Younger generation aircraft have been developed with flexible maintenance programmes that do not define checks. Operators are free to group maintenance tasks as suits them. This makes it challenging for lessors to estimate check costs and determine maintenance reserves.

Tracking maintenance reserves for new generation aircraft

Since the number of aircraft being acquired under operating leases is expected to continue its upward trajectory towards 50% of the world's narrowbody fleet, the importance of appropriate security for lessors has become more critical. This is especially true for less financially sound airlines which, as a result of the increased supply of leased aircraft, are able to access new generation equipment for which lessors provide 100% finance.

Along with an appropriate level of security deposit, typically equivalent to three months of rental payments, the regular payment of maintenance reserves (MRs) provides an additional layer of security for lessors in the event of default. The reasoning is that if a lessor has to repossess an aircraft from a defaulting lessee, the accumulated MRs can allow the aircraft to be prepared to the required delivery condition for its next lessee, without the lessor having to invest additional capital in the aircraft.

Since good credit-quality airlines generally do not pay MRs to lessors, the need to pay them applies principally to higher risk credits where default risk is significant.

While the concept of MRs is not new, modern generation, maintenance steering group (MSG)-3 maintenance programmes have made it more complex to define how MRs and lease-end return conditions (RCs) should be gauged.

This article seeks to examine the issues that current MSG-3-based maintenance programmes generate for MRs. For illustrative purposes, it will focus on the 737NG series, since this aircraft has the most segmented maintenance programme.

The items against which MRs are collected by lessors have not significantly changed, but the way in which they are determined has evolved. MRs, as before, are collected for scheduled maintenance only. The main items comprise: the airframe, engines, landing gears and the auxiliary power unit (APU). The first three, particularly the engines, are the items that typically concern lessors the most because they represent the highest value items. Each of these will be examined in turn, although it is airframe and engine maintenance where most changes have occurred.

Aircraft maintenance

Maintenance of airframes has always been, and continues to be, based on flight hour (FH), flight cycle (FC) or calendar-determined intervals. For example, under MSG-2, for the 737 Classic series, there are a series of fixed times between overhauls embodied in 'C' or 'D' checks.

While the tasks to be performed in each C check differ, all scheduled base maintenance tasks are grouped into the same interval so they can be performed during such checks. Calculation of MR rates, therefore, becomes a function of the cost of the 'C' or 'D' check tasks amortised over the relevant check interval. In the case of the 737 Classic, this generates a reserve rate per FH.

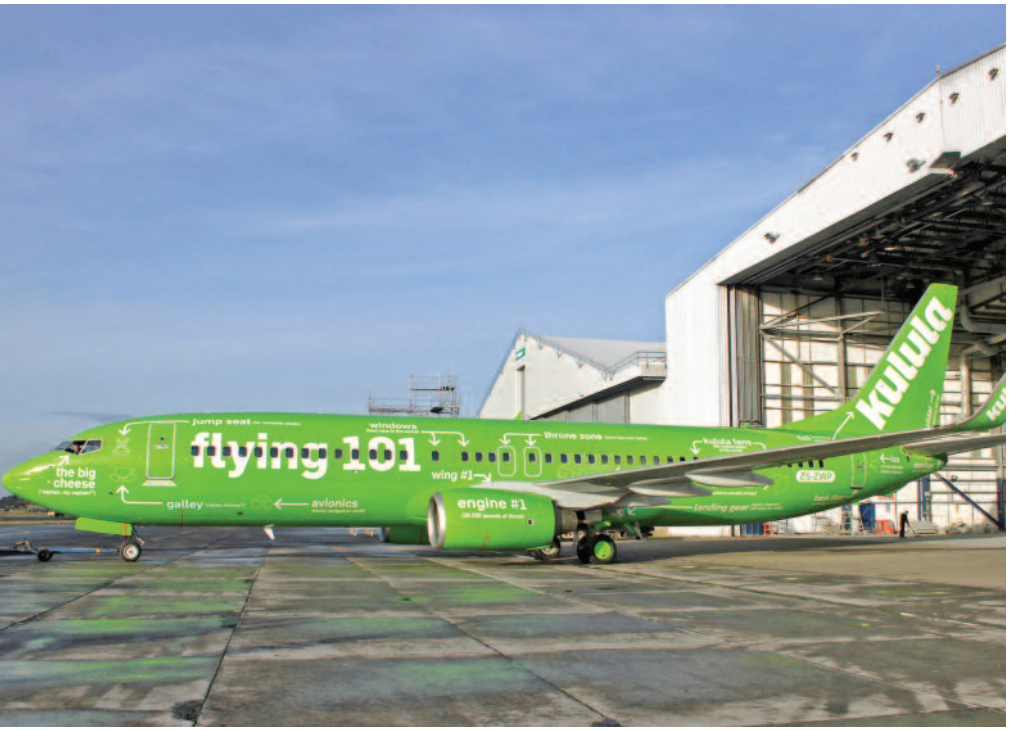
The maintenance programme as defined under the maintenance planning document (MPD) for the 737NG series is more than subtly different. The MPD 737NG's MPD simply lists all maintenance inspections *(see 737NG maintenance analysis & budget, Aircraft Commerce, June/July 2010, page 12)*. It does not group them into pre-defined 'A', 'C' or 'D' checks. Peter Cooper, planning manager at Civil Aviation Services in Ireland, explains that there are about 1,700 tasks in the latest MPD revision, issued on 15th Feb 2013, that need to be performed over a 12-year period across the 737NG family.

He adds that not all of these tasks apply to all variants, and some apply only to certain serial numbers. While there are clusters of tasks that fall due every 24 months, which approximate to the previous 'C' check cycle, there are many tasks that fall due outside these intervals. Within this cycle, there is a larger cluster of tasks at 7,500 FH, but the largest groups of tasks arise at the eight-, 10- and 12-year calendar intervals. According to Alan Robinson, managing director of Aircraft Leasing and Management (ALM), the intervals are further complicated by second run repeat cycles. For example, he explains that some first-run tasks to be completed at the 8-year point, have a repeat interval of 6 years in the second cycle, while others do not. The implications are that clusters of routine tasks disperse further for second-run maintenance.

This more widely segmented maintenance philosophy brings benefits to airlines, since large numbers of tasks can be performed in smaller checks that minimise unproductive base check downtime. However, it makes the calculation of MRs more complex.

Since it is neither practical nor contractually realistic to document MRs for every maintenance task that is specified in the MPD, lessors need to use a measure of approximation.

Gary Fitzgerald, vice president,



The 737NG's MPD has about 1,700 tasks. These have a variety of intervals, although there are some tasks with equal intervals that can be grouped together. The aircraft does not, however, have traditional 'C' and 'D' checks. This makes it challenging for lessors to determine appropriate maintenance reserves.

commercial, at Ireland-based aircraft trading and asset management company Avinco, explains that, with 24-month checks being less intensive than 'C' checks on the classic aircraft, it is now more routine to collect reserves just for the larger eight-, 10- and 12-year checks.

The previously described 737NG airframe base maintenance analysis illustrates the typical man-hour (MH) and materials costs of base checks up to the eight-year point, that are described as C1 to C3 checks with 2000MH, 3,000 MH and 3,700 MH.

Fitzgerald adds that the lessee becomes responsible for the cost of tasks completed before eight years. While this means no reserves exist to cover those items if a lessee defaults before eight years, he says this is something that most lessors have learnt to live with. Thomas Schmid, chief counsel at CIT Aerospace, agrees that, except in cases where a lease is short-term or the default risk of the airline concerned is deemed to be high, most lessors do not collect reserves for base checks before the eight-year point.

Heavy maintenance visits

The cost of eight-, 10- and 12-year checks for the 737NG is substantial, so most lessors want to collect reserves.

These are normally referred to as heavy maintenance visits (HMV). It should be possible to calculate an appropriate MR.

A typical lease agreement would account for the tasks that need to be completed at this point and define an HMV as having to carry out: (i) the next sequential 24-month check; (ii) systems, zonal and structural tasks (including tasks applicable to corrosion prevention and control); and (iii) the rectification of each defect discovered during the performance of tasks specified in (i) and (ii) above. On the basis of a projected workscope for (i) and (ii) above, an MR rate could be calculated.

According to Shannon Ackert, senior vice president of commercial operations at San Francisco-based aircraft lessor Jackson Square Aviation, and founder of website Aircraft Monitor, such a check costs about $780,000.

On that basis, the applicable MR over a 96-month period should be $8,125 per month. The MR clause in a lease would therefore contemplate the collection of MRs for the above-mentioned scheduled items, and would include rectification of defects arising out of routine inspections. It would, however, exclude non-scheduled maintenance. Such non-scheduled items include: repairs caused by incidents or accidents; elective modifications; airworthiness directives (ADs); service bulletins (SBs); deferred maintenance discrepancies; any foreign object damage; and costs associated with removing or shipping the aircraft or parts to maintenance facilities.

This approach, however, is fraught with difficulties. Schmid points out that, while lessees are often prepared to pay MRs for new aircraft on this basis, this takes no account of future maintenance obligations after the eight-year point.

He explains that from a lessor's perspective, MRs should also be collected for 10- and 12-year tasks. If the leased aircraft is returned after eight years, which as Fitzgerald points out is now common for a new aircraft, then the lessor will need funds in the MR account, paid by the original lessee, to cover those items when they fall due. Schmid explains that this is a common debate with lessees taking delivery of new aircraft from lessors.

Airframe age

A further complication in calculating the costs to which MRs should apply arises with airframe age. The previously described Jackson Square presentation describes first, maturing and ageing run maintenance implications.

In the first run the maintenance burden is usually much less than in the mature or ageing runs. Jackson Square suggests that maintenance costs should be escalated by 10-15% in each run. This is mainly due to increased non-routine tasks, but is also a function of cost escalation over time and reduced second-run intervals. Since MR calculations generally only account for scheduled maintenance, non-routine task and cost escalation should be less relevant.

Irrespective of the cost of repeat inspections, which may escalate, any reduction in the interval will have a more dramatic effect on the hourly, cyclic or monthly reserve rate.

Lessees of new aircraft are likely to take the view that expecting them to contribute to maintenance items that fall due several years after a lease has terminated may not be justified. The view of lessors, however, is that MRs should account for the life-cycle of the aircraft, and reflect the total life of the aircraft irrespective of its age. They argue that if this is not taken into account there will be shortfalls in the MR balances at the start of each subsequent lease.

Fitzgerald and others agree there is no industry-wide approach to this, so each case is negotiated with the lessee. Accordingly, if at the time a new lease is being negotiated the market for the aircraft is particularly weak, the lessee may have the upper hand in negotiating favourable MR rates, based on first-run assumptions. This would not be achievable if demand for that aircraft had been higher.

From a lessor's perspective, if maintenance tasks are more widely dispersed than before, there are two further issues that need closer examination. First, there needs to be clarity on what items are considered to be scheduled routine tasks, and which

A large portion of 737NG checks are multiples of 24-month intervals. There are also deeper inspection tasks with eight, 10- and 12-year intervals. The aircraft does not, however, have a clearly defined based check 'run' or 'cycle' interval.

would be non-routine tasks for which MRs are not normally collected. Second, given that other maintenance items fall between major base checks, a mechanism is also needed to capture these tasks.

Scheduled & non-scheduled

Regarding included tasks, the starting point is the scheduled routine maintenance elements as described in the MPD. These tasks, and the defect rectifications would be included in the MRs. For clarity, a lease agreement would typically specify the maintenance tasks that are not eligible for MR claims from the lessor. These are non-scheduled items, as described.

Out-of-phase items

While a clear differentiation between scheduled and non-scheduled tasks is not in itself a complication confined to new-generation aircraft, the definition of which items count for MR collection and disbursement can become less clear for tasks that fall outside the eight-, 10- and 12-year intervals. Robinson points out that there are now a significant number of tasks in the MPD that fall out-of-phase (OOP) between the major tasks.

From a maintenance performance perspective, Remzi Saltoglu, commercial director commercial at maintenance, repair and overhaul (MRO) company MyTechnic, points out that for those airlines that segment their maintenance, some of these OOP tasks can be performed when checks are due without any major issue. If the airline performs larger block checks, then it makes sense to perform these tasks early by bringing them forward and combining them with tasks in a C check, so the aircraft is clear of major airframe maintenance for the next 24 months. Robinson agrees that it can often make sense to do this when a particular zone has been opened up. This not only clears the aircraft for the next period, but it can also reduce the cost of the OOP tasks because MH used for access are not duplicated in two airframe checks.

For lessors, this begs two questions: is it feasible to collect MRs on such OOP tasks? And what are the consequences of performing those tasks early? Although there is no firm consensus, most lessors now do not collect reserves for OOP items, so that the cost of such items falls to the lessee's account. If lessors are not collecting for 24-month checks, and are also not reserving for OOP items, then the risk of a shortfall in the event of default increases.

This security issue can be further compounded in cases in which the systems-related tasks of the HMV checks are also excluded from MRs. Jackson Square explains that lessors draft MRs by predicting where in the maintenance cycle the bulk of tasks are concentrated. For the 737NG it is easier to make those predictions for structural and zonal tasks, but less so for the systems tasks. This is because most of the systems tasks are FH- and FC-driven, so these tasks will need to be phased according to the aircraft's rate of utilisation. This means many of these items could fall out of phase with the calendar-driven items. Jackson Square maintains that excluding the systems tasks from reserves is a policy choice, and not all lessors adhere to this strategy.

Performing individual tasks early may facilitate clearing an aircraft from major base maintenance for a full two years after the first HMV occurs at eight years, but it then creates new issues. Schmid points out that CIT generally does not like tasks being performed early. In theory, a lessee could argue that, if these tasks are not covered by reserves, then surely a lessor's security position is improved by performing some tasks early. It means, however, that the stub life of certain tasks is wasted.

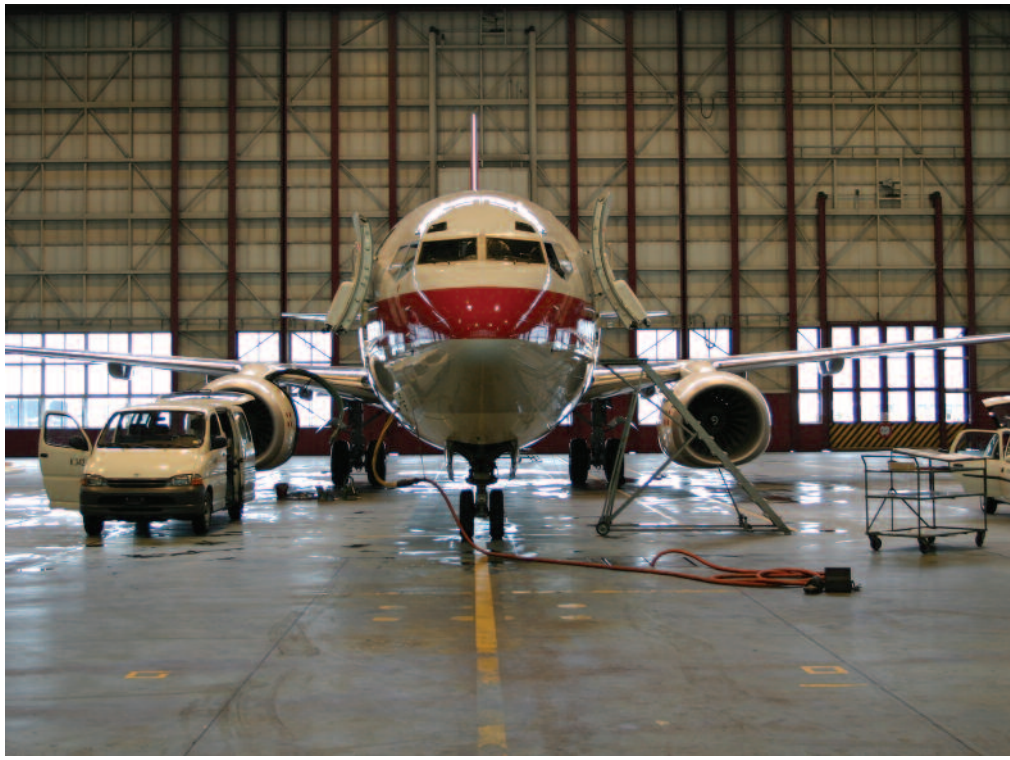
This would then mean that the tasks performed early would also need to be performed early in the second-run HMV, which might make the transition between the first and second lessee more complex. Robinson adds that, if certain tasks are performed early and the lessor pays for those items from its MR account, this could lead to a reserve shortfall in future when the same tasks are performed early in the second run. Any such shortage of MRs then diminishes the value of the reserve pot as security.

Mitigation options

Given the myriad risks to lessors associated with MSG-3-based maintenance programmes on the 737NG, how can lessors minimise their exposure? There appears to be no standard industry best practice so that any possible mitigation needs to be negotiated on a case-by-case basis. Much of this depends on the lessor's perception of the likely default risk of each individual lessee. To the extent that this risk is perceived as relatively low, lessors might not only accept excluding MR collection for checks before eight years and OOP items, but also the systems parts of the HMV cycle. In some lower risk circumstances lessors might accept excluding airframe reserves altogether, and just insist on engine reserves or enrolment in a power-by-the-hour (PBH) programme.

If the lessee's default risk is perceived as greater, then lessors are likely to want to hold more reserves as security. In practice, there are few examples of collecting MRs for checks before eight years on the 737NG, but the starting point would be to collect sufficient reserves for eight-, 10-and 12-year checks from new. Jackson Square estimates that the total first-run costs, including all three checks over 144 months, amounts to $1.3-1.5 million, assuming a full

Many lease contracts will require that maintenance reserves include the cost of scheduled routine base check inspections, plus the non-routine defects that arise. They will not include, however, unscheduled maintenance such as repairs and foreign object damage.



workscope of systems, structures, zonal and material items. This would imply a monthly reserve rate of $9,000-12,500.

In theory, it should also be possible to capture the costs of OOP items into the overall maintenance cost projections throughout the life-cycle of the aircraft. If a block check system is used that brings some items forward to the preceding check, and where other tasks are deferred to the next block check, then this is possible.

Another option would be to escalate MR rates over time to increase the funds in the accounts to compensate for items where no reserves are collected. Jackson Square suggests that a simple approach is to escalate the MR rate by, for example, 15% after each HMV. This allows the lessor to reduce its exposure to the maintenance risks of ageing aircraft, and allows for some funds for non-routine items under an event of default. This would also allow for the costs associated with shorter repeat intervals.

Engines

Engine maintenance represents the largest cost item of any aircraft type, including the 737NG. Jackson Square estimates that an engine performance restoration can cost $2.2 million, while a full set of life limited parts (LLPs) can more than double the cost to $4.5 million.

Historically, the CFM56-3 series engine, which powers the 737 Classic, performed to a predictable overhaul pattern so that on-wing time could be projected relatively easily. Robinson explains that the standard deviation from the mean on-wing time is relatively small, which means that it was relatively easy to calculate an appropriate MR rate based on the projected overhaul cost divided by the expected on-wing time.

Improvements to the CFM56-7 series, however, means that on-wing times have dramatically improved. According to Robinson, a longer possible on-wing life means that across the fleet of CFM56-7 series engines there is now much greater variability of times between shop visits. Thus the deviation from the average is much greater than was the case for the -3 series, so that predicting an appropriate MR rate is now more difficult than before. This is also reflected in the long intervals for some of the LLPs that can last for up to 30,000 FC.

Given the high cost of engine overhauls, the predicted on-wing time of engines has a huge impact on MR rate calculations.

If a predicted engine performance restoration cost is $2.25 million, and the projected interval is 25,000 FH, this would imply an MR of $90/FH.

If, however, the engines are removed at 20,000 FH there would be a $450,000 shortfall in the MR account, so that the MR rate should have been $113/FH for that engine.

If the average LLP life is 20,000 FC, then the MR rate, assuming a cost of $2.2 million for a full LLP set, should be about $110 per FC.

Further complexity is introduced when the engine rating, the FH:FC ratio, and the respective operating environment for individual carriers is introduced. If engine thrust is de-rated then on-wing time and LLP life would improve, which should lead to lower reserves.

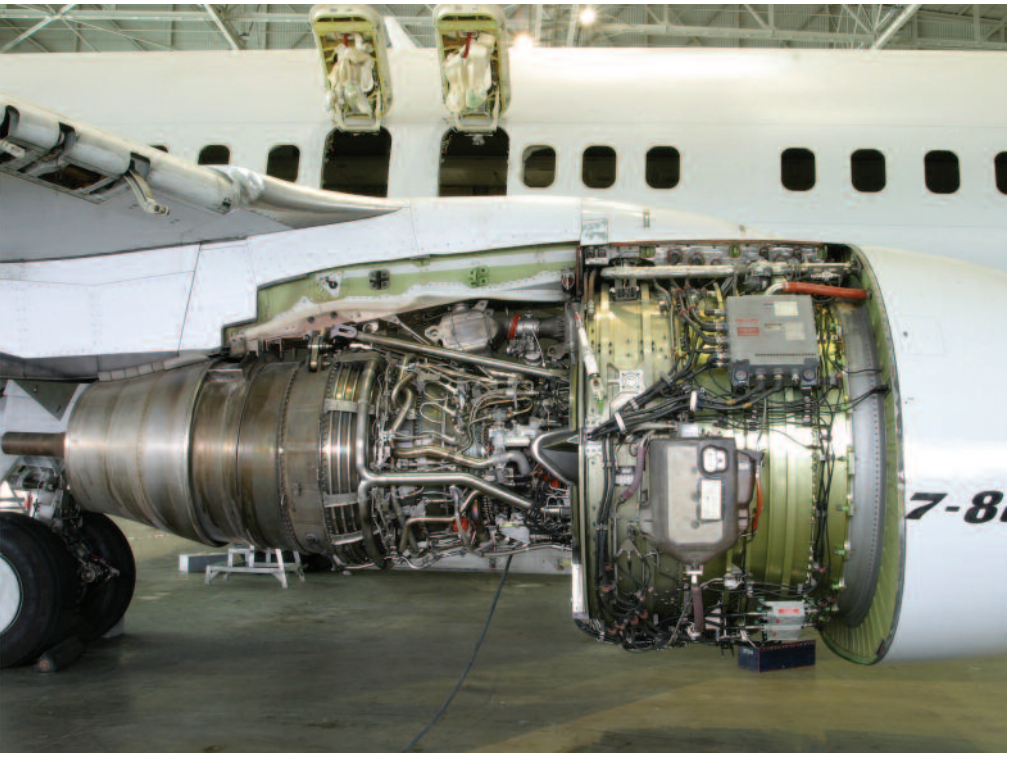
Longer sectors, which increase the FH:FC ratio, increase the on-wing time for engines, although FC-limited items would remain constant.

Conversely, a harsh operating environment -- one in which sandy or dusty conditions prevail or where corrosive elements or pollution content are high -- has the opposite effect on engine performance. These factors need to be accounted for in projecting maintenance events, and therefore MRs.

Age is also an important factor, since the engine hardware deterioration rate increases as the powerplant gets older. This means that on-wing time for the second shop visit is likely to be shorter for the second and third visits.

As with airframes, unused life on parts can also be a cause for concern. In an engine context, it is not cost-effective to complete an engine overhaul and leave LLPs installed that may have only a few thousand cycles remaining. This means it is common to waste an element of stub life on LLPs. Indeed from a lessee's perspective, if there are sufficient reserves in the relevant MR account, the operator may even be incentivised to perform an engine shop visit early, either to meet return conditions or to suit the peaks and troughs of its operations. Furthermore, as an engine type matures, manufacturers often extend the life of certain LLPs which could mean that lessors would over-collect MRs as the calculations would have been predicated on the original LLP lives.

The prevalence of engine PBH agreements on 737NGs also has implications for MRs. Lessees that enrol in the GE OnPoint programme are unwilling to pay engine MRs to lessors, since this would require them to pay twice. Fitzgerald says that lessors have reluctantly agreed to accept payments into such programmes in lieu of MRs, but this can leave lessors exposed to the constraints of the programme. A detailed review of these risks is outside the scope of this article, but lessors have had issues relating to, among others, the ability to transfer programmes between lessees, and the provider's insistence that it controls when shop visits occur. This could, for example, conflict with lease return conditions if these required engines to be free of major maintenance for a defined period.



There are several items that are not included in basic airframe reserves. There are several methods that can be used to account for these. One is to escalate reserves by 15% after each heavy maintenance visit.

Mitigation options - engines

Since there is no one-size-fits-all for every operator, lessors are now adjusting their MR rates to account for region of operation, the FH:FC ratio and engine thrust ratings. Jackson Square, for example, would apply a region factor, a de-rate factor, and a flight leg factor to a base scenario. This base might assume a temperate region, so the factor would be 1.0, and the effect on the MR rate would be neutral.

In a hot and dry climate, however, lessors might apply a 1.2 factor, so that if the engine base MR were $80/FH, then the region adjusted factor would be $80 X 1.2 = $96/FH.

Similarly, factors would be applied for derate and flight legs to generate a composite factor. For example, a hot factor would typically imply a higher thrust rating so this would also increase the MR rate.

Typically lessors now also have one rate for restoration and another for LLPs. Schmid explains that CIT would apply an engine restoration reserve per FH. This would be adjusted on each MR payment date according to the FH:FC ratio for the preceding period. There would then be a separate engine LLP reserve based on FCs. While the average LLP life might be 20,000 FC, Schmid recommends that the intervals and costs of each LLP should be accounted for in deriving an appropriate reserve.

There is less consensus on the treatment of wasted LLP stub lives. One approach could be to impose a stub factor. This might be 10% for narrowbody engines.

Most lessors now agree that where engine PBH programmes exist, some protection can be achieved through a tripartite agreement between the lessor, the lessee and GE in the case of 737NGs. Such agreements now typically allow for portability between lessees, and can provide comfort to secondary lessees that they will only pay for the FH that they use, provided that the new lessee agrees to enrol in the programme.

Landing gears & APUs

Maintenance implications for 737NGs with respect to landing gears and APUs have remained relatively the same from the Classic series, so that the principles under which MRs are calculated and applied are broadly constant.

With landing gears, care is however required in determining the MR rate for high and low utilisation operations. For the 737NG the maintenance limiters are 10 years or 18,000 FC, whichever occurs earlier. If the assumed replacement cost is $350,000 and one operator flies 1,500 FC/year over 10 years, the gear overhaul would be driven by the calendar limit. On these assumptions, the MR should be $2,917/month. If on the other hand another operator flies 2,500FC/year, the cyclic limiter would hit after 86 months, in which case the monthly MR would need to be $4,070.

APU maintenance costs are principally driven by materials, and installed times do not vary greatly. Typical on-wing times for a GTCP 131-9B unit on a 737-800 would be 6,000-6,500 APU hours, and the average restoration cost is $240,000, so that the MR rate should not exceed $40/APU FH.

Concluding remarks

Given that there are more than 1,500 airframe maintenance tasks that do not neatly conform to predetermined 737NG block checks, the manner in which MRs are calculated and collected is having to evolve accordingly. The simplest approach to date has been to adapt the traditional block maintenance method of collecting reserves by excluding reserves from lesser checks and only including major eight-, 10- and 12-year checks. In some cases even the systems portion of those major checks has been excluded, but the more items are excluded, the less security a lessor achieves in the event of default.

If a lessee's credit is at the higher end of the quality spectrum, then this may be acceptable, but for financially weaker carriers the leasing community would appear to need a more robust way of achieving adequate security that is more in line with the MSG-3 based maintenance philosophy. It may be that an increased number of bankruptcies involving these aircraft types in future years will force a revised approach.

For engines, 'on-condition' maintenance is nothing new, but the variance in on-wing performance is greater than before so that MR rates can frequently under-, or indeed, overshoot the actual expenditure. There have been examples in which lessors have accepted that the MRs on engines no longer need to be paid when the full cost of the engine maintenance cycle has been collected, and is a way of addressing the over-collection of reserves.

Under-collection is harder to address, and would only come to light when a maintenance event occurs. Engine PBH programmes can neatly remove these risks, but in doing so have created other risks for lessors instead. Tripartite agreements with the engine manufacturers partly address these concerns, but no optimised industry best practice appears to exist. AC