M&E IT systems have been adapted to provide an increasing number of maintenance & engineering functions. One additional benefit of the data held and functionality developed is the ability to analyse an individual aircraft's and fleet's total maintenance costs in detail.

Using M&E systems to identify total aircraft maintenance costs

Maintenance & Engineering (M&E) IT systems provide a wide range of capabilities for airline and independent maintenance, repair and overhaul (MRO) providers. One function of M&E systems is to give users detailed information on the direct labour and material maintenance inputs for aircraft, together with associated overheads, so as to provide detailed maintenance costs on individual aircraft, engines and parts.

This has several purposes, including providing an element of aircraft operating costs for fleet planning and overall financial performance. It is also essential for knowing actual in-house costs when quoting for third-party maintenance contracts.

The functionality of M&E systems that provide detailed and in-depth maintenance cost information is examined. This starts with the collection of raw labour and material direct input data and information.

Maintenance costs

All the elements of maintenance costs have to be considered when configuring IT systems to provide a detailed analysis of complete maintenance costs.

Maintenance costs can be divided into two main groups of direct labour and material inputs, with elements that can be applied either as semi-direct costs or overheads.

Maintenance for a complete aircraft is first broken down into its main elements: airframe, engine and components. These are then broken into sub-categories that make analysing and calculating full maintenance costs complex.

Airframe maintenance

Airframe maintenance has to be considered in terms of line maintenance, and hangar or base checks. The content of each category and the nature of its performance makes analysing the costs of each a complex process.

Line maintenance

Line maintenance is performed mainly on the line or at the aircraft stand by line mechanics; although some basic routine tasks can be performed by flight crew. Routine tasks are relatively simple items, such as visual inspection of the airframe, tyre treads, brake disc thickness; and checking hydraulic and oil levels. Larger line checks, such as overnight or weekly checks, also include some functional and system checks, many of which can be performed via the central maintenance computer (CMC) on the flightdeck.

The non-routine tasks that are performed in line maintenance usually relate to: clearing defects that arise in the cabin; clearing flight deck effects and problems; and malfunctions with aircraft systems and components. System and component malfunctions are diagnosed with the use of printed or electronic technical manuals provided by an operator's engineering department.

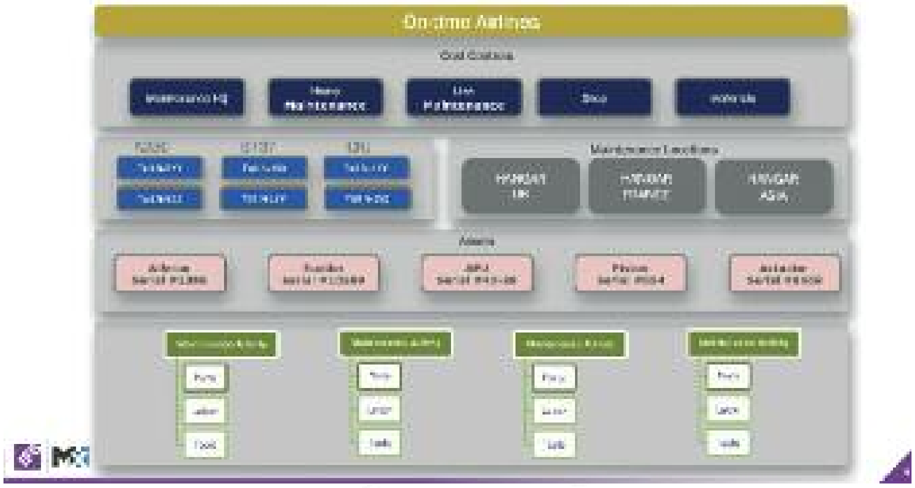
Most routine and non-routine line maintenance tasks on the aircraft's systems and cabin items are performed by line mechanics licensed for these areas. Any casualty maintenance for physical damage to the aircraft during operation requires a specially planned check, carried out by mechanics licensed for structural repairs.

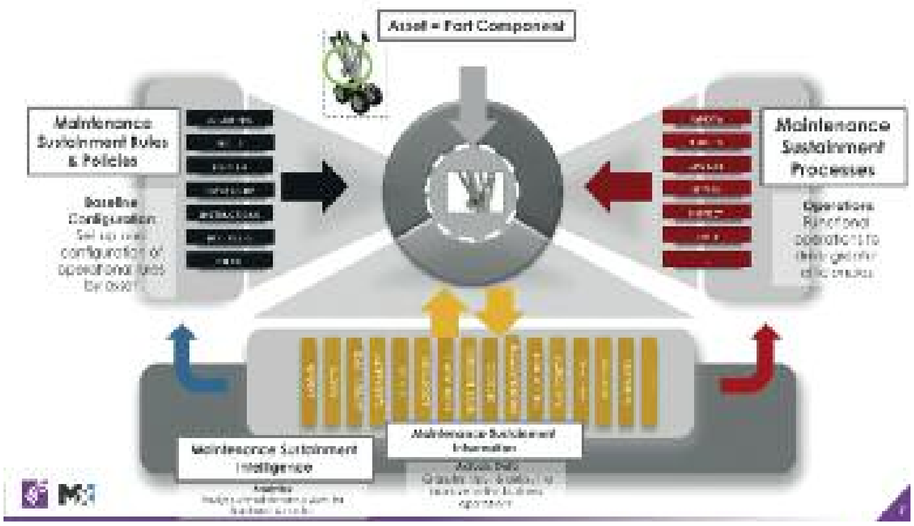
In addition to performing routine fixes and diagnosing faults, line mechanics often have to remove faulty or damaged components and replace them with serviceable units from an inventory.

All categories of materials, parts and components will be used during line maintenance. These include consumables such as cleaning fluids and liquids, sealants, greases, oils, tissues, rags and papers. It is virtually impossible to measure the cost of consumables used on each check. Instead, the total cost of consumables used at each line maintenance base or outstation will be recorded over an extended period. This will have to be amortised as a semi-direct cost or overhead, and apportioned either per aircraft flight hour (FH) or by aircraft fleet type.

Expendables are basic, non-repairable parts, such as nuts, screws, washers, clips, wires, filters and other simple parts. More complex expendables include lightbulbs, batteries, valves and regulators. All expendables are throwaway items. It is difficult to track the cost of some on an individual aircraft or fleet basis, although this is becoming easier because items can now be individually tracked with barcodes. This requires every expendable component used to be labelled, and its use and association recorded with a maintenance task card.

Repairables and rotables are components that are economic to repair on removal from the aircraft, and are then returned to the inventory stores to be installed on an aircraft at a later date. The cost of these components will therefore be their initial capital cost, which will be amortised over the





The multiple elements of direct, semi-direct and overhead costs in aircraft maintenance are illustrated by IFS. The chart also gives a diagrammatic presentation of how these elements should be organised to analyse total aircraft maintenance costs.

component's full life; its repair and testing costs for each repair; and some possible modification or upgrade costs once or even several times during its useful life.

Line maintenance cannot be viewed in isolation. This is because it overlaps with hangar maintenance and casualty maintenance, and involves the constant repair of repairable and rotable components, which is an element of component maintenance.

Base & hangar maintenance

While base and hangar airframe maintenance differs in several key ways to line maintenance, it also has a few similarities. The main similarity is that the larger line checks are sometimes performed in the hangar, and need some gantry, aircraft access and ground servicing equipment. The hangar also has several associated overhead costs, including: heat and lighting, general maintenance, and administration staff. These factors also apply to base maintenance.

The main difference to line maintenance, is that base maintenance checks are arranged in a pattern of light or 'A' checks, and base or 'C' checks. Base or 'C' checks are arranged in a cycle of varying depth, number of maintenance tasks, and total downtime. All checks, however, require a variety of skills because of the diversity of tasks that have to be performed.

These skills include electronics and avionics, aircraft structures, mechanical fitter, and painter. A variety of mechanic licences will therefore be needed for the performance of base checks, and in the correct number and ratios, according to the task cards scheduled in the check. Base checks also involve removing aircraft components and structures for repair and refurbishment in hangar backshops. This includes flight surfaces and various interior items such as galleys and toilets.

Base checks involve testing and calibrating various aircraft components and systems as part of some of the task cards. Discovery of defects can involve removing faulty components, as in the case of line maintenance, which are then sent for repair.

The performance of routine tasks in base maintenance is divided into several categories, including: simple visual inspection, detailed inspection, cleaning, removal and replacement, lubrication, functional test, measuring, calibration, operational check, restoration, and discard.

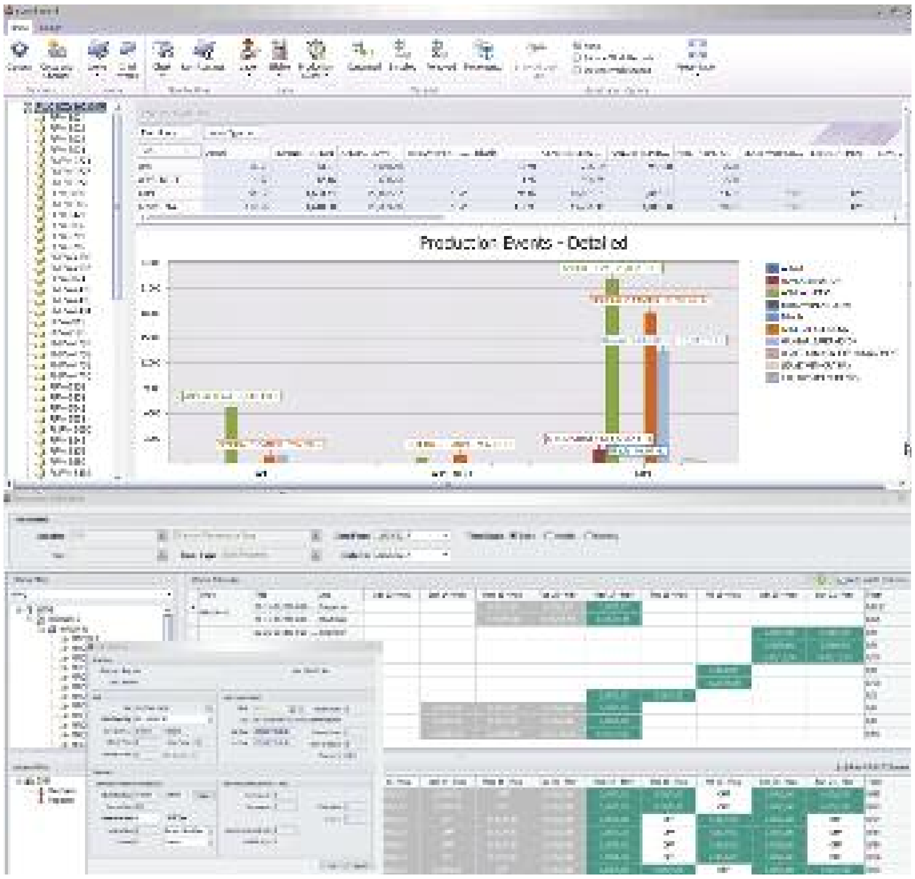
Non-routine tasks in base maintenance arise from physical damage or corrosion to the aircraft structure, certain components or systems not being correctly calibrated or functioning, or the replacement or repair of parts or assemblies. A certain portion of non-routine cards can be standard, so they can be pre-written by engineering staff and supervisors, while others have to be written after a full assessment of the defect has been made. This can include a structural repair, or a defect relating to a non-component or major assembly finding being designed and developed by the original equipment manufacturer (OEM).

The two main elements of base checks are routine tasks, and non-routine defect rectification tasks that arise as a result. There are, however, several other elements of base checks that incur the use of labour and consumption of materials and parts. The first of these is aircraft preparation and docking in the hangar, and flight testing following the check. Further to non-routine there is simple cleaning and removal of more basic interior items such as curtains, seats and carpets.

More significant elements are the routine portions related to the inspections detailed in airworthiness directives (ADs), related non-routine defects, and the implementation of service bulletins (SBs) and engineering orders (EOs). Further to this, there is the removal and replacement of fixed life components, such as safety equipment, and the removal of heavy components and engines for repair and overhaul, including the auxiliary power unit (APU), landing gear, and thrust reversers. Repairing these comes under component maintenance costs, while the MH used to remove and replace them will be part of the airframe check.

Other elements of base checks include interior refurbishment, and stripping and painting.

Base checks will use a higher degree of expendable components than line checks. Some of these will be standard for routine task cards, and others will be predictable. In this case the part numbers (P/Ns) that an airline or MRO can use for a particular task or sub-task will be listed in the approved parts list (APL), and on a paper printed traditional task card, or on an electronic task card in the case of a mobile maintenance system. The mechanic can select an appropriate P/N and request it from the parts stores



Seabury Solutions' Alkym M&E system has production control and roster control modules for the accurate planning, monitoring and recording of airframe maintenance events and checks.

located within or close to the hangar. It is possible to associate each expendable used for each task card.

The functional, system, calibration, and measuring tasks performed during base checks often reveals malfunctioning components and systems. These are often repairable and rotable components that will be removed for repair and replaced with serviceable units from inventories, as in line maintenance and on-going aircraft operations. As with line maintenance, this is where airframe maintenance overlaps with component maintenance.

SFDC

Shop floor data collection (SFDC) is a system that records all the direct labour man-hours (MH) for all categories of task cards and all expendable parts and components.

Its main use has been in hangar and base airframe checks, but SFDC has more recently been adopted for line maintenance. The SFDC system was first developed for printed task cards, which were labelled with barcodes that could be swiped with a reader by the assigned mechanic at the start of a task, and then at the completion of each sub-task. The system records how many minutes are used to perform each sub-task, and the total time to complete the task.

The AMOS system not only records the time used for each sub-task, but also records the labour used at each sub-step. "This can be a requirement of some users," says Ron Schaeuffele, chief executive officer at Swiss AS. "The detail of the information kept is determined by the user's engineering department. The AMOS mobile system records these times simply by clicking each sub-step."

"SFDC is not just direct labour MH recorded for each maintenance task," says Chris Reed, managing director at Trax. "It also records the total MH and productive hours logged each day by each mechanic performing maintenance tasks. The ratio of the two is required to calculate labour efficiency.

"MH could be recorded with barcodes on printed cards, and mechanics could log their shift start and finish times on the human resource module of the M&E system," continues Reed. "Mobile maintenance systems for electronic task cards have been designed to make the performance of maintenance tasks easier. An additional benefit is the ability for a mechanic to record their shift start and finish times, save time looking for assigned task cards, save time searching through paper manuals, and record MH used for each sub-task. This improves employee efficiency and the accuracy of recording labour used. Each employee can also be tracked with a mobile maintenance system.

"It is even possible that with a paper task card system, with or without barcodes to manually record MH, many maintenance providers were often under-charging MH used for third-party maintenance they performed," adds Reed. "With accurate labour MH used for checks, accurate forecasts of labour required for future checks can be made, improving the accuracy of providing quotes."

M&E systems have generally developed an SFDC functionality. Alkym, provided by Seabury Solutions, is accompanied by a maintenance performance analysis system called MPAS. MPAS is a financial system, unique in the M&E system market place. "We have configured Alkym for both paper task cards with barcodes, and for a mobile system. With the latter, each mechanic has a mobile device, such as a tablet, to record all direct inputs for maintenance tasks. The tablet device also has a camera.

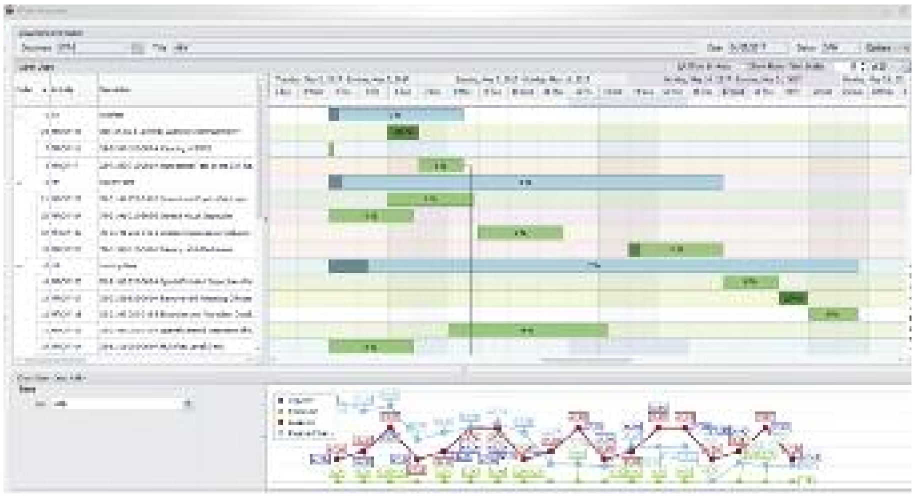
SFDC with printed cards and mobile maintenance systems is also used in the same way to record the consumption of expendable pars. Each expendable part will be requested by a mechanic, or supplied as standard with a task card, and can be recorded as being consumed using a barcode system.

"All materials and parts have a unit cost," says Barend van de Vrande, vice president product management, implementation and support at Aerosoft. "The use of materials or a part is tracked in an audit table for the job card and maintenance event."

Equally, returned parts not used are also recorded so that their associated cost is not included. This system is used by Commsoft's OASES, as it is by Trax, AMOS, Alkym and a host of other M&E systems.

"A lot of data can be pre-loaded from the maintenance planning department, since it is predictable," says James Elliott, director MRO edition product line at IFS. "A mobile system with interactive task cards will automatically capture the remaining direct maintenance cost data. Our interactive task card system takes the engineering assistance that a mechanic may require into account when a problem arises during a task card performance. This is because some users may want to add this input into the direct costs."

Another issue to be appreciated with SFDC data for MH used is that it only applies to the direct labour used for maintenance. That is, the MH used by mechanics performing the various tasks. The direct cost of labour will of course be more than their mechanics' pay rate per hour. Additional direct labour costs



Seabury's Alkym system has a check planning simulator. This analyses all required inputs and elapsed time of tasks, and produces an overall plan and total downtime for the check.

incurred by the employer and maintenance provider will include the cost of training, mechanics' clothing, employer's insurance and pension contributions, as well as overtime labour hours.

There will also be additional overheads associated with labour provided by mechanics, including: the cost of employing engineering, supervisor and management staff; the cost of providing staff facilities; and all cost elements associated with hangar facilties. These are generally regarded as overheads. There are several ways in which the total of these can be amortised over direct labour costs to provide a burdened labour cost. SFDC is only concerned with the direct labour consumed to perform maintenance checks.

There are also packing, transport, storage and handling costs associated with supplying expendable parts and consumable materials. In most cases these will be added to the direct costs of the parts and provide a gross cost, rather than a burdened cost.

In the case of rotables exchanged during checks following functional tests, SFDC can be used to record the serial number (S/N), which also enables the M&E system to track parts for compiling component reliability and inventory calculations.

Line maintenance inputs

Several factors complicate the recording of direct inputs for line checks. These include the fact that line maintenance is performed at several bases and all outstations of an airline's route network. Some of this will be performed in-house by mechanics, but it is outsourced to other airlines or specialist providers in most outstations, which can number dozens or even hundreds of locations.

Inputs for in-house line checks are becoming easier as the use of electronic technical logs (ETLs) and mobile maintenance systems becomes more widespread. Using subcontractors for line maintenance adds complications because they all use different systems, and have different methods for charging the operator.

"The recording of line check inputs in AMOS is always performed on the lowest defined level, which is worksteps. They can later be aggregated to any level the airlines requires, such as individual aircraft or a fleet type," says Schaeuffele. "This is according to the customer's wishes. The system can go into further detail and analyse costs by Air Transport Association (ATA) Chapter if required.

"Recording inputs used at outstations will often require manually inputting the direct cost data into AMOS, because most third-party line maintenance providers do not have IT systems that can feed data directly into an airline's AMOS system. This data will have to include rotable component consumption. An airline will also want the same level of detail as that recorded by their own mechanics for line checks performed at their home bases."

Outsourced line maintenance contracts are often charged on a fixed cost basis. The detail of the split between labour, consumables and expendables will vary by supplier. This makes it difficult to analyse details of actual expenditure on line maintenance. "Third-party contractors do, however, need to supply details of rotable component changes for compliance purposes," says Elliott. "The remainder of the information provided and its granularity will vary with suppliers. Fixed-price contracts usually supply the least amount of detail."

Van de Vrande says that the cost of line maintenance performed by a third party is associated to the aircraft via its registration and the work order, making some details of line maintenance relatively easy to track.

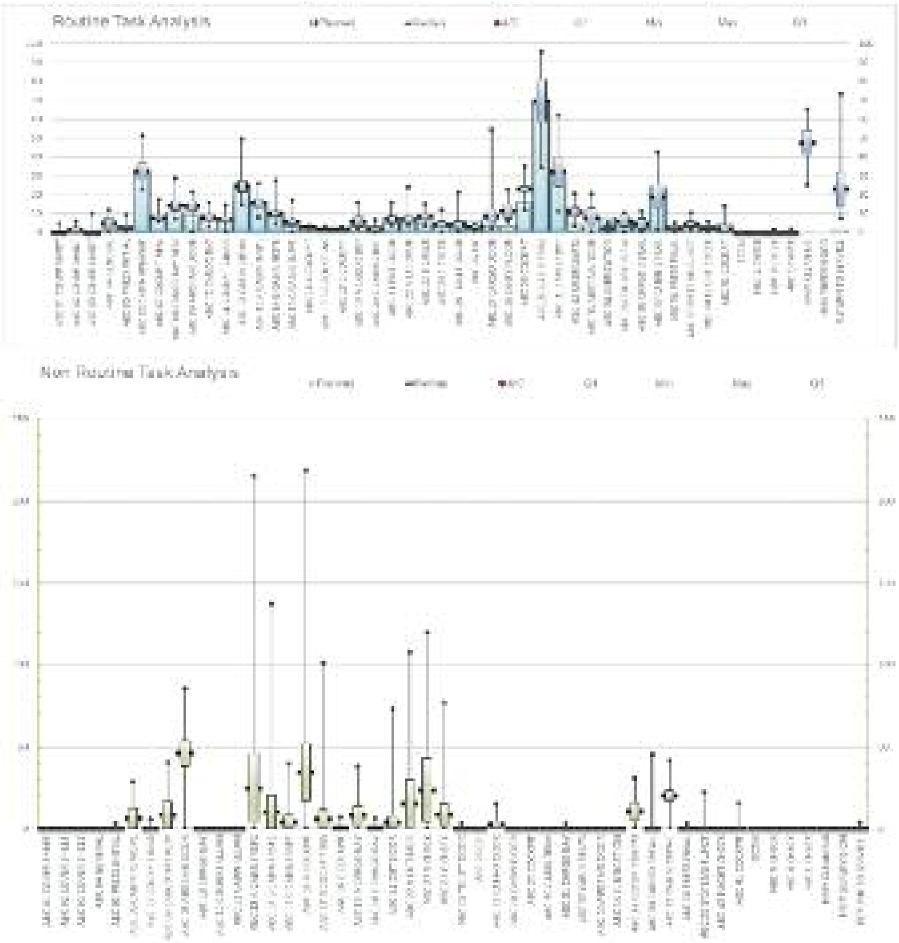
In the case of paper-based maintenance, the direct inputs have to be manually recorded by line mechanics, and then manually entered into the M&E system. If an ETL is used then any data relating to maintenance performed will be uploaded into the M&E system, since they have to be interfaced. "The materials used for clearing defects performed on the line can be entered into ETLs, and this is then picked up through component changes or issues for each aircraft in the maintenance cost module," explains Julian Beames, business operations manager at Commsoft.

The issues of rotable exchanges and replacements also have to be considered. "Not only do the S/Ns of components removed and installed on the aircraft have to be recorded, but there are several other issues relating to rotable components used during line checks," says Reed. "One is that many airlines use pooling agreements and rotable supply contracts to provide rotables, especially for the high-cost items. If the costs of these are to be analysed in depth to provide a true and detailed picture of an aircraft's maintenance costs then the system has to be able to track rotables at all locations inside and outside of the airline's operation.

"There is also the issue of tracking parts that have been loaned or acquired through the international airline technical pool (IATP)," continues Reed. "The cost of the IATP will include standard membership fees, but will also require a daily charge for each component not returned after a particular time. The details of the component borrowed, the aircraft to which it was fitted, and the permitted time the component can be used before a penalty is incurred, and an alert to return the part can all be recorded and the relevant functionality included in Trax."

SFDC data utilisation

"Our system breaks down labour input data to a granular level," says John Barry, senior vice president head of sales and marketing at Seabury Solutions. "MH are not just recorded for each task, but for each individual step performed. One reason for this level of detail is that the complexity of sub-tasks varies between basic steps and functions, such as opening panels or preparation; and performing complex items such as repairs or calibrations. Different steps require different skills."



Trax has a module to analyse the man-hour inputs for all categories of routine and non-routine labour inputs in an airframe check taken from SFDC data. These inputs can be displayed to show how they compare to averages, minimum and maximum values.

The same functionality is included in other M&E systems, such as AMOS provided by Swiss Aviation software. The individual steps of a maintenance task can be recorded, as well as the MH for the different categories of tasks performed, such as: aircraft preparation, routine, non-routine, inspections for ADs, non-routine defects for ADs, performance of SBs and EOs, and all other elements of airframe maintenance checks. This will give the airline or maintenance provider a detailed picture of MH used for the different elements of the check, and other useful information such as the non-routine ratio. It also allows the user to apply different labour rates for different skills when quoting for third-party maintenance contracts.

The detailed and categorised MH data for an airframe check and for a particular aircraft can be used to collate information for other checks performed. The detailed MH data for the same check, such as the first C check in a base check cycle, are collected for every aircraft in a fleet. This first gives a spread and average number of MH used in total for the check, and averages for each element of the check, including: aircraft preparation, routine inspections, non-routines for clearing defects and findings, performing SBs and EOs, and all other elements. It also provides an average non-routine ratio.

The data for a series of checks can then be analysed for an aircraft to examine issues such as the increase in non-routine ratio as the aircraft gets older, and as each successive check in the cycle is performed. This can also be done on a fleetwide basis. The non-routine ratio generally increases throughout a base check cycle with each check, and reaches its maximum at the last, deepest and heaviest check in the cycle. The non-routine ratio then declines at the first base check of the subsequent base check cycle. It will then steadily climb with each subsequent check in the cycle, and overall be higher in the second check than the corresponding checks in the second and subsequent base check cycles.

The M&E system, and the MH data collected, can be used to analyse these changes in non-routine ratio, and overall MH consumption, during an aircraft's operational life.

The same analysis of the use of expendable parts and the consumption of rotable components, or frequency with which they are changed, can be analysed in the same way as labour costs. That is, the direct MH and material cost inputs can be examined over a period or maintenance interval according to the user's requirements.

Ultimately therefore all levels of line, A and C or base checks, and upgrades and modifications can be examined over check cycle intervals, or FH accumulated over a year, or per base check interval.

Such analysis not only indicates how the maintenance costs of a fleet type are changing with age, but also highlights aircraft with particular problems that are resulting in higher than average maintenance costs.

The use of SFDC can therefore provide granular detail of direct maintenance costs. Aerosoft uses its DigiREPORTS to analyse SFDC data and produce the reports of inputs used either on screen, or as soft or hard copies.

"The use of SFDC goes further than analysing direct labour, consumable and expendable inputs for airframe and other maintenance," says Reed. "In the case of hangar and base checks, SFDC data can also be used for planning hangar capacity, identifying when a maintenance provider has spare or surplus capacity to sell, calculating maintenance reserves for future airframe checks for a fleet type, gathering non-routine and findings or data relating to defects to be used in extending maintenance task and check intervals, and making warranty and insurance claims on prematurely failing and defective rotable components."

Engine maintenance

The second main element of aircraft maintenance relates to engines. The nature of engine maintenance has changed a lot over the past 25 years, with many larger airlines having divested their engine repair and overhaul shops. A large portion of engine maintenance is now sub-contracted by airlines, so maintenance providers give limited details of engine shop visit (SV) inputs.

The first issue to be appreciated is the dividing lines between engine maintenance, maintenance of engine line replaceable unit (LRU) rotable and accessory components, and maintenance involved in removing and installing engines. While the maintenance of engine turbomachinery is managed separately to airframe maintenance, the removal and installation of engines is timed together with airframe checks because of the elapsed time and gantry required. This is regarded as an element of airframe maintenance, and the relevant MH and materials will be recorded along with all other SFDC data taken from a check.

The LRUs and accessories mounted on the engine casing are a portion of the aircraft's rotable components. Similar to other rotable components, they are removed and installed during line and hangar checks as required.

The disassembly, inspection, repair and reassembly of the engine for turbomachinery maintenance is classed as actual engine maintenance. This is first broken down into engine modules that include the fan, low pressure compressor (LPC), high pressure compressor (HPC), combustor, high pressure turbine (HPT), and low pressure turbine (LPT). These are then inspected, and can be broken down to piece part level. The parts can be repaired or replaced, and then the assemblies, modules and engine re-assembled. The details of the direct labour, new parts and repairs to existing parts can all be recorded if required to provide detailed analysis of engine SV costs.

These details can then be matched with the removal intervals in engine flight hours (EFH) and engine flight cycles (EFC) for the respective engine. The costs for maintaining each module and the engine as a whole over the relevant interval can then be analysed if required, provided the engine operator has the functionality in their M&E system. "Our airline customers do not have their own engine shops, and they all sub-contract engine maintenance," says Barry. "Alkym does, however, have the capability to examine the detail of all the inputs for the different modules in an engine. It can also analyse the costs for the different parts of the engine, such as how the cost of repairing and maintaining the blades and vanes in the HPT module is changing per EFH or EFC over successive removal intervals."

There are several types of maintenance contacts, but few will provide the granular level of detail that allows this depth of analysis. Besides in-house engine maintenance, only time-and-material contracts are likely to provide the detailed analysis. This will come from the invoice provided by the shop after the SV, but the level of detail depends on the engine shop being used.

Other types of engine maintenance contract include fixed-cost and fixed-cost per EFH or EFC contracts. Their nature means that details of inputs are unlikely to be provided, especially for contracts provided by engine OEMs.

The IFS system also has the functionality to capture the detail of the work done in an SV. "The system can record the detail of an engine SV done to the individual part and component level," says Elliot. "The detail of which blades and vanes have been replaced at what cost, and which parts have been repaired together with either the associated in-house or sub-contracted repair cost can also be recorded."

AMOS can also record details of engine SV maintenance if the user requires it, but the main issue is the detail provided by the engine shop. "The information will always be captured against the actual workstep. There is no difference between engine maintenance, and line, base or component maintenance," says Schaueffele.

For most airlines, engines are maintained on a fixed price per EFH or EFC basis, and these rates will be loaded into the M&E system and associated with the engines and their respective removal intervals.

Component maintenance

The repair and maintenance of repairable and rotable components is broadly the third main category of aircraft maintenance. Rotables and repairables are sub-divided into several categories.

The first of these are heavy components, and fall broadly into the four main classes of landing gear, wheels and brakes, the APU, and thrust reversers. The landing gear has fixed

Swiss AMOS has a module to calculate and display the financial performance of third party maintenance in terms of revenues received versus inputs and incurred costs.

overhaul intervals, while the other three are maintained on an on-condition basis. Brakes and wheels, including tyres and wheel rims, are some of the simplest components to maintain, so many airlines have their own shops. Most airlines sub-contract the maintenance of the other three. The APU is similar to an engine, so many maintenance contracts are similar to engine MRO in terms of fixed cost SVs or cost-per-hour contracts.

The largest group of rotables and repairables is airframe system components that relate to avionics, electronics, electrical and wiring, pneumatics, pressurisation, hydraulics, lights, water and plumbing, safety equipment, and fire control, among others. Engine LRUs and accessories are included in these groups.

These can be acquired, repaired and managed through several mechanisms. Traditionally, large airlines have owned these components, and repaired them in their own shops. In this case, the details of MH and parts used can be accurately recorded on the same basis as SFDC data.

Airlines have managed to avoid the capital costs of acquiring inventories of these components through a variety of packages. A popular system is for the airline to pay for fixed rates per FH for a base core inventory of parts and access to a pool of remaining components. A third rate per FH can then be paid for their repair, management and related logistics.

Commsoft's OASES, for example, has a module that supports the set-up of material pooling agreements. These provide an inventory of rotables kept in a pool, and give access to a group of airlines operating the same aircraft type. The typical structure is for each airline member to pay an access or membership fee on a fixed rate per month or FH basis, and then pay a separate fee for a component each time one is required.

"Agreements are specified for a fleet, sub-fleet or even a selected aircraft," says Beames. "The costs incurred by the agreement can be shared in OASES between applicable aircraft on an equal basis, or apportioned according to total FH accumulated by the fleet. Agreements can also be entered in any currency, and then converted into another for a set of specific dates if required. Parts covered in the agreement will have a zero cost when used, and instead an apportioned agreement cost will be added to the calculations for each aircraft, which reflects the contracted cost per FH or FC."

Some components can be managed through simple exchange programmes, where serviceable parts are provided in return for a fixed fee which includes an element for the item's capital cost and another for its repair. This is a popular system for landing gear.

In many cases it is easy to track and analyse the maintenance costs of components. More details of the cost of repairing a component are available in the case of in-house repairs or repairs done by third-party shops, and the information on labour and materials used for the repair order generated.

"The elements of direct inputs used will be provided by most independent component repair specialists," says Barry. "There is now a combination of manual paper component repair records and electronic or pdf records. Truly electronic records clearly make it easier to transfer data from the repair shop's finding and repair reports to the M&E system." What limits the information available, however, depends on what is available on the invoice. This will inevitably vary between shops.

"OASES supports quotations and invoices for repairs performed by a third party," says Beames. "Work provided by a third party is collected into a works order. This is sent to the maintenance provider for a quotation, and the system can record all the quotes gathered, and the user can specify the preferred quote. These are used for budgeting purposes. When the work is completed by the MRO, the invoices can be entered, and are added to the historical costs. Quotes and costs can be entered into the supplier's currency, and then converted into the user's local currency or another currency as required."

In addition to the labour and materials used, other cost elements of rotable and repairable component maintenance costs are related to transport, customs and taxes and all other logistics. These can all be added to the repair costs to give a total direct cost for repairable and rotable components.

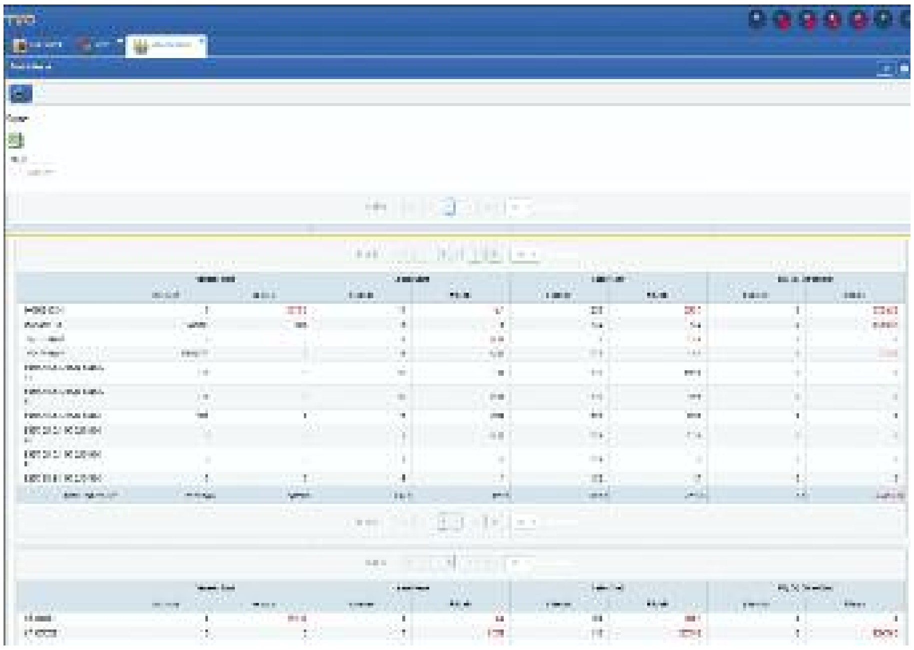
The use of component repair cost information will vary, and M&E system functionality can be provided for the variety of ways a user may want to analyse rotable-related costs. M&E systems already have the functionality to provide component removal interval and reliability data, as well as rotable component tracking. The follow-on from this, therefore, is to use the cost information to compare the removal interval and reliability information together with repair costs for an individual component of the same P/N or even dash number of a P/N to track its average repair cost per FH over the long term. This information can be used to identify areas for improvement, or opportunities to reduce costs.

The system can further collate all rotable repair and ownership cost information to generate a total cost for a fleet type. This might be based on a cost per FH. This could be recalculated monthly for example, and displayed as a rolling 12-month average.

Fixed costs & overheads

There are additional costs to those of direct labour from mechanics performing touch maintenance and all the materials and parts used. These are the fixed and overhead costs that are added to the direct costs to provide total costs of maintenance.

Overheads include the cost of: employing engineering and supervisor staff; maintaining and distributing a library of technical manuals and IT systems; and maintaining staff facilities,



Trax has a work order cost module to analyse the labour and material inputs for a maintenance event, compare actual inputs with estimates, and break down inputs into categories such as routine, non-routine, and EOs and ADs.

administration, maintenance facilities and equipment.

It is possible to apportion or attribute some of these fixed costs to particular aircraft checks or fleet types, while others cannot be apportioned. Those that can be attributed to a fleet type or split between several fleet types may be regarded as semi-fixed costs. These can include the cost of engineering staff, particular manuals and sets of documents, or certain facilities and equipment that are dedicated to a fleet or fleets. Examples of the latter are hangars and other facilities that are used exclusively for regional aircraft, and others that are used solely for narrowbodies or widebodies.

The issue of whether costs can be attributed to aircraft or fleet types depends on the detail of invoices relating to those costs, the IT functionality and ability to easily apportion them, and the finance department's requirements. If facilities for different fleet types are sufficiently separate and have different invoices for the costs of depreciation, heat and lighting, and staff facilities, and general maintenance then it is easy to attribute them between, for example, the regional, narrowbody and widebody fleets.

Other costs that may be apportioned are engineering and management teams, and related costs of IT systems. It depends, however, on how the user organises its engineering department staff. "An example of apportioning these costs per fleet type or by individual aircraft is the time spent by planning engineers on preparing a check for each aircraft," says Schaeuffele. This method, however, only relates to a small portion of the total cost of employing an engineering team.

Pure overheads include general staff facilities, such as car parks and canteens and related amenities; administration and accounting staff; IT systems; and general equipment and vehicles. These will be regarded as pure fixed costs, and will be apportioned as an overall cost per FH over the entire fleet in the case of an airline.

Commsoft's OASES system allows the user to enter associated costs, or semi-fixed overheads. "These can be allocated in one of three ways," says Beames. "The first is by apportioning them equally across all fleets, the second by deriving a cost per FH by using the individual aircraft FH for each aircraft, and the third by apportioning the cost on an FH to flight cycle (FC) ratio which more accurately apportions cost for items such as landing gears."

Most M&E systems specialise in direct maintenance costs and inputs, and their analysis, and traditionally do not have the functionality to operate as an overall financial and accounting system.

The cost of facilities, general staff and administration comes under the user's financial accounting and human resources (HR) system, which provides data to the M&E system for the engineering department to calculate total maintenance costs.

Seabury's Alkym system is one of the few M&E systems that accounts for all general costs relating to overheads, as well as direct maintenance costs. It captures administration and general staff, and engineering management costs. It also captures all costs relating to the equipment and facilities for component repairs and maintenance, as well as those relating to equipment and tools. The only costs that Alkym does not deal with are those relating to hangar and staff facilities.

"The MPAS product we offer can also take general overheads and other fixed costs from a user's accounting and HR system, and the direct maintenance cost inputs from their M&E system, and put them together to provide a combined total maintenance cost," says Barry. "MPAS allows the user to define how to allocate overheads and semi-overheads. How they are allocated depends on the user's requirements."

Once semi-fixed costs have been apportioned as required and calculated on a per FH basis, and pure fixed costs are also determined on a per FH basis, then the total cost per FH for a fleet type and individual aircraft can be calculated.

"MPAS is purely an analysis system. Administration and general overheads are usually held in a user's finance and HR system, and MPAS can be fed by these plus an M&E system," continues Barry.

Total maintenance cost

The ultimate goal of reaching the total costs for a fleet type and individual aircraft will be to have a detailed breakdown of all the elements of direct maintenance costs, and the associated apportioned overheads of each element where possible, and finally the general overheads. In addition to this, these total maintenance costs can be observed over a 12-month rolling average, or over a C or base check cycle interval. Different elements can be observed over various intervals. An example would be A checks over an A check cycle interval, base checks over a base check cycle interval, landing gear over its overhaul interval, and most other elements on a rolling 12-month average per FH rate.

In addition to total costs per FH for the aircraft, users can also derive the total burdened labour rate, and breakdown of all its elements. This is essential for quoting for third-party work, and for an airline to assess on-going maintenance costs.

Total burdened maintenance costs for an aircraft, and all its various elements are necessary to determine which elements of maintenance can be performed efficiently in-house, and which it would be more economic to sub-contract. - *CHW* AC