M&E and CMS systems increase process efficiencies and reduce overall aircraft maintenance costs in a number of ways. The main elements of engineering management and maintenance to benefit from these systems are document & maintenance programme management, line & base maintenance, and rotable inventory management.

Using M&E systems to increase efficiencies

Maintenance & engineering (M&E) IT systems have been acquired by a large number of airlines and independent maintenance, repair and overhaul (MRO) organisations. Some M&E systems have also been acquired together and interfaced with content management or document management systems (CMS). The reasons why these systems have been acquired, as well as the many improvements in efficiency and cost savings that they can deliver, are addressed here.

System rationale

M&E system acquisition is driven by the need to overcome the lack of visibility and inherent inefficiencies of a traditional paper system of managing the M&E process.

A first main priority for airlines and MROs is to ensure and prove compliance. The thousands of tasks in each aircraft type's maintenance programme, their different intervals, and the number of technical defects that could affect an aircraft at any one time are all difficult to monitor and manage using paper records. "M&E systems were primarily acquired to track maintenance tasks coming due in relation to each aircraft's on-going utilisation and calendar life so that an operator could ensure and demonstrate compliance, at all times," explains Chris Reed, managing director at Trax. "This is coupled with the control of safety. An M&E system makes it a lot quicker to identify when an aircraft is behind with maintenance task completion, or to keep track of outstanding defects."

The ability to improve maintenance process and engineering management efficiencies has developed from these initial advantages. Operators and MROs gain efficiencies and savings in: documentation management; maintenance programme efficiency; line maintenance; base maintenance and airframe check execution; rotable inventory holdings; labour planning and staff numbers; and the utilisation of facilities and fixed assets.

Document management

The first change in document and content management that these M&E systems have delivered is from traditional paper manuals and documents stored in microfiche format to electronic data.

Paper documents have several inherent inefficiencies and problems: they have to be searched manually each time a maintenance task has to be prepared, or a defect analysed; while superseded pages must be removed manually each time a revision or update is made, and each set of manuals needs to be replaced with new ones throughout the organisation. The laborious and time-consuming nature of the process means there are inevitable delays of up to several months in managing and completing all updates.

This library management process can be executed more accurately and quickly when documents, manuals and content are loaded into M&E and CMS systems in an electronic format.

"The first obvious changes brought about by this system are the saving of paper and storage volume, and the time that management engineers spend searching through paper documents," says Thanos Kaponeridis, president at Aerosoft. "The integration of M&E and CMS systems has further knock-on benefits of being able to prove compliance, because of the accurate manner in which data is recorded."

Another related benefit is the speed at which managing engineers can search for documents and access the correct information. "There was no particular way to index paper documents and related documents," says Dinakara Nagalla, president and chief executive officer at EmpowerMX. "Electronic documents can be searched quickly, saving time and administration costs."

Having documentation in an electronic format brings several benefits.

The first is that maintenance carried out is recorded and reported in real time. "The benefits of this are that the aircraft's configuration and maintenance status are instantly updated in the same process," says Kaponeridis.

The availability of electronic documentation makes possible the creation of electronic job cards, which can be viewed on computer stations in hangar kiosks or on tablet computers. There are several advantages as a result. The first is that electronic technical records become a possibility, although a lot of infrastructure is required to create and display task cards on computer screens. Once in place, this system allows all completed task cards to be recorded and stored electronically as e-technical records, and so allow a paperless process.

"e-technical records can have many meanings," warns John Stone, vice president product manager at Ultramain. "From an Ultramain perspective, the benefit is derived from electronic signature and real-time data collection, or often referred to as data entry at source. Mechanics using our Mobile Mechanic execute task instructions from a tablet device. Work assignments are delivered directly to the tablet in the form of an electronic task card, and mechanics can quickly see material availability, tooling requirements, and other important information. Work instructions, for routine and non-routine task cards, are generated on the device, and signed off on it too. The cards also contain a link to the manuals, which can be viewed directly from the tablet. The back-office system automatically performs the necessary certification validations and compiles the tally sheets.

Everything, including ordering materials and recording parts changes, is done from the mobile device, so mechanics can stay on the aircraft, which improves their efficiency," continues Stone.

"A further benefit of such a system is that maintenance is recorded instantly as it is completed, and shop floor data collection (SFDC) of man-hours (MH), and material and parts consumption is accurately recorded," says Reed.

The same benefits apply to the changing of rotable components or aircraft hardware. Not only is the aircraft's configuration and maintenance status updated, but component removals and installations are also recorded in real time, and component removal interval data is also recorded accurately. Other useful statistics also become available.

Reed explains that a further benefit derived from the generation of real-time data and accurate SFDC information is that more accurate and instant billing of maintenance work packages for a customer's aircraft is now possible.

While using tablets has several advantages, there are also limitations. "Only relatively small projects can be performed through tablets, such as performing maintenance tasks and all the related issues," says Ron Schauffele, chief executive officer at Swiss Aviation Software. "Larger items that are included in engineering management, for example, cannot."

Another issue with tablets is that it is more complicated to use them for customers' aircraft. "Preparing electronic documentation for a customer's aircraft, performing paperless maintenance, and returning all technical records in an electronic format is hard or even impossible, because electronic, paperless maintenance is not a single, straightforward process for all maintenance facilities," says Schauffele.

The up-to-date maintenance, configuration and reliability data can be used in several engineering management functions.

Maintenance programme

Maintenance programmes are getting more complicated. Fewer tasks have the same intervals that group them into pre-arranged checks, and a larger portion of tasks have individual or out-of-phase (OOP) intervals. "More complex maintenance programmes need an M&E system to monitor when tasks are coming due, group them together and plan them into work packages," says Tim Alden, commercial director at Rusada SA. "It is now too complex to track each aircraft's accumulated flight hours (FH) and flight cycles (FC) manually with a paper system. Management with an M&E system requires maintenance data, manuals and documents to be in an electronic format."

Several gains in the efficiency of maintenance programme management have been made possible by the application of M&E systems.

"The switch from a maintenance steering group 2 (MSG-2) system to an MSG-3 system for maintenance programmes of modern aircraft types, combined with an M&E system, can deliver significant savings," adds Nagalla. "The overall advantage is the increased predictability of maintenance. The M&E system will alert the user to all maintenance tasks coming due as the accumulated FH and FC aircraft utilisation data, and calendar time are fed into the system. This means that the utilisation of maintenance intervals (yield) can be improved. The effect of this is that the system can bundle checks more efficiently, which also results in improved aircraft utilisation."

M&E systems can list all maintenance activities coming due, as well as all the opportunities and downtimes available to plan maintenance events. These can be shown graphically on a timeline of events. "It is not always best to achieve the highest possible level of interval utilisation, because this can

lead to several other inefficiencies," says Schauffele. "This is because maintenance events require varying amounts of resources, such as labour skills, tooling and equipment, and parts. Their availability will depend on where the aircraft is predicted to be at each possible time that the maintenance event could be performed.

"The user can tell Swiss AMOS what their planning preferences are," continues Schauffele. "An engine change, for example, would probably state that it should be performed at the operator's main base or another major hub where spare engines are located. Preferences for other types of maintenance events include the minimisation of aircraft ground times, and the need for certain tooling, parts and labour skills. There are also constraints, such as mechanics with the appropriate skills and the right tooling only being available at certain maintenance locations. AMOS will give the user several options of where and when to perform a group of consecutive maintenance events."

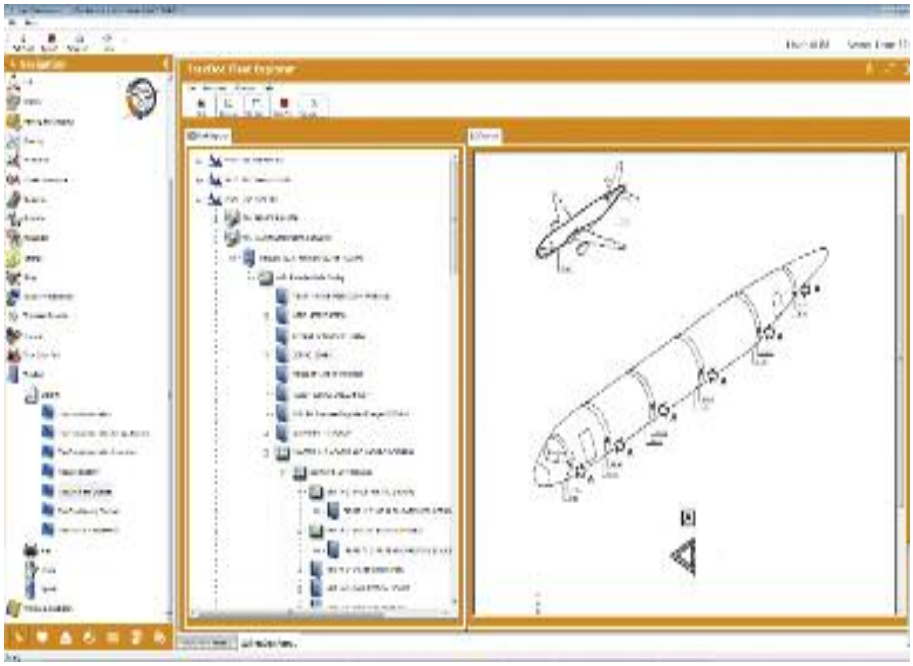
An important issue when planning medium-sized or large maintenance events is grouping appropriate maintenance tasks together. A heavy maintenance visit, for example, will include tasks that require the removal of a lot of interior items and deep access, inspection of flight controls, and corrosion inspections. These should all be combined, even if it means performing some tasks earlier than their interval to avoid repeat access MH. Swiss AMOS has the functionality to plan and group related tasks together.

Swiss AMOS plans to make it possible for users to automatically plan maintenance events. The system will create several workpackage options for the user, and list the aircraft's location, timing of the maintenance event, and all the other related parameters. "The overall aim is to optimise not only all maintenance costs, but also all aircraft operational costs," says Schauffele. "This is not possible for an airline that is outsourcing its maintenance to a third-party provider. Instead, it is indirectly hiring the maintenance provider's costs, which it is seeking to optimise. Now that the power of M&E systems to optimise an operator's maintenance costs has increased, many airlines are now insourcing some maintenance activities that they had outsourced. Costs can only be optimised within an airline itself."

Another issue relating to maintenance programme management is that a lot of specialist knowledge from maintenance planners is required to make full use of an M&E system's ability to improve efficiencies. "Good planning engineers, with a lot of specialist knowledge of the aircraft's maintenance programme, are needed to assist with optimising and scheduling maintenance events," says Kaponeridis. "Airlines can often use more MH than others for similar maintenance checks, due to less efficient maintenance planning and execution. The only way to optimise maintenance planning is by planners knowing all the relevant parameters, provided by the M&E system, and having the experience to use them correctly."

Following maintenance execution, airline engineering departments need to analyse and collate all defects and findings arising from a maintenance check. "Airline engineering departments need a system to collate and analyse these data," says Alden. "The results are used to extend or de-escalate maintenance intervals.

"Engineering teams can use Rusada's Envision to change the intervals of tasks to projected new intervals," continues Alden. "The user can analyse how newly formed maintenance packages fit into the operator's flight schedule, and how the changed maintenance programme and schedule of events affect demand for maintenance capacity. The user can then compare the two maintenance programmes, schedule of projected events, and the demand for maintenance



Documentation and manuals in electronic format has multiple benefits. Trax's system illustrates here how users and mechanics can search through multiple manuals, that are linked, and also search through an aircraft's configuration and structure. Electronic format allows the system operator to ensure that all users are using the same set of manuals throughout the organisation.

capacity. The user also needs to be able to examine the utilisation of aircraft and maintenance facilities in different scenarios. This is not possible without electronic data and a M&E system, since it takes six months to do it manually."

Stone adds that further improvements in maintenance programme management are possible. "Tools like Ultramain's Mobile Mechanic make MH collection and linkages between routine and non-routine task cards more reliable," says Stone. "These are important factors in planning optimised heavy checks in terms of ground time, as well as having a well-established feedback loop that will guide the reliability programme. Also, as Ultramain provides a simple mechanism for recording time on task, accurate data are available for future analysis."

Line maintenance

Improvements in line maintenance efficiency can be realised through better communication of faults and defects occurring on the aircraft with ground stations, such as maintenance control and line maintenance.

Most defects that occur in flight, especially those related to aircraft systems, are detected by built-in test equipment (BITE) and generate central maintenance computer (CMC) codes. Aircraft have had these systems for several decades, and many airlines can transmit these fault codes to the ground via the aircraft communication addressing and reporting system (ACARS).

This transmission of fault and defect data has allowed MCC and line maintenance departments to analyse defects and prepare rectifications before an aircraft's arrival. The aim of this is to save long delays on the ground that could occur if faults were reported manually on the aircraft's paper tech log.

Some airlines do not have the connectivity systems on their fleets to transmit CMC fault codes while in the air, so technical faults and defects can only be reported once the aircraft has landed, and the paper tech log is handed to line mechanics.

Many M&E systems have been configured with functionality to analyse CMC fault codes as they are received. This requires some level of integration with the various manuals, such as the fault isolation manual (FIM) and troubleshooting manual (TSM).

A second category of faults is those that do not generate CMC fault codes, such as physical breakages and sluggish or sticky flight controls. These have always had to be recorded in the tech log, and can be reported via ACARS messages or voice calls on the radio while the aircraft is in the air.

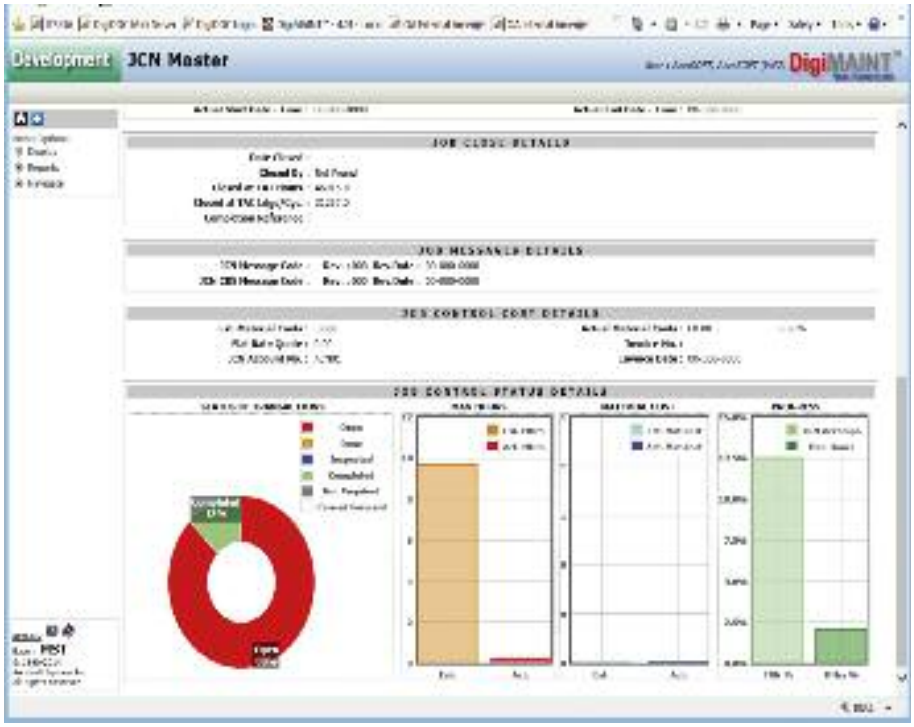
Improved and real-time communication of all technical defects, and the aircraft's flight log, in an electronic tech log (ETL) are expected to improve line maintenance efficiency. "The problem with a traditional line maintenance and paper tech log system is not that aircraft cannot transmit all the aircraft's technical defects and faults to the ground," says Stone. "It is more that the information exists in several systems, and not all maintenance personnel have access to these. A properly implemented ETL can bring all the information together, including a well formed pilot write-up. Our Ultramain efb TechLog can be configured to provide a fault reporting manual that is easy to search and navigate, ensuring that all pilot reports are linked to CMC fault codes and messages. This reduces the time used to search problem history and previous repair records, which is a main issue in speeding up fault rectification and turnaround times. Ultramain also has status boards that show the aircraft's location, what maintenance problems it is experiencing, and the parts available and shortages at the same location."

There have been many developments in ETLs in recent years, and these are due to be implemented by more airlines over the next few years. "The big advantage of ETLs is the faster transmission of information. About 10 airlines are introducing ETLs over the short term," says Schauffele. "Swiss will do a fleetwide ETL implementation in one day in conjunction with Swiss AMOS.

"The main issue with line maintenance and ETLs is the speed with which a technical problem can be handled," continues Schauffele. "This includes getting fault and defect information into the M&E system more quickly, searching through manuals and diagnosing the faults, and preparing remedial action. This ensures that ground time is not lengthened unduly or excessively during the scheduled turn time between flights. This has significant advantages given that a flightcrew exceeding its legal duty time can translate into a cost of $250,000-300,000 for a 24-hour delay of a long-haul flight."

EmpowerMX is currently deploying its ETL with its first customer, ABX. "ABX is a US freight carrier that operates to a large number of remote locations, including airfields in Africa with very limited ground facilities," says Nagarra. "Our ETL performs line maintenance, and is designed to replace the aircraft's paper tech log. The line maintenance tasks are on the tablet computer, located on the aircraft, that also hosts the ETL, where technical defects will have already been recorded during aircraft operation. The system works 100% offline, and it can be used to make basic technical records.

"When working offline, and there is no connectivity with the operator's main M&E system, the ETL and tablet can still be used to collect data," continues Nagalla. "When there is connectivity, and the system can work on-line, the system can be used to report and update the aircraft's maintenance status. It can also be used to order and request parts, view manuals, and report non-routines."



One advantage of M&E systems, and the use of electronic data, is that the progress of maintenance events and airframe checks can be monitored in real-time. The labour and material cost inputs used in maintenance checks can also be examined accurately and soon after maintenance event completion.

Rusada has similarly developed several mobile applications for an Android-based maintenance and tech log. "Most airlines want an ETL to replace the traditional paper tech log with a fully electronic and paperless system," says Alden. "The two halves of the tech log are the flight log, and the recording and reporting of technical faults and aircraft defects. Our tech log is an Android application hosted on a tablet computer. The tablet stays on the aircraft, and the flightcrew record the technical defects as they occur. The device can send and receive data while it is on the ground using 3G or WiFi signals. The system can then be used to keep the aircraft's technical log, and by line mechanics to work on defects that were recorded in the previous flight by the flightcrew. It is also used to complete the scheduled line checks and tasks. The mechanic needs all the information to complete a work package. The system also needs to be on-line for the mechanic to requisition parts, and communicate with other departments. The system can work off-line and be autonomous, and the mechanic can still open a pre-prepared task, sign it off, and report findings, so it allows fully paperless line maintenance."

Once the system establishes 3G or WiFi connection, it can be updated.

Airframe check execution

The MH needed to perform an airframe check are estimated in the MPD. Airlines use multipliers to estimate actual MH required, and this is modified and fine-tuned over time. The efficiency of labour used in airframe check maintenance is a large factor in determining maintenance costs. Labour efficiency is the mechanics' productive time expressed as a percentage of their clocked-on time.

"Labour efficiency under a paper system is 60-65%," claims Alden. "Improving labour and airframe check execution efficiency requires the M&E system to have all the necessary data. This includes the number of MH available from mechanics with each type of licence, the tools and equipment available, and the parts and facilities open space time.

"If the M&E system has all the necessary data it can generate a maintenance capacity plan," continues Alden. "The system then plans all the maintenance check packages coming due. The user will want to analyse the check package in terms of a breakdown of the estimated MH used for aircraft preparation, access for deep inspection tasks, routine inspections, a breakdown of these routine tasks, expected rectifications, interior cleaning, and all the other elements that form an airframe check. Users like to have different phases or elements of a check coded, so that they have full visibility of what is going on in the check. If this is as detailed as possible, then labour efficiency can be improved. It has improved from 60-65% under a traditional paper system to as high as 90% with an M&E system that has all the necessary data and sufficient functionality to improve and fine-tune check planning and maintenance processes. SFDC from previous checks is also an element in improving labour efficiency, since an accurate picture of labour used can be gained."

Ultramain has the functionality to produce several real-time status boards that indicate the status and real-time progress of a maintenance check.

A recent development is the ability to provide task cards electronically on tablet computers, interact with task cards so as to access documents and manuals, request parts and report findings, capture MH and material cost input data (SFDC), and create electronic technical records. "This can improve the flow of tasks, and may end up reducing MH consumption," says Schauffele. "Swiss AMOS is encouraging customers to use maintenance kiosks in the hangar until they are all using tablets. The transition to tablets is a much bigger step."

The other advantages that SFDC and the use of electronic tasks deliver are the reduction in check administration, faster reaction times to large findings and technical difficulties, a higher quality of information, and better billing data when performing third-party maintenance for customers.

Many details affect the efficiency of labour and the speed at which an airframe check can be completed. "A mechanic may find it hard to decipher what another mechanic did on a large maintenance task that was halfway through completion at shift change," says Nagalla. "Such confusion is common when using a traditional paper system, which causes delays and makes it harder to establish when a maintenance check will be completed. These issues can be avoided if the M&E system planning the check has full visibility of all the parameters, is able to identify critical paths in planning the sequence of task cards, monitors check progress in real-time, and provides real-time communication between mechanics and various engineering departments. These all provide visibility of the maintenance check and the factors that affect its completion. Delta TechOps improved efficiency by 25% using our system."

Rotable inventory

It is not possible to optimise rotable part inventories held at each of an operator's main bases and all its outstations, with a manual system.

An airline will seek to have a 95% availability, or service level, of essential or 'no-go' parts, and parts whose failure cannot be deferred across their

operation. While this is essential to secure a reliable operation, many airlines have excessive stocks of inventory. There are several reasons for this. "One is that airlines change aircraft types serving particular routes, but then fail to remove the relevant rotable stocks for that type from the outstation the aircraft was operating to," says Bob Merrifield, SLM business development director at PTC. "This may be because optimising rotable inventories, and preventing wastage or surplus material from accumulating, is not a main priority for airlines, and there is no active management procedure for tracking idle or surplus stock."

Another reason for surplus stock accumulating is that part numbers can go through several modifications and upgrades over an extended period, and so become less applicable to the aircraft types they are fitted to. Parts may not be modified and upgraded, while older aircraft of a fleet may be replaced with younger examples of the same type that use different dash numbers of the same part number. Either way, rotable parts can become obsolete and so gradually become utilised at a lower rate.

Another reason is inaccurate reliability and fleet utilisation forecasting data. The electronic tracking of parts can help engineers develop soft times that predict the removal of components.

Optimisation of inventory is improved with specialist algorithms in the M&E systems, and specialist point solutions to consider all relevant factors.

"Flight operations departments need to know the probability of needing parts, and where they will be needed," says Stone. "Ultramain has several functions that identify slow moving and non-moving parts, while balancing these with pre-purchases for the future modification of parts. The system also needs to know why the parts are non- or slow moving, and which will be needed in the future to avoid identifying them as surplus to requirements."

PTC acquired Servigistic's Lifecycle Management solutions, and now offers its Service Parts Management (SPM) software as a specialist solution to optimise rotable inventory. Several airlines interface it their M&E systems. Air Canada, for example, integrates SPM with Trax, while Qantas integrates it with Mxi's Maintenix. SPM is also used by Delta Air Lines, Air France, American Airlines, and Southwest Airlines.

Besides taking into account all factors that determine and affect the amount of stock required, SPM helps the airline user create a two- to three-year rotable order plan, based on the aircraft scheduled maintenance events that are expected to happen over the same period, all probable and possible rotable removal and maintenance events, and fleet changes. These data are taken from the M&E system and are used to generate a forecast of demand for rotable inventory over the period.

SPM can also be used to determine an initial provisioning requirement for each fleet, and to recommend stocking levels, optimise stock levels, and calculate safety, minimum and maximum stock.

SPM can then prompt inventory adjustments in response to excesses and shortages, by making comparisons between repairing stock and buying new items.

By implementing SPM, Qantas improved the accuracy of its demand forecast for inventory, raised availability rates from 92% to 95%, reduced costs by avoiding repairs, and significantly reduced the amount of inventory held.

New generation aircraft, such as the 787, generate a lot more aircraft health management (AHM) data, so it is getting easier to predict rotable component failures and removals, and to calculate component removal soft times. Aircraft manufacturers have developed algorithms to correlate different factors that can lead to component or system failures. AC