Managing an aircraft's maintenance programme is a complex task. Task intervals and the aircraft's operating pattern continuously change, requiring the maintenance programme be readjusted. IT systems streamline the process of maintenance programme management.

Managing maintenance plans with IT systems

Managing an aircraft's maintenance planning document (MPD) and maintenance programme is a complex and continuous task for an airline's maintenance and engineering department. This process is difficult when performed manually, but IT systems for maintenance and engineering have simplified this task, which starts by storing all task cards in the IT system.

Main principles

The MPD and maintenance programme has to be organised into line, base and heavy checks, but it can also be re-written or modified by an airline's maintenance and engineering department. The MPD and maintenance programme then have to be incorporated into the aircraft's planned flight schedule, with adjustments constantly made with the aircraft's actual operation.

The maintenance programme also provides maintenance departments with estimates for labour, skill types, materials, parts, tooling and service equipment for maintenance planners. The MPD therefore includes a large volume of data and information, which are used to match maintenance requirements with available resources to enable a high utilisation of each check interval, and a minimum of parts and material inventory to be kept.

The final task for maintenance programme management is the analysis of findings made during maintenance tasks, such as non-routine ratios, defects and actual material and man-hour (MH) inputs. These findings, which tend to be subjective when made and recorded manually, are then analysed to determine if inspection threshold and repeat intervals need to be adjusted, and MH and material estimations need to be changed. The analysis of data from findings recorded manually during a large number of checks is a difficult process and provides poor statistics. If IT systems are able to make accurate recordings of defects and faults, MH, materials and parts used, airlines can then make accurate statistical analyses. These can be used to make applications to airworthiness authorities for extensions of task inspection intervals. These findings also provide planning engineers with useful data for revising and estimating MH, skill types, materials, parts, tools and service equipment and facility requirements.

High quality, post-performance maintenance analysis is also required for re-assessing an aircraft's maintenance requirements as it ages. Different maintenance tasks that have to be done emerge and downtimes to complete checks increase, and good quality analysis helps manage and plan for this.

MPD & maintenance plan

The aircraft's MPD is supplied by the original equipment manufacturer (OEM) and is essentially a collection of task cards. The MPD can either be an older type of maintenance steering group two (MSG2) or more modern MSG3.

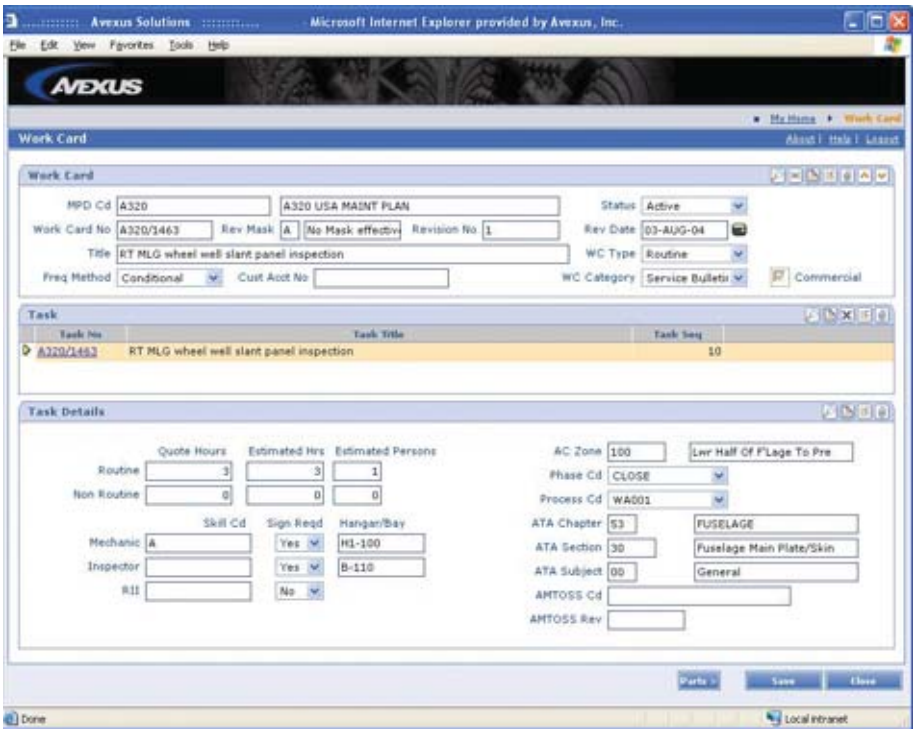
MSG2 maintenance programmes are used by older types such as the 737-200, 747 Classics and MD-80. The tasks in MSG2 programmes require that inspections are performed more frequently than actually required, and these tasks are grouped together in checks by the OEMs for convenience.

MSG3 programmes are a list of individual maintenance tasks, each with their own interval and frequency, which can be grouped by airlines into whatever packages and checks they want. Each airline's maintenance programme can therefore be unique, although OEMs still recommend a maintenance programme structure.

Maintenance programme task cards are originally supplied by the OEMs. "Task cards are instructions for mechanics to perform a maintenance task," explains Geoff Hughes, sales director at MIRO Technologies. "Although these are supplied by the OEM, larger airlines with large maintenance and engineering departments may write their own task cards, or edit those supplied by the OEM.

"Each card supplies a set of instructions and requirements for the particular inspection. It lists the air transport association (ATA) chapter number concerned for the task, as well as the zone of the aircraft affected. Estimates are given for the number of MH and elapsed time to complete the task, as well as listing the skill types required by the mechanics to perform the task," continues Hughes. "This includes a parts list, the number and quantity of each part number required, and instructions on whether parts should be replaced or repaired depending on inspection findings. The task card also lists ground service equipment and tools required."

MPDs and task cards can be customised by maintenance organisations and large airlines. "This is because tasks and inspections can often be accomplished in several ways," says Chris Reed, managing director at TRAX Software. "Different part numbers can also be used for a task, and a maintenance facility may wish to add its own graphics, diagrams and manual references to the task card. Although large maintenance organisations have customised their task cards and



Task cards supplied by OEMs to airlines to be loaded into IT systems contain just the task card data. The data are then formatted into task cards by the IT system. The data also includes information such as estimates of MH, materials, parts and different skills required to complete the work.

maintenance programmes, many airlines are finding it cheaper to use the OEM's task cards."

The process of managing aircraft MPDs and maintenance programmes with IT maintenance & engineering systems starts with loading and entering of the OEM's task cards into the IT system. "The MPD and maintenance plan can be loaded into the system manually or electronically. Electronic formats include CD and DVD," says Paul Dibble, director of solutions management at Avexus. "The MPD can be loaded into a system in different formats, and Avexus has integration capability for taking several formats. A task card does not look like the original OEM task card after it has been loaded into the IT system, but as that shown *(see picture, this page)*. This is because it is not the actual task card that is entered into the system, but the data from the task card. The data also include other information such as the categories the task card falls into (for example, a revision date), and whether the task is a routine or non-routine. The other data are estimates of MH, number of personnel, parts and materials, codes for different skill types, and aircraft zone and ATA chapter affected."

Once tasks are loaded into the IT system it has to model the maintenance requirements into a complete maintenance inspection programme. "For MSG3 programmes this means treating each task individually or grouping them into checks," says Hughes. "The trend is now towards equalised maintenance programmes, and IT systems are required to do this effectively. The system has a structure or configuration of the aircraft loaded into it, and this is attached to the MPD. Our AuRA system sub-divides the aircraft into airframe, engine, sub-assemblies and components. Airworthiness directives (ADs) and service bulletins (SBs) change the maintenance requirements of components in terms of new inspection frequencies and part numbers used.

"Once MPD data is loaded into the system it is manually checked by maintenance programme engineers. Cards grouped together for each check can be examined to check for MH and materials, equipment and tooling, manual references and graphics, as well as associated references for ADs, SBs and engineering orders. Each task will also state the aircraft serial numbers related to it. As an example, integral airstairs on the 737 are a customer option, and so inspection task cards for airstairs will only relate to specific aircraft serial numbers that were fitted with integral airstairs on the production line. AuRA can also order task cards by defining dependencies on other tasks already performed. This is part of critical path analysis used to plan maintenance events."

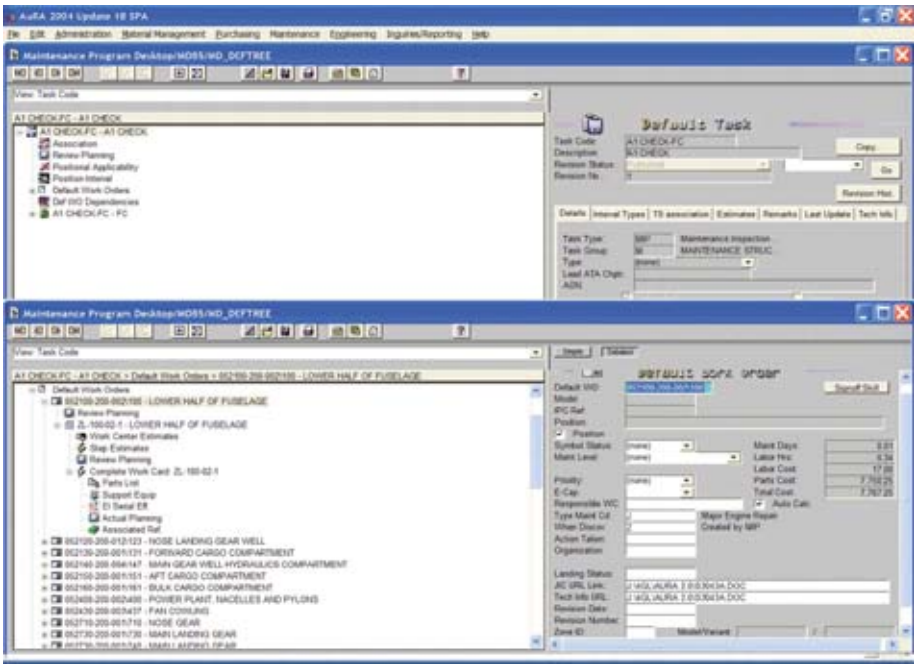
Different airlines want task cards in different formats. "Task cards were previously cards with manually typed information," says Reed. "The fact is that most airlines do not do their base maintenance, so they generate task cards and give these to a maintenance provider when the aircraft is sent for a base check. Copies of task cards are then signed for maintenance records. Total care maintenance packages can include the production of task cards by the maintenance provider. Airlines still have to be responsible for their maintenance programme management and maintenance records, however."

Component maintenance

Besides maintenance inspections stipulated by the task cards in the MPD and maintenance programme, there are also components in an aircraft with hard-time maintenance intervals. The maintenance of these components falls outside the task cards in the MPD. An example is the inspection or removal of a generator or fire extinguisher with a hard-time interval that has been provided by a sub-contractor to the OEM. These intervals have to be reconciled with the task cards in the MPD, so that the inspection or removal of these hard-time components can be planned at convenient times in the maintenance and flight schedule plans.

"Hard-time components are listed in Avexus and other maintenance IT systems because the aircraft configuration system lists all components and parts on each aircraft. The data for each component and part include serial number and maintenance inspection interval or removal hard-time," says Dibble. "Avexus also tracks the maintenance condition of every part. This allows the time since last inspected and installed for every part, and MPD task card, to be tracked with respect to calendar time, flight hours (FH) and flight cycles (FC). This then allows a list of maintenance items and tasks coming due for each aircraft to be listed, with time and interval remaining to be displayed."

IT systems for managing maintenance programmes need to be fully integrated with flight operations, maintenance operations control and inventory control departments. "The aircraft's operation and accumulated FH and FC need to be tracked," says Hughes. "AuRA can put a warning on each task so that maintenance planners are alerted with sufficient lead time that a task is coming due. This helps them achieve a high interval yield for each task and check. AuRA can also deactivate tasks such as a repeat inspection once a modification has been completed. Once tasks are grouped



MIRO Technologies' AuRA system allows planning engineers to edit task cards. The system also groups them into checks, and provides an estimate of total MH, materials and parts that will be consumed to complete the check.

into checks, MH, materials and parts required can be estimated. The different skill types required and MH for each, as well as the cost of materials and parts required from different suppliers, can then be used and collated to provide an estimate for the cost of completing the check."

In addition to including the removal and inspection of hard-time components, comprehensive maintenance IT systems that manage the complete maintenance and engineering process should track components that are removed or sent for repair. This is an integral part of the inventory management process, and an illustrates both the overlap between different areas of maintenance and engineering and why a single IT system is desirable for monitor and control.

Customising task cards

The process of editing and customising task cards follows once they are loaded into the IT system. The editing process is done manually by engineers, and may involve the addition of documents, graphics or references to various parts catalogues and manuals.

"One of the first editing processes is grouping task cards into checks," says Dibble. "Other processes include examining parts and material requirements. This includes a detailed view of the consumables, rotables and repairables required or affected to complete the task. It also includes an audit of the tools needed. Avexus distinguishes between tools and parts, both of which can have serial numbers for them to be tracked. This monitors the consumption of consumables, but individual tools can be assigned to a specific task for a specific check by planning engineers. This system prevents the loss of tools, since they are assigned to tasks and also have to be returned. This is a useful feature of the system in respect of resource planning."

Edits to task cards also include the addition of manual references from maintenance manuals, illustrated parts catalogues, ADs, SBs and engineering orders. IT systems allow documents, manual pages or graphics to be attached to task cards.

Another benefit of customising task cards is to review the inspection intervals and requirements for replacing parts. "These can be over-estimated in the OEM's task cards," explains Reed "since OEMs tend to overmaintain an aircraft. An experienced airline can make adjustments to the task cards when it has experience of an aircraft so that MH and parts consumption are at more realistic levels."

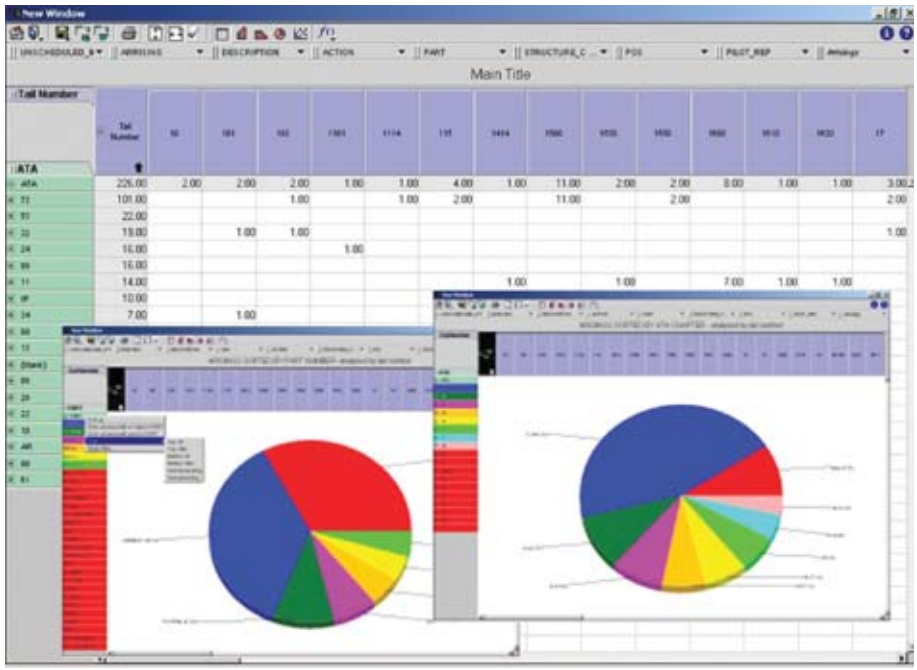
Maintenance & flight plans

Once maintenance tasks have been analysed and grouped into approximate checks they have to be reconciled to fit into the aircraft's flight plan. One core objective of maintenance programme management is to compile a programme that allows the highest possible aircraft utilisation. Different airlines have different rates of aircraft utilisation, styles of operation, route networks, and peaks and troughs in traffic demand.

Charter carriers, for example, have demand peaks in the summer months, and find it difficult to schedule C checks once every 14-19 months, they often sacrifice C check intervals by having annual inspections, but this problem can be partly circumvented by equalising C checks into smaller jobs that are included in A checks. Scheduled carriers have more even traffic volumes throughout the year and can make better use of long C check intervals.

Maintenance programme managers' tasks are to make maximum use of task intervals while also preventing a high level of disruption and downtime to an aircraft's operation. "AuRA takes each aircraft's planned operation from the flight operations department and compares this with non date-based tasks in the MPD. This is so that an A check with a 100FH interval is scheduled in a convenient place in the planned flight schedule," says Hughes. "AuRA puts non-date based and date-based maintenance tasks in the order in which they are coming due in the system. Co-ordinating maintenance plans and flight schedules cannot be done simply by comparing the two, since other factors have to be taken into account. These include examining the availability of maintenance capacity. AuRA starts by examining the slots and capacity available at each maintenance facility on each date, including the number of mechanics, with differing and appropriate skills. This indicates whether there is sufficient capacity to perform a certain type of check at that facility. The next step is for AuRA to combine the flight plan of the fleet with the maintenance programme, and to see which aircraft is at the appropriate location at that time. An aircraft and a check from its maintenance programme are selected. The availability of all labour, parts, tooling and support equipment is then checked."

IT systems can provide maintenance planners with details of maintenance events coming due to ease planning. "Avexus classifies tasks by category: engine; airframe checks; component repairs; technical defects; and line maintenance," explains Dibble. "The user is taken to the maintenance planning engine, and the planned flight schedule of the aircraft is shown graphically, showing the date on the flights and listing each flight in order with the number of FH accumulated, and showing the airport location after each. When the user picks any of the flights in the list, Avexus changes the time remaining to each task,



Data collected by AuRA from maintenance checks has to be analysed to make adjustments to estimates of future checks. Data can be analysed in terms of MH used for each ATA chapter and each aircraft tail number, and also broken down by consumption for each skill type.

taking into account the FH, FC and calendar time. The system can also show the amount of labour available at the station or maintenance facility at which the aircraft is located on that date in the flight schedule. The system will also show the ground time between each flight, and the time of day, so the manager can consider the possibility of performing some tasks if sufficient labour and other resources are available. The flight schedule is constantly updated from the flight operations department so the system shows managers where and when is the best time to complete maintenance tasks on a real-time basis. Impresa gives the user visibility and control over information to plan when to perform maintenance."

Maintenance programme management is an on-going process. Although the intervals of most tasks rarely change, the actual interval at which a task is performed differs every time it is carried out for each aircraft in the fleet. Each task card therefore has to be scheduled into the maintenance and flight plans every time it is performed to ensure that intervals are not exceeded. For example, a task may have an interval of 125 flight hours (FH), but it is actually performed at 105FH because it has become impossible to schedule before another 20FH have been accumulated. This means the same task has to be repeated within another 125FH, not 145FH, and may actually be carried out again in less than another 105FH. Managers cannot assume that all tasks and checks will be automatically carried out at their exact intervals. They can easily fall out of phase with other tasks and checks and must constantly monitored, while achieving the highest possible interval utilisation. Managers also have to deal with aircraft operation and schedules changing, and task intervals being upgraded or increased. This has consequences for facilities and resources. Maintenance programme management is a different process to maintenance check planning, which involves analysing the detail of task cards, MH, materials, parts, tooling and facilities required. It further analyses the order in which different tasks should be performed.

Feedback loop

Another major function of maintenance programme managers is to analyse data and findings from performed tasks. If MH and materials consumed for an inspection can be accurately tracked they can be re-assessed for future maintenance checks. Analysis of findings also indicates the ratio of defects and non-routine maintenance relative to routine inspections, and may indicate what this ratio will be in the future. The level of corrosion can also be recorded on structural parts of the aircraft. These findings and data can further be analysed to assess if the intervals of individual inspections can be extended. This requires an accurate assessment of data.

"The objective of the feedback loop of analysed data is to make changes to inspection intervals and get accurate budgets for MH and materials required to complete tasks," says Reed. "Maintenance programme managers analyse the work done so that the maintenance schedule can be amended. This completes the cycle of maintenance programme management. Accurate assessment cannot be made, however, unless maintenance production is accurately recorded."

Task cards now have individual bar codes, which are used in conjunction with mobile tablet computers or desktops in the hangar to allow the MH of each skill type and materials used to be recorded. These systems can also use fingerprints for authentication of work done by each mechanic. These data provide information on the number of routine and non-routine MH, materials and parts used to complete each task as well as record findings and corrosion levels.

"Mechanics can record the parts they have used, removed and installed, as well as the consumables they have used," says Hughes. "The mechanic also enters data such as findings and a code for corrosion level on each task card. Malfunction codes and action codes taken can also be added. Data can be attached to each task card and analysed statistically. AuRA allows managers, for example, to analyse the non-routine ratio, of a particular task card across an aircraft fleet. Other examples are analysing the total MH for the same C check across a fleet, or the corrosion level for a particular task card over a specific time period."

Analysis of workcards allows them to be updated and modified. The most common objective is to increase intervals. "Extending one job card may take it out of phase with other cards in an airframe check, but the item might then be treated as a line maintenance task," explains Reed. "Analysis may show that extending this interval improves the utilisation of the aircraft fleet. TRAX allows the alteration to task card intervals and the maintenance programme to be made dynamically. That is, the effects and benefits of extending an interval by various degrees can be analysed, and the most beneficial extension identified. Applications to extend a task interval are made by airlines to their regulatory authority, and have to be supported by data and analysis. Good quality data and analysis from maintenance production allow the extension of task cards and checks to be made more quickly than traditional management systems. Extensions to tasks can take between 10 days and three months." AC