**It is already well established that MRO IT systems can measure and collect shop floor direct maintenance cost inputs. With varying levels of human resource and financial functionality, MRO IT systems can also provide airlines with an assessment of total aircraft maintenance costs.**

# Can MRO IT systems measure maintenance costs?

MRO IT systems have become more complex and their functionality more sophisticated. System functionalities include the ability to capture man-hour (MH) and material consumption, shop floor data collection (SFDC); track components and aircraft configuration; track mechanics' qualifications; and compile component reliability data.

The objective of using MRO IT systems is to provide airlines with control and visibility over their maintenance and engineering. This ultimately leads to the issue of whether the costs of all elements of maintenance can be monitored and analysed down to the level of cost per FH. Moreover, this also raises the issue of whether these costs can provide visibility into why the costs are at the level they are, and if or how they can be improved.

## Maintenance costs

While there are regional and cultural differences in definitions of maintenance, the different elements of maintenance costs are more or less universally accepted. Maintenance costs can first be divided between direct and indirect costs.

Direct maintenance costs are the inputs of MH actually used in productive maintenance, materials and sub-contract repairs. Labour cost is a product of MH used and hourly labour rates. Labour rates vary according to skill and qualification type. The number of mechanics with each skill type has to be planned according to future maintenance activities. Total labour MH cost is also affected by employer's insurance and other overheads relating to costs of employing staff. There is thus a connection between maintenance planning, workforce management or human resources and SFDC.

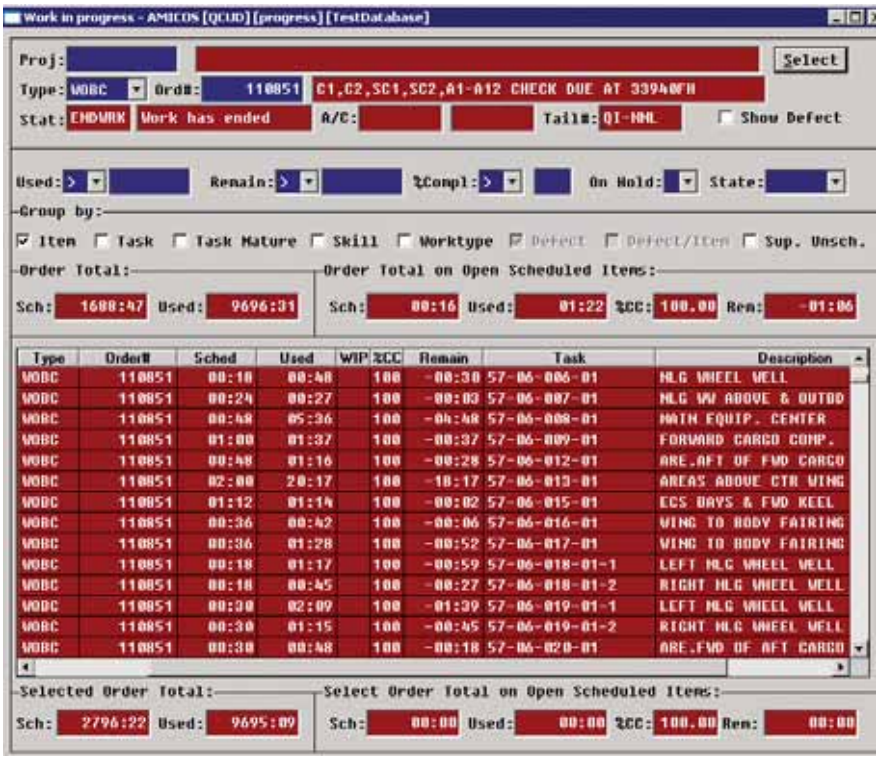
MH, materials and sub-contract repairs can all be recorded with varying degrees of accuracy for all elements of maintenance. These are line and light maintenance checks, hangar and airframe checks, aircraft interiors, stripping and repainting, engine maintenance, repairs of heavy components, and management and repair of rotable components and logistics. These costs are classified as direct costs, because they can be directly attributed to particular aircraft or fleet types.

Indirect maintenance costs are overheads and other costs that cannot be directly attributed to individual aircraft and fleet types, but are necessary to allow maintenance to be completed.

These include unproductive labour. That is, time that mechanics have to be paid for when they are not working on a maintenance task on a particular aircraft. This time spent in between productive jobs has to be paid for, and relates to labour efficiency. There are different philosophies of how this labour cost should be attributed to aircraft or accounted or charged for.

There is also the use of general consumables, and these are items such as grease and lubricants, and nitrogen gas; the consumption of which cannot be recorded against particular checks.

Other indirect costs are those associated with facilities and repair shops,




*The AMICOS system has the functionality to list and summarise all the inputs used for each task or inspection for a maintenance check or work order. It also lists the routine and non-routine MH used for each task and inspection.*

tools and equipment, light and power, engineering and supervisor staff, manuals and records, office equipment, staff and mechanics' training, and general overheads.

There is also the various costs relating to engineering management. This includes the costs of managing ADs, SBs and EOs. There is also maintenance records, technical manuals and publications, planning hangar checks, and keeping and reporting reliability statistics. An increasing number of airlines are sub-contracting these activities to specialist providers.

## System capability

Indirect maintenance costs first have to be recorded and accounted. "Most MRO software systems have the capability of improving the efficiency of managing different maintenance tasks, and recording direct inputs," explains Nick Godwin, business development director at Commsoft. "Not all, however, have the ability to account for direct and indirect costs, and apportion them in particular ways by fleet, individual aircraft, by element of maintenance or by aircraft FH. MRO systems need the ability to interface with an accountancy system to make these analyses."

Many MRO IT systems deal with just direct inputs. Some of these are able to analyse these inputs in terms of total costs over a specific calendar period, base check costs over a base check interval and other parameters specified by the airline user.

Other systems are able to deal with both direct inputs and indirect costs, but at varying levels of sophistication. "Our DigiMAINT and WinPMI systems can deal with direct and indirect costs," says Barende van de Vrande, aviation specialist at AeroSoft Systems. "They keep track of materials by matching invoices with their assignment to specific work orders and maintenance tasks. Our systems even adjust cost of materials with varying rates of exchange to ensure correct value tracking. We track all issued parts in relation to maintenance event, aircraft, date and time, work card, and breakdown per aircraft, maintenance event or work card.

"Our two systems also record MH, and staff can assign themselves to specific maintenance events," continues van de Vrande. "Maintenance management can then use our systems to view the complete direct cost of maintenance per aircraft and for a specific period in terms of materials and MH used, using built in queries and reports. Airline users can also use the DigiREPORTS suite to create their own reporting and analysis tools.

"There is also the issue of indirect costs. These include materials that cannot be assigned to particular aircraft, as well as non aircraft-related items. These are items such as office supplies, tools and ground support equipment," continues van de Vrande. "There is also general staff, other than mechanics, that do not work on the aircraft, and these costs have to be recorded and included in the analysis. Our systems have basic accounting and HR capabilities. These keep track of staff skills, regular and overtime rates, when they are due to be re-licensed or re-trained. The accounting function retains each maintenance customer's contracted labour rates, and rotable and consumable parts mark-ups so that they can be applied, and the customer invoiced accordingly. All tracked labour and material is applied to a particular customer."

Other MRO IT systems include a full enterprise resource planning (ERP) capability. This includes a full HR and finance capability. These can thus provide a view of all direct and indirect maintenance costs, and these can be analysed over calendar time or specific maintenance intervals.

RAMCO has HR and financial modules that, if chosen by a customer, have the ability to interface direct maintenance inputs and overheads. It thus allows fully burdened labour costs to be calculated, and produces reports of total maintenance costs. If these modules are not chosen, RAMCO can pull data from a customer's payroll and financial systems to calculate the complete maintenance costs. A customer can also input its own

burdened labour rate. Moreover, RAMCO has a fully-integrated financials package so that all costs relating to fixed assets and all other general overheads can be included in the analysis.

HCL Axon is one system that has a complete ERP functionality, and links costs to individual resources. For example, it can use multiple labour rates for different groups of mechanics, and apply the different labour rates to different jobs. "The system has data in the HR module that all relate to the overall cost of labour. This includes information on pensions, cost of healthcare, training and licensing, administration, insurance and all other costs. These are used to calculate the total cost of employing a person," explains Duncan Carruthers, head of aerospace & defence Europe & Africa, at HCL Axon. "This is complex to calculate, and companies do it differently. The cost of staff can then be worked into a workscope or work breakdown structure (WBS). This is a string of activities that compile a maintenance activity, such as an airframe check or engine shop visit. This can be analysed either at a simple level, or in a complex and deep manner. This analysis is then used to allocate the appropriate people to particular tasks, which gives a projected labour plan and labour costs."

## Maintenance cost analysis

Some airlines may ultimately want to examine their maintenance costs for each aircraft type in the fleet. This can either be just unburdened or direct costs, or fully burdened costs with overheads included. Maintenance costs expressed as unburdened would thus provide costs relating to all direct labour and material inputs, and this reflects the aircraft's maintenance requirements.

Airlines may wish to see these expressed in terms of costs per flight hour (FH). Some relevant elements of maintenance would be expressed as costs per flight cycle (FC). These are items such as landing gear overhaul and engine life-limited parts (LLPs) which have maintenance intervals expressed in FCs.

Further analysis of maintenance costs would be to split them into the main elements of: line & light maintenance, clearing of technical defects, base check maintenance, cabin interiors and aircraft painting, engine maintenance, heavy components, all relevant costs associated with rotable inventory support, inspections and modifications relating to ADs and SBs, and casualty maintenance or non-routine repairs.

Airlines may wish to go further in the analysis of maintenance costs, and analyse the costs per FH or FC of each of these main elements. Taking base maintenance as an example, an airline may wish to examine the costs of base checks over each base maintenance cycle, and see how these costs increase with the completion of each base check cycle. Another example would be engine maintenance costs, and how they increase with age or each cycle of life limited part (LLP) replacement cycle.

There are various reasons and ways an airline may wish to analyse its aircraft maintenance costs. These can include monitoring the costs of base checks over successive base maintenance cycles, or the overall increase in labour MH per FH over time as the aircraft ages. Another issue may be the monitoring of sub-fleets of a type that differ in age, configuration or modification status. Airlines may also wish to compare the maintenance costs of different aircraft types. These are all ultimately linked to fleet planning and aircraft disposal and replacement decisions.

## Direct maintenance costs

The six main elements of maintenance are line checks, base maintenance, engine maintenance, heavy component repairs, and rotable inventory support. These each require specific consideration in how their direct inputs should be monitored.

## Line maintenance

Line maintenance is less exact than other parts of maintenance, since airlines employ enough line mechanics at operational bases to maintain a reliable operation. "Mechanics may work 8-12 hour shifts, and because they have to work on aircraft while they are at terminal gates there are gaps between different aircraft where mechanics are naturally idle," explains Chris Reed, managing director at TRAX. "The time a mechanic spends working on an aircraft can be allocated by TRAX, but how the idle time between aircraft is accounted for depends on airline strategy. There is also the time that mechanics spend servicing tools. These are often treated as general overheads, and can be spread across a whole fleet as a cost per hour, or factored into the hourly rate of direct maintenance."

TRAX and other MRO systems can allocate some materials and consumables to individual aircraft or fleets. "Other materials have to be treated as overheads," continues Reed. "This includes items such as grease and lubricants and nitrogen gas."

Another issue is inputs used for clearing technical defects. This means aircraft technical logs also have to be kept by the MRO system, since these are the origination of technical defects. Technical defects also have to be cleared from the technical log when they are rectified.

## Base maintenance

Base and hangar maintenance includes hangar checks, interior refurbishment, and stripping and repainting. The functionality of various systems for SFDC in hangar checks have already been described in detail *(see Systems for measuring MH and materials, Aircraft Commerce, April/May 2009, page 46)*. Direct inputs are recorded by mechanics using barcodes and scanners on job cards, material packaging and non-routine job cards. These direct inputs are then recorded, and varying labour rates applied to the MH used for the different job cards according to skill levels. "Our AMICOS system knows the skill type required and used for each task card in a work order or maintenance check," explains Rune Hagen, president and chief executive officer at Cimber Air Data. "AMICOS also knows which mechanic is performing a task when they swipe the barcode on the task card. The system has several options for applying MH rates. One is to have a pre-set cost per MH for each skill type, and the labour rate is applied to all MH used in the check for each skill type. The labour rate for each skill is input manually by the airline user. AMICOS has a facility for the airline to input the mechanic's skill and their specific labour rate."

Materials used are recorded using barcodes on packaging, and their utilisation sent to an invoice preparation system. This will have to include the pricing and mark-up policy for each third party customer.

AMICOS can then summarise all the tasks performed in the work order, the total MH and materials used for each task, the split between routine and non-routine MH in the whole check, and the total cost of the check. The system can also of course drill down back to the detail of each task card. Tasks can be grouped by Air Transport Association (ATA) Chapter, for example. "AMICOS can also add a mark-up to labour rates for certain types of work. Examples are dirty work, nightshift work or labour charged at overtime rates," says Hagen.

Most MRO systems will have several other functionalities, that work in conjunction with SFDC, to predict MH and material inputs prior to checks. These include aircraft configuration, component tracking, check planning, and task card production. A material forecasting capability is used to order materials and parts.

Writing of non-routine task cards during line and base checks requires

interfaces with the aircraft maintenance manual (AMM), illustrated parts catalogue (IPC) and other manuals, parts ordering, and the management of mechanics with different skill levels.

MRO systems will ultimately provide summaries of MH and materials used. This will list routine and non-routine MH, and routine and non-routine materials used. MH used will also be broken down by skill levels and aircraft zones. The data from MH and materials used in non-routine task cards is fed into the reliability module of the MRO system. Non-routines are also classified by air transport association (ATA) Chapter, while data is also compared with other aircraft in the fleet.

The SFDC functionality of MRO systems also follows the progress of airframe checks, allowing improvements in labour efficiency. Data can then be fed into the planning module for future checks.



All this analysis can also be used to follow an aircraft's maintenance costs, accurately invoice customers, and accurately forecast maintenance requirements.

In addition to the main checks of airframe hangar maintenance, there is also the additional work of aircraft interiors, and stripping and repainting.

Aircraft interior work and refurbishment comes under line and base maintenance. This will be cleaning and small repairs in the case of line maintenance, and MH can be recorded for individual aircraft. Heavier refurbishment of interiors, as well as stripping and repainting, will be part of base check workscopes and the MH and materials consumed will be recorded and allocated in the same way as for base maintenance as described.

## Engine maintenance

The third main element of direct maintenance is engines. "Most airlines now sub-contract their engine maintenance, and so just receive a simple invoice. This details MH, materials and cost of sub-contract repairs used in the engine shop visit and can be treated as a repair order," explains Reed. "The power-by-the-hour (PBH) agreements that airlines manage their engines under are easy to track."

AMICOS would treat engine shop visits as a repair order, and the invoice entered into the system as such. "These invoices will list the MH, materials and cost of sub-contract repairs required to complete the shop visit," says Hagen. "AMICOS also knows the removal or repair interval of the engine, which is followed by its component tracking functionality. AMICOS does not, however, have the functionality to illustrate the cost per engine flight hour (EFH) or engine maintenance reserve of that engine shop visit."

Individual engines can be tracked for removal intervals, making it possible to calculate maintenance reserves per FH or flight cycle (FC). In many cases engines are maintained under fixed rate per hour agreements, and so the accountancy and engine management modules of MRO systems are simply required to compare invoices and removal intervals.

A minority of airlines still maintain their own engines. In this case airlines would need to record the MH, and materials and parts used in the same way they are recorded in airframe checks. All engine shop visits require some level of sub-contract repairs for the most complex or expensive repairs. These incur an invoice, which includes an element of overhead cost for the repair provider.

Engine LLPs are also tracked, both for the purpose of monitoring their use

and removal at life limit expiry, and to analyse their cost per FC. Engine maintenance management is a complex process, and there are several specialist software products available that deal purely with this activity.

## Heavy components

The fifth main element of maintenance is heavy rotable and repairable components. This includes wheels and brakes, thrust reversers, landing gears, and auxiliary power units (APUs). Airlines can source and maintain these components in a variety of ways. Wheels and brakes may be repaired in-house, and so direct labour and material inputs would be recorded, as would overheads relating to the shop.

Most airlines sub-contract the repairs of the other three types of components to specialist shops. This incurs direct and indirect costs. These have to be analysed with tracked removal and repair intervals to provide maintenance reserves per FH or FC. AMICOS, for example, can record the costs of these repairs as repair orders and treat them in the same way that it treats engine shop visits.

These components are also likely to incur transport costs, which will be substantial in the case of airlines in remote regions far from repair facilities.

## Rotable inventories & logistics

The sixth and final element of maintenance relates to rotable inventories and related logistics.

Rotable components are also continuously removed and installed on the aircraft during operation. This involves labour during both line and base maintenance, which has to be recorded. Airlines also need to record the removal intervals of each rotable for the purpose of keeping and reporting reliability data. This means the MRO system therefore also requires the capability to track each rotable component and the associated MH used for these activities.

There are many other issues relating to rotable components. Parts are borrowed, returned, exchanged, repaired, bought and sold. Not only do all these movements need to be tracked, but they also have an associated cost. All this ideally needs to be followed in real-time.

Rotable components also have warranties, and these need to be tracked so that airlines can maximise their warranty claims.

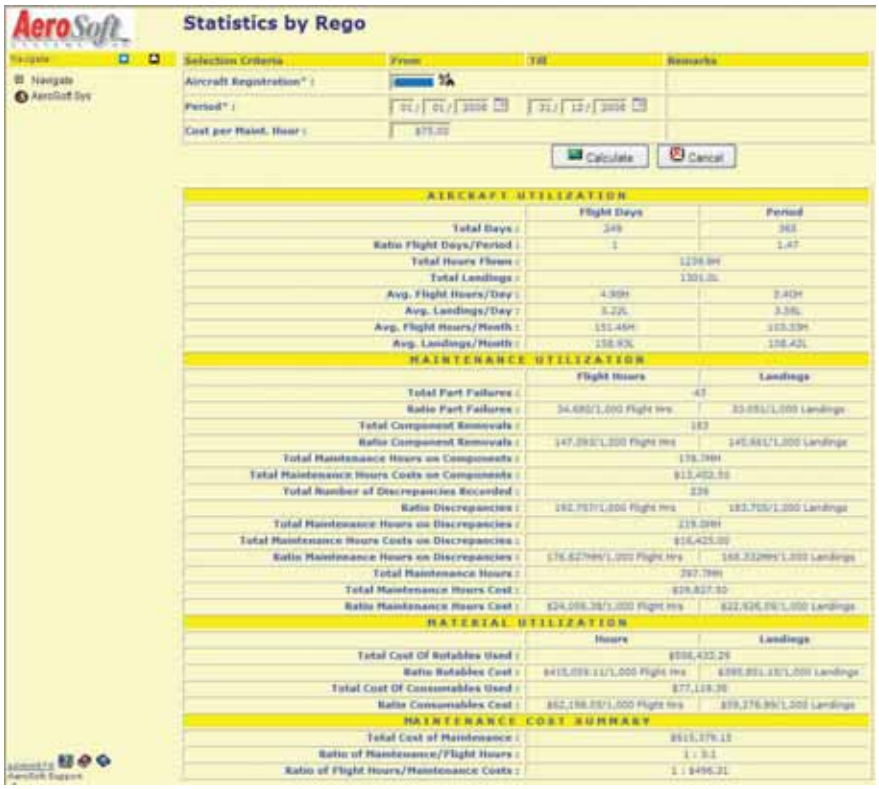
Rotable components thus involve several costs. Few airlines own the complete inventories of rotables to support their fleets, and a smaller number of carriers repair the items removed from aircraft.

The first cost element relating to rotable components is the ownership or lease rentals of the rotable inventories. Then there are the test and repair costs for components removed from the aircraft, which is followed by placing them in an inventory kept in a warehouse or at a rotable suppliers' pool depot. In addition to these three main cost items, there are the costs relating to staff for managing the entire logisitics of the process of managing the rotables, transporting parts, certification documents, and customs duties.

Not all rotable items will be sourced and managed this way, and there are always some parts that are purchased as and when required, borrowed from other operators, or exchanged from component providers and repair shops. The associated costs of this also have to be accounted for.

Large airlines with maintenance and engineering departments, such as Lufthansa and the US majors, will complete most of these processes in-house. They will consequently incur direct and indirect costs.

More airlines are outsourcing the acquisition, and repair and management of rotable inventories to specialist providers. These providers have several methods of providing inventories that include leasing of an entire inventory,




*AeroSoft's two systems have the functionality to analyse maintenance costs and operating statistics down to a per aircraft level.*

leasing of a homebase stock and access to a pool of remaining items through a fixed PBH rate, or access to parts through a fixed rated per FH contract. All parts can then be repaired and managed through a fixed rate per hour contract, making analysis per FH simple.

### Additional items

There are also miscellaneous items required in the entire maintenance of an aircraft. These include items that are not specifically maintenance, and can be aircraft interior cleaning, exterior washing and casualty repairs. These items can be recorded as specific work orders, but do not come under any of the six main categories described. "These are referred to as service orders in AMICOS, and the costs of these are recorded in the system," says Hagen.

## Total inputs & analysis

MRO systems can list or summarise every defect, work order, check, task card, repair order or service order. These individual inputs can be examined over a specific period, such as a year of operation or period equal to a base check cycle. "AMICOS can also list specific types of tasks, work orders or maintenance checks over a specified period," says Hagen. "For example, all A checks performed in a year can be listed. The associated MH and material cost of each A check can also be analysed."

Like AMICOS, OASES records only direct inputs of MH, materials and sub-contract repairs. "Once all these inputs have been recorded and work orders and maintenance items input, OASES can report maintenance costs at any level. That is, by fleet, by sub-type, by individual aircraft, by aircraft zone, by workcard, budgeted versus actual cost, by repair or check type and several other parameters," says Godwin. "This analysis is usually handled by the airline's accounting system, but the key cost collections are tracked by OASES. It is important to use these costs to make business decisions."

AeroSoft has a function to analyse maintenance costs and statistics per aircraft *(see picture, this page)*. This analyses all costs over a specific period. It takes into account the number of days; actual flying days and aircraft FH and FC; FH:FC ratio; component failures; discrepancies; MH spent on component removals, discrepancies, and maintenance actions; cost of rotables and materials; and total cost of maintenance per FH. "We also have DigiREPORTS, which is a software solution that is an extension of the standard reports. DigiREPORTS is a web-based business intelligence platform that allows developers to create management reports. This is based on an SQL interface and can generate outputs in various formats."

RAMCO has a similar capability. It has maintenance cost 'cubes' in its analytics package. This takes inputs from payroll and the various financial modules to include labour, as well as all other overheads. All facilities and tooling costs can be reported. Maintenance reports can then be produced to show maintenance cost per FH or check cycle. There is also a budgeting forecast module, which projects maintenance costs over a future period and per FH. The total maintenance events per year, the total maintenance cost per year, the MH per year, the materials per year, the MH per FH, and the total maintenance cost per FH can all be calculated.

HCL Axon's functionality takes the work breakdown structure (WBS) analysis it makes of a particular work order, and the estimates of labour that were predicted to be required, and these are then compared with the actual used for each task. "This allows the user to see which tasks require an improvement in efficiency or better estimates," says Carruthers. "This information then goes into invoicing and billing, and actual labour rates can be used to calculate an airline's own maintenance costs, and estimated overheads can be added to these labour costs when billing for an external customer. MRO facilities can use the system to identify their actual cost, use a billing rate for a particular third party customer, and calculate an invoiced cost. Some MROs invoice customers at a fixed rate, and others charge at time and material with margins built in. This is possible for the system to calculate, since it stores data and policies relating to customers' mark-up rates and invoicing policies. The system also tells you what your labour efficiency is, so you can build it into your billing rate.

"Overheads can also be recorded and calculated and analysed," continues Carruthers. "These are treated in the same way as the full cost of labour. The same applies to the cost of rotable components."

## Summary

The systems with the functionality to provide an airline with an analysis of its entire maintenance costs clearly exist. For the airline it is an issue of using systems that deal with just direct maintenance costs in conjunction with other HR and financial systems, or using products such as HCL Axon with a full ERP functionality. It is at least now possible for airlines to get full visibility of aircraft maintenance costs at the particular level they require. AC