There are several management functions a M&E system must be able to perform to complete the full function of managing the maintenance process. These management functions include personnel and human resources, manpower planning & assignment, finance, and asset management.

M&E system functionality for HR, finance & asset management

There are several management functions that have to be carried out within an airline's maintenance & engineering (M&E) division. These also overlap with the airline's main management tasks, such as personnel, finance, and asset management tasks.

These management tasks are integral to managing the maintenance process. An airline M&E division or an independent maintenance repair and overhaul (MRO) facility needs the functionality to perform these tasks in their M&E or enterprise resource planning (ERP) systems.

ERP systems were first developed to provide a system for performing all management tasks for all types of organisation. Some ERP systems were also customised to perform the specialised tasks of aircraft M&E. Airlines and MROs that have selected ERP systems should therefore have sufficient functionality and capability to perform all required human resources, finance and asset management tasks.

M&E systems perform these management tasks to varying degrees, although they do not generally have the complete management task capability that ERP systems do. The completion of all management tasks, partially performed by the airline's or MRO's management system, will have to be completed by its main management IT system. There therefore needs to be an interface and data flow between the M&E and management systems. The M&E system, however, will need to have sufficient management task functionality to perform most of the tasks on its own.

Human resources

To perform maintenance, the M&E system has to keep a large amount of information and data in relation to its employees: the engineers and mechanics.

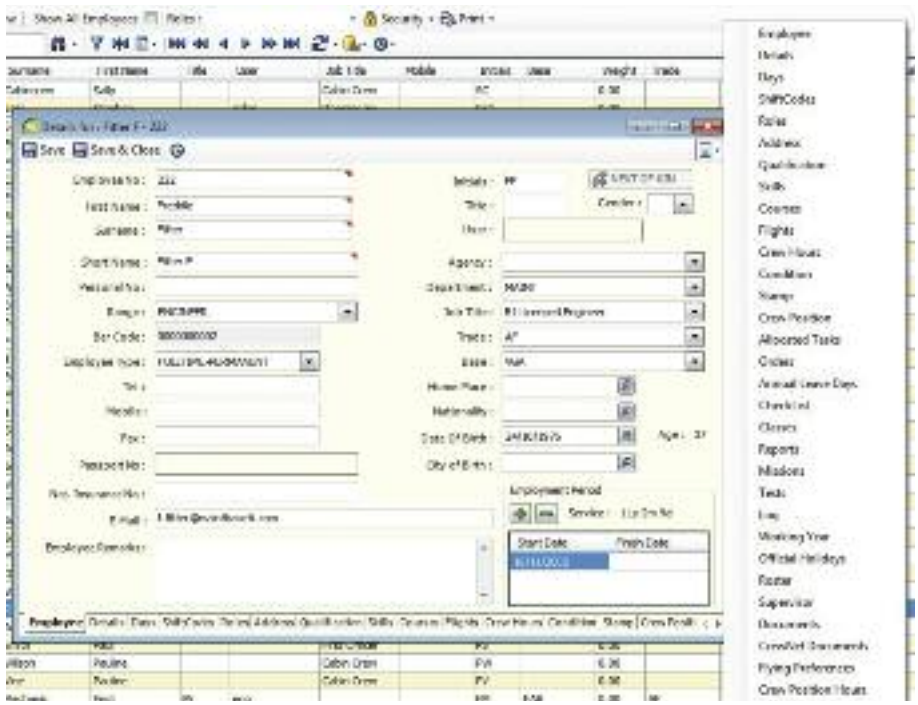
Employee database

The basis for managing employees and work schedules is having all relevant data for each employee.

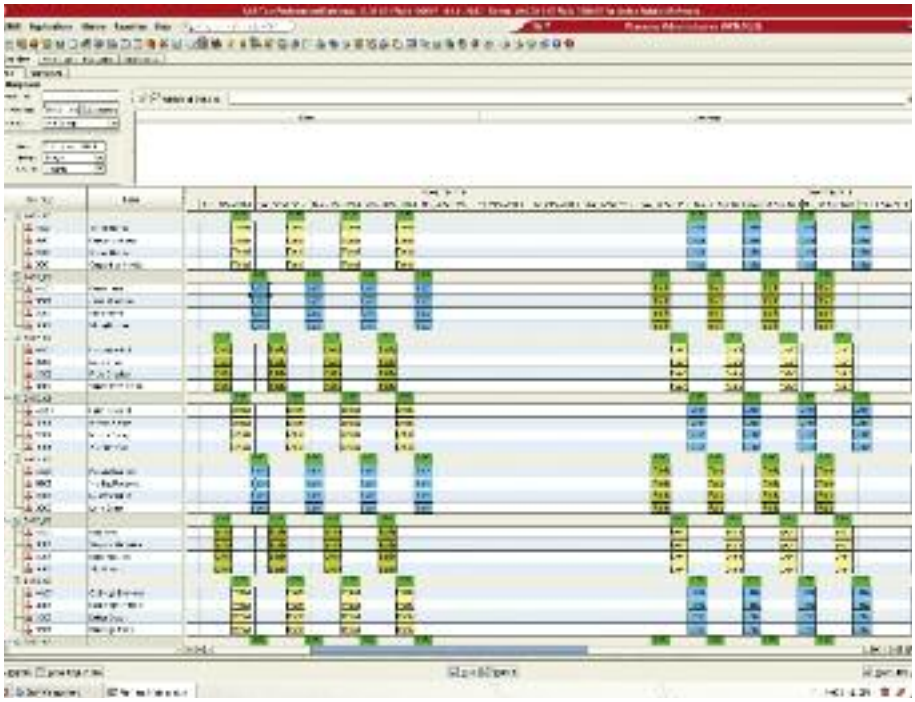
M&E systems will build a database of all employees' details, starting with basic personal information, such as full name, date of birth and gender. The main function of managing each engineer and mechanic, however, revolves around their skills, qualifications and licences. In the case of aircraft line and base maintenance, for example, mechanics will have B1 and B2 licences. Some will also have aircraft types and specific approvals on their licences.

Information on employees' licencing, qualifications and skills includes: when licences and qualifications expire; what approvals for particular regulatory authorities the employee has for their licences and qualifications; what training courses will be required and when; what hours the employee is permitted to work and what hours they have actually worked; hourly basic and overtime rates of salary; work locations and what work schedules they are in or could be included in.

"This type of data may be held by an organisation's main management or ERP



Rusada's Envision provides an employee information record, so that all relevant details of every mechanic and engineer.



Swiss AMOS & Ultramain have a system of grouping employees, such as mechanics, into working groups or workshifts. The available groups of employees can be automatically matched to the workpackages that are planned on the same date in the forecasting module.

system," says Ronald Schauffele, chief executive offer at Swiss Aviation Software. "While some mechanic or engineering union rules may prevent the system user from seeing personal data, such as age, the user needs access to the main facts about the employee so that work shifts can be planned."

One main HR function that an M&E system will require is the ability to track the currency and expiry date of all licences and qualifications. "Maintenance and personnel managers need to have sufficient time to prepare for mechanics to take the necessary re-training courses and tests to keep their licences and ratings current, so that the amount of time they are not available for work is minimised," says Chris Reed, managing director at Trax. "Trax has a function to illustrate the expiry of all employees' licences on a timeline gantt chart. It also has the capability to provide alerts in advance of licence and qualification expiry, so that plans can be made to retrain employees without disruption to workflows."

The tracking of licence and qualification expiry dates has to be considered against in-house and external training schedules and programmes that have already been organised. This will then allow a system user to match the expiry of employees' licences with training programmes so that mechanics can be sent on the appropriate training classes and courses. "Ultramain has the functionality to set up a gantt chart of training schedules coming due, so that the user can plan each employee's training requirements," explains John Stone, vice president of product management at Ultramain. "The system will also produce a timeline of how many mechanics will have particular qualifications on every date several months into the future. This provides the necessary background information for labour planning. That is, the system can inform the user how many mechanics have B1 and B2 licences, and specific aircraft types and various approvals. This then allows the user to make appropriate decisions when planning allocation of labour and work shifts to particular maintenance checks and work packages."

A further capability linked to the employee information database is regulatory compliance in relation to licences and qualifications. "This is required because when a mechanic signs for a task; either manually on a printed task card, electronically on screen, or digitally; it has to be able to prove regulatory compliance," explains Stone. "In the case of electronic and digital signatures, Ultramain will only allow the mechanic to sign off the task if it has the appropriate licence and approval. This functionality is part of the system's capability for supporting end-to-end paperless operations."

Time & attendance

Another main issue with employee management is recording hours worked, and the rates paid per hour.

The number of hours worked requires a time and attendance function. Each employee will have the hours they have worked recorded by the system. "There are several technologies an employee can use to identify themselves when signing on for work," says Reed. "These can include the use of a fingerprint scanner, a radio frequency identification (RFID) smart card, or the use of a personal identification number (PIN). Trax then has a log for each time an employee signs in for work, and signs out again. This log, and the related hours each employee has worked, are fed into the payroll system."

The time and attendance recorded for each employee has to be compared with the system's database of the permitted hours and various stations and bases that each employee is allowed to work.

The recorded time and attendance for each employee is also more complicated than making a simple recording of hours

between signing in and out. "The M&E system also needs to keep a record of positive and negative working hours," says Schauffele. "Negative work will be the time an employee is not in active work. This will include time spent due to sickness or an accident. AMOS has the functionality to track the small amount of time that an employee is temporarily not working. This time is thus recorded as negative time, and deducted from the total time worked to calculate the positive time."

Not all M&E systems have a full payroll functionality. A payroll module in a M&E system needs at least to have the hourly rates of pay for each employee. There are several rates per hour, the first being the basic rate. There is then at least one hourly rate for overtime.

While an M&E system may not have payroll functionality, a user may require the system to have a database of all the different rates of pay for each employee. "AMOS uses a formula and algorithm to determine the number of hours an employee is paid for each of the different basic and overtime rates," explains Schauffele. "The formula will therefore be used to determine how many hours, above those paid at the basic rate of pay, are permitted for each rate of overtime for an employee. Several factors may determine what basic and overtime rate is paid, including the time of day worked and the day of the week, and if the employee has been called in to work on an off day or a holiday. The system therefore needs a grid or matrix of the multiple rules for hourly rates."

Labour & workshift planning

M&E systems plan and assign available labour to specific maintenance checks and workpackages by arranging groups of mechanics into workshifts or shift groups.

"The grouping of mechanics into workshifts is the simplest way to match available labour with maintenance checks. A typical method groups four or five mechanics into the same workshift, although larger groups in each workshift may be usual for some operators and MROs," explains Reed. "The grouping of mechanics starts with those that are able to work at the same location, or those that can work on similar types of maintenance. A relatively large group of mechanics that work at a particular outstation may be used for line maintenance, and another large group at an operator's main base or base of maintenance operations may be grouped into a large pool for base maintenance."

These larger groups of mechanics are sub-divided into smaller groups (the workshifts or shift groups), so that there are groups of mechanics available for the two or three shifts worked each day, and during the six or seven days a week that the organisation performs work. The sub-division of mechanics into smaller groups always ensures that mechanics have an allowance of unproductive periods when taking holidays, or sick leave. Mechanics can stay on the same workshift or shift group for the long term, until they gain new licences and approvals, are promoted or retire.

"A further macro issue, before the micro-planning of assigning each workshift to particular maintenance workpackages, is that the system should take each facility's capacity to perform maintenance, and its equipment into consideration," says Stone.

It is important for a system user to group particular mechanics into a workshift so that each one has a balance of skills and licences. There would have to be mechanics with B1 and B2 licences, and some with the aircraft type specified, and some with various approvals if a heavy base check with a variety of tasks was coming due. A smaller number of different skills would be required for line or light hangar checks.

"AMOS also maintains a productivity factor for each employee to ensure that only one inexperienced mechanic is

grouped into a workshift with several experienced ones. This means that the planned work is completed in the allocated time, which may not happen if there are too many inexperienced mechanics in the workshift," explains Schauffele.

There is also the issue of the holiday time each mechanic has requested in the year, and how this will affect labour planning.

Long-term maintenance planning can be made 12 months in advance. This will provide an approximate number and timing of all the different types of checks coming due for each fleet over that 12-month period. Short-term planning for base maintenance would be about six months in advance.

Mechanics may not know that long-range and even short-range maintenance plans are made when they plan or expect to have an annual holiday or vacation. Each mechanic in a workshift or shift pattern may later ask to take a vacation at a different time to the others, and so disrupt the organisation of the workshift.

Once mechanics have been grouped into particular workshifts, a plan has to be made so that there is the correct number of workshifts, or group of mechanics, available during each shift and on each day of the week to perform the maintenance that is required.

This plan of the day and time that each workshift is available can then be plotted and viewed on a timeline gantt chart. A separate chart can be made for each maintenance location. The time that each workshift is available for is indicated by a coloured horizontal bar.

The user can drill down on each bar to see the number of mechanics and what their skills and licences are, as well as the start and end time and date of each workshift.

The M&E system also needs to have information on the maintenance workpackages that are coming due. These will have already been determined in the system's maintenance planning module, which works together with the airline's scheduling module, if the user is an airline.

The M&E system will further know each maintenance location's capacity for several months ahead. For example, it will know that a particular line station has the capacity to use 25 man-hours (MH) each weekday evening.

"Ultramain will take the available labour at each maintenance location, from the workshifts available, and match it with the scheduled maintenance work packages and equipment," says Stone. "The system therefore decides where to place each aircraft for its upcoming maintenance workpackage. Ultramain therefore attempts to optimise maintenance that has to be performed and coming due with facilities, available parts and components, equipment, and relevant staff. The system will then indicate what shortages of labour, parts and other items there are. It can also indicate if the duration of a planned maintenance workpackage needs to change."

Once the available labour has been matched with the maintenance packages coming due, the shift plans get sent to the individual employees and mechanics. "A mechanic may then make requests, such as time off for a holiday, or a change to a different workshift," says Schauffele. "The maintenance and labour planner can decide if a request by a mechanic is possible. The user can also simulate the impact of certain requests, before deciding to grant or decline them."

Rusada's Envision has the ability to 'bank' overtime. That is, the user may have a policy that overtime already provided by mechanics can be stored or held. This then can be later used during periods of low demand, and applied to the individual mechanics or workshifts that provided the overtime. This way the overtime is used as regular labour, and so charged at basic rates of pay.

Asset management

The core function of tracking assets is to determine book depreciation schedules for parts, components, tools, equipment and vehicles. A record of the purchase price and residual value at disposal is also kept. Another main function involves tracking the location, serviceability status and ownership of rotable components.

The assets that can be monitored by an M&E system's asset management module or functionality therefore include: engines; rotable and repairable components; vehicles; tools; equipment; aircraft jacks and gantries; and facilities.

"To start the asset management process, the M&E system needs to have a register of all major fixed assets," explains Schauffele. "A database, similar to the one kept for employees, has to be kept in the system. It will have details such as the asset's unique serial number, the part number if an aircraft component, and the date of purchase."

The database is divided into the different categories of assets held by the

airline or MRO. Each asset is entered into the database when purchased and delivered to the user. "The records kept for each part or asset include: the date and value of the purchase (in several currencies if necessary); the annual depreciation; the depreciation term; the net book value at any time the user looks at the database; the final depreciated book value; and the residual value when the asset is sold," says Reed. The system will therefore need to be programmed with pre-defined depreciation rates for the different asset categories. These can either be standard depreciation models, or are defined by the user.

Many M&E systems also have the functionality to evaluate the total stock of rotable and repairable components and parts held by the user.

"This functionality comes from AMOS's ability to track all rotables," says Schauffele. "That is, all rotable and repairable components and parts are tracked and monitored as they are installed on an aircraft, removed from an aircraft, passed into transit, inspected, repaired and tested, and placed into inventory. The system will also be able to distinguish between components that are owned, and those that are borrowed or on exchange from other operators.

"The value of stock held by the airline or MRO user at any one time will only make the calculation based on components that are not installed on aircraft," continues Schauffele. "It therefore includes parts that are in store and inventory, in repair and in transit, and that are unserviceable. AMOS can break down the information on total asset value further. For example, it can list the value of inventory held by different aircraft and engine types, or the value of inventory held at each base and outstation. The user can further drill down to see what part numbers are held at each outstation, as well as sub-dividing inventory by owner and ATA chapter."

Similar data and information can be held that relates to tools, rigs, jigs, equipment and vehicles. The location, maintenance and serviceability status, and age of all this is required for maintenance event planning.

Ultramain is able to provide the user with a lot of detailed information on each asset, and the user can drill down the data to retrieve this. "An example of this is the assembly tree of an aircraft structure or a complex sub-assembly," says Stone. "The structure can be viewed on screen by ATA chapter and sub-chapter, and the individual components in each part of the structure listed by part and serial numbers. All of this is possible through the rotable component tracking functionality."

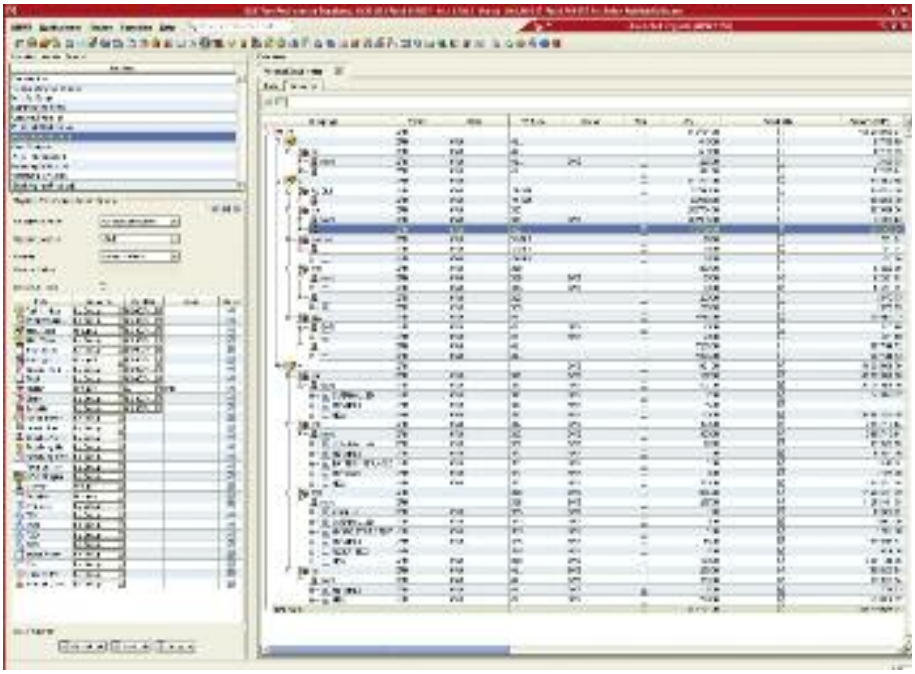
Finance

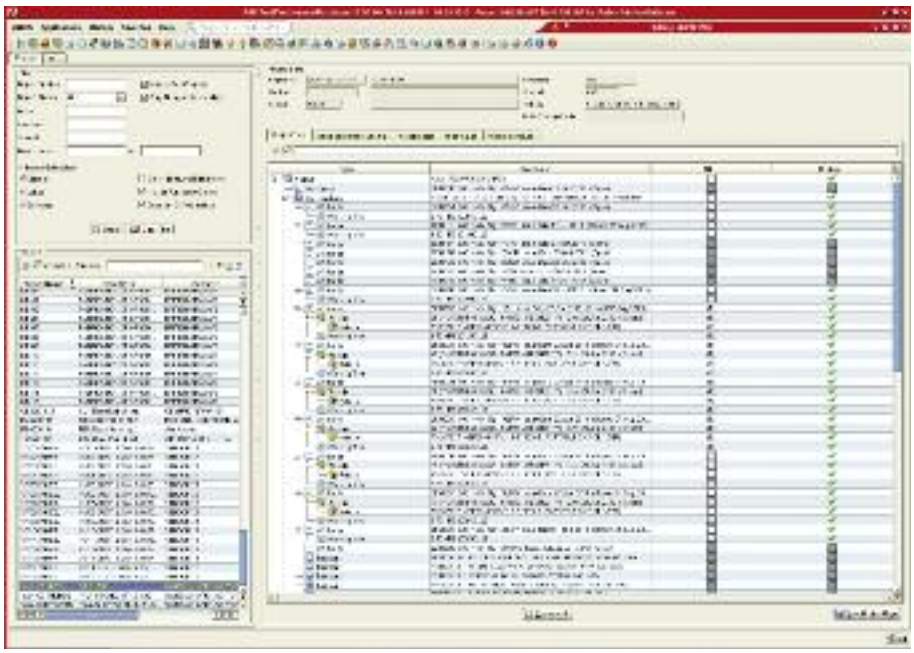
Besides the key function of payroll, finance involves purchasing and invoicing. Another main aim of using an M&E system to manage engineering and maintenance and activities is to get visibility of maintenance costs.

The functionality for purchasing and invoicing is relatively basic. An M&E system will typically reconcile purchase orders (PO) and invoices from suppliers, and will then send an instruction to the main accounting system for the invoice to be paid. "This process is a three-way matching of a PO, a delivery or receipt of goods, and an invoice," explains Reed.

Generating an invoice for third-party customers can start with the original data and information taken from the shop-floor data collection (SFDC) stored by the M&E system as maintenance is performed *(see Technology for SFDC & paperless maintenance, Aircraft Commerce, December 2011/January 2012, page 46)*.

The barcodes on printed or electronic task cards are scanned by the mechanic at the start of working on a job or task card, and scanned again when the task is completed. This therefore records the MH utilised for each task card. The same process can be used to record all the individual parts and components used





Swiss AMOS has the functionality to provide the value of all rotable and component stock held in total and at individual locations (top).

The system also has the capability to provide a detailed breakdown of the cost of a work order (below).

throughout a complete workscope and maintenance check.

"The SFDC data collected when performing a check for a customer can therefore be reviewed in AMOS," says Schauffele. "These results, as well as all other activities, such as part loans and exchanges, can all be recorded against a maintenance check. AMOS then cross-checks all the inputs in a check with contracts that have been made with the customer. This can, for example, be capping clauses for non-routine MH inputs on non-routine task cards, so that SFDC non-routine MH are not used and the flat-rate cost is used instead. AMOS then indicates what is billable, what is not billable, and what is invoiced for on a flat-rate basis."

An M&E system will then summarise all the labour MH, materials, parts, consumables, loans and exchanges relevant to the maintenance check.

Maintenance cost analysis

M&E systems can be used by airlines and MROs to provide details of maintenance costs for whole fleets, and different aircraft and engine types.

The basis for this functionality comes from the detailed SFDC data collected by an M&E system during maintenance. The detail from the task cards and the SFDC data collected in relation to them can be used to generate detailed analyses of maintenance inputs. Users may ultimately wish to examine total maintenance inputs for a fleet type over a calendar period, a specific maintenance cycle, or for the same type of check for every aircraft in the fleet. They may also wish to analyse maintenance inputs in more detail. MH, and materials and parts cost data can be sub-divided into that used for: routine inspections; non-routine rectifications; aircraft cleaning; interior repairs and refurbishment; stripping and repainting; incorporating airworthiness directives (ADs) and service bulletins (SBs); and performing engineering orders (EOs) and modifications.

"The maintenance input data can be analysed and sub-divided in many ways, and can be specified by the user," explains Stone. "Ultramain has powerful tools for analysing SFDC information, and once the data has been sub-divided into groups and categories it can be exported into Excel, and other analytical tools such as tables and Pi charts.

"Ultramain will have a forecast of labour and material inputs for each maintenance check prior to its execution," continues Stone. "A post-maintenance analysis of all inputs can therefore be compared to pre-check estimates."

Envision has a useful tool which allows the user to actually review the profit margins of work orders being performed for third-party customers in almost real time. That is, the SFDC data can be collated and analysed in a short time and compared against the contractually agreed rate for the client. Some of Envision's customers have system dashboards that use such data on a shift-by-shift basis, rather than making an analysis at the completion of the maintenance check. The shift supervisor can then review the analysis shortly after the shift is completed.

Users, particularly airlines, like to use the M&E system to monitor the consumption of materials and parts. Besides examining the inputs used by particular aircraft types or for certain categories of maintenance check, they also like to use the system to manage the consumption of materials, consumables, repairables and rotables.

One method is to analyse consumption by part number. The activity of each part number can be analysed in detail. "One way is to look at a list of parts that have been reserved for a maintenance check, and compare this to its availability in the inventory stores," says Stone. AC