Planning and executing maintenance checks involves many variables and the use of many resources that have to be coordinated. The use of MRO IT systems makes it possible to optimise the scheduling of maintenance tasks, smooth labour requirements and save downtime.

Using MRO IT systems to optimise check planning, labour & resources

Planning and executing airframe checks involves organising and co-ordinating a lot of resources. These include: mechanics with different skills; hangar space; gantry and equipment; tools, parts and materials; and task cards. The traditional method of manually planning checks and managing their execution led to many inefficiencies, mainly because the task is complex and involves a large number of parameters. Maintenance, repair & overhaul (MRO) information technology (IT) systems have the functionality to improve the planning of checks, and to monitor their execution and progress to reduce downtime and all other resources used.

Check planning

Check planning starts with the organisation of routine task cards, which number several dozen for lighter checks, and several hundred for base checks.

Traditionally, maintenance planning engineers would plan a check by grouping all routine tasks, airworthiness directives (ADs) and service bulletins (SBs) due. Each task card had to be put together manually with all relevant pages from the aircraft maintenance manual (AMM), illustrated parts catalogue (IPC) and other manuals. Other instructions had to be collated, such as the parts and tools required for the task, and the skill type of the mechanic that would be carrying it out. It would take engineers several days to complete this laborious process.

Planning engineers also had take into consideration the occurrence of defects, write non-routine task cards, which are not always easy to predict, and collate all relevant information.

The inefficiency of this process is due firstly to the large amount of time and man-hours (MH) spent by planning engineers in manually grouping all relevant job cards, and collating their relevant and related information.

This is compounded by the constant need to update maintenance planning documents (MPDs), maintenance programmes, and manuals. Updates to each major document or manual are issued three or four times per year, at different times of the year to each other, and may apply only to particular aircraft line numbers. Airline engineering departments therefore rely heavily on engineering staff to manage these updates, and apply them to the relevant aircraft.

Grouping and ordering the tasks to be completed during a check is also complex, and therefore prone to several inefficiencies, such as poor utilisation of task card intervals, uneven labour requirements, and extended check downtime.

MRO IT systems

MRO IT systems have been developed to co-ordinate all inter-related factors related to check planning and execution.

This starts by using and managing manuals in XML and SGML format, although many airlines and older aircraft types still have all their manuals in PDF format.

The utilisation of individual aircraft in terms of flight hours (FH), flight cycles (FC), and calendar time has to be monitored. This information then has to be matched and monitored in relation to the intervals of each task card in the operator's approved maintenance plan. There will be several task cards within a maintenance programme that have different intervals for different groups of aircraft line numbers in the fleet. Moreover, some tasks will apply to certain line numbers, but not to others.

MRO IT systems then group the relevant tasks for the particular aircraft into a check, specifying those that have to be completed in a particular order, and those that can be performed in parallel. Mechanics then have to be assigned to each task card, or a group of task cards. Check planning is complicated by the need for different skills on different task cards.

"Check planning and the assignment of labour is best made using a gantt chart," says Chris Reed, managing director at Trax. "Labour planning depends on the shift pattern used at the maintenance facility's operation: a fixed number of shifts each lasting several hours; around the clock or only during daylight hours; only on certain days a week; and fixed or only on demand when customers require it.

"These shift patterns are one of the first issues addressed by Trax when planning checks," continues Reed. "A gantt chart plots the timeline on the horizontal axis, and the resource being used or other factor on the vertical axis. A horizontal line or bar can therefore be used for each mechanic available in each shift, with the length of the bar indicating how long they are available for work. These bars are colour-coded, so that one colour will show when a mechanic has not been allocated work, and another can be used when they have been allocated work and are no longer available. This is necessary because the demand for labour

in task cards has to be compared with the available mechanics.

"The first stage involves inputting the production plan of task cards into the system. The labour required can be divided into each skill type," continues Reed. "Trax will analyse the MH required for each skill type, and also see how much is required per day and during particular times of the day. Other elements of the check have to be included: the forecast non-routine defects, component changes, interior work, out-of-phase (OOP) tasks and cleaning. The whole workpackage has to be analysed for detailed planning to be possible."

Workscope planning

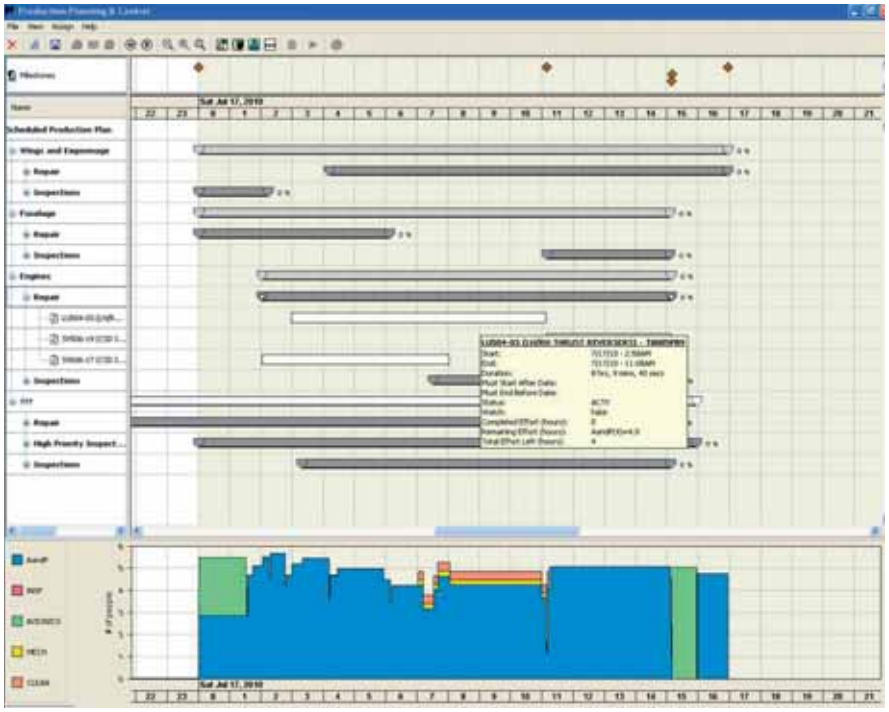
"The basic plan of a check starts with the maintenance programmes and the actual and expected aircraft utilisation," says Richard Minney, head of product innovation at HCL AXON. "We then look at the operator's planned maintenance checks, which includes all the tasks, anticipated non-routines, and all other elements of the workpackage. With all the anticipated checks and their workscope plans in the system, the user can view what is going to happen for up to a year. The ideal is to get as close as possible to 100% of interval utilisation. There are many resources to take into consideration when timing the start of checks, including the maintenance requirements of other aircraft, and the availability of labour, hangar slots, tooling and equipment. A 100% use of check interval time indicates that there are insufficient resources, while a low rate of utilisation indicates a surplus of resources. The SAP iMRO system has a minimum check interval allowance, whereby the operator can set the shortest minimum allowed interval for each type of check on each aircraft type."

SAP presents check plan information from the macro level all the way down to the micro level. A bar representing a whole check can be clicked to provide further levels of detail down to the individual task for analysis.

Commsoft's OASES system has an integrated planning tool which plans all the requirements of a maintenance check on a single screen with tabs to list the details of each workcard, order the different workcards, and programme in other details relating to the check. The functionality also allows document attachments to be uploaded, so that they can be attached to the relevant task cards, and also plans all materials, tooling and labour required for each check on a single screen. OASES also has a closed loop system that constantly updates materials and MH requirements as the check progresses and the schedule changes.

The grouping and sequencing of related task cards is extremely important. "The dependencies of linked task cards can be built into the system, and this is done in advance," says Evan Butler-Jones, manager, product marketing at MXi Technologies. "Our Maintenix system will start with the aircraft's point of entry into the check. There are related cards that have to be completed in a particular order, and others that are not related to each other."

All the information for each task card has to be programmed into the MRO IT system. In the case of older aircraft types and some airlines, task cards are available on paper or in PDF format. As a result, the information on task cards must be entered into MRO IT systems manually. Newer aircraft types have task cards that are in XML and SGML format, an electronic system that allows all the data to be entered into the system. "It is therefore possible to import electronic information relating to task cards automatically," says Rob Litzenberger, senior account manager at EmpowerMX. "Once task card information has been entered, templates can be built for each bill of work, such as the different types of



MXi's Maintenix system plots a gantt chart for a planned check, using horizontal bars in the upper screen to denote tasks and task groups. A histogram in coloured bars in the lower screen denotes labour and labour skills required throughout the period of the check.

standardised check for an aircraft type, or for particular modifications. The template for a bill of work contains a lot of information, including: start and end times; the task cards and their dependency; the number and type of mechanics; and the materials and tools required. Like other systems, our FleetCycle software groups related tasks and orders them. They are also updated as a group whenever updates are made to the MPD and other manuals.

"Another function of FleetCycle is to add milestones to the check plan," continues Litzenberger. "These will include the start and the end of the check, and important stages during the check by when certain tasks must be completed."

Besides routine inspections, check plans comprise three other main elements: the occurrence of defects leading to non-routine task cards; the inclusion of ADs and SBs; and the constant updating of maintenance programmes and manuals.

Non-routines

"Non-routine cards are initially based on a production planner's knowledge," says Butler-Jones. "Experienced maintenance planners with extensive experience of an aircraft type can predict many of the non-routines that are likely to arise, and how much labour they will need. Maintenix builds in the initial estimate of non-routine cards and labour. A mechanic can raise a non-routine as it occurs while they are working on a task card. It it is then automatically added and scheduled into the check workpackage and all the estimates are updated.

"If there are standard findings, the task cards for these can be pre-created and held in the system to save time," continues Butler-Jones.

There will inevitably be no experience of non-routines in younger aircraft, thereby making it harder to plan workpackages.

OASES has a non-routine task card creation function, including all relevant cost elements such as MH, materials and other inputs.

Non-routines are problematic because they spoil the plans for airframe checks. Often, just one or two systems in an aircraft can be responsible for a large number of non-routines. Some non-routines occur frequently, others less so, making it difficult to write and load standard non-routine cards.

ADs & SBs

The issuing of ADs and SBs, and the need to perform engineering orders (EOs) is an unpredictable occurrence. ADs often only apply to certain line numbers, and vary in terms of the impact they have on aircraft maintenance, such as the quantity of inputs they use, and how quickly airlines have to comply with them.

SBs have similar variations, but it is also not compulsory to perform them on an aircraft.

ADs and SBs can therefore form a large part of a check's workscope, and planning engineers may have little advance time to prepare fully for them. One issue that has to be addressed is the applicability of ADs and SBs to individual aircraft. OASES, for example, has a new evaluation tool, which can download and evaluate ADs, SBs and EOs from European Aviation Safety Agency (EASA) and Federal Aviation Administration (FAA) sources. OASES has various approval mechanisms, and AD and SB hierarchies can be set up in the system for approval by various departments, which are sent to them by a chain of e-mails. OASES evaluates ADs and SBs by fleets, sub-fleets, individual aircraft, and even component effectivities, in terms of associated parts, MH, costs, skills and all relevant publications and documents. It then incorporates the MH, materials, task cards and other manuals into the system so that relevant task cards may be prepared.

It is also important that affected aircraft comply with ADs and SBs. The complexity of maintenance planning and updating all documentation and manuals, makes it hard for engineers to track which aircraft are affected by ADs and SBs, and when compliance is required. Maintenix monitors the ADs, SBs and EOs that apply to each aircraft line number, inform the user which ones are still open for each aircraft, and when compliance is due. It also shows which ones have been completed. Some ADs have repeat inspections, and Maintenix will show the user when these are next due in relation to upcoming checks.

System updates

Keeping the MRO IT system up to date with the latest revisions for manuals, maintenance programmes and job cards is a major management issue. "The first issue to contend with is that 30-70% of original equipment manufacturer (OEM) manuals are delivered in PDF or paper format. The rest are now in XML or SGML format," explains John Snow, vice president marketing and business development at Enigma. This causes problems, because whenever a revision is is issued, the impact of each change must be evaluated against the airline's current maintenance programme, a task that is made more difficult with PDF or paper manuals. Even when using XML, updating all of an airline's maintenance systems to reflect OEM changes is typically a manual, labour-intensive process. The AMM, for example, has 15,000 tasks in 8,000-page blocks, containing information concerning every tail number for the aircraft type concerned - and the configurations of aircraft are different. An average revision will have 30-80 new page blocks, have 400-600 new tasks added, about 10

deleted page blocks and 20 deleted tasks, and 1,000-2,000 revised page blocks and 2,000-3,000 revised tasks. It clearly requires hundreds of engineers to go manually through these updates, which are issued about once every three months.

"Looking instead at the IPC, the average revision involves about 12,000 figures. That is, images and graphics," continues Snow. "Moreover, there are 200-300 new figures added at each revision, 10-20 figures deleted, 3,000-5,000 figures revised and 2,000 part number data changes. It is important to understand that 50-80% of these revisions are due to effectivity changes based on tail number.

In addition to these two examples, airlines rely on another 10-12 manuals, each of which is also revised on a regular basis. These revisions all have their own schedules, so airline engineering departments must spend a lot of resources evaluating their documentation and updating and scheduling systems and job cards. "This creates a problem for the airline that is trying to get publications and maintenance planners fully synchronised," says Snow. "The airline is legally responsible for the maintenance plan, and is left to check all of the OEM revisions against the plan. Airlines find it hard to keep up, and are often about two revisions behind. An added problem is that ADs and SBs are issued at irregular intervals. Updating and processing this constant stream of information has a huge impact on the airline's maintenance plan and MRO IT system.

"Enigma has a system for automatically processing XML, SGML and PDF revisions and updating the MRO system and job cards. The first benefit is a reduction in the time needed to process each update, from several months to less than a week," continues Snow. "The system filters out OEM changes that conflict with any customised procedure updates made by the airline. These are changes an airline makes to its maintenance programme, task cards, maintenance manuals and other documentation. For each conflict, the system allows the airline to choose the original equipment manufacturer (OEM), or the airline's customised version. Depending on the airline's choice, Enigma will implement the appropriate version of the task/procedure and automate the process of propagating that change to the technical publications and MRO systems, as well as the job cards. In addition, depending on the nature of the OEM's change, the airline may decide to edit its customised manuals and then update the systems. This keeps the airline in control of its entire maintenance programme."

Overall, Enigma ensures that an airline bases maintenance decisions on the latest information. Another part of this solution is creating dynamic job cards. They are not manually-created, static job cards. Instead they are created electronically, automatically embedding the latest XML, SGML, PDF and graphics information. "This means that the maintenance plan is automatically updated with OEM revisions, once these have been approved by the airline. This eliminates the time that engineers spend updating task cards and acquiring all relevant information prior to maintenance. Instead, task cards can be created on demand, since Enigma has the latest information, manuals and tasks," explains Snow. "The system can simplify the preparation for maintenance by taking the list of tasks from the maintenance planning system and creating the required job cards automatically for each mechanic, with all the necessary information."

Enigma also issues non-routine task cards. "The traditional system may take a long time, and often holds up the progress of a maintenance check, because mechanics have to stop working on a task when they have findings while a non-routine task card is manually written. This can take several hours," says Snow. "Now the maintenance planner simply specifies the required tasks, and Enigma creates a non-routine card with all the relevant information. Enigma takes the work pack details from the maintenance planning system, and in a few seconds creates and distributes each job card. The system has therefore eliminated the

manual part of searching for the appropriate documents, pages and information.

"The added benefit is that the mechanic quickly receives the required documentation and approval to execute a non-routine," continues Snow. "The mechanics can play a role in this process. When they encounter a non-routine defect they can use Enigma to troubleshoot a problem. When they identify a solution they can raise a defect on the MRO IT system to ask the engineering department to create a non-routine job card. If approved by engineering, it may only take a few minutes from the time a defect is raised until a non-routine job card has been created, and so maintenance remains on schedule."

Labour assignment

Once workpackages have been defined in as much detail as possible so that engineers can determine the workcards that will be included in the check, individual mechanics then have to be assigned individual tasks.

Systems plan the workpackages in a gantt chart. MRO IT systems also need to be programmed with the details on individual mechanics, including their skills and licences. Other information includes the shifts for which mechanics are available.

This is all required for the system to reserve labour. "The task is to match available mechanics in each shift with the the requirement for mechanics with different skills according to the check plan," says Reed. "Trax will provide a block chart, below the gantt chart of the workpackage plan, showing the amount of labour required as the check progresses. Different sections of the blocks will be colour-coded according to different skill types. The system will further indicate which labour skills are in short supply, and which are in surplus. The plan can be changed to smooth out peaks and troughs in labour demand, or overcome labour shortages, with the result that the check end date changes.

"The user can also use Trax to drill down to look in detail at each employee to see how they have been allocated work, and the amount of available time they have," continues Reed. "The system summarises the allocated and available MH. Tasks in the check plan can also be moved, taking into account their links with other tasks, to match labour demand and availability. Trax can also manually re-plan the use of labour, and re-assign mechanics or tasks."

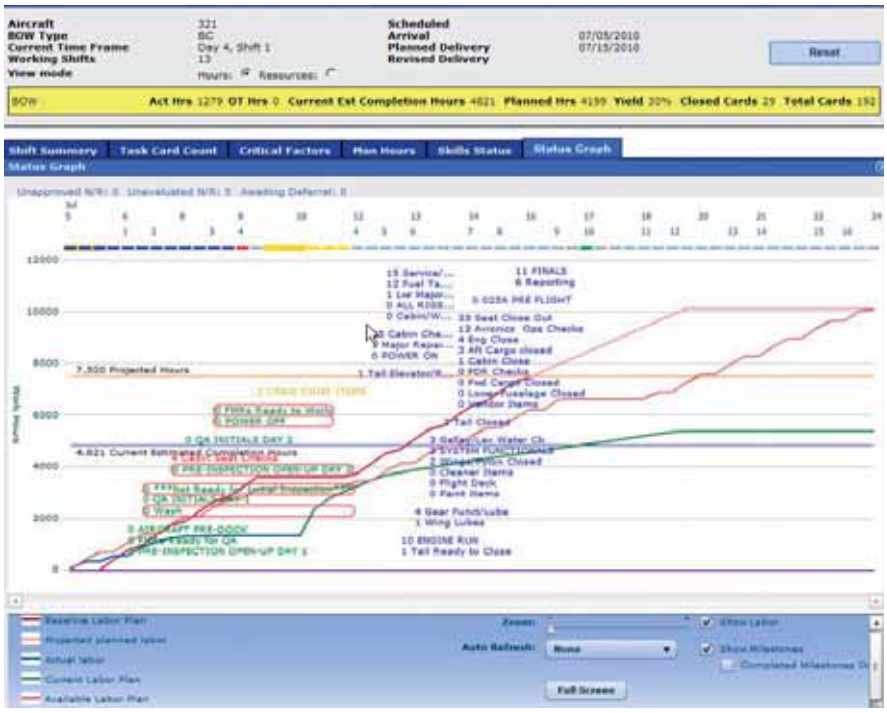
The problem with labour assignment and management is the defects that arise and the non-routines that have to be issued as a result. This can delay the completion of tasks, as well as inter-related tasks, and push back the completion date of the check. "Planning checks for facilities with several hangars, and checks progressing in parallel can actually make it easier to achieve a smooth labour profile, since surplus labour on one check can be balanced by labour shortages in another," says Minney. "This can include changing shift patterns, and asking mechanics to work overtime. Taking a long-term view of labour requirements is also important, since anticipated shortages can be dealt with by training and hiring more people."

Materials, parts & tools

Besides hangar slots and labour availability and assignment, the other resources that require consideration are materials, parts and tools.

The information on parts and materials is an integral part of routine, non-routine and other job cards. This has either been entered into MRO IT systems manually, or automatically where documents have been loaded electronically. A completed check plan, with information for each job card, will therefore be able to generate a bill of material. "Maintenix ensures that parts are ready for a mechanic when they are scheduled to start a task," says Butler-Jones. "The objective is to reduce wasted time waiting for parts. Maintenix has a tab to generate a list of required parts for the check, and compares this with the parts that are available in the maintenance provider's stores. This list is updated as the check progresses, tasks are performed and parts are delivered to the maintenance facility."

At a more detailed level, the list of



EmpowerMX's FleetCycle system has a status page used for monitoring the progress of a check. Colour-coded plots are used to indicate accumulated MH used, MH available and MH required to complete the check on time.

parts needed for a planned check package should be divided between those that have a short lead time and those with a long lead time. "The parts with a long lead time clearly have the potential to cause delays in a check's progress," says Minney. "SAP creates a schedule of demand for long lead time materials, and puts this into the materials planning module. This schedule is then compared to stock levels, and the list of required parts is sent to the buyers. SAP also indicates if there is no stock available or if purchase orders have been raised to indicate if there are likely to be shortages. The problem is that you never know exactly which parts are needed. Non-routines can increase a parts requirement, while there is always a percentage of parts requested by mechanics that are not used. MRO IT systems should be programmed with this information."

Check execution

Once the check has started, maintenance providers need to ensure that staff assigned to tasks are available. Tasks need to be re-allocated to other technicians, or the check downtime replanned if mechanics are ill.

"Trax can re-allocate tasks, tools and parts to different tasks or technicians, and uses a traffic light system to indicate when resources are available," says Reed.

The progress of a check is done by following the gantt chart of planned tasks and labour assignments. There are inevitably changes to the plan. "Maintenix has a histogram underneath with the tasks shown above. If tasks such as non-routines get added, then the histogram is changed," says Butler-Jones. "At the top there are major milestones, such as power off, aircraft on jacks, power on, and so on. If a task is clicked on, there is a window with a lot of detailed information about the task. At the end of each task bar there is information about how far through the task is, and what percentage of the task has yet to be completed."

EmpowerMX's FleetCycle system has a progress chart, where the cumulative MH used are displayed on a vertical scale, and the time is on the horizontal scale. The chart shows milestones as vertical lines, and tasks are shown in blocks at the times they are scheduled to be performed. These task blocks are colour-coded to indicate their status. "One colour is used for open tasks, another to indicate they are late, a third to show they have been completed, and other colours to show other levels of status," explains Litzenberger. "The user can also drill down into each block of tasks to get detailed information, as well as assign groups of tasks to crews, or add a non-routine card.

"The system also has a function that visually plots the progress of check," continues Litzenberger. "It does this by first plotting the number of accumulated actual MH used against time, and shows this as a blue line. A green line shows the amount of accumulated labour that needs to be applied to keep the check on track. A gold line is a plot of the labour available as the check progresses, so the accumulated labour that the facility has planned to use can also be viewed. The data used to draw the three lines is updated every 15 minutes, as technicians scan task cards to say they are completed. The three lines, when viewed together, indicate to managers if the check is behind schedule in labour terms, because of delays. Also, the available and required labour can be compared to see if additional labour is required. The system will also alert if there is going to be a shortage of labour. Other tabs in the system show the MH and task card count to date, and the skill status of technicians. The system also predicts the end time of the check, and the tracking of check progress gives the user plenty of time to add in resources and get the check back on track or even finished earlier."

Records

Time spent manually signing off on task cards, making maintenance records, and updating aircraft configuration records is another source of inefficiency. This can be overcome by using electronic signatures and maintenance records.

"Records of job cards completed and the MH used, materials and tools used, non-routine observations, components changed and aircraft configuration changes made all have to recorded," says Butler-Jones. "This can all be done electronically with Maintenix. Electronic signatures mean that MH are recorded for each task card as soon as each one is completed. If part and component changes are made electronically then the system will alert the user to say if the part and dash number is correct for the particular aircraft line number. The aircraft configuration record is also updated automatically, which is considerably faster than doing it manually. Automating this record-keeping means that the audit process is also done automatically, saving further labour time. Moreover, all the work that is being done can be tracked in real time. Other detail such as the time remaining on task card where work has been paused can be examined, as can the parts that have been removed and installed on the aircraft. When a task card is completed, the electronic signature means an electronic maintenance record is automatically made. The use of electronic records also means that the possibility of errors being made is virtually eliminated." AC