Planning hangar maintenance is a complex process that requires the sequencing of complex and interrelated maintenance tasks and the bringing together of all required resources. The correct use of IT systems and management techniques can realise substantial efficiency gains.

Improving the efficiency of hangar check planning & execution

Planning hangar maintenance is a large and complex co-ordination exercise. Improving the efficiency of planning and executing hangar maintenance partly involves: identifying tasks and the resources required to perform them, sequencing tasks and providing all necessary resources to limit or avoid bottlenecks and delays throughout the progress of the check. This requires the skill of experienced planning engineers and the appropriate software systems.

Hangar checks are a series of tasks that start with routine maintenance inspections, but also include several other categories of tasks, not all of which can be predicted accurately prior to the event starting. Checks also consume materials, and use several types of labour skills, as well as facilities and tooling. This all has to be planned, co-ordinated, supplied and arranged. Several benefits can be derived from improving this planning and execution stage, including the reduction of: check downtime; idle labour and total labour consumption; and inventory and stock of idle materials and spare parts. It has been known for some airlines to take several weeks to complete narrowbody C checks, due to the unavailability of parts.

First stage

The first stage in hangar maintenance planning is co-ordinating the timing and length of checks with the airline's flight operations department. Flight operations needs to be aware that the aircraft will be out of service for a certain amount of time, and the maintenance that is due will depend on the flight hours (FH) and flight cycles (FC) that the aircraft has accumulated and the calendar time accrued since earlier maintenance events.

Basic information is used to monitor what maintenance is due on each aircraft in the fleet, and when it needs to be performed. The aircraft's maintenance programme (the accumulated FH, FC and calendar time of each rotable component installed on the aircraft) is co-ordinated with the fixed maintenance intervals of hard-timed components on the aircraft.

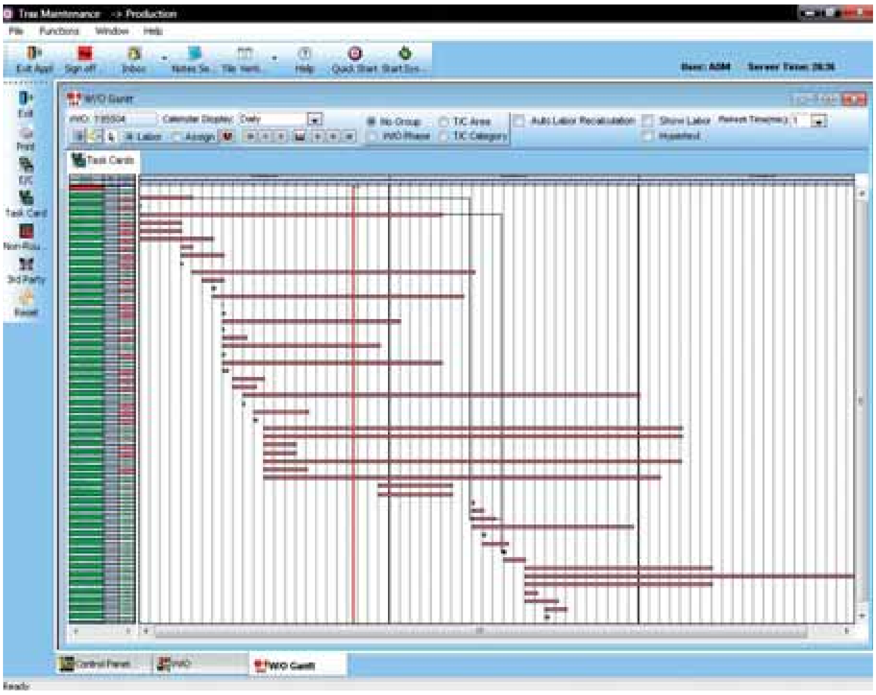
"Our system, SAP iMRO, has all of an operator's fleet loaded into it, and also the rotable configuration of each aircraft," explains Richard Minney, head of product innovation at HCL AXON. "The system also has each aircraft's maintenance programme and tasks loaded into it. To predict when each task and check comes due, the system requires total FH and FC and calendar time since new to be constantly updated and fed into the maintenance system, and monitored. As each aircraft flies, operational data are taken from the on-board logbook and transferred to the system. The electronic flight log also has various technical details, such as technical defects that have occurred, as well as current levels of fuel and oil on the aircraft.

"The system also communicates with the operator's flight operations department to get flight schedule information for each aircraft," continues Minney. "It uses this and updated FH and FC data to predict when maintenance tasks and events are coming due."

The core of maintenance planning is the aircraft's maintenance programme. This requires all the tasks in an aircraft's maintenance programme to be loaded into the maintenance planning system electronically. "There is a function in Maintenix called 'multiple maintenance programmes'," says Jocque Butler, aviation business specialist at MXi Technologies. "This allows users to author several maintenance plans for an aircraft or fleet. It lists and summarises all the relevant tasks listed in each fleet's maintenance plan. The core tasks are those specified in the maintenance planning document (MPD), but other tasks are included as contained within the operator's Approved Maintenance Programme (AMP). There is an approved set of the operator's own tasks that it has added to the original equipment manufacturer's (OEM) maintenance programme, as well as engineering orders (EOs) related service bulletins (SBs) and airworthiness directives (ADs). A multitude of other tasks are included, such as removals and maintenance inspections for hard-timed components.

"Once the maintenance programme has been loaded into the system, the user can view the details of any task contained therein," continues Butler. "The job cards in the maintenance programme provide detailed information such as: the relevant zone of the aircraft and how access has to be gained to perform the task; what labour, material and tooling resources are required to execute the task; the job card steps required to execute the work; which aircraft in the fleet the task applies to; a listing of all previous MPD task revisions; what mechanic skills are required to perform the task; and estimates of man-hours (MH) and materials required to complete the non-routine rectifications. An attachment or link to the relevant pages of the original OEM documentation is also included as reference to anyone interacting with the specified task."

"Each task has several steps, starting with access and preparation prior to inspections being made," says Minney. "SAP iMRO lists the basic information about each task, and each step of the task, and the MH and materials required to complete each step. The system can



One feature of maintenance planning systems is to present tasks sequenced and planned into a check workscope in the form of a Gantt chart. This shows the plan for each group of tasks against a timeline, showing the intended start and predicted end dates. This is then used to monitor the progress of the check.

also be programmed to sequence each of these steps in the task card for planning purposes. All this information can be uploaded automatically from the aircraft maintenance manual (AMM) that is provided by the OEM."

While this is a substantial amount of information, other data relating to the task also has to be held by the system. "In addition to basic instructions and the resources required, the relevant pages from the AMM, illustrated parts catalogue (IPC) and other manuals have to be attached to the task card in the system," explains Chris Reed, managing director at TRAX, "so that when a mechanic performs the task all the relevant information that will be required is ready."

Tasks are not just loaded individually into maintenance planning systems. "Tasks are grouped into checks, initially as specified by the MPD and maintenance programme," says Minney. "The system can assign or re-assign these checks as required by the operator. Operators are free to group tasks into checks as they please, because not all tasks have the same interval. Once tasks with different intervals have been grouped into checks, the system then makes the interval of these tasks the same so that they don't constantly have to be re-grouped into the same checks."

Maintenix allows tasks to be grouped into checks or blocks as required by the planning department. Each of these blocks are usually driven by a similar deadline held by the tasks within, but Maintenix allows planners to package in extra tasks or remove them as required. This allows planners the flexibility to react to scheduling and resource situations as they arise.

Long-range planning

Once all the basic task card, maintenance task, SB and AD, utilisation, and previous maintenance task completion data for each aircraft have been loaded into the system, the next stage is to compile a long-term maintenance plan for the fleet.

This will first require the basic maintenance programme to be defined for each aircraft. For example, the main line and hangar checks are defined in terms of which routine tasks form these checks. "Together with a prediction or forecast of the aircraft's operating schedule and rate of utilisation, the upcoming maintenance events are compiled for each aircraft," says Butler. "This allows for a view of the maintenance activities due for all aircraft in the fleet, and therefore a timetable for all the different types of checks. For example, it can be seen when C checks and heavy checks for the whole fleet are due, and if too many or too few are coming due at the same time.

"Maintenix can show each maintenance event as a box on a planning Gantt with the details of the check being revealed if the user requires additional information," continues Butler. "The scheduled timing for execution of the check can be manually brought forward or delayed, and an alert is made if the timing is beyond the programme interval."

The same basic philosophy is used for all maintenance planning systems. "While iMRO at this stage predicts when each check will come due, it takes into account availability of resources at this stage," says Minney. "This is checked later when each individual check has been planned in detail."

The long-range planner in Maintenix first shows a timeline of checks due for each aircraft, which can then be made to show more detail. "The user can select which checks and maintenance events are shown in the long-term view. In addition to the main checks there are out-of-phase (OOP) items, replacement of hard-timed components, modifications, engine changes and other small events," says Butler. "Some or all of these can be displayed, and additional details can be viewed for each of these. The long-term planner in Maintenix allows users to add in maintenance locations for line and hangar maintenance, allowing for what-if scenario planning. The system will provide a list of suitable locations and scheduled time for each maintenance event. The resources required for the check can be compared with those available at each location for the workscope and check planning."

Workscope & check planning

Planning each maintenance event and check is a detailed and skilled process. This used to be performed manually by several planning engineers prior to the availability of systems. Checks start with routine inspections. Each inspection task card has estimates for MH and materials, but many additions have to be made.

"The first part of the check will be inducting the aircraft into the facility, de-fuelling it, turning off internal power, connecting external power, putting the aircraft on jacks, and putting docking and rigging in place around the aircraft. These all use labour and other resources," says Reed. "Then there are non-routines, EOs, SBs, ADs, clearing defects, the operator's own tasks, OOP tasks, modifications, interior work, and finishing the check, all of which use MH, materials and other resources. These also have to be planned in a particular sequence, and all the required resources and downtime estimated. This requires considerable skill by planning engineers, and the process is made easier with maintenance systems.

"Each task card from the OEM has all the labour skills, estimates of MH and materials, and tools required for the routine part included, but the OEM's estimates need updating," continues Reed. "The OEM does not sequence tasks, and this is another of the first steps in check planning. This sequencing, together with instructions for inducting the aircraft and turning off power, is part of building the check's workscope. Non-routine rectifications will have to be estimated by planning engineers."

Part of the planning process is to grant access to the task cards, and systems generate bar codes for each task card and attach the relevant pages from the AMM and IPC. "Maintenix has a check details page which lists all the tasks and other details. It also summarises the MH, labour skills, materials and parts required," says Butler. "It can also list which materials are available in real time with the materials management system, and those which are not. It will also show details of the materials that are available, but which are reserved for checks on other aircraft. This allows planners with authority to break reservations if required."

One major element in check planning is estimating the number of MH required for non-routine rectifications. These can account for up to two-thirds of the total workscope. These have to be made by experienced planning engineers, who make close estimates for each task. "The inspection phase should be finalised no later than 30% of the way through the entire ground time of the check. This then gives us sufficient time to arrange for proper repairs and material," explains Emil Frehner, head of heavy maintenance at SRTechnics.

"Maintenix grants visibility into the total labour assigned to each task, and also has start and stop times, and an estimate of MH usage," continues Butler. "The actual MH used will then be displayed against the estimated MH required following shop floor data collection (SFDC). There is a similar tab which shows which tools are required for each job card, and lists their availability and which mechanics they have been checked out to.

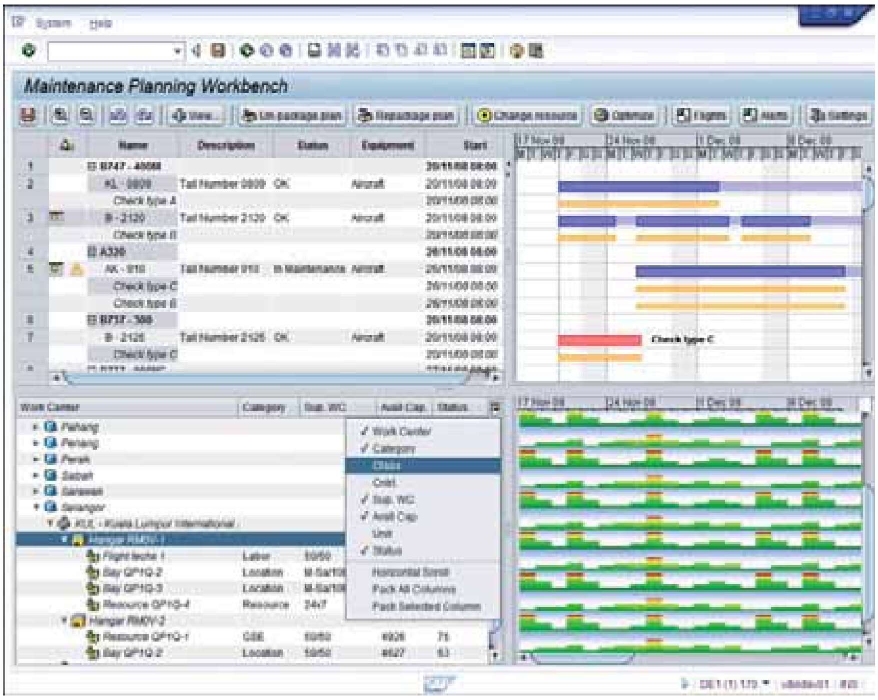
"The biggest job with planning is sequencing tasks in a check, which Maintenix does automatically, based on many factors, including aircraft milestones, conditions and non-routines. These are shown in a Gantt chart which provides a visual description of the check," continues Butler.

The Gantt chart shows how the check has been planned to progress needs, including: the time taken for each task; the skills and the number of mechanics; and the materials and tooling used. The check can then also be divided into phases. "The TRAX planning module allows the user to see which tasks are due on each date, for example," says Reed. "The inputs and resources required for check completion are estimated. Tasks which have been grouped manually or automatically into a work order can then provide the user with an end date. A group of additional tasks can also be inserted into a planned check, such as for an engine change. TRAX knows how to sequence all the relevant tasks. Once the whole workpackage is defined, then all the required inputs and resources can be listed. These are then compared with what is available, and TRAX reserves the necessary labour, individuals, materials and all relevant resources.

Labour planning

TRAX has a manpower planning module, so that it knows which mechanics are working on what tasks and when. This forecast can be changed if the mechanics become available for more hours if they do overtime.

Further detailed analysis can be made for each resource required so that accurate planning can be made. "Maintenix performs a granular analysis of all the skills required, and number of mechanics for each skill," explains Butler. "The analysis will then show how many mechanics of each skill type will be required on each day of the check. This can then be matched with the labour available. A detailed labour plan assigns job cards to different groups of mechanics, so that a graphical representation of the number of mechanics required each day of the check can be made. Since the amount of labour required for each task is known, the



Maintenance planning systems are able to display a long-term maintenance plan for a fleet. This will show the planned dates for all checks for each aircraft. The locations where each check is planned to be performed, and the utilisation of resources at each can be displayed.

knock-on effect of a particular labour skill not being available can be analysed. This allows for what-if scenario planning where controllers can see the end result of certain decisions before making this decision. Maintenix will also warn the user if a specific part, tool or labour resource is unavailable at the chosen location."

Another issue is dealing with the varying amount of labour with each day of the check. "The typical profile is for there to be a peak during the middle of the check. Daily labour requirements are low when the aircraft is being inducted, power is being connected and the aircraft raised up on jacks at the start, and then when it is being cleaned and final checks are made in the last few days of a check," explains Reed. "The peak in the middle comes from routine inspections, resulting non-routine rectifications, and completing modifications and SBs. There is also variation in the amount of each skill required each day throughout the check. One technique to smooth labour requirements is to have overlapping checks at the same facility. A narrowbody C check can start several days after another has started, and a third C check can start a few days later when the first has been completed. Surprises and delays can also be avoided by better estimates of non-routines. TRAX allows the non-routine ratio to be manually input for each task, and this automatically goes into the Gantt chart."

SR Technics applies six sigma technology to check planning. "This eliminates waste and non-value added work," says Frehner. "One way to achieve this is to shorten mechanics' walking time by having all the necessary equipment and tools as close as possible to the aircraft. Another example is that we have introduced a 'spider man', who is an engineer with technical expertise that supports mechanics directly at the aircraft. His function is to write non-routine cards, order materials and parts, and monitor the progress of the check plan. This reduces the time spent by mechanics looking for help."

Maintenance systems divide the check into phases, so that milestones such as aircraft induction, power off, aircraft on jacks, power on and others can be flagged, thereby allowing the progress of the check to be monitored.

Lufthansa Technik has developed an approach to check planning where it has divided the check into smaller differentiated work packages. "This has made it easier to estimate total MH and materials needed, and also to monitor the progress of the check as it is being executed," says Oliver Sturm, manager line production at Lufthansa Technik in Hamburg. "Our planning process starts with a statistical assessment of the MH used in previous checks. This is followed by a software calculation of all the job cards that need to be completed. Both sets of figures are then used to schedule a number of MH for the check, which is highly influenced by the experience of our planning experts. Our experience shows that the difference between the MH consumption projection using these techniques rarely differs from the number of MH actually used by more than 5%."

Materials planning

One important issue in limiting bottlenecks and delays throughout the progress of a check is accurate materials and parts planning. "From the task and check planning system, TRAX can generate a pick list of materials and parts required for the check," says Reed. "The materials warehouse gets the pick list, reserves parts for the check, and orders any that are unavailable. TRAX also knows typical lead times for parts and their suppliers.

"TRAX can also list each task and the part or parts required for it, and indicate whether or not a part is available," continues Reed. "The lead time for parts ordering is also shown, as well as the list price. Lead time can be several months in the case of some parts, especially those related to interior furnishings, SBs or ADs. Planning such workscopes has to be made well in advance, if possible. TRAX has a traffic light system to show if parts are available, on order or unavailable. Unavailability of parts causes delays in checks, although in some cases they can be taken from other aircraft in the fleet, or even parked and retired aircraft."

SR Technics has a similar technique with materials planning as it does with labour. "We store consumables directly on the aircraft at different locations," says Frehner. "We make an extensive provisioning based on past checks to have as much material available as possible from stock instead of ordering parts while the check is in progress."

Delays in providing parts or shortages of parts and materials can lead to delays in completing checks by several weeks. This increase in aircraft downtime results in lower aircraft utilisation and a larger fleet to operate the same schedule. This ultimately leads to higher aircraft financing costs or lease rentals. Financial efficiency can clearly be improved with efficient materials and parts planning.

Facilities planning

Once the workpackage for a maintenance check has been built, a hangar slot is planned. Maintenance systems have a module for this process. "The hangar planning module in TRAX will have all the maintenance locations, the resources at each and the checks already reserved. It tells the user what slots are available for the check being planned," says Reed. "This is only possible if the probable length of the check is known."

Check execution & feedback

Once the check has started, the user should use the Gantt chart in the maintenance system to monitor the progress of the check. Checks do not proceed to plan, and unexpected additions or problems arise. This requires the maintenance system to be flexible. Delays or extensions to tasks will delay later related tasks, and increase the downtime of the check. This can be countered to some degree if mechanics that have been working on another part of the check and are idle are diverted onto the task that requires additional labour or is taking longer to complete. This is again where experienced planners can predict these occurrences to plan ahead to minimise delays.

Maintenix allows for an automatic re-optimisation of the production plan, which is used to re-plan checks in the event of unforecast non-routine ratios or a shortage of resources.

"A maintenance system needs to have the capability of making critical path analysis to help planners deal with delays," says Butler. "The system should also have a feedback capability. This is where the recorded MH and material inputs that are gathered from SFDC are maintained within the Maintenix database. These are then used for estimating inputs and non-routine ratios for future checks."

Feedback loops also apply to better task sequencing, provisioning of tooling and better estimates of lead times for materials.

Efficiency gains

Airlines and maintenance providers can make several improvements in efficiency through better check planning.

The first of these is improved labour productivity. This is achieved first by better estimates of non-routines and task sequencing, which leads to greater visibility in labour requirements by each day, by zone of the aircraft and by skill type. Once a detailed and accurate picture of labour requirements can be achieved then a dynamic maintenance system will allow the user to analyse the consequences of re-sequencing tasks or changing the execution plan of a check.

Labour efficiency is also improved by reducing idle time through better labour planning. That is, the ratio of productive labour time to total labour time is improved.

A second benefit is reduced downtime for a check. Again this can only be achieved through greater visibility of a check plan. Improvements in task sequencing and reductions in the time taken to prepare for tasks and to execute them can be made. An example of shortening check downtimes is Lufthansa Technik reducing the time for an A340 D check from 36 to 26 days.

Better material and parts forecasting, and allocation of parts for particular checks means that surplus inventories of consumable, repairable and rotable parts can all be reduced, realising another saving.

"The important issue is improving accuracy of predicting the amount of resources required," says Minney. "An improved prediction of check downtime, check timing, ordering of materials, and making the right amount of labour available contributes to improvements in efficiency. Some of these improvements also come from wireless SFDC entry, and e-signatures. A paperless environment reduces non-productive labour time, since mechanics are not signing paper forms. Capable maintenance systems also give improved visibility into SB, AD and maintenance task compliance, and also eliminate the duplication of work. This can also lead to a better utilisation of maintenance intervals, which will reduce costs per FH or per FC." AC