition. Airlines may incur penalties for returning engines in an incorrect maintenance status, and can misunderstand or misinterpret technical definitions or terms.

Main principles

Long-term engine leases are typically five-year agreements, with lessors leasing engines to airlines to provide coverage for their spare requirements. As Tom MacAleavey, senior vice president sales and marketing at Willis Lease Finance Corporation points out, the engine leasing market is much smaller than the aircraft operating leasing market. Only about 120 spare engines for narrowbody aircraft are built per year when new aircraft deliveries are high. This is equal to about $750 million worth of new spare engines. $60 million of engines is equivalent to just one or two aircraft. "It is also more difficult for a lessor to buy a spare engine from a manufacturer than it is for a lessor to buy several aircraft," says MacAleavey. "Engine leasing is also difficult because engine lessors have to provide extensive technical support, and it is challenging for lessors to keep the utilisation of their engines high."

Airlines pay lease rentals to cover the lessors' cost of financing, but also make agreements with lessors on maintenance reserves and maintenance return conditions. To preserve their assets' value and re-marketability, lessors stipulate required minimum maintenance status return conditions. First, lessors which lease engines on a medium- or long-term basis need to have an engine that can be re-leased on at least a medium-term basis. This requires them to have enough performance capability, exhaust gas temperature (EGT) margin and remaining life on life limited parts (LLPs) to allow at least two years of typical airline operation. In the case of short-haul engines this will be about 6,000 engine flight hours (EFH) and 4,000 engine flight cycles (EFC), while long-haul engines will need about 9,000EFH and 2,000EFC left.

Engine management

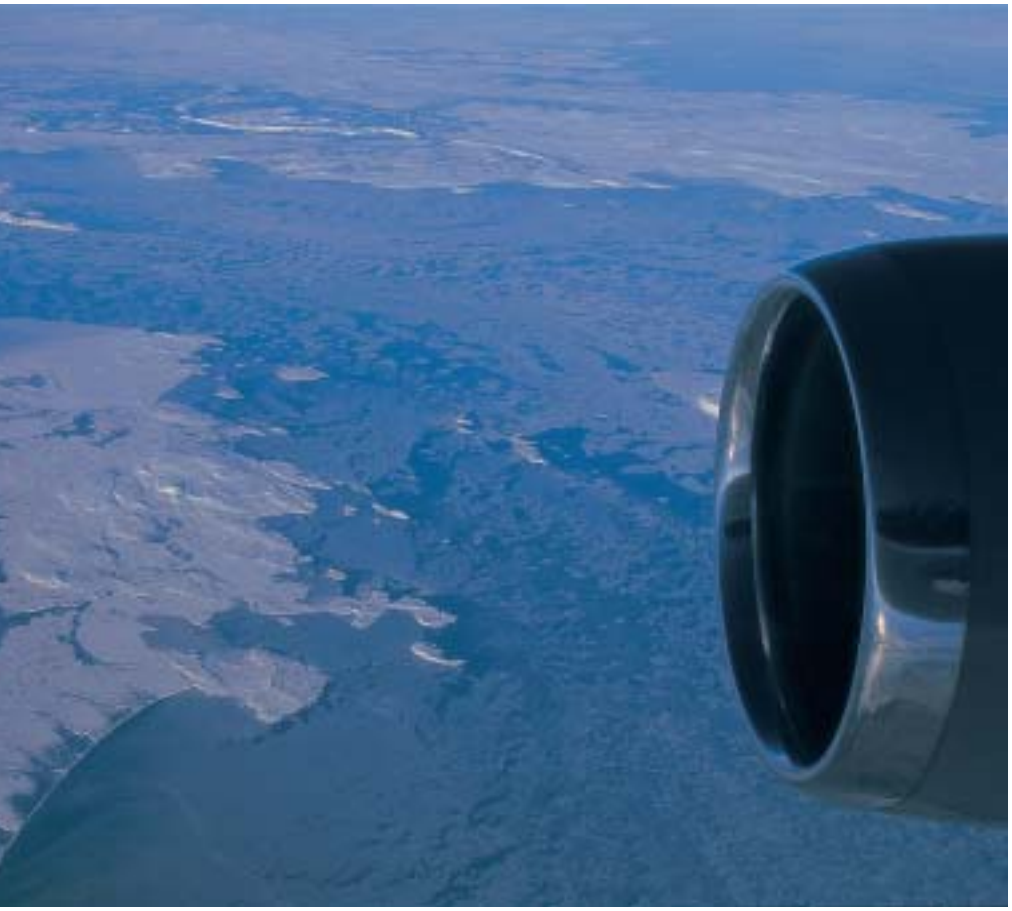
Under an uninterrupted operation, an airline will seek to manage an engine to achieve optimised maintenance costs per EFH. First, time on-wing between shop visits is generally maximised to reduce costs per EFH, although extended intervals can lead to extensive deterioration in engine condition and an actual increase in costs per EFH. Time on-wing and costs per EFH also have to be compromised with LLP life.

In most engines these are 20,000EFC or more. In long-haul engines the EFH:EFC ratio is at least 5.0:1, and annual utilisation is about 4,000EFH. LLPs will thus not need replacing for about 20 years in many cases. On-wing intervals are also in the region of 10,000-14,000EFH (2,000-2,800EFC) in most cases, so LLP lives are less of a consideration in optimising engine maintenance costs per EFH.

In the case of short-haul engines, EFH:EFC ratio is 1.0-1.5:1 and on-wing intervals are 7,000-10,000EFC for mature engines. Since the costs of LLPs are high in relation to the cost of a shop visit, the life of LLPs has to be considered carefully in relation to on-wing intervals and shop visit workscopes when attempting to minimise costs per EFH.

Thus any reduction in on-wing interval or requirement to disassemble an engine prematurely to replace a LLP escalates maintenance cost per EFH. Airlines may swap LLPs with other engines during the lease as part of their engine maintenance management strategy, but they should be cautious. "Return conditions often state that engines have LLPs with a minimum life at the end of the lease, and that any replaced LLP must have a life and utility at least equal to or greater than the LLP replaced. There is therefore a danger that an airline can swap LLPs into a leased engine with the result that return conditions are not met and consequently incur a high penalty," explains Andrew Pearce, director at Macquarie Aviation Capital.

Lessors and lease terms may stipulate that engines are returned in the same condition as when they were leased. The performance of a shop visit workscope, however, to achieve this will increase its maintenance cost per EFH to a level



When assessing maintenance reserves the lessee's nature of operation has to be considered. This includes examining operating environment, thrust rating, pilot de-rate and EFH:EFC ratio.

higher than would be achieved in an uninterrupted operation. This can make leasing the engine uneconomical compared to owning a spare unit. The key to engine lease management is thus for lessors and airlines to agree minimum return conditions and an appropriate way to compensate for the life used during the term of the lease and any differential between condition on delivery and and at return.

"There are three ways this can be done," explains Richard Hough, vice president technical at Engine Lease Finance. "First, the operator can make a financial adjustment for the difference in delivery and return maintenance conditions. The second is for the lessor to provide an agreed fund to cover the predicted cost of maintenance life already used at delivery. This way the lessor has paid its share of the subsequent shop visit, and the lessee pays its share whenever the engine comes off-wing. The third is for the cost of the shop visit to be pro-rated between the lessor and operator if the shop visit occurs during the lease, but this method is used the least. It is only used if the two lessees have very similar operating profiles, since this makes it possible to pro-rate the cost between them."

Start of lease considerations

"A maintenance assessment, prediction of the engine's utilisation and estimate of the engine's maintenance condition at the end of the lease should be made at the start of an engine lease," recommends Lionel Van Buylaere, engineering business manager at Total Engine Support Limited, part of the TES Aviation Group. "We recommend that an airline does a pre-delivery inspection at the start of the lease in order to fully understand the engine condition and to be able to predict the maintenance liability during the lease term."

This is an extensive exercise. "This should start with at least the engine's last shop visit history and preferably all shop visits," says Phil Seymour, managing director of the IBA Group. "Just looking at the time since the last shop visit is no longer enough. Key modifications and airworthiness directive (AD) status should also be examined, as well as the lives of all LLPs in the engine. The quick engine change (QEC) module also has to be assessed, and the maintenance status of its components."

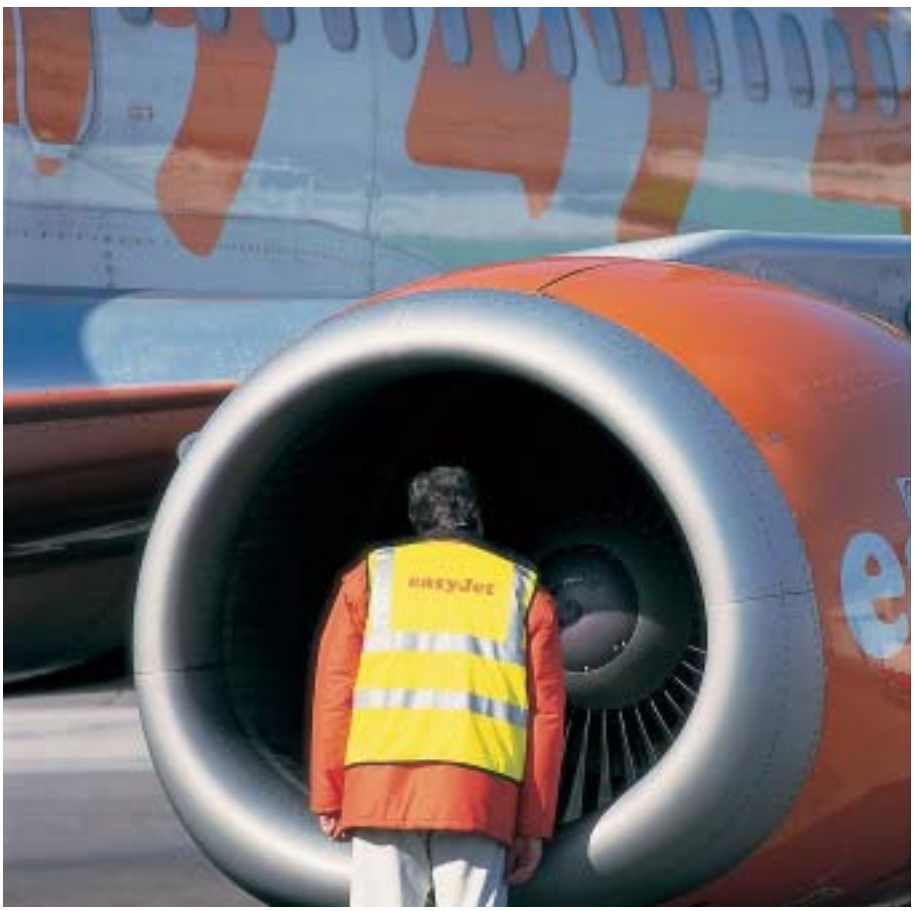
Items such as borescope inspection findings, the current installed EGT margin and the rate of EGT margin deterioration to that point since the last shop visit will give a good indication of the time remaining to the next shop visit. "These all allow a prediction of how long the engine can remain on-wing and what shop visit workscope will be required at the next removal," explains MacAleavey. "There are, of course, unpredictable events, such as foreign object damage (FOD). Possible remaining time on-wing can, however, be assessed with good quality engine condition and trend monitoring."

Other factors also influence remaining time on-wing: the hardware standard of blades and vanes installed at the last shop visit; whether parts were repaired or new, and the operator's maintenance policies. These will further influence the projected workscope and cost of the next shop visit.

"The operator has the responsibility for performing the engine's maintenance for the normal wear and tear of the engine during a long-term lease, since the engine's EGT margin and LLPs will be used during the lease," explains Hough. "The responsibility for abnormal wear, caused by issues such as mechanical breakdown and FOD also lies with the operator."

Hough says a test cell run to assess EGT margin is recommended. "This should be followed by a full borescope inspection, and trend monitoring data should be assessed."

"The disk sheets and traceability of the disks also need to be examined," says Seymour. "IBA has an engine inspection format, which includes a review of past operators, the thrust ratings at which the engine has been used (which affect LLP lives) and the shops that have performed past maintenance. A physical inspection should also be performed. Some engines are bought by lessors on-wing, as happens with purchase and leaseback transactions. There are several maintenance records that need to be



Besides operation and shop visit workscopes, a lessor should also review a lessee's line maintenance practices. The operation should also be tracked in terms of actual utilisation and policies with respect to pooling should be understood.

reviewed including: original certification certificate; engine logbook; history of incidents or accidents; and outstanding inspections and repeat items for ADs and service bulletins (SBs)".

Some lessors have engineering departments to manage their engines while on lease. "We have an engineering division in San Diego that provides the same technical management that an airline's own engineering department can provide," says MacAleavey. "Lessees are often very specific about the time they require until the next shop visit. We constantly consider the maintenance status of our engines on lease. Although engine EFH and EFC should always be tracked and matched to the aircraft's logbook."

Besides maintenance condition being used to predict remaining time until the next shop visit, Pearce explains it also provides a lessor with an indication of what it is worth. "Lessors have large models to evaluate this, and with 32,000 installed engines there is a large body of data to assist this," says Pearce.

Lessee status

Besides assessing maintenance condition, lessors also like to consider a lessee's status. "Although a lessee's creditworthiness is a consideration, it is not a driving force. Leasing engines is regarded as spare parts provisioning and as such, handled differently to aircraft leasing by an airline; particularly larger carriers. Spare parts provisioning is regarded as a regular expense," explains Macaleavey.

Besides the basic assessment of an airline's financial status at the start of a lease, it may also be prudent to have a better understanding of the airline's internal process in managing the leasing of engines. "The airline's maintenance capability, for example, should be examined, as well as which party performs the maintenance," says Pearce. "The lessee's country and political risk may also be an issue. The law in certain countries can make it expensive to repossess an engine if necessary, and this increases the lease rate factor. It is also good to understand the airline's strategy and performance compared to the rest of the market. The airline should also provide the lessor with a report at the end of each month on the EFH and EFC accumulated and the maintenance actions taken on the engine. A record of where the engine is and which aircraft it is installed on should also be provided.

These all mean that it will be easier to predict the maintenance status of the engine at the end of the lease."

Future maintenance status

Once maintenance condition at the start of the lease is assessed, lessors and operators need to predict the utilisation and shop visits performed during the lease.

"The engine's expected utilisation during the lease is projected forward, and based upon the detailed analysis completed at lease commencement it can be predicted with reasonable accuracy when the next shop visit will occur," explains Van Buylaere. "The content of the workscope with respect to man-hours consumed and cost of materials and sub-contract repairs can also accurately be assessed and therefore the costs of the all the shop visits determined for the entire lease period. Projecting out to the end of the lease period, the LLP status maintenance condition at the end of the lease can also be accurately predicted."

Predicting end of lease maintenance condition requires an analysis of expected EFH:EFC ratio, engine thrust rating, pilot de-rate, utilisation, start of lease maintenance status and mid lease shop visit workscope to be accurately considered. These are factors that are included in the analysis to predict EGT margin loss and timing of the next shop visit.

Environment conditions have a large influence on end-of-lease maintenance condition, as MacAleavey points out. "While Scandinavia is a cool environment, it is actually dirty with volcanic ash in the atmosphere. Salt, sand, sea and tropical conditions also all have negative effects on performance degradation. Changes in thrust rating also affect the life of LLP lives. It is, however, possible to predict end-of-lease maintenance condition with 98% accuracy, and there is a range of software

available for this purpose. Only nasty shocks, such as FOD or uncontained failures can upset these predictions."

"Trying to predict end-of-lease maintenance condition for a long-term lease can be difficult, so it is often easier for a lessor to stipulate minimum return condition," comments Hough. "Lessors usually prefer to have an engine returned that has at least 18 months of scheduled on-wing time left so that they can re-lease the engine. One with just 12 or six months left will be hard to remarket. These return conditions are included in the lease terms. Lessors follow their engines during the lease to try to prevent engines being returned with too short time remaining, but maintenance condition is ultimately the the lessee's responsibility."

Lessee's maintenance

An integral part of future maintenance condition prediction and asset management is the lessee's maintenance practices.

"The lessee's maintenance standards, practices, policies and activities relating to engine pooling all have to be considered," says Hough. "An operator may asset strip an engine, by taking parts or even whole modules from an engine to keep its fleet operational. These often result in problems with LLP lives and mixed hardware standards. Expensive parts from parts manufacturer approval (PMA) providers and the use of designated engineering representative (DER) hi-tech repairs are other considerations. ELF does not allow either of these in its engines, and this may conflict with the lessee's maintenance practices. There are, however, a significant number of airlines that do not accept PMAs and DERs, and this can also limit the number of airlines to which a lessor can lease an engine to." Airlines need to consider the issue of using PMA parts or using DER repairs to avoid penalties at the end of the lease.

Seymour makes the point that the airline's maintenance schedule with respect to items such as blade lubrication, trend monitoring, compressor washing and oil sampling should be examined. "Lessors should also have a non-discrimination clause, stating that airlines should treat leased engines in the same way they treat their own."

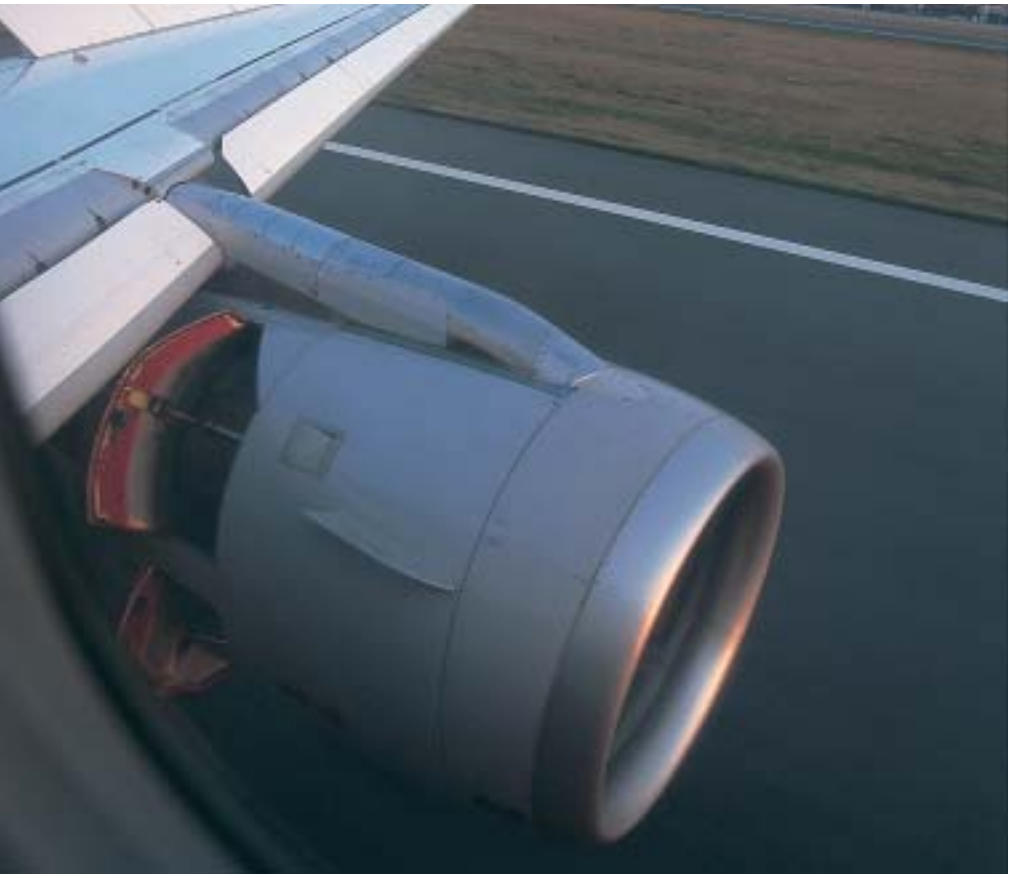
Condition monitoring is also an important issue. "Although we do not get involved in the actual monitoring, we review the data at the end of the lease. The actual collection of the data and analysis is done by the lessee," says Hough.

A monthly report for each engine is advisable, and should include information on engine utilisation, incidents, on which aircraft the engine is installed, and a record of rentals paid. "Lessors often ask for annual inspections on engines and the lessee," says Seymour.

While the lessee is obliged to use condition monitoring, it does have free enjoyment of the asset, and it is the lessor's responsibility to track their engine with respect to performance deterioration and AD and SB status as well as LLP status and time since shop visit in order to have an accurate and real time prediction of their maintenance liabilities and compare them continuously to their maintenance reserves.

Maintenance reserves

Once utilisation, maintenance performed during the lease, and end-of-lease maintenance status is predicted, lessees and lessors have to agree maintenance reserves. Ultimately the lessee should be aiming to pay its share of the maintenance time used, which has to consider both shop visit workscopes and LLPs. This can be made more difficult if a shop visit is expected during the lease term. "If the agreed amount of



Lessors and lessees have to agree maintenance reserves. A lessee should aim to pay its share of maintenance time used, which has to consider shop visit workscopes and LLPs. Airlines have to predict actual maintenance cost and negotiate accordingly. This requires clear definition of a shop visit.

maintenance reserves has been paid up to date since the engine was new, then the engine is effectively at zero time financially," explains MacAleavey.

"Airlines have often just looked at the lease rate and return conditions and got caught out by the maintenance reserves," says Van Buylaere. "Airlines have to predict the actual maintenance cost and negotiate accordingly. This requires a clear definition of a shop visit, since terms such as 'performance restoration' and 'overhaul' are generic and open to different interpretation from one manufacturer to another. Airlines have been caught by this vagueness with legal battles resulting. Clear indications of expected return EGT margin are also required. A comparison of predicted maintenance costs during the lease and reserves paid should be made. A shop visit occurring during the lease should be reviewed by both parties and an agreement made as to how shop visit costs are to be split. Ideally the airline should pay its share based upon their utilisation of the engine as in many cases the shop visit cost may exceed the funds available within maintenance reserves. This may be because the current and previous operators had different operating profiles and used the maintenance time on the engine at different rates per EFH. The previous lessee, for example, may have had a lower EFH:EFC ratio but flown in a cooler environment to the new operator, making it hard to apportion deterioration and hence cost of the shop visit.

"The lessor and lessee should also negotiate reserves between the last shop visit and lease end," continues Van Buylaere. Lessees should also be aware that most leases only claim reserves for standard or scheduled shop visits, and do not take account of unscheduled visits or small repairs such as a fan or booster replacement. A relatively minor workscope can cost $250,000-500,000, and the lessee will generally be responsible for these costs.

"Lessees have to pay for a shortfall between reserves paid and a higher shop visit cost, for example if the interval is shorter than expected or the accrual rate is insufficient. In this case it is advisable for airlines to accrue internal maintenance reserves on top of the lessor-paid ones. If the interval is longer than expected or the maintenance reserves are too high, the lessee will have paid more reserves than was originally anticipated, but can only claim the cost of the shop visit from the lessor. That is, reserves are paid to the lessor during the lease and then provided to the lessee when the engine is sent for a shop visit. Overpayment of reserves cannot generally be reclaimed. To avoid this, airlines have to be cautious about making accurate predictions of shop visit timings and costs when negotiating maintenance reserves to prevent overpayment but also to ensure that enough cash is available when it comes to the time of the shop visit."

The lessee should have a precise idea of what its maintenance reserves are. Lessors have stipulated maintenance reserves in the past. "Most lessors have a good idea of what they are," says Pearce. "It is prudent to collect them every month. Reserves will change if the operating profile of an engine changes during the lease, since they are normally based on an expected utilisation, operating procedures and environmental considerations."

Hough says maintenance reserves can be predicted fairly accurately and are collected each month. "One factor that may raise the cost of a shop visit during the lease term is parts price inflation. We refund maintenance reserves at the end of lease if they are surplus, however." For this reason some lease terms have escalation clauses.

Most lessees pay reserves during the lease, rather than at the end as a matter of a credit issue and asset risk protection for the lessor.

ADs & SBs

Besides shop visits other maintenance costs have to be considered. "Since ADs are mandatory for operation the lessee pays for their incorporation, and this is stipulated in the lease. Many operators install SBs during shop visits, and may be instructed to do so by the lessor. Who actually pays for them depends on which party wants them," says Pearce.

Policies on ADs and SBs vary with lessor. "WLFC pays for ADs and SBs in the shorter-term, while the lessee pays for the more important ones for leases longer than one year and benefits from the

incorporation," says MacAleavey.

Hough explains that ELFC shares the cost of ADs and SBs with its lessees on a commercial basis. "The lessee pays for them on a long-term lease, since we expect to get engines back in a reasonable standard and most also improve on-wing life and reduce maintenance costs."

Seymour adds that SBs are usually paid for by the lessee, which relates to the non-discrimination clause in the lease contract, but that costs of ADs are shared, since they are mandatory.

Van Buylaere makes the point that SBs and ADs will be incorporated during a shop visit that occurs during the lease, and that a lessee may argue that because the lessor has accumulated reserves from another lessee prior to the lease it should then pay for at least part of the ADs and SBs. Also, some lessors accept power-by-the-hour rates for lease rentals and maintenance reserves, and are not so concerned about actual shop visit cost. They may therefore pay for the incorporation of ADs and SBs.

LLPs

Another issue is LLPs. "Remaining LLP lives may actually be short at the shop visit during the lease, and the lease contract may stipulate they have to be replaced by new ones. This, of course, is considered in the maintenance cost prediction and reserves agreement," says Van Buylaere. "Replacement of LLPs raises further considerations, since new LLPs that are installed during the lease may then only have a fraction of their lives subsequently used by the lessee before the lease expires. The lessee may not have enough maintenance reserves to pay for them, and so it should negotiate to pay the appropriate fraction of the cost or should appropriately plan to source quality part life LLPs on the market in advance of the shop visit."

End of lease

Lessees will have to meet minimum return and maintenance reserves conditions at the end of a lease. The issue is simpler if an engine is put through a shop visit at the end of a lease, but more complicated if it is time-continued. Lease contracts may ask for compensation for engines not being returned in the same condition as at the start of the lease. These are paid for in reserves, most of which are paid during the lease, but this then requires assessment of the engine's maintenance status at lease end and a comparison with the actual condition at lease end. Without a strong and clear agreement significant discussion may occur at re-delivery relative to this issue. It is unfortunately rarely done, but the re-delivery condition should be assessed prior to signing the lease contract and both lessor and internal maintenance reserves adapted to prevent any bad surprise or adverse cashflow. Also a detailed pre-lease analysis to identify such potential issues soon enough allows the airlines and lessors to customise the overall contract (fees, maintenance reserves and return conditions) prior to taking delivery of the engine.

"An engine should have a test cell run and borescope inspection, and the trend monitoring data should be analysed," says Hough. "These will be used to calculate the remaining life on-wing that can be expected, and also if the minimum maintenance conditions are met. This includes remaining LLP lives. The actual maintenance condition should be compared with the expected maintenance condition to assess if there is a shortfall in maintenance reserves collected during the lease or a surplus."

If the engine comes out of a shop visit at the end of lease then the lessor and lessee have to agree a workscope. This will be based on the workscope that was predicted to be required at the start of the lease. "The issue is more complicated if the engine is time-continued," says Pearce. "A borescope inspection is required, records have to be inspected, the engine's performance has to be assessed, ECM data has to be analysed and LLP sheets examined." Some lessors provide compensation for engines being in a better than expected condition and where excess reserves have been paid, and charge extra where reserves are insufficient to cover shop visit costs. Lessors do not often make these adjustments. AC