The accurate recording of labour used; and its sub-division in to skill types, and materials consumed during maintenance checks and work orders is now possible. The systems available and the functionality they offer is examined, as well as the several benefits that maintenance providers realise.

Systems for measuring MH & materials

Accurate recording of labour man hours (MH) and materials used during aircraft maintenance is one of the ultimate goals of airline management. The complexity of maintenance planning and production, and its manual management, for years has meant there have been several inefficiencies. Systems for maintenance shop-floor data collection (SFDC), data relating to MH and materials used in maintenance, have been available and in practical use for several years.

SFDC & MRO systems

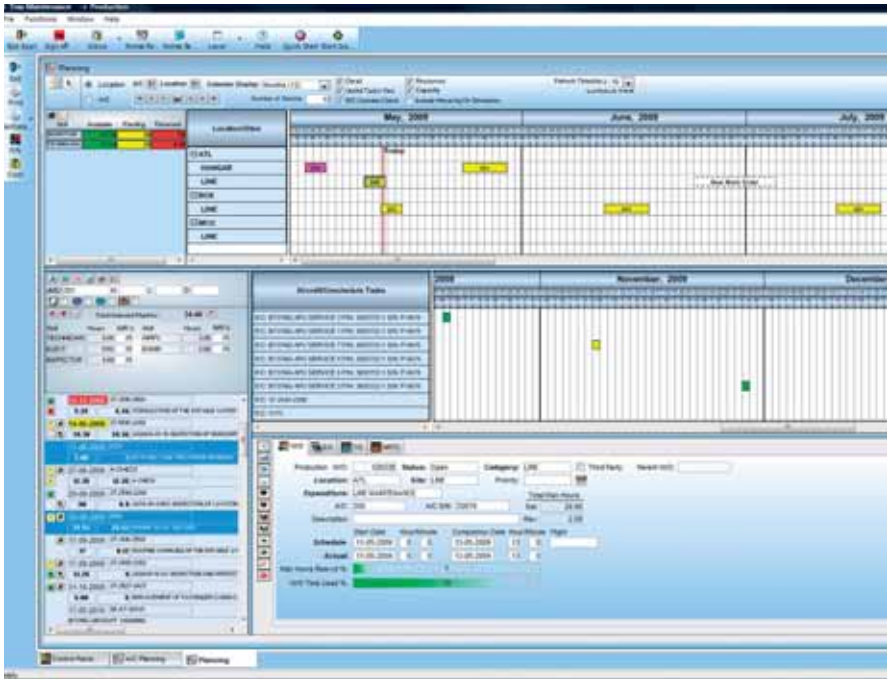
Virtually all airlines and independent maintenance repair and overhaul (MRO) providers use IT systems for keeping records of aircraft flight hours (FH) and flight cycles (FC), aircraft technical logs, and managing the MRO process. There are numerous IT systems to choose from, ranging from: complete 'pure play' systems, from providers such as Trax, Swiss AviationSoftware, Commsoft and Mxi; to modular systems that airlines and MROs can use with other previously acquired modules from other suppliers *(see MRO IT market suppliers survey, Aircraft Commerce, February/March 2009, page 53)*.

A comprehensive MRO system will have many modules that communicate and pass data between each other for a full maintenance management system to work. The main objectives of SFDC are to accurately record MH and materials used so that maintenance planners and supervisors can accurately follow the progress of maintenance checks and component repairs in real time, gain a high degree of visibility in MH and materials used, and improve labour efficiency and consumption. SFDC therefore has to take data and information from many modules. Once SFDC has collected MH and materials data these then have to be passed it to several other modules. SFDC is based around mechanics using barcode readers and scanners to read barcodes on job cards when starting work, and again when finishing work.

For this to be possible, the SFDC module of a system has to communicate with a maintenance planning module. This in turn takes information relating to several issues that include: aircraft configuration data; aircraft technical logs; aircraft FH and FC data; maintenance programmes; human resources; materials and procurement; rotables inventory management; facilities and tooling; and maintenance manuals. All these issues provide information and data necessary to plan maintenance checks and produce check job cards.

Once SFDC has recorded MH and materials data, for the collected information to be utilised to its maximum effect the module needs to communicate in real time with a check management module, as well as with documents and maintenance records, invoicing, finance modules, time and attendance, and human resources modules.

SFDC has several objectives and uses. The first is that the production and closing of individual job cards can be monitored by the maintenance system in real time. This allows the progress of an airframe check to be monitored closely by check supervisors and maintenance planners.



Trax's planning screen allows the user to see the timing and location of planned checks, and also view the resources and manpower available. It also shows unscheduled tasks in a timeline format that need to be planned into checks for individual aircraft.

Another main objective is to gain accurate data and information relating to routine and non-routine MH and materials used. This allows maintenance inputs to be analysed in detail, and costs and invoices to be allocated accurately to third-party customers. Correct input data allows more accurate forecasting of future maintenance inputs, and can lead to improved labour efficiency and lower labour consumption.

There are many providers and vendors of MRO IT systems, but the vendors which are best known for SFDC capability are MXi Technologies with its Maintenix product, Commsoft with its OASES product, TRAX, RAMCO, and Swiss AviationSoftware with its AMOS product.

SFDC software is used together with barcode scanners and computer kiosk terminals hardware.

Traditional recording

Prior to MRO IT systems becoming commonly used, airlines planned maintenance checks and produced job cards manually. Mechanics performing task cards manually recorded the time and materials used to perform each task card, as well as signing each task card manually. These signed task cards were then filed and stored for the purposes of keeping maintenance records.

The process started by the maintenance planning department issuing a workpackage, which was a group of task cards written in paper format. Many maintenance operators had used a system to punch each card when a mechanic started work on a task card and again when it was completed. In other cases mechanics manually wrote the time they spent on the task card. This manual recording resulted in inaccuracies of time used. The time recorded then had to be manually entered into a system by clerical staff, which lead to further inaccuracies.

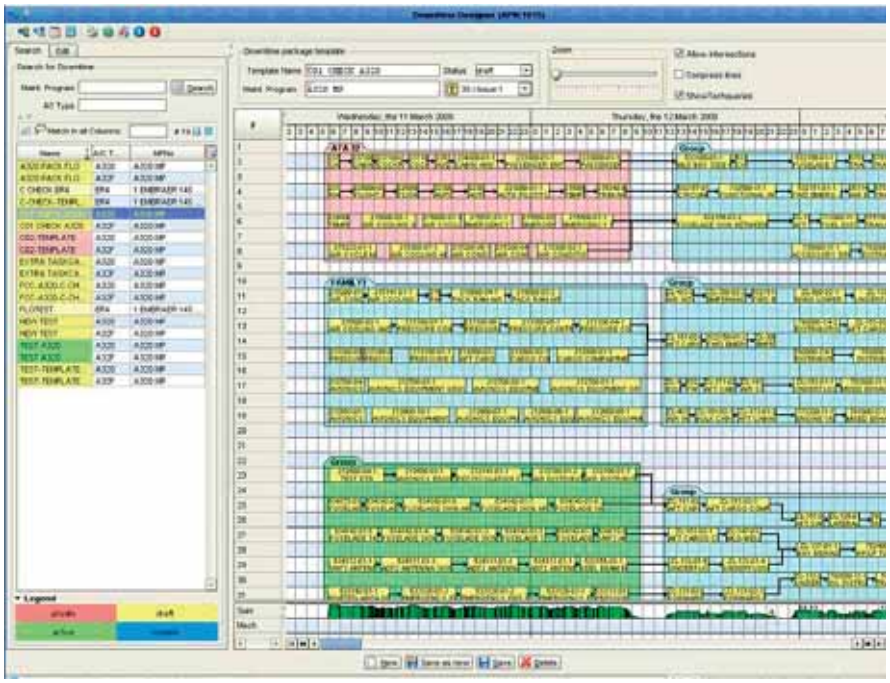
"Small maintenance shops find it is sufficient for mechanics to manually record MH and materials used, and enter them into our AMOS system," explains Ronald Schaeuffele, chief executive officer at Swiss AviationSoftware. "In that case the accuracy of the data recorded depends on the mechanics."

Maintenance planners have original equipment manufacturer (OEM) estimates of MH required to perform each task from the aircraft maintenance manual (AMM). Experienced maintenance planners know that the MH estimates provided by OEMs have to be multiplied by certain factors to get the realistic amount of labour used. Ramco explains that the Ramco system estimates the number of MH used to finish each task. To maintain the accuracy of these estimates, Ramco has a review activity to compare actual MH used with estimates, and then periodically update the estimates as required.

The materials required for each routine task are also indicated on the job card. Maintenance planners could therefore predict the routine labour and material requirement of the check.

Mechanics performing routine inspections on the task cards have findings, which lead to non-routine task cards being written by supervisors. This would include a request for materials and parts, and then mechanics had to record the non-routine MH for these task cards.

Besides the inaccurate recording of MH and materials used, the length of time taken for clerical staff to manually enter recorded MH and material data from completed task cards into the system and produce an analysis of it, meant that it was too slow for maintenance planners and supervisors to follow the progress of a check in real time and then use this information to their advantage. "The manual entering of data meant there is a long feedback loop for maintenance planners to get the MH and material data they need for estimating requirements for future checks," says Evan Butler-Jones, product marketing manager at MXi Technologies. "The



The AMOS system has recently launched a functionality that allows the downtime of a check to be drawn graphically. This allows the user to put in routine tasks into each day's work, and in a particular sequence. The user can then add more tasks; such as non-routine rectifications, component changes, and SBs. The screen also shows estimates of the time it takes to do each task.

analysis of labour time used to perform each task was made on an unscientific basis, and in many cases was done using estimates."

The implication of a long feedback loop for providing MH and material data is that mechanics could often be idle between task cards, since maintenance planners would have to provide a surplus of mechanics at many stages of the check to ensure there were no delays in its progress. More mechanics would be idle towards the end of a check as most task cards got completed. This idle labour leads to labour inefficiency, and inflates the burdened labour rate.

SFDC system

As described, SFDC modules and systems can only work with data from several other modules in a MRO system. "SFDC in TRAX starts with the maintenance planning module. This has the task cards listed for a particular check, and each task card has a predicted routine MH and material content," explains Chris Reed, manager director at TRAX. "Our planning module lists the tasks for a check on the left of the screen, and it totals routine MH. It also breaks this total down into skill levels.

"TRAX then goes onto the capacity planner module," continues Reed. "This lists the MH and the number for each skill level the facility has available each day, which it then breaks down further into the MH available for each hour of the day, showing how many of the MH available are already reserved for another job. The tasks are then loaded into the available time and labour, and the system allocates tasks and job cards to particular days and technicians, having taken the different skill levels into account. It therefore generates the entire work package for a check. It lists the location of the check, provides estimated start and finish times, and lists each task with MH and material requirements, together with the skill required."

Maintenance planning involves more than MH, skills and material forecasting. "Planning checks also involves predicting the tooling and facilities required, and the downtime used," explains Nick Godwin, business development director at Commsoft. "Maintenance planning in OASES also starts with the aircraft technical log that has FH and FC data, as well rotable components that have been changed. This leads to a reliability analysis that is derived from the installed intervals for each component on the aircraft being followed. This can be used to forecast demands for inspection of rotable components during checks and material requirements. In OASES this ultimately leads to an aircraft maintenance and modifications forecast. OASES lists the detail of a maintenance package, which ultimately leads to task card production. It also provides a barcode for each task card that is used in SFDC. OASES also orders and reserves routine materials and parts, and it can also earmark each part for a specific task card. If the parts are used prior to the check OASES then re-orders them."

SFDC process

The production of task cards in MRO systems should provide mechanics with all the information they need to perform each task. "The task card printed out in TRAX lists the actual task, the routine materials required, the access required, an estimate of routine MH used, pictures from all the relevant maintenance manuals the mechanic requires, photographs to assist the mechanic, and a barcode on the task card for SFDC," says Reed.

The AMOS system prints job cards with the routine tasks and indicates the parts required. "The job cards can either show all the parts required or parts that are probably required," says Schaeuffele. "All job cards are evaluated, and a list of all routine parts required for the routine checks is produced. Basic job cards can be produced that do not have barcodes for SFDC, and about a third of our customers do their own maintenance and record shop floor data manually.

"A higher level of sophistication is for job cards printed with barcodes for SFDC," continues Schaeuffele. "Mechanics scan these barcodes at the start and end of a task."

SFDC recording of MH and materials requires hardware equipment. Many maintenance shops and facilities provide computer kiosks on the hangar floor, in close proximity to the aircraft. "We perform base checks for A320-sized aircraft and the CRJ family members at our facility in Ljubljana," says Robert Rozman, engineering manager at Adria Airways. "We have two barcoding stations close to each aircraft. Each of these stations is a kiosk which has three computers. One is for documents and manuals, such as the AMM and illustrated parts catalogue (IPC). The second is for warehouse information and ordering parts, and the third is for reading barcodes on task cards and recording the MH and material data. Mechanics swipe barcodes on job cards when they start work, and swipe barcodes again when they finish a task card, with the MH used consequently being recorded in the process. We have found that two kiosks per aircraft are adequate.

"We use the OASES system from Commsoft, and we have pre-printed documents with job cards, pages from the AMM and IPC, and pictures to assist the mechanics," continues Rozman. "This saves the mechanic time, since the only time they need to look for more information is when they get a defect or a finding."

The SFDC system measures the time and material used for the task only. This

should not be confused with the total time a mechanic is at work during the day. This is recorded by most maintenance facilities using a time and attendance system. "SFDC can be integrated with the maintenance facility's time and attendance system," says Godwin. "This is because a mechanic may forget to sign off on the SFDC when he leaves work. The time and attendance system will sign off on a specific task card if the two systems are linked.

"The barcode reader scans each task card, and the AMOS system can also apportion MH spent between several task cards if the mechanic is working on several at one time," says Schaeuffele. "For example, there may be three related tasks cards for a landing gear inspection. All three cards are scanned at the start with a mobile device. After completion, the mechanic puts his ID on the reader and the system displays the open task cards automatically. The system distributes the MH automatically according to the previously estimated MH. The routine MH estimates may be five minutes each for two cards and 10 minutes for a third card: a total time of 20 minutes. The actual time spent by the mechanic might be 40 minutes, and so the system apportions 10 minutes each to two cards, and 20 minutes to the third card."

MRO systems can also allocate job cards to individual mechanics, so that the time spent by each mechanic can be followed and analysed if a maintenance facility requires. MRO systems allocate particular job cards to particular mechanics. This is an important feature necessary for different skill levels and invoicing, because different skill levels are invoiced at different MH rates. Some task cards also require jobs to be done by several mechanics.

"A mechanic can swipe a task card at the start of the job, and TRAX can validate the particular mechanic to the task. The mechanic is identified with a smart card, a fingerprint or password," says Reed. "This capability can also be extended to verify that the mechanic has the correct qualifications for the task, and that their qualifications are current. Once a routine card is started a mechanic can put a job on hold while they take a break, are waiting for parts or are raising a non-routine card after making a finding. Task cards are then signed off by the mechanic when they are finished."

The Ramco system assigns task cards to each mechanic. The mechanic sees the tasks in their timesheet screen. The MH reporting is done in real time, and task card sign-offs are managed electronically using a smart card. Ramco installations with totally paperless electronic sign-offs have been approved by regulatory agencies and in operation since 2004.

Most systems have the ability to accept electronic signatures, but few operators actually use this and they need regulatory approval for this. Most maintenance operators record stop times using the workshop kiosk, and then physically signing the task cards. Few companies accept just e-signatures, and still require physical signatures.

There is also the issue of recording the consumption of materials and parts for routine inspections. "In AMOS the consumption of routine materials is predictable, since the list is already prepared in advance," says Schaeuffele. "Mechanics may sometimes have to record that the reserved parts were actually used, and this is done using barcodes on the parts."

Ramco has a functionality for the recording of ad hoc material consumption that allows a part to be requested by a mechanic via their timesheet entry screen. The same screen is used to report the consumption of expendables and consumables. The mechanic only has to reset the consumption if some parts are not used and are sent back to the stores.

For rotables, Ramco allows mechanics to select part from an aircraft 'tree' structure.

All the materials captured against a work order are routed through Ramco's invoice preparation screens. The pricing policies for a particular customer are

applied, and the user can review and finalise the materials to be invoiced.

Non-routine task cards

Mechanics have to halt or pause routine inspections when findings and defects arise. "The traditional system of dealing with non-routines was for a mechanic to take a finding to a supervisor to get a non-routine card raised," explains Reed. "This would put a pause on the completion of the routine task card. The supervisor would write the non-routine card manually and raise a request for parts from the parts store and warehouse. TRAX allows supervisors to write non-routine cards at the kiosk. The system first has non-routine templates in its database, which can be used to write the new non-routine card. These usually come from the AMM. TRAX also links the non-routine card with the routine task. Non-routine cards are then printed with their own barcodes and pages from the relevant manuals. The time spent on performing these is tracked in the same way that routine cards are monitored."

Raising non-routines requires the use of various manuals and the ordering of parts. AMOS raises a pick slip, for example, which is used to order a part that is selected from the IPC in the system. Parts required for non-routines will be listed in the AMM, and cross-referenced with the IPC. MRO systems can be used to write part numbers into a non-routine card, and place an order with the stores. "The storeman also uses the system to record the usage of the part," says Schaeuffele.

Summary of data

The objective of SFDC is to ultimately provide detailed data relating to the different types of labour and materials used in routine and non-routine tasks.

"Once a check is finished, OASES provides a check pack accomplishment analysis," says Godwin. "This summarises the tasks, the MH and materials used, and the labour rate used for each skill level. This detailed analysis is the basis of generating the customer's invoice.

"MH summaries are provided for aircraft zone, skills and maintenance checks," continues Godwin. "This includes estimated labour and inspection hours, manufacturer-recommended labour and inspection hours, last used airframe hours per task, sequence number and summary card details. Real-time reporting of check status is provided. This shows the check status, percentage complete, non-routine cards raised, and budgeted versus actual completions and costs. The materials summary includes details on the works order, aircraft, input date, task card, part number and quantity. All materials can be automatically pre-loaded and managed from the planner's forecast."

TRAX summarises the raw MH and material data. "The system lists both estimated MH and actual MH used for each task and in total for the check," says Reed. "The system can use different labour rates for each skill level and apply them to the correct task cards. The estimated and actual labour cost is then also summarised. The system uses a colour code for MH or labour cost in each task that is over the estimated amount.

"Once a check is finished the system can also list the MH for non-routine tasks in the summary list," continues Reed. "It can also identify non-routine task cards that are constantly required, and add these to the routines if the user requires. This summary then also produces a ratio of routine to non-routine MH. The reliability module of TRAX takes account of non-routines. Non-routines are classified by Air Transport Association (ATA) Chapter. These data then provide statistics on the rate of fault by ATA Chapter. The non-routine ratio can also be compared for the same check on other aircraft in the fleet, and also

with earlier checks on the same aircraft.

"Similarly the system also provides a comparison of the materials used with the materials requested prior to the check. This analysis is used to modify maintenance planning," adds Reed.

Benefits & rewards

There are several benefits to acquiring accurate MH and material data for each check.

The first of these benefits involves following the progress of a check in real time. "As each mechanic starts and finishes a task card, this is automatically and instantly recorded, so that the check supervisor can constantly follow the progress of a check in real time," says Rozman. "This can be compared to the planned workflow of the check, so mechanics that are not required can be moved to other checks and aircraft. This is important, since the profit margins in maintenance are thin, and having a good and instantaneous overview of the check allows the supervisor to see exactly how many MH are being used, and when mechanics can be removed when they are no longer required. This is possible with OASES, because the work-in-progress module communicates with the SFDC module."

This visibility of a check's progress allows labour efficiency to be improved, since the ratio of active to inactive labour can be increased. In some cases, users can use the system to monitor which employees are working the most effectively. There is strong resistance to this, however, from labour unions with most airlines and MRO providers.

A second main benefit is that the user is given an accurate analysis of routine and non-routine MH and materials. This ultimately makes it possible to follow an aircraft's maintenance costs, and can also be a useful tool in fleet planning, since rising non-routine ratios and maintenance costs can be followed.

A third benefit is accurate invoicing for third-party customers. "One difficulty accurate MH and material recording produces is knowing how to allocate the MH and materials used for all the maintenance performed," says Rozman. "For example, a decision has to be made about how to allocate the cost of labour and materials used for some sheet metal work, since this is not related to a particular task card". Nevertheless, accurate MH and material data allow an MRO provider to give its customers detailed invoices with all maintenance tasks itemised.

This leads to a further benefit of more accurate forecasting of future maintenance to be possible. This is the consumption of materials and rotable components. Rotables can be removed during base checks following functional system checks. Removal data will be fed into a system's reliability analysis module, and more accurate forecasting of rotable removals will be possible. Resources, particular labour, can also be more accurately forecast, since the real-time capture of MH and materials allows a faster feedback loop.

There is also the issue of maintenance records. How they are kept depends on the operator and their respective airworthiness authorities. "The authority may allow the operator to scan the physical records, and then the electronic version can be linked directly to the respective record in AMOS," explains Schaeuffele. "The authority may allow the physical records to be discarded, but if they do not then they have to be archived."

Maintenance records are usually kept as physical copies for up to seven years in most cases, and as scanned pdf copies that can be accessed easily. Examples of companies providing scanning services are ADS in France and Waviatech in Ireland. AC