Several main issues have to be considered when configuring a maintenance IT system for the future. These include system functionalities, system configuration, documentation management for modern aircraft types, and providing a fully electronic system.

Considerations when configuring a maintenance IT system

The elements an airline or maintenance repair and overhaul (MRO) user should consider when configuring a maintenance and engineering (M&E) information technology (IT) system are wide and far-reaching. A user must be aware of the capability they need from the system once it has been fully implemented and is operational, and ensure the system has the flexibility to keep up with the user's requirements as these evolve over time.

The first and most obvious consideration is the range of functionalities and capabilities that are likely to be required going forward. Another, and perhaps overriding and more important issue, is the system's overall configuration and architecture. It should be structured from the outset to make it adaptable to the user's progressive changes in functionality and developments in software and applications.

Another main issue to consider is the system's ability to operate with a range of document and manual standards and formats to start with and into the future. This will be partially influenced by the system's configuration. This has become a more relevant issue because modern aircraft types have their documentation and data supplied in a variety of specification and standards, and formats. These include iSpec 2200 specification and standard, and written in standard generalised mark-up language (SGML) for most modern aircraft types. The latest types of the 787, A350 and C Series have their documentation supplied in S1000D specification standard and in extensible mark-up language (XML). An increasing number of aircraft types is likely to have their documentation and data provided in S1000D and XML as they enter service. This will include the 777-X.

Given the variety of document standards and languages available for electronic documentation content for a range of aircraft, engine and component types, another main consideration for an airline or MRO is how it is going to manage documentation and data. This will be partially influenced by how much authoring and editing it is going to want to do for its documentation at the start of operations, but also how much this policy may change in the future. In general terms, the approved maintenance programme (AMP), the aircraft maintenance manual (AMM), the illustrated parts catalogue (IPC) and the approved parts list (APL) are the manuals that an airline may want to edit, or add its own authored contents to. The other manuals, which include the structural repair manual (SRM), the troubleshooting manual (TSM), the fault isolation manual (FIM), and the aircraft wiring manual (AWM), do not require any edits or changes. An airline or MRO will use original versions that are issued by the original equipment manufacturer (OEM).

How documents are managed also depends on the user's plans to have electronic and paperless maintenance, either when the system is first implemented or in the future. The ability to conduct electronic and paperless maintenance will be influenced not only by the system's configuration and its ability to handle specific data and document standards, but also by factors including: the number of airline operational and maintenance hubs; the type of maintenance being performed; whether maintenance is performed in-house or sub-contracted; and if the user performs third-party maintenance for others.

System architecture

The majority of M&E systems operated by airlines and independent MROs are a two-tier configuration. The systems being offered by some M&E vendors now have a three-tier structure. These vendors include Trax, Ramco, nd IFS.

Original single-tier systems that had both stored data and software or applications located on the mainframe are inadequate for today's airline and MRO requirements. There may now be no more than 100 users with this type of configuration in an airline environment.

Two-tier system

A two-tier system is based on a number of desktop personal computers (PCs) linked to a main database server. A two-tier system can operate with wireless links between the database server and at least some of the users' computers.

The number of PCs used depends at least on the number of management and planning engineers that need to perform their functions simultaneously.

The individual PCs have the applications stored on them. An identical set of applications does not have to be hosted on each PC.

Data is passed from the database server to individual PCs as each user performs functions and operations via the various applications. Updated data and information is then passed back to the database server for storage. This can include simple information such as updating aircraft flight hours (FH), flight cycles (FC) and flight log information, or more complex data such as the changes to an aircraft's component configuration.

A two-tier system is also based on the traditional system of the user physically

More airlines and MROs are progressing to fully electronic, paperless maintenance. Users of M&E systems will soon have to consider how to configure these systems to allow for seamless fully electronic maintenance, whether performed in-house or sub-contracted to another party.

owning and operating the database server, and so holding responsibility for maintaining the system and software.

Traditionally, this type of system configuration has been used for traditional paper-based maintenance, whereby planning engineers use the M&E system to generate and produce printed task cards, which are then used by mechanics and manually signed. These might then be scanned for storage.

The completion of tasks could be recorded electronically using an electronic signature process, which requires the mechanic to inform the system that a task has been started and completed by swiping a barcode on the task card. This is backed up by the mechanic identifying themselves with a PIN number. This records the time taken to complete the task. Other information, such as findings and component changes, have to be written on the card by the mechanic, and then manually keyed into the M&E system after the check has been completed.

Although a barcode scan removes some of the manual steps that are involved in task completion, this is not a truly electronic system. Developing system architecture to perform purely electronic maintenance and remove all paper documents and manual processes presents several challenges to the user.

Three-tier systems

The basic structure of a three-tier system is a database server, which like a two-tier system stores all the data. This is connected to one or more application servers, which host all the required applications. Each server should have an identical set of applications. These are in turn linked to a large number of user devices. These can be desktop PCs, tablets or portable devices, such as tablets. Each user will therefore draw data from the database server and use an application hosted on the application server to perform a function and use and generate data on a fixed or remote device via a web browser. "Accessing data on a web browser via the internet means the systems can use a vast array of the rich functionality supported by HTML5 capability," says Tony Louw, presales consultant aerospace and defence at IFS. "A lot of mainframe and legacy systems do not have this capability, and they are also more limited in what can be accessed over the internet".

Completed maintenance data and information is transferred back to the database server post-maintenance.

The main difference with a two-tier system is that the user can be linked to more than one server. The architecture also makes it easier for the user to upscale the system if it needs more users, such as a larger number of mechanics, to use it. This is because the number of application and database servers can be increased without disrupting the system that is already in place.

The three-tier architecture therefore provides its user with flexibility and redundancy. This is partly because the application servers host identical applications, and also because the data and application servers can be updated to provide more capacity for data and applications. This architecture also makes it easier to implement truly paperless functionalities, because the system will not be interrupted by changes or additions.

The system can also be Cloud-based. The database and application servers can therefore be accessed via the internet, rather than the user having its own servers on its premises. This means the airline or MRO does not have to maintain system infrastructure, and only has to own the devices used by each engineer and mechanic. Some M&E system vendors use a third party to provide the database and application servers. Trax, for example, uses Amazon as its provider. Other vendors, such as Lufthansa Systems, have their own database and application servers.

Three-tier systems can be configured in two main ways. The first is for the user devices to be constantly connected to the application servers. This does not present a problem for fixed desktop PCs, but causes difficulties for remote and portable devices that are connected wirelessly and which are used for line or hangar maintenance. "The main issue is that the wirelesss connection can be temporarily lost while a user is performing a function or task while connected wirelessly," says Chris Reed, managing director at Trax. "This causes a problem in some systems with data being lost and the function or task having to be performed again. Some vendors have developed applications that require a constant connection via the internet, and cannot function by saving work when a connection is not established. Such an architecture is expensive to operate.

"The second type of configuration will be for the users' devices to host applications that can function off-line, when connectivity is lost," continues Reed. "The completed data on the user's device can then be re-synced with the database server when the function is completed and connectivity is restored."

With applications hosted on users' devices that can work off-line, wireless connections between the devices and the application servers, and a system that transfers all relevant data and information in both directions, then fully electronic and paperless maintenance with 'intelligent' task cards can be performed at every maintenance location and by every user of the system.

FleetCycle by EmpowerMX is an example of a vendor that offers a system for mechanics to perform maintenance through both permanently and temporarily connected portable computers. "For line maintenance we

have the e-Log book. This is used by pilots to record issues such as defaults and defects, and pilot logs," says Hugh Revie, vice president regional sales EMEA at EmpowerMX. "This can then be accessed by a line mechanic, and it effectively provides them with the non-routine tasks in line maintenance. The app can be used to complete these.

"We also have another app for routine line maintenance tasks. This has to be constantly connected, but we are about to release an upgraded version that does not have to be constantly connected," continues Revie. "The data and information can be sent to the M&E system when the tasks are completed, and connectivity is re-established. Airlines want the flexibility to have line maintenance apps that work whether they are connected or not, since connectivity can be erratic on the line."

Performing base maintenance is a different issue. The hangar environment means that connectivity is rarely lost, and airlines and MROs that operate such a system use both desktop PCs and portable computers. EmpowerMX's FleetCycle also has a module and an app for base maintenance. This only works when constantly connected. "The system is designed so that the mechanic has to enter a few pieces of information from each page of a maintenance task," says Revie. "This means the steps of a task do not have to be re-done when connectivity is lost."

Maintenance organisation

A three-tier M&E system has a greater degree of flexibility to suit an airline's and an MRO's requirements. The system's configuration has to be structured around the user's organisation. "The design of a new M&E system has to consider the number of different maintenance locations, the number of people at each location, and the availability of connectivity at each maintenance location," says Louw. "Another major consideration is the different levels of education and experience of a system user's staff."

The first issue to consider is the number of locations where maintenance is being performed, and the number of users and mechanics at each location that are simultaneously using the system. This also raises the issue of the different types of maintenance being done.

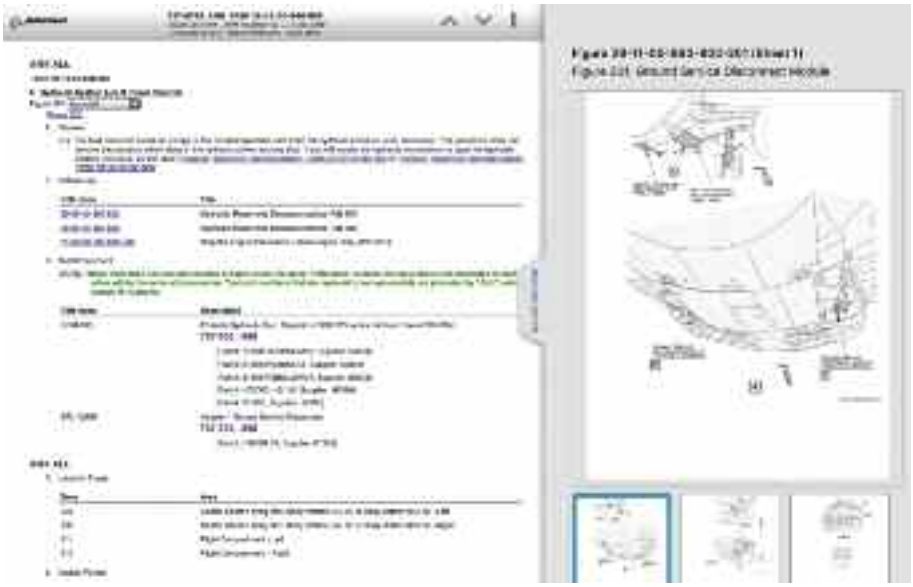
The first location is the engineering department, which comprises the traditional and core group of people that have used M&E systems.

The main elements of touch maintenance are airframe hangar maintenance, line maintenance, engine maintenance, and component repairs and testing.

The number of airframe hangar maintenance locations is relatively small, even for airlines that perform a lot of their airframe maintenance checks in-house. The number of mechanics simultaneously using the system can, however, number several hundred. The same applies to an independent MRO.

Line maintenance will be performed at a large number of locations, including all an airline's hubs and many of the destinations it flies to. Even with outsourced line maintenance, data has to be sent back to the user's M&E system. There will be up to several hundred line maintenance locations, and hundreds or even thousands of users. The ability of an electronic task card system to transfer task card data back to the M&E system depends on programming. Most M&E systems require a mechanic's recorded inputs to be manually entered into the M&E system.

Electronic flight bags (EFBs) and electronic technical logs (ETLs) are increasingly being used to record flight operations data and information electronically. The data and information can therefore be transferred to the M&E system database automatically. As with line maintenance mechanics, there will need to be an interface for hundreds of



EmpowerMX is one of the first M&E system vendors to develop a fully operational intelligent and interactive electronic task card system. One functionality of a fully interactive task card is electronic links with the relevant pages of manuals associated with the task.

flightcrew members.

Maintenance control, and parts and component stores also require access to the M&E system.

A final main element of in-house airline maintenance will be parts and component repair shops. The nature of these shops is that mechanics work in close proximity to components, so they can use desktop PCs.

System functionalities

A system user will clearly have to consider the functionalities and capabilities it requires from a new system. There are 17 general categories of system functionality, but most airlines and MROs have not needed all of these capabilities, or have not had all of them performed by the M&E system. Some functions have been performed by point solutions.

The 17 main categories of system functionality can be divided between several sub-categories: general management; engineering management or continuous airworthiness management organisation (CAMO) functions; documentation and content management; maintenance planning and production; inventory and parts management; and maintenance records and reporting.

General management functions include human resources and finances, invoicing, accounting, and tracking of tooling and equipment.

Engineering management and CAMO functions include: aircraft configuration management; engineering change management and reliability analysis; quality control and assurance; warranty management; and regulatory compliance .

Documentation and content management is regarded by some as an element of engineering management, because it is a core function of an airline's engineering department.

The advance in the technology of documentation standards and formats, such as S1000D and extensible mark-up language (XML) data for the most modern aircraft types, and a growing requirement for paperless maintenance processes, however, means that documentation and content management is now more likely to need its own dedicated system in the form of a content management system (CMS).

Maintenance planning and production functions include: long-range maintenance planning and maintenance bay allocation; maintenance packaging and planning; production and control planning; and maintenance execution and control.

Inventory and parts management include sourcing and material management, and inventory control and warehousing.

Aircraft maintenance records and reporting may also be considered as an element of engineering management, but can also be regarded as a category of its own right.

These functions and capabilities can be divided between those that are standard functions that require little or no further development in system capability than current M&E systems, and those that require an increase and improvement in M&E system capability to allow performance of maintenance with intelligent task cards.

The functionalities that require little or no extension in system capability are all the general management functions, engineering management and CAMO functions, and the inventory and parts management functions.

Content management

The maintenance planning and production capabilities, and the documentation management or CMS functions are the ones that require better capability than that offered by most current M&E systems for performing truly electronic and paperless maintenance. Truly electronic maintenance includes having a system for the bi-directional transfer of data between airlines and all of their maintenance providers.

The key to fully electronic and intelligent task cards is the full functionality to perform all items that a mechanic does manually on a paper card. The key for a system's ability to do this is the functionality of the electronic data that is sent to the mechanic's device.

First, the task card needs to be viewed on a mechanic's device screen. This is achieved by rendering the card on the screen using HTML pages.

The task card also needs to be 'intelligent' or interactive. This includes having links to electronic versions of relevant manuals, such as the IPC or APL. A mechanic also needs to be able to request parts electronically from the task card.

An electronic task card also needs the functionality for the mechanic to contact a check supervisor electronically; as well as record findings, and measurements. The findings will be data and information that has to be transferred back to the M&E system.

Finally, the electronic task card will have to be signed digitally, using a secure identification system such as a fingerprint, and then rendered as a reputable electronic image.

All these functions and capabilities are only possible if the data sent to the device, to be rendered in HTML pages, is written in XML or a language with similar functionality. The M&E system therefore at least needs the ability to deliver XML content to the devices.

The majority of commercial transport aircraft have their technical documentation supplied in iSpec 2200 specification. This includes the 737 Classics and 737 NG families, the 757, 767, 747-400 and -8, 777 family, the A320 family, A330/340, and A380. It also includes: the CRJ and Dash 8/Q400 families from Bombardier; the Embraer ERJ and E-Jets; and the ATR turboprops.

Content in iSpec 2200 follows the same linear standard for manuals of earlier aircraft that are printed. That is, every update and revision has to be made to every affected page. iSpec 2200 content is written in SGML language.

"This gives the content some intelligence and functionality, but is generally insufficient for fully interactive task cards," says Dinakara Nagalla, president and chief operating officer at EmpowerMX. "Content in SGML has to be converted to XML if a truly electronic maintenance system is to be implemented."

Besides being the language required for an electronic maintenance system, XML has several other advantages. This includes a series of links between other pieces of content in various manuals, which can allow a faster and automated changing of documentation content each time these are issued by the OEMs.

Utilising the full advantages of XML content is not possible with most legacy and current M&E systems, however. "There is a limit to what most standalone M&E systems can do with XML content, and they only have limited capability to edit and amend all its characteristics," says Reed. "An airline or MRO will not get the full benefit of XML content with just an M&E system. This is due to their database structures."

The full functionality and capability of XML-written content can only be realised by using a CMS that is interfaced with the M&E system, or by using the OEM's on-line document management portals.

While an M&E system primarily performs functions relating to aircraft data, a CMS has the database structure required to maintain and manage all the relationships between sections and pieces of XML content, and allow it to utilise all its functionality. In addition to fully managing XML content, a CMS may also be required to edit and author content, such as the task cards in the AMM, and the IPC and APL.

"Editing and authoring these manuals is easier and more efficient with a CMS, although it is not mandatory," says Reed. "While smaller airlines may usually use the standard AMM published by the OEM, medium-sized and larger airlines may want to author their own additions, such as adding their own tasks, or editing tasks in the AMM. Airlines may want to add alternative parts to the IPC, and list them in the APL. This can be done in an M&E system, but requires a lot of manual editing for every update or revision."

CMS systems are available from Flatirons Solutions, IDMC and Aerosoft.

The alternative to using a CMS is for the user to maintain a version of these manuals in an OEM's on-line document management portal. These include Boeing's maintenance performance toolbox (MPT), and Airbus's ADOC.

Boeing's MPT can operate as a CMS for an airline's M&E system with which it is interfaced. The data for most Boeing types, except the 787, is provided in iSpec 2200 standard and written in SGML. It can also be made available in PDF and standard written ATA format to take account of the range of airlines' M&E systems.

Boeing also has a system for electronic task card operations. MPT has the capability to manage task card information in SGML or XML. "The data can be exported in XML format to the maintenance provider's system for forming task cards on the mechanics' devices," says John Maggiore, managing director maintenance and leasing solutions, at Boeing Digital Aviation. "The data can also be exported to an airline's or MRO's M&E system, so MPT effectively operates as a CMS.

Airlines that use MPT have the choice of using the standard MPD, AMM, IPC, and task cards; or customising the AMM and task cards using the XML authoring capability. Moreover, the system can be used for non-Boeing types, including Airbus and Embraer aircraft.

Another option is for an airline or MRO to use third-party CMS support. Flatirons Solutions is one provider of this service. Flatirons offers several options for an airline. The first is to render the original OEM content in XML without any edits. The second is for Flatirons to edit the original OEM content on behalf of the airline. In both cases task card

content can be held in the Cloud for the maintenance provider to then use on mechanics' devices.

Bombardier, for example, provides a similar system for the CSeries. An operator can have the task card data for the aircraft provided on an XML data exchange platform, which is interfaced with its M&E system.

S1000D content

In addition to the preferred content language of XML, the databases of current generation M&E systems also do not fully handle the S1000D specification/standard that is used for the 787, A350 and CSeries in a way that allows all its features to be fully utilised.

Since S1000D is likely to be the standard used for new aircraft, component and engine types to come, airlines and MROs will require systems that are capable of taking full advantage of the benefits of S1000D/XML content.

The first feature of S1000D is that, unlike its predecessor iSpec 2200 which is constructed in the linear process of writing a manual, the content is written in data modules (DMs). Each DM provides a piece of content.

Each DM will contain information such as task card text, a diagram, a reference to a part number (P/N), and all the other elements that are used to form a manual page. Each DM is often used in several dozen task cards and manual pages.

The correct DMs will be pulled together and rendered into a 'page' on the mechanic's device by an interactive electronic technical publication (IETP). The S1000D system therefore works by holding each DM only in one place on a common source database (CSDB), and being used from there on multiple pages.

The advantage of this modular system is that each time the information on a DM is changed because of an OEM's revision or update, it only has to be changed in one place on the CSDB, rather than on every task card and page in the manuals that the DM is used in. An example may be the changing of an approved P/N that is listed on 25 different task cards. If the content was written in the iSpec 2200 standard it would have to be changed separately on all of the relevant task cards, in addition to the IPC and APL. The S1000D structure and XML language means that content revisions and updates can be made quickly.

The drawback is that M&E systems have limited capability to operate with the DM structure of S1000D. More aircraft types will have their data supplied in S1000D/XML in the future, so M&E systems will need the ability to handle multiple formats for a variety of fleet types.

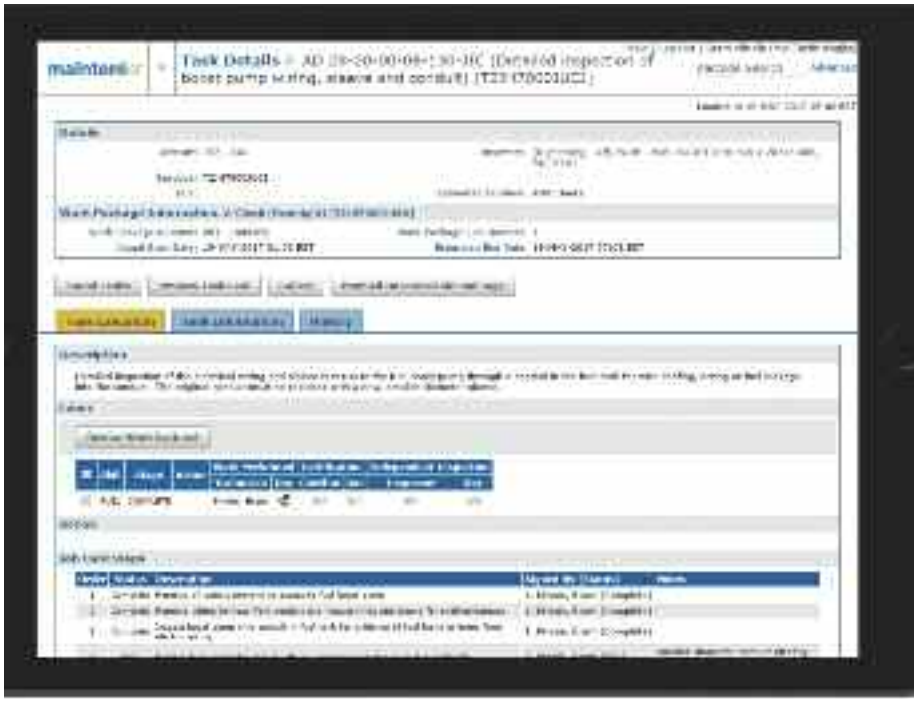
The benefits of S1000D/XML content can only be fully realised when an M&E system is used together with a CMS. One choice for an airline without a CMS is to convert the S1000D content into a format or structure that it can use. This means transferring the content into simple text and picture files, which loses its intelligence and modular structure. It would then take about three months to manually apply a revision.

This also leads to another problem, which is that pulling the relevant pieces of content to form a page has to be re-programmed.

In contrast, the use of a CMS allows the content to maintain all of its S1000D structure, and all the functionalities provided by the XML language. These are all required to author, edit and manage content with minimum time and efficiency; and provide all the functionality for electronic task cards to be fully intelligent and interactive.

Third-party maintenance

Third-party maintenance is a consideration for both airlines and MROs. There is no airline in the world that performs 100% of its maintenance in



Mxi developed an electronic task card system for Maintenix. Mxi has developed a system for converting electronic content into its unique specification and language. The converted data is then sent to mechanics' devices to form interactive electronic task cards.

house. Airlines will inevitably sub-contract at least a portion of their line and light maintenance to third-party providers, whether at outstations that are remote, or destinations to which the airline seldom flies, or where another airline or specialist line maintenance provider has a significant line maintenance capability.

Many airlines also sub-contract all or a large portion of their hangar and base airframe maintenance to other airlines or independent MROs. Even large airlines with a substantial in-house capability and network of partners and subsidiaries, such as Lufthansa, have to sub-contract some airframe checks on certain occasions.

In addition to engine maintenance, the majority of airlines also sub-contract a large portion or 100% of their rotable component repairs and management.

The basic implications of sub-contracted maintenance are the need for bi-directional communication of data and information between the airline and maintenance provider.

The traditional method of managing the process of sub-contracting base maintenance was for the airline's engineering department to prepare paper printed routine task cards, using pages from several manuals, and send them to the MRO together with the aircraft. The MRO would manually record findings, measurements and other information on the printed cards. The MRO would also have to write and generate non-routine cards.

The airline would then have to manually enter the data and information from the routine and non-routine cards that had been returned by the MRO. The information that would have to be recorded would be the completion of the task, the MH and any parts or components used for shop floor data collection (SFDC) purposes, component changes, and any findings or measurements made.

Not only is this laborious and inefficient, it also prevents the airline from operating with completely paperless maintenance.

Electronic third party

The preferred situation would be a bi-directional transfer of all data and information when sub-contracting maintenance. That is, all data would be sent by the airline to the MRO, which would then use its M&E system to present the information digitally as electronic and 'intelligent' task cards to mechanics on screens. The information from the task card completion would be recorded electronically, and then passed back to the airline as intelligent information that could be used by the airline's M&E system. The completed task cards would also be digitally signed and stored as electronic copies.

The bi-directional transfer of maintenance data and information when sub-contracting maintenance has several difficulties. Although much of the information used in aircraft maintenance, such as the format of task card numbers and component part numbers (P/N), were standardised by the air transport association (ATA), these did not have to be adhered to. As a result, few airlines and M&E systems did use them, and instead have their own formats and systems for data such as task card numbers, component P/N, approved parts list (APL) numbers, and aircraft serial numbers (S/N). This information causes problems when being transferred between airlines and MROs.

Other problems arise in data transfer because, for example, one type of M&E system uses a different number of data sets to calculate a value than another M&E system. With more than 30 vendors of M&E systems, it rarely happens that an airline and its MRO of choice are operating exactly the same M&E system. Even when this does occur, each user may still have its unique formats for certain data sets. The overall problem is that almost every user has a bespoke system.

Another set of problems with transferring data between different M&E systems is the differences in their database structures. The databases of modern systems can store certain types of data that other, older systems cannot store.

These issues all mean that data needs to be converted before it is transferred to another M&E system, for example from an airline to an MRO before an airframe check. This requires an intermediate conversion database, often referred to as a staging database. This has all the conversion factors and algorithms to convert the data and information. A staging database is required for every permutation of two M&E system types. The transfer and conversion process is therefore not simple or automated, and instead consumes a large number of an engineer's man-hours (MH) to prepare data before transmission.

EmpowerMX has recently released a new module of its M&E system FleetCycle. "This is called FleetCycle Connect, and serves as a staging interface between two M&E systems," says Revie. "The objective of the Connect module is for a user to deploy the system as a staging and transfer application. This can be programmed to perform the data conversions required between two different systems. Overall, this will make it more efficient when an airline transfers data to an MRO, as well as in the other direction when the maintenance is completed." This process has to be performed efficiently if an airline is to be able to sub-contract aircraft maintenance, and have it performed purely electronically so that no paper or manual inputs to IT systems are required.

Intelligent task card

With an ability to create 'intelligent' and truly electronic task cards by

Air Canada Jazz developed an electronic task card system for the maintenance of its CRJs. Task cards are sent from Bombardier in PDF format. Additional capabilities to provide an intelligent maintenance capability were developed to be used together with the task card.

rendering them in HTML pages on screen using data written in XML, it becomes possible for an MRO to circumvent the problem of data conversion during transfer. "This is simply achieved by the devices used by the MRO's mechanics connecting wirelessly and via the Cloud directly with the airline's M&E system, rather than data coming from the MRO's M&E system," explains Reed. "This way completed maintenance data is also fed straight back into the airline's M&E system without having to be converted by the MRO before transfer back to the airline. A three-tier system makes it a lot easier to carry out paperless and fully electronic maintenance that is sub-contracted."

EmpowerMX is the first vendor to configure a system for an airline that provides interactive task cards on screen, allows the mechanic to use the system to do all maintenance activities paperlessly, create electronic maintenance records, and have a system configuration for third-party maintenance that circumvents the problems of data transfer.

EmpowerMX uses its FleetCycle system, which was first developed as a maintenance production module to be interfaced with other M&E systems. EmpowerMX has since added other modules to make FleetCycle into a complete M&E system. FleetCycle operates an electronic task card system for Southwest Airlines, Delta Tech Ops, Aeromexico, and Tech Ops Mexico (a joint venture between Delta Tech Ops and Aeromexico). All of these users perform maintenance on aircraft types that have their documentation supplied in iSpec 2200 specification and written in SGML. "The electronic task card system needs the data to be written in XML to have all the necessary functionalities. Intelligent and interactive task cards are only possible with XML," says Nagalla. "We therefore convert the SGML content into XML. There are various ways we have configured the system. Southwest sub-contracts its 737 base maintenance, and it uses Trax as its main M&E system, but uses Boeing's MPT for its task cards. MPT converts the data into XML, which is then sent to FleetCycle. FleetCycle is accessed in the Cloud by the maintenance provider's PC and portable devices. This means there is no need to convert the data into a format that the sub-contractor's system can use, and also it means that the sub-contractor does not require a CMS."

Aeromexico is using FleetCycle to generate intelligent task cards for line maintenance. Delta Tech Ops and Tech Ops Mexico are both using the system for intelligent task cards for base maintenance.

"We have also configured FleetCycle so that it operates on the same basis as S1000D," says Nagalla. "This means that although data for most aircraft types is not provided in S1000D, we convert the document and manual content into a data module structure, since this adds functionality. This is our own version of a S1000D style of structure, and not a version used by an OEM. We also add content to the data to make it into an executable version of S1000D."

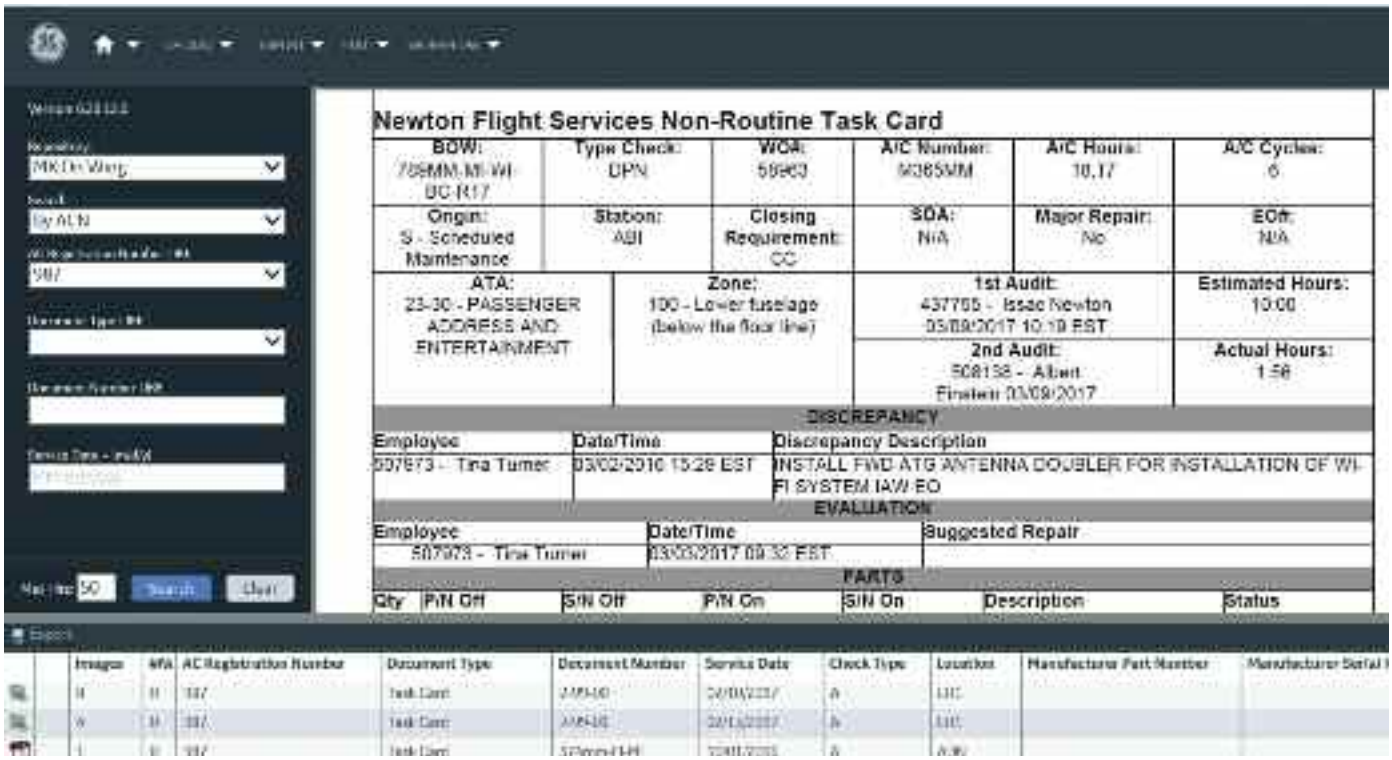
EmpowerMX configures the FleetCycle intelligent task card system so that the system performs all the necessary CMS functions for preparing the data to render task cards, and the maintenance production. This means that the airline does not therefore require a CMS. "FleetCycle is interfaced with the airline's M&E system, and it does the conversion to XML and all the subsequent functions with the data during maintenance production. The airline may have a CMS for other reasons, such as authoring and editing if it does not use an OEM system," says Nagalla. "One aspect of FleetCycle's CMS functionality is that it manages all release versions of task cards issued by the OEM. Like a CMS, it also ensures that the correct version of a card is issued for the aircraft line number and serial number; and AD and SB status."

The functionality provided by FleetCycle's own S1000D data structure and the use of XML gives the system all the functions of an intelligent task card. These include the links to other manuals, and the ability to request for parts and tools, communicate with supervisors, and report and record findings. "The links we have to other manuals such as the AMM and IPC are to the relevant page block level, and not the entire manual," says Nagalla.

In addition to the bulk of aircraft types that use iSpec 2200 for their documentation, EmpowerMX has also configured FleetCycle to use S1000D/XML content for modern types that include the 787 and A350. "Delta and Aeromexico both operate the 787, and this development means that FleetCycle will be the first ever M&E system vendor to provide a purely intelligent task card for an aircraft that uses S1000D standard," says Nagalla. "Aeromexico will use FleetCycle for the CMS functions, whereas Delta Tech Ops has a Flatirons CMS system.

After maintenance is performed on the interactive cards, the completed data is sent back to the customer's M&E system in the format that their system can handle. It is possible that Southwest will use the system for base maintenance subcontracted to AAR. "FleetCycle has a digital signature system, and two maintenance records are produced. One is an XML file, and the other is a pdf," says Nagalla.

In addition to EmpowerMX, Mxi (which has recently been acquired by IFS) has developed a system for a completely electronic maintenance execution with its Maintenix system. "The system basically builds an electronic version of the task card on the screen; and overlays instructions, diagrams and other information from the AMM and other manuals," says Kirk Strutt, product



manager at IFS. "We store the document and other data in a unique format that we developed for Maintenix. This is not the raw version delivered by the OEM. We have our own specification and language for electronic textual information, which is close to HTML, and had to be developed for an electronic task card system to operate. The conversion is done by the customer's CMS system, which is used together with Maintenix."

The Maintenix system therefore does not use SGML or XML, and instead the textual information is similar to HTML. The diagrams are unchanged. "This means the user's CMS has to separate all the information, data and diagrams into pieces," explains Strutt. "The associated meta data for the information, such as aircraft S/N applicability, is used by the M&E system for maintenance planning. The system is used by Air France Industries KLM Engineering & Maintenance for in-house maintenance. It is not used for sub-contracted maintenance."

The Maintenix system has links to the relevant pages of specific manuals, such as the AMM and IPC. The electronic task card has the functionality to communicate with supervisors, request parts, and record measurements and findings all electronically. Once maintenance task cards are completed, a full digital signature is used. A digitally signed pdf is made, and the raw data is also stored if it needs to be extracted. "While the system cannot yet be used for aircraft types that have their data supplied in S1000D/XML, we are looking at adapting it for this purpose," says Strutt.

Air Canada Jazz has developed an electronic task card system for the maintenance of its CRJs. This works by providing a task card for a mechanic on an iPad, but relies on data sent by Bombardier in PDF format. Air Canada Jazz, which uses Trax as its M&E system, has developed the ability to generate electronic links to the relevant manuals as well as various functional buttons for the mechanic to request parts, report findings, and communicate with supervisors. Once the task is completed, the system uses a digital signature and the data is stored in Trax.

"The Boeing electronic task card system operates by MPT interfacing with M&E systems," explains Maggiore. "The airline or MRO is given access to the task card data on-line, which is exported in XML language to the mechanics' devices. This is effectively a Cloud-based system, since the data does not have to transferred to the maintenance provider This creates integrated, intelligent task cards that can be viewed on mobile devices. Completed task cards can be signed-off digitally, and findings can be transmitted electronically. Other features are on our development road map for 2018. The system can be adopted by 787 operators that use MPT as a CMS for electronic task cards."

A scanned or electronic copy of the task card can be stored in the user's M&E system as PDF and XML. The XML export is data that looks like a task card.

Data analysis

Following completion of maintenance tasks and the creation of paper, PDF and electronic maintenance records, the data from completed maintenance can be analysed. In addition to the collection and analysis of SFDC information relating to labour and material inputs using the M&E system, it is now possible to analyse maintenance record information. Air Vault was acquired by GE Digital in early 2017, and is used to acquire a lot of data and information post-maintenance. This includes a digital scan of text from each task card. "Our Air Vault system performs a lot of data analytics from the maintenance process," says John Oldham, chief executive officer at Air Vault. "This includes the ability to examine the efficiency of specific maintenance facilities and hangar bays. There is also the auditing of compliance reporting, optimising maintenance practices, and generating reliability reports. The data that we use in Air Vault can also provide a lot of detail with respect to the maintenance performed, including all the inspection reports and the 8130 forms for components. Air Vault can therefore store all the maintenance documents and information for each aircraft, engine and component asset. It effectively operates as a warehouse for electronic task cards. - CHW AC

GE Digital uses the Air Vault maintenance records system to derive and analyse maintenance data on a large number of parameters. The system can warehouse all maintenance information for an asset's entire history.