Airlines are seeking increased visibility of detailed aircraft maintenance costs from their M&E systems. Starting with the basics of shop floor data collection and other tracking functionalities through to collating indirect and overhead costs, a more detailed view of maintenance costs is now possible.

Does my M&E system make my maintenance costs transparent?

The original rationale behind developing maintenance and engineering (M&E) IT systems was to ensure compliance and automate engineering management processes. The functionality of M&E systems has continued to grow, and now offers customers the benefit of gaining visibility, transparency and granularity of a fleet's overall maintenance costs. This is not something that airline technical and financial departments have required from M&E systems. A growing number of airlines are now showing a greater interest in examining the detail of their maintenance costs, and asking for such functionality from their M&E systems.

What transparency and granularity of maintenance costs do M&E systems actually provide?

Maintenance cost elements

Maintenance costs can be first sub-divided between direct and indirect costs.

Direct costs relate to those directly attributable to an aircraft or engine type, and include the hands-on or 'touch' labour and materials used to perform the four main elements of line, hangar and base, engine, and component maintenance.

The majority of direct maintenance inputs and costs can be attributed and apportioned to individual aircraft and fleets relatively easily.

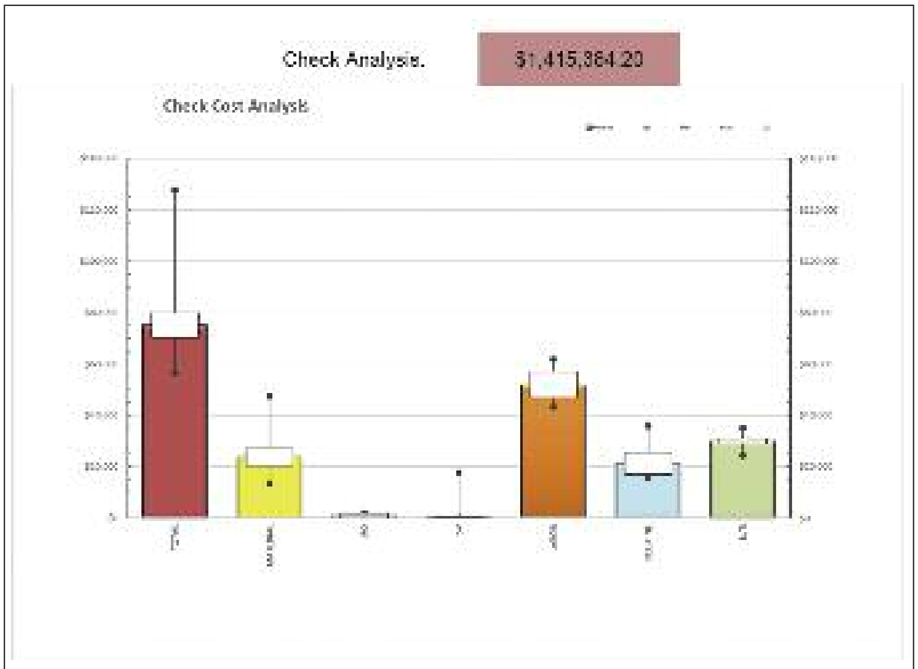
Indirect costs are those that cannot be apportioned to a single maintenance task, package or aircraft type. Instead they are incurred while performing maintenance for an airline's fleet as a whole. Indirect costs include items such as: engineering management and maintenance supervisors; facilities, tooling and vehicles; administration, light, heat and water; and general overheads for items like staff canteens and amenities.

To identify total costs for an aircraft or a fleet, the related direct costs for each type could be considered together with the indirect costs that have been apportioned to each of an operator's fleets and aircraft types by a parameter such as annual flight hours (FH).

One problem with identifying all direct costs for each aircraft and engine type is that a lot of maintenance is sub-contracted to a large number of third-party providers. These providers charge for maintenance in a variety of ways, and this can complicate allocating costs to specific fleet types.

There are many elements of direct maintenance costs that an airline incurs for a fleet or aircraft type. Each one has to be recorded and attributed to an aircraft or a fleet, whether the maintenance is performed in-house or sub-contracted, if the highest level of detail or granularity is to be possible.

M&E systems used to lack the functionality and capability to fully examine every element of direct and



One analysis of airframe maintenance costs that airlines may seek is a breakdown of the different elements of base airframe checks. Trax can provide this is in graphical and chart form. It can also present average, low and high inputs for each element of a particular type of check performed across a fleet.

indirect maintenance that is attributable to an aircraft and fleet type. Some M&E systems, however, are developing their functionality further to provide their users with a more detailed and granular view of total maintenance costs. Commsoft's OASES, for example, has an active project to provide a full Aircraft Maintenance Costs management-reporting module that will be reviewed by the OASES user group in November 2014. A new module is being developed to bring all costs together into a management dashboard. This could be reviewed in 2015. It will permit analysis of maintenance costs at a fleet and individual aircraft level.

SFDC

A large portion of overall aircraft maintenance is the 'touch labour' of mechanics' time used in airframe, engine and component maintenance. The other main portion of maintenance costs is the cost of materials and parts for the four main elements.

A first step to gaining transparency in maintenance costs, and being able to apportion labour and material inputs to individual components and aircraft, is to record the labour man-hours (MH) and cost of materials and parts used in many elements of maintenance using shop-floor data-collection (SFDC) technology.

SFDC functionality is an element of several M&E systems. It requires, however, task cards to have barcodes and for all line mechanics at all maintenance stations to have the necessary hardware to swipe the barcodes. Swiping these barcodes at the start and end of a task or job card allows MH used to be recorded. This has several advantages. "Besides making it possible to know the actual MH used for a task, it also allows post-maintenance analysis to be conducted. This in turn allows feedback for more accurate maintenance planning in the future," says Thanos Kaponeridis, president at Aerosoft. "For example it is necessary for planning engineers to know the multiplier factors they should apply for MH estimates in the manufacturer's maintenance planning document (MPD)."

The consumption of all materials will have to be recorded, or at least apportioned, in some way. Individual parts would therefore also require barcodes to be placed on their packaging.

Some material items, such as consumables (which include greases, rags and paper, and skydrol), clearly cannot be barcoded, so their exact consumption for each maintenance event cannot be recorded. Their cost will have to be apportioned for a group of maintenance events on a FH basis, or by another suitable parameter.

The consumption of expendable parts in airframe maintenance is relatively easy to predict for routine tasks. They will therefore not necessarily be barcoded. A reasonable estimate of their consumption can be estimated by maintenance planners using the check planning modules of M&E systems.

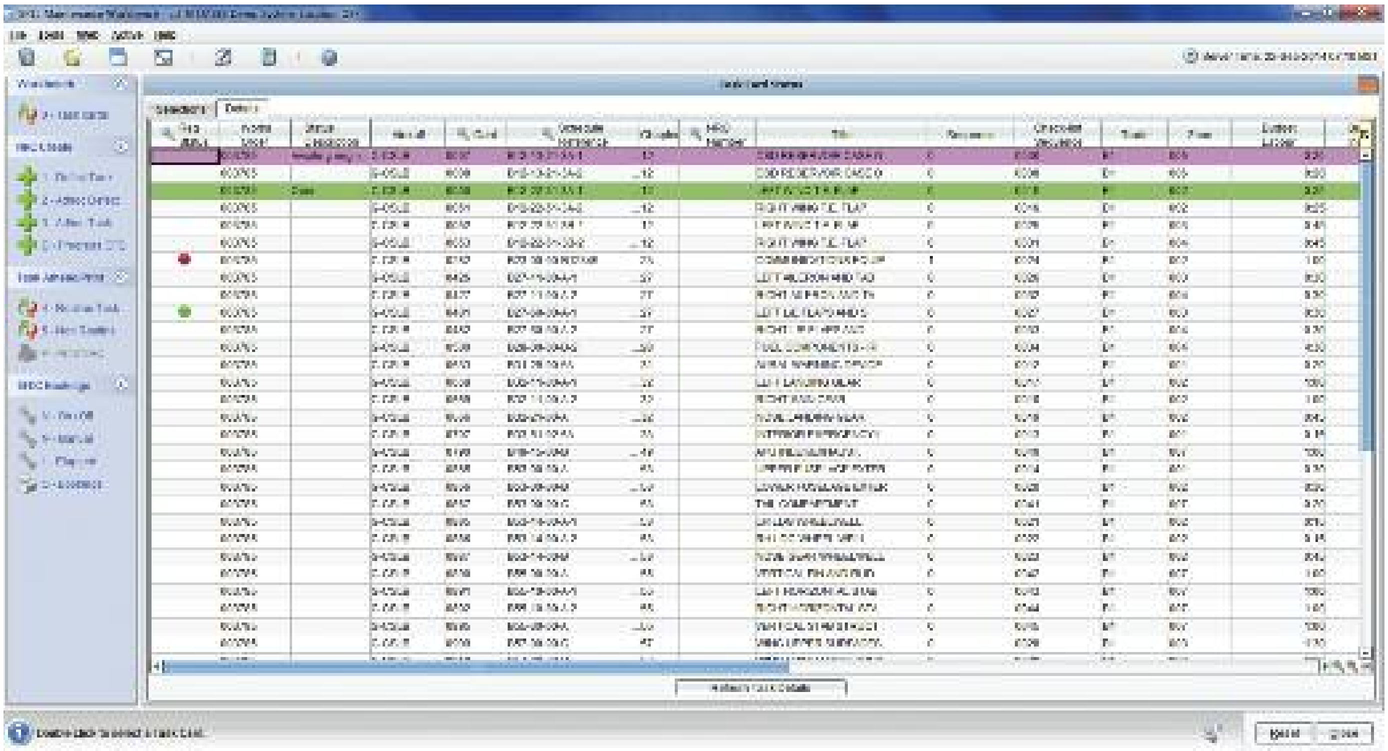
An airline or independent maintenance & repair organisation (MRO), using hard copy, paper task cards, needs two kiosks in the hangar and one at the parts store in terms of hardware required for SFDC. Two hangar kiosks are thought to be enough for narrowbody maintenance. One is used for scanning task card barcodes at the start and finish of each task with the barcode reader, while the other is used by mechanics to access technical manuals. A kiosk at the parts store can be used for requesting parts and associating their use with particular task cards.

The alternative is a completely electronic task card system. Task cards are presented on tablets or other remote devices, signed electronically and stored electronically. E-task cards on remote devices have a wireless connectivity link with the M&E system.

"Providing mechanics with a stack of task cards to perform on a wirelessly connected tablet or remote device makes collecting SFDC information easier than with printed hard copy task cards," says Kaponeridis. "This includes recording materials and parts consumption, since ordering parts can be associated with the appropriate task card."

Ultramain has its Mobile Mechanic functionality as part of its SFDC system. This is a tool for signing off task cards and non-routine work orders, as well as entering logbook entries if an electronic tech log is not being used in flight operations. Mobile mechanic can also be used to request parts and record MH. The system works on all types of mobile devices and computer kiosks. Ultramain's overall objective is to provide a mechanic with the same feel or experience that they would have with traditional paper task cards and work orders.

With the appropriate functionality in



A first stage in examining maintenance inputs is to compare the budgeted and actual labour inputs for individual tasks completed in a check package. Commsoft's OASES system provides an example of such an analysis.

the M&E system, a mechanic can request parts for non-routine task cards, and also record that initially requested individual parts were not actually used, and have been returned to stores. Recording expendables consumption for each task can therefore be simplified. This requires the e-task cards to be fully interactive. Further functionality can be added to prevent mechanics requesting incorrect part numbers.

For the labour consumption recorded in SFDC, several layers of functionality will be required to give detailed information relating to MH inputs. A distinction between time used for maintenance tasks and a mechanic's total on-duty time has to be made. Total duty time has to be recorded with a time and attendance module in the general management functions of the M&E system. The time used for tasks will be recorded by SFDC, and then presented in a post-check analysis of all labour and materials used. A comparison of the two can be used to measure labour efficiency.

Further detailed analysis of labour and materials used in maintenance can be made with some M&E systems. Swiss AMOS, for example, allows the time spent between several task cards worked on simultaneously to be apportioned. Similarly, the labour used for a task can be apportioned between several mechanics where more than one is used.

Line maintenance

Line maintenance has several elements. The first of these is routine maintenance tasks. Most are relatively simple, and some are even performed by the flightcrew. Small amounts of consumables (such as greases, rags and paper, and skydrol) and expendables (such as compressed air, hydraulic fluid, filters, and bulbs) are used in these tasks.

Non-routine tasks in line maintenance involve fixing faults as they arise during operation. They will involve the changing of aircraft rotable and repairable components, as well as line mechanic labour and materials.

The overall cost of maintaining an inventory of rotables, including ownership, and repair and related management costs is treated as an element of component maintenance costs, instead of as an element of line maintenance, even though most rotables are removed and installed during line maintenance.

A third element of line checks, which can include overnight or weekly checks that have a relatively long downtime, can be the inclusion of small airworthiness directives (ADs), service bulletins (SBs), and engineering orders (EOs).

Since line mechanics are on duty at line stations for fixed periods in most cases, and have to perform varying amounts of actual routine and non-routine work on the aircraft during the shift, it is less likely that their MH used would be directly recorded using SFDC. Moreover, line mechanics at line stations often work on several aircraft types, making it harder to apportion labour MH and materials used during a shift between individual aircraft or fleet types.

It is more likely that an overall cost of providing line maintenance for an airline's fleet would be calculated and apportioned to each fleet type.

"Line mechanics will have a number of aircraft to turn around on the line during their particular shift. Each aircraft will require varying and unpredictable amounts of non-routine tasks," says Chris Reed, managing director at Trax. "Most airlines will therefore already have a schedule for a certain number of line mechanics to be on duty at a particular line station to deal with a certain number of aircraft according to the operating schedule. The line mechanics on duty during a shift would perform all the routine line tasks, and any non-routine tasks or defects that can be dealt with if an aircraft-on-ground (AOG) situation arose."

The use of consumables and expendables for the routine tasks is also fairly predictable. Many airlines therefore have an allowance of 'free issue' parts for this portion of line maintenance.

The line mechanic's shift time has to be paid for, regardless of how many non-routine tasks and defects must be carried out. The cost of this and the 'free issue' consumables and expendables is likely to be included as an overall line maintenance budget. This will be apportioned between the fleet types according to a parameter such as number of turnaround checks.

It is likely that additional labour will be required for larger non-routine tasks, defects and AOG situations. This demand will be satisfied by bringing in additional mechanics. This labour, and the associated expendables and other materials, will be recorded and apportioned to individual aircraft and fleet types. Non-routine task cards will need to be written, and SFDC information recorded. Tablets are now being used by a small number of airlines in line maintenance, and this will make it easier to record and analyse the inputs for non-routine line maintenance in detail.

As well as routine and non-routine line maintenance tasks, there would also be the costs of aircraft cleaning and line servicing of on-board passenger amenities. These are often regarded as an overall cost, and apportioned to fleets in the same way as the shift labour and free issue materials in routine line maintenance.

Base & hangar maintenance

It is easier in some airlines' cases to record and apportion actual MH and expendable parts used for individual hangar maintenance events and checks than it is for line maintenance. As described, the process of monitoring and analysing hangar check inputs starts with collected SFDC data.

The division between line and hangar maintenance is not always clear, however. The largest line checks can be performed in hangars, while some A checks or equalised A checks can be performed as larger line checks by some airlines.

There are many different parameters and levels of detail that an airline or MRO may want to analyse in respect of hangar-check inputs: aircraft preparation and docking; routine tasks; non-routine rectifications; ADs and SBs; EOs and modifications; component removal and installation; aircraft cleaning; interior refurbishment; and stripping and repainting.

Once a maintenance check has been completed, M&E systems can generate a post-check report. The MH and materials used for each of the elements described can thus be illustrated in tabular form.

Such a level of detail is first required so that accurate invoicing is possible for an airline or MRO performing a check for a customer.

The MH and material data for the different elements of hangar checks can also be analysed in a number of ways.

"An airline with a fleet of 20 aircraft may want to compare the routine and non-routine labour, and the routine and non-routine materials for the same check," says Reed. "This might be a C1 check, the first base check the fleet has gone through. The airline may want to have visibility on the average cost of the check, and also the smallest and largest inputs for the aircraft in the fleet. This can be displayed visually in Trax.

"Similarly, the airline may want to make the same analysis for all the successive checks in a base check cycle," continues Reed.

Another level of analysis required might be to examine the ratio of MH used for non-routine tasks, and see how much this varies between individual aircraft in the fleet for the same check. Another might be to see how the non-routine ratio changes through a base check cycle.

Airlines may also be interested in analysing the different elements of each check as the aircraft progress through a base check cycle. Furthermore, it may also be interesting to analyse how base check inputs increase through successive base check cycles.

With SFDC data captured during a hangar check, M&E systems can be configured to present input data in many ways.

Ultramain's analytics suite offers several functionalities for analysing maintenance costs data. The system allows the user to create their own dashboards, pivot tables, charts and graphs, and statistical tracking. SFDC data captured in the analytics suite allows labour productivity, or estimated and actual inputs to be compared.

Kaponeridis makes the point that the data captured during maintenance visits also allows the relative labour efficiencies of different maintenance bases to be compared. This is important when targeting areas of efficiency.

As described, labour efficiency is a measure of a mechanic's time spent performing tasks expressed as a percentage of their total paid-for, on-duty time. The time spent performing tasks will be monitored through SFDC. Total on-duty time will be collected through the time-and-attendance function of the management and human resources modules of the M&E system. The M&E system therefore needs the functionality to collate data for individual mechanics to perform labour efficiency calculations.

The time and attendance module in Ramco Aviation M&E system tracks direct work and total hours worked by employees. This provides the user to examine details that include employee logged normal and overtime hours, the consumption of resources and materials by individual employees, the allocated and signed off task cards, the estimated and actual MH used for each assigned task, reported discrepancies and delays, and the estimated and actual parts consumption. All this data can be integrated with the time and attendance module.

Engine maintenance

As with airframe maintenance, the MH and material inputs for any type of maintenance task can be captured. It is therefore possible to record the inputs for engine shops at all stages and individual tasks of engine shop visits.

The first stage of engine maintenance is workscope definition, and M&E systems have different functionality to generate engine workscopes. The increasing portion of engines that is maintained by engine manufacturers and independent engine shops means that few airlines require detailed functionality for monitoring engine maintenance costs.

Ultramain is one M&E system that allows engine workscope packages to be created for tracked assets. These include engines and complex components. Workscope creation starts with routine tasks that include disassembly and inspections. These are standard, and MH and material inputs can be estimated. As routine tasks are performed, non-routine tasks arise. Some of these are predictable, and experienced users will have standard non-routine repairs created. Other non-routine tasks will have to be created while the engine shop visit is in progress. "Ultramain automatically generates work orders behind the scene," says John Stone, vice president product manager. "Work orders track all aspects of work performed against the work package. This includes parts, labour, sub-shop visits and vendor work orders. The MH and materials used during each stage can then be recorded against each work order."

Other elements of engine maintenance include the amortisation of life limited parts (LLPs). Each LLP is tracked as a component asset. This includes the initial cost of the part, and its accumulated engine flight cycles (EFC).

A third main element of engine maintenance is unscheduled shop visits and AOG situations. These may include expensive situations where teams of engineers and mechanics, together with tooling and components, are sent long distances to overseas outstations. The high costs can all be attributed relatively easily to individual engines and fleet types.

With all relevant cost data and engine removal intervals collected, Ultramain can present engine maintenance costs in terms of cost per engine flight hour

(EFH) or per EFC.

AerData's EFPAC system has the ability to analyse engine health monitoring (EHM) data. Considering this against other issues such as LLP lives, ADs, and probable rates of engine utilisation, EFPAC can generate an optimum timescale for removal for a shop visit. EFPAC can also predict the workscope content and associated cost, taking into consideration deterioration of airfoils with continued time on-wing. The system can therefore generate an optimised engine maintenance management plan, and calculate the predicted costs per EFH and EFC. Similarly, EFPAC can record actual shop visit costs.

Ramco is another system that can closely monitor the inputs of engine shop visits. It has a structured process to follow an engine shop visit through its component maintenance programme where the resources and labour cost are recorded at each task. Engine-related costs are tracked at all levels, from individual serial number to complete engines. These collected costs and the associated removal intervals allow the maintenance cost per EFH and per EFC to be monitored.

Component maintenance

Repairable and rotable components are repaired either in-house or sub-contracted to specialist shops. All components with serial numbers will be tracked by the M&E system. This includes monitoring them through the test and repair process.

In the case of components being repaired in-house, the operator's own shop will use the M&E system to write repair orders. An example is Kenya Airways, which uses Commsoft's OASES system to this effect. "The airline has a significant component repair capability, and it uses OASES to generate work orders and request parts and materials for component repairs," explains David Pusey, projects director at Commsoft.

The direct cost of labour and material inputs can therefore easily be monitored.

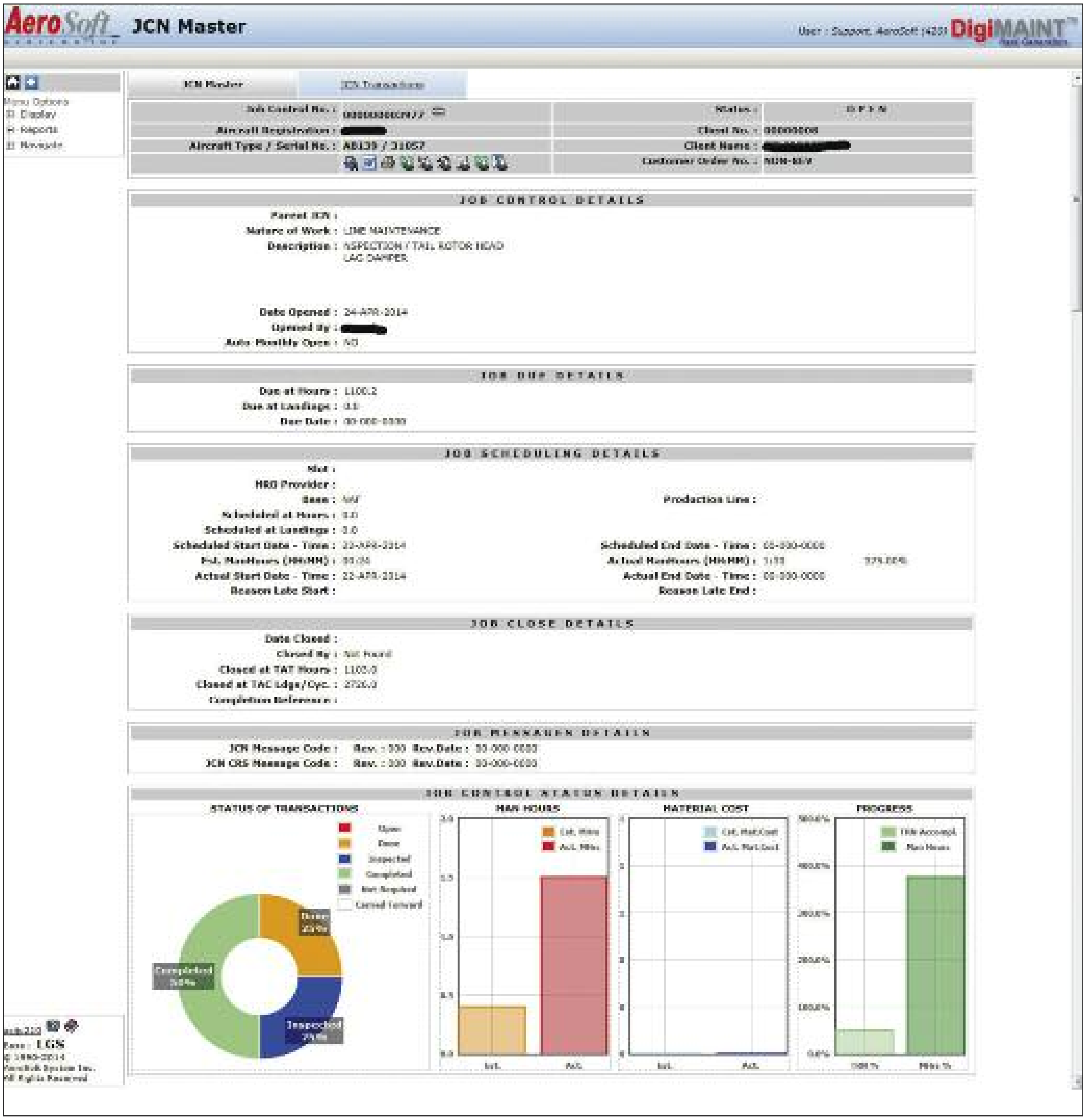
The cost of components repaired by independent providers can also be monitored relatively easily. Repair shops will provide an invoice for each item, which can be identified by its serial number. This can be linked to the component tracking functionality in M&E systems. Costs are therefore easily apportioned and allocated to part numbers and related fleet types.

Ramco monitors all costs associated with owning and managing an inventory of rotable and repairable components, including: repair fees from sub-contractors; transport and logistics costs; pool access fees; and exchange and borrowing fees. Ramco monitors all of these elements. Repair fees from external providers are handled through the repair order management module, while the pool access, and borrowing and exchange costs are managed through the loan and rental management module. PBH costs are managed through the purchase orders, and there is a shipping module to track transport and logistics costs.

The reports in Ramco's finance and materials modules provide the overall cost of repairable and rotable component support for each fleet type.

Indirect costs

While most inputs for the elements of maintenance can be recorded relatively easily for maintenance events, and hence individual aircraft and fleet types, airlines also have to closely monitor indirect



costs.

Some airlines may only want to analyse or examine the direct costs when scrutinising the maintenance costs of fleet types or sub-fleet types.

Some carriers, however, may want to examine the full costs of providing maintenance. This will therefore first require taking account of all indirect and overhead costs associated with maintenance. These will be recorded and collated in the finance and human resources modules of the M&E system.

Costs of facilities, tooling, vehicles and engineering teams can all be apportioned between fleets on the basis of FH performed. While some costs may regarded as semi-direct and semi-indirect, or related to two fleet types, the analysis of total maintenance costs for a fleet type with detailed granularity will allow an airline to make a more informed decision between performing maintenance in-house, selling surplus maintenance capacity, and subcontracting it to third-party providers.

The warehousing of data allows the grouping, collating and analysis of all the many direct and indirect cost elements that make up the total maintenance costs attributed to each aircraft and fleet type. The technique of data warehousing will be used to combine the captured direct maintenance costs recorded in the maintenance modules with the overheads recorded in the finance modules of an M&E system. The two will be combined according to parameters set by the user.

More detailed and granular analysis is gradually becoming possible with M&E systems as their functionality is developed.

An example of a M&E that can combine the direct maintenance costs for an aircraft with apportioned indirect costs for a fleet type is the Ramco Aviation M&E system. It tracks the maintenance cost through integrated modules that include materials and finance.

Aerosoft's DigiMAINT provides one of many examples of how a detailed breakdown of inputs in a maintenance event can be displayed to the user.