The use of mobile hardware and applications is increasing in aircraft maintenance. Their use extends across line and base maintenance, engine and component shop repairs, spares and inventory requisition and management, and purchasing and authorisation.

Mobile applications & hardware for maintenance

Mobile applications and hardware for aircraft maintenance are developing at an increasing pace, and more systems are being deployed in commercial airline and third-party maintenance. This is a result of the necessary technological elements coming to maturity and being available. These include: the appropriate and correct data standards and formats; electronic signature; the functionality and capability of the hardware devices used for maintenance; and connectivity.

Mobile applications and hardware can be used in line and base maintenance airframe checks, in repair and overhaul shops for components and engines, and in parts and component stores and warehouses.

Three main types of systems are used for mobile aircraft maintenance: tablet, laptop and personal devices; wearable devices such as glasses, headsets, watches and hybrid devices; and voice control systems. These will eventually be deployed on all three main elements of aircraft maintenance. The most advanced, in terms of number of systems used by airlines and maintenance, repair and overhaul (MRO) organisations, are mobile systems using tablets in line and base airframe maintenance.

Mobile systems

A system for mobile maintenance in airframe checks enables a mechanic to perform all their tasks without having to refer to any paper and printed manuals, leave the work position or station to speak with or contact a supervisor or department, or leave the work station to request or find parts. An indirect benefit is shorter check downtimes, leading to increased aircraft utilisation.

The overall objective is to provide all the information and necessary communication links through a mobile device. Handheld and tablet devices, such as Panasonic Toughpads, Apple iPads, and the Samsung Galaxy are now superseding laptop computers in this role. The initial trend with mobile aircraft maintenance was to use iPads, an iOS system, but recent trends have shifted to Windows-based systems. Few have yet selected Android-based systems.

The overall function of a mobile airframe maintenance system is to provide an interactive task card, which can be viewed on the tablet screen. The airline's planning section in the engineering department will plan the task card content for a check, and plan the assignment of particular tasks to each mechanic on duty. There are several ways of transferring data and presenting task cards on laptop and tablet devices. Relatively simple technology is available to present task cards on a screen, but these are only images of the card for viewing purposes to provide instructions. The mechanic performing the task cannot modify them or sign them.

An alternative to an interactive task card is to have a PDF overlay system. The created task card is generated in the M&E system, and transferred as a PDF to the mobile device. The mechanic can then write over the PDF on the screen, filling in data and signing individual tasks. The finalised card is then rendered as a completed PDF. This system has been certified, and is in use with several airlines and independent MROs.

An interactive task card will not just be an image of a task card presented on a screen, but will first allow the mechanic to fill in values or tick boxes as each step of a maintenance task is completed.

Links between the task and technical publications such as the illustrated parts catalogue (IPC), aircraft wiring manual (AWM), and structural repair manual (SRM) will allow the mechanic to consult any relevant documentation and diagrams through the tablet.

While an interactive task card is the goal for airlines and system vendors, intermediate developments include mobile technical publication and document viewers. An example is the system developed by Flatirons Solutions. "We have a content and technical manual viewer for line and base maintenance, and these are available in desktop and mobile tablet versions," says Wayne Enis, vice president Middle East at Flatirons Solutions. "We have recently updated the mobile version to ensure that it has the same functionality as the desktop version. We support Android and iPad for the mobile version, and will soon also offer a Windows-based version. We are seeing more airlines going to mobile maintenance systems, which are already in use with American Airlines, Delta Airlines and British Airways."

An interactive task card also allows a mechanic to contact a supervisor or make a report through it. All of this therefore negates the need to leave the workstation, or spend time writing reports and searching through manuals.

Data standards

There are several ways to provide a mobile task card system. One is for the relevant manual page to be formed in pieces or modules from raw XML data. The data will either be on the device; or accessed through a wireless link to the maintenance & engineering (M&E) system and CMS, provided the mechanic's device has connectivity.

Other crucial elements of an interactive task card are the ability to request parts and components from parts and rotable stores via the task card

Cathay Pacific uses the Ultramain M&E system, and subcontracts its base maintenance to HAECO. Ultramina has developed Mobile Mechanic, and the systrem operates as a pDF overlay system. Task cards are transferred in PDF format from Cathay to HAECO, and viewed on mechanics' mobile device screens.

presented on the screen. The correct part number (P/N) will be identified via the links the task card has to the IPC, the airline's own approved parts list (APL), or P/Ns listed on the task card.

Mechanics also have to record measurements or make calibrations. This requires the system to have the ability to perform calculations.

Coupled with this communication of text being sent to supervisors and other senior staff members, mechanics need to send data and information, as well as photographs.

In addition to the completion of task steps, sub-tasks, and tasks, mechanics have to report rotable component changes, and record values by filling in boxes and other relevant fields. This will include inputting the serial number (S/N) of the removed and installed part on the card. This is required for tracking removal intervals, and generating reliability data. The data will be transferred back to the M&E system.

An interactive task card will also record labour man-hours (MH) used, as well as consumed parts and components. This is classed as shop-floor data collection (SFDC) data, and provides accurate cost inputs for the check.

Many of the capabilities and functionalities of interactive task cards come from the source data being in the correct language and format. Most modern commercial aircraft types have their data and technical publications supplied electronically in iSpec 2200 and standard generalised mark-up language (SGML). iSpec 2200 format is an electronic version of printed page blocks of technical manuals for older aircraft types. These can be viewed on screen, and are agnostic to the hardware being used. It includes an interactive electronic technical publication (IETP), which ensures the information is displayed correctly as a page on the screen.

SGML gives the data the functionality to form an electronic task card, but not all the capability required for it to be interactive. A higher level of data language of extensible mark-up language (XML) is required. XML has enhanced functionality over SGML, allows a wider range of data types, and allows calculations and algorithms to be used. XML also permits relationships between pieces of content. An example is interchangeability of P/Ns for particular locations on the aircraft, and links between a P/N listed on the task card and its availability in parts stores. Another example is that certain tasks and P/Ns only apply to certain aircraft line numbers (L/Ns), and thus applicability of P/Ns to individual aircraft is an important issue that can be automated in the process of planning relevant tasks in airframe checks.

A truly interactive task card, which allows measurements to be recorded, calibrations to be made and alternative P/Ns to be searched for in stores, is only possible if the original task card data is in XML.

XML also makes it easier to render pages or task cards in HTML on a computer screen. HTML is the basis of forming a task card on screen using modules and pieces of the data.

Since most aircraft types have their data and information provided in SGML, a conversion to XML is required.

A final essential element of an interactive task card is the ability to sign it electronically, as well as create an electronic copy. Both these features avoid the need for the mechanic to print a final paper copy of the completed task card, sign it manually, and store it in a physical repository. It also clearly keeps the entire process electronic, and all functions for the mechanic within the tablet and mobile process.

Several vendors of M&E IT systems have developed an interactive task card system.

Flatirons Systems is now working on the development of an interactive task card. "This will be integrated with our mobile technical manual viewer, so that the mechanic can carry out the entire task card via a single tablet device," says Enis.

EmpowerMX

The first system deployed in commercial airline maintenance operations was the system developed by EmpowerMX. EmpowerMX's interactive task card system is its FleetCycle product.

One of the first users of the interactive task card was Southwest Airlines for non-routine line maintenance tasks.

Another early user of the FleetCycle system is Delta TechOps for base maintenance checks at its Atlanta facility. The system was used on Samsung Galaxy tablet devices. Another user of the FleetCycle interactive task card system is Tech Ops Mexico, the maintenance division of Aeromexico.

The interactive task card system uses data in XML format and the task cards are rendered on the screen in hyper text mark-up language (HTML) pages.

The system was first developed as a maintenance production module that could be interfaced with M&E systems. FleetCycle was then developed into a full M&E system.

Some of the system's users have much of their aircraft documentation provided in iSpec 2200 format and SGML language, so EmpowerMX has to convert the data into XML to get the fully interactive functionality the task card requires. This will have to be done for most aircraft types, since their documentation is supplied in iSpec 2200 and SGML.

The system can be used by airlines performing in-house maintenance, or sub-contracting maintenance to third-party

providers. The problems of transferring data to a different M&E system can be avoided by holding the task card data in the airline's FleetCycle M&E system, so that the maintenance provider's mechanics can access it in the Cloud via portable devices.

FleetCycle has also been configured so that it can operate with data provided in S1000D format. This applies to the A350, 787 and CSeries. This functionality will allow Delta and Aeromexico to use the interactive task card system to maintain their 787 fleets.

Swiss AS

Swiss Aviation Software (AS) is one of several M&E system vendors to have developed a mobile system for airframe maintenance in recent years. "We have developed AMOSmobile, which is the name for a suite of apps that are used for the performance of line and base airframe maintenance," says Ronald Schaeuffele, chief executive officer at Swiss AS. "AMOSmobile has the functionality to allow any kind of line and hangar maintenance activities to be performed with a completely mobile system.

"The system works through a laptop or tablet device, with functionalities including: reporting faults; performing maintenance tasks; requesting parts and components; viewing manuals and diagrams; photographing damage; and electronically signing completed tasks," continues Schaeuffele. "AMOSmobile provides the capability for everything that a mechanic needs to do in a mobile system, and through a tablet device."

The system can be used by any kind of tablet device, including iOS-, Windows- and Android-based systems. "The system only integrates with the Swiss AMOS M&E system, because we want to have 100% integration," says Schaeuffele. "This means that AMOS and AMOSmobile share the same 'programming objects'. Our goal is to ensure to our customers that any extension of AMOS is immediately available on AMOSmobile. They will, for example, behave in the same way so not to create any security issues.

"AMOSmobile is based on the software used on the Swiss AMOS desktop system. AMOSmobile therefore works the same way as AMOS. It provides information on screen in HTML form, and is configurable for the airline or MRO user."

Examples of configuration settings for the user are the number of fields that have to be filled in by the line mechanic when performing line maintenance. This configurability is very different to a mobile maintenance point solution that can be connected to a M&E system.

"We have developed different versions of AMOSmobile: Type A for line mechanics performing routine and non-routine line maintenance tasks; and Type B for supervisors and managers that need to monitor the maintenance status and progress of line checks of several aircraft at a line station simultaneously," says Schaeuffele.

AMOSmobile is relatively new to the market, and is being used by the Russian carrier UTAir and the Turkish airline Pegasus. Swiss AS has another 15 Swiss AMOS customers that are in a trial phase with AMOSmobile.

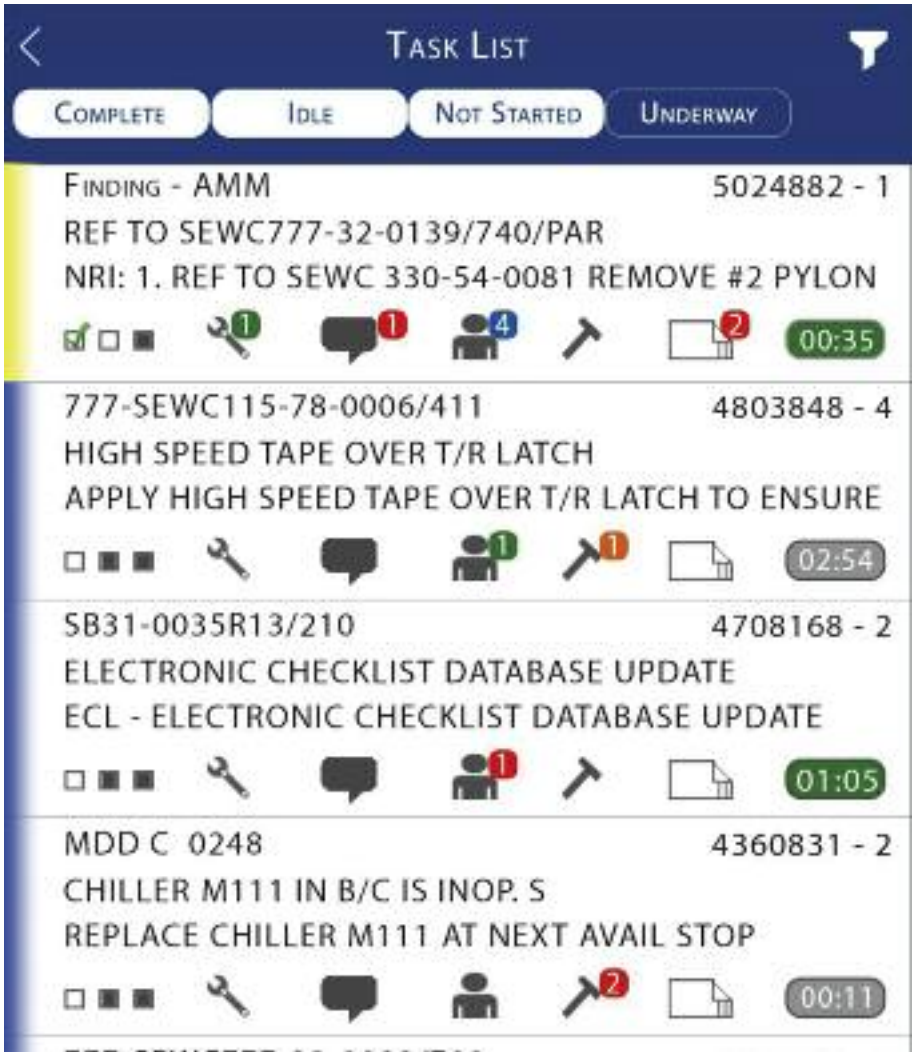
"A crucial element to mobile maintenance using tablets is the e-signature when closing maintenance tasks," says Schaeuffele.

The natural follow-on from aircraft maintenance checks will be the development of a similar mobile system for parts and component stores that can receive goods and transfer parts to other departments in the airline and areas of the M&E department.

A further natural development may be a mobile application and system for component and engine repair shops.

Ultramain

Ultramain is another M&E system vendor that has developed a mobile system for aircraft maintenance called Mobile Mechanic. It has a system in place for Hong Kong carrier Cathay Pacific and its base maintenance provider Hong Kong Aircraft Engineering Company



One feature of Mobile Mechanic is to list all task cards due, and use symbology to provide information relating to task number, number of mechanics required, toolinbg, and probable man-hours used.

(HAECO).

One of the first technical issues to be resolved was the exchange of engineering data between Cathay's Ultramain system, and HAECO's legacy M&E system. Cathay's engineering department monitors its fleet's utilisation rates, when checks are coming due, and plans the checks with respect to timing and task card content. "The check plans are then reviewed by HAECO to ensure feasibility," says Kevin Kruger, executive general manager of line services at HAECO.

Engineering data is transferred from Ultramain to ECHO, the enterprise resource management system used by HAECO, to form PDF task cards, generated in Ultramain, and supplemented with a tally sheet, which lists all task cards included in the check workpackage. The cards are downloaded by HAECO from Cathay's portal, and the tally sheet is generated in Ultramain. HAECO then converts the tally sheet to meet its requirements, and uploads it to ECHO.

Since PDF cards are transferred to ECHO, rather than data, the transfer is simple, and avoids all the issues of converting data in a staging database.

"While we do have the datasource and the meta schema available between Cathay and HAECO to make task cards electronically, we need to use the Mobile Mechanic for our other customers' maintenance work in the future, so we must have a system that can work with all their IT systems," says Kruger. "A PDF overlay was therefore the best option from a cost point of view, and to ensure both task content integrity, and that information is not lost. The completed check package is saved as the overlaid PDF task cards as the final maintenance record. Each PDF is also encrypted for security, and Ultramain has provided us with an integrity checker to prove PDF integrity."

The Mobile Mechanic system operates through the internet with iPads, but it can also be used on Android-based tablets or laptops through Internet Explorer or Chrome.

Mobile Mechanic has an array of functionalities and capabilities, but one main feature is electronic sign-off. "The app also has other key capabilities. These include the creation of non-routine task cards, duplicate inspections, and the production of a continuous worksheet," says Kruger. "The app is also linked to any technical manual or publication that the mechanic may need to consult. The app does not yet have the functionality for mechanics to request parts from, or check their availability in, the parts store, but we are developing this with Ultramain."

Another important capability is the recording of findings. These are noted by overlaying text on the PDF cards. The mechanic can also create a non-routine card that is automatically linked to the originating routine card. Pictures or reports can also be attached through Mobile Mechanic or from Ultramain version 9.

SFDC inputs and information are recorded by mechanics clocking on and off the tasks, and parts consumption recorded by using material traceability. Mobile Mechanic can allow the mechanic's processes to be performed entirely paperlessly together with other mobile applications. These include document browser systems from the original equipment manufacturers (OEMs), such as Boeing Toolbox and Airbus eDoc Browser. The progress of the check in terms of completed tasks can be monitored visually via a dashboard display. HAECO uses a secured electronic signature at task completion.

Mobile Mechanic is still in the regulatory approval stage, but Kruger does not envisage a need to perform any functions or actions once the system has been approved.

In addition to base checks, Mobile Mechanic is used in light airframe checks such as A checks, and other small inputs such as engine changes. It is not yet used for line checks, but there are plans to give it this capability.

The system requires connectivity to be maintained 100% of the time. HAECO uses a 4G cellular connection provided by a local telecoms company at the hangar.

Once the check is completed, the electronic records, which are a set of PDF files, are manually uploaded to Cathay's document management system, which is used together with Ultramain. "The benefits of using the system are that we can be more efficient and accurate when completing an airframe check," says Kruger. "We pass these efficiencies on to the customer as reduced aircraft downtime. Other benefits include the non-routine findings being linked to originating work orders, and passing reliability data back to the airlines. The completed package is passed back to the airline as soon as the aircraft is returned to service, so the check data is on hand before the first flight after the check."

Trax's eMRO system has several modules, and these allow the process of mobile maintenance. An example of a module is Quick Turn, which is used for line maintenance. One section of Quick Turn is an overview of the fleet's line maintenance and operational status.

Trax

Trax has developed a new version of its M&E system, eMRO, that allows it to operate for mobile maintenance. The system is based on XML data, and uses a display with cascading style sheets (CSS) version 5 for the display standard for digital documents.

"eMRO was introduced two years ago, and is platform-agnostic, so it can run on iOS, Windows, Android, Linux and Unix operating systems," says Chris Reed, managing director at Trax. "We have written a suite of mobility apps to work with eMRO, but they also work with old versions of Trax. Existing operators of Trax will transition to eMRO over the next few years. Trax has written several specific mobility apps to be used for iOS-based systems, and so they work on iPads.

The mobility apps that operate with old versions of Trax and eMRO, have been configured to provide its users with a fully interactive task card. There are several variants with different, role-specific functionalities. "These will work either offline or online," says Reed. Many mobility systems only function when they have connectivity, so work has to be done again when connectivity is lost, or work has to stop.

The versions of mobility apps for eMRO include: 'Quick Turn' for line maintenance; 'Task Control' for base and hangar maintenance; CabinLog which is a version for cabin maintenance; 'Pilot Log' a tech log version for the flight crew; 'AeroDox', which carries technical documentation for viewing; and 'EZStock' for locating and managing parts in the warehouse and controlling stock.

"The line and base maintenance versions have all the usual interactive task card capabilities that are required for a mobile system," says Reed.

The Quick Turn system for line maintenance is based on a tablet, such as an iPad, and has tech or pilot log data sent to it from the tablets held by the flight crew. This will include technical faults that occur on the aircraft during flight. These will not be those generated by the central maintenance computer (CMC), and automatically transmitted via Aircraft Communications Addressing and Reporting System (ACARS). "The system works offline, and the two sets of tablets can synchronise when connectivity is re-established," explains Reed. "Some of the data can be sent during flight, but if it has not been sent to the line maintenance department while in the air it will be transferred when the aircraft lands.

"A second iPad for cabin defects may be kept by the cabin and flight crews," continues Reed. "The mobile device hosting the cabin log has a camera so that a flight attendant can take a picture of, for example, torn or spoiled seat covers, or physical damage to an overhead bin. The pilot and cabin logs both have a recording device for the user to make a small verbal recording to add description to the damage. Once the defect has been sent to the line maintenance department, the system on the ground at maintenance control and line check planning will automatically prepare a line maintenance package in terms of a job card by ordering relevant parts. This is only possible with relatively simple defects, such as a damaged seat cover or missing life jacket. This is not possible with more complex defects that require some diagnosis. An example is a light or air blower not working on a passenger service unit (PSU)."

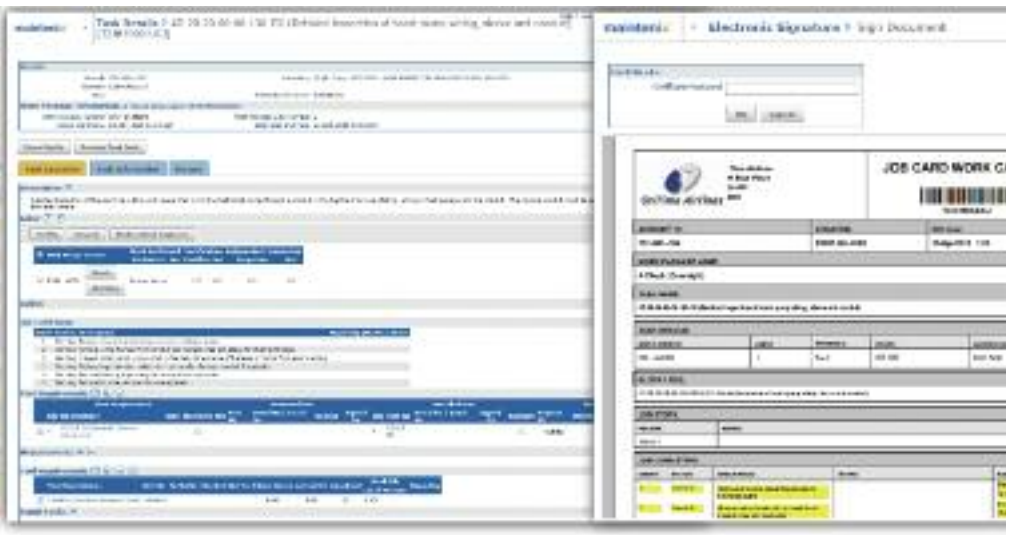
The cabin log data can get sent to the ground during flight if the cabin has a WiFi system, which is then connected to the aircraft's external connectivity system. The data will have to be transferred using on-ground connectivity if the cabin does not have a WiFi signal. The system is also built in with a time alert if logged defects and data have not been transmitted after a specified interval.

The data transferred from the pilot and cabin logs is sent to MCC and check planning in engineering. This system constantly updates the maintenance status of each aircraft in the fleet with respect to outstanding technical and cabin defects. MCC can filter the fleet's technical log by gate numbers at the airport, by fleet types, or by severity or number of outstanding faults. This filtering of the fleet is viewed through the fleet status screen, a dedicated page of the line maintenance application.

The performance of line maintenance tasks and line checks may also require the use of technical publications and manuals. "The line mechanic will need to consult manuals, so will need to use the AeroDox version of our mobility suite," says Reed. This system has already provided valuable savings to airlines by reducing delays in line maintenance when fixing technical defaults. Line mechanics no longer have to physically travel to the location of technical publications, search through them to diagnose faults, and sometimes carry them back to the aircraft. This time-consuming process has been changed by a technical documentation viewing system, which saves airlines a lot of accumulated time by rectifying technical defects faster. Airlines in Europe can particularly benefit, since passengers are entitled to compensation of several hundred euros for delays exceeding three hours. Some airlines have reported reducing the number of delays that are longer than three hours by more than 50% as a result of using a portable digital documentation system.

Another feature of Quick Turn is a set of videos included in the documentation library. These show how to remove and install certain rotable components. These work offline, allowing the mechanic to continue working in all environments.

"Despite the system being able to



The IFS Maintenix M&E systems has an intractive task card system. This is based on the use of XML data to render fully interactive task cards in HTML on mobile device screens.

work offline, the technical publications need to be synchronised with the airline's central library and documentation management system once every 24 hours to ensure that the mechanic is always working with the most up-to-date information," says Reed. "Technical publication materials are updated and revised at frequent intervals."

All these features of the Mobility suite make it possible for an airline to operate a paperless line and base maintenance system. "The system also allows us to have an overall view of the maintenance status of the aircraft fleet, and view the progress of performing maintenance on each one," explains Reed. "This visibility has changed the culture in some airlines, and staff are now more motivated to help each other to clear technical problems.

"Another feature in line maintenance is the ability to raise non-routine cards, and request materials and parts," adds Reed. "The whole system is based on the use of XML data that has originally come from the OEM and been converted."

The Trax Mobility suite of apps also includes: management modules for monitoring the progress of line maintenance; a production control system for monitoring the progress of airframe maintenance checks; and a shop control module for monitoring activities in a component repair and overhaul shop. All three require constant connectivity.

IFS

IFS is another vendor of an interactive task card system, for use by both airlines, and third-party MROs performing base checks for airlines.

"The system is based on an exchange of data in XML format between the airline and an MRO," says Jeff Cass, vice president of strategy at IFS. "The use of XML data is required for a problem-free exchange of data between two different M&E systems, but we are also interested in ATA Spec 2500. This is an upgrade of chapter 13 and 14, and will minimise or overcome the problems experienced when transferring data between two M&E systems.

The prominent players of ATA Spec 2500 are IFS and Swiss Aviation Software. The objective of ATA Spec 2500 is to create standards for electronic data to ease its transfer between different M&E systems. The aircraft transfer records working group (ATRWG) is responsible to identify, evaluate and develop electronic data exchange standards. These records include airworthiness directive (AD) status, service bulletin (SB) and modification status, tracked parts list, last done and next due maintenance reports.

"In the meantime, placing maintenance task card data in the Cloud circumvents problems of data transfer between an airline's M&E system and an MRO's M&E system," adds Cass.

Problems are still encountered when transferring task card data. "Our Maintenix M&E system can handle XML itself, and we have customers that transfer data into XML so that it can send manuals, such as the AMM, to other parties," says Cass. "We are able to ingest the manual's content into Maintenix when it is in XML."

IFS Maintenix M&E systems has a truly interactive task card system, and it provides all the content the mechanic requires on the task card displayed on the device's screen. "We are trying to eliminate the need for the mechanic to move away from the device to get information. The data in XML format is rendered on screen as HTML pages."

Most of IFS's customers are using iPad minis, especially in the case of line mechanics, and the next size up. Some are also using Microsoft Surface tablets.

The interactive task card system has eight main functions, including: consulting electronic versions of manuals and documents; requesting and ordering parts; report findings; taking photographs; taking measurements and calibrations; recording shop visit inputs; performing maintenance 100% paperlessly; charting and monitoring check progress; and using electronic signature. It can also execute deferrals on the basis of the minimum equipment list (MEL). That is, what deferrals can be done, and what are the follow-up actions.

The recording of SFDC is either by the manual entering of start and stop times, and part S/Ns, or the automatic recording of start and stop times and part S/Ns through the use of barcodes.

"The system has to work 99.99% of the time. The only module that can work offline is the pilot tech log, while all other modules require constant connectivity," continues Cass. "Once work is completed with an electronic signature, the cards stay as HTML, but a duplicate copy is also saved in PDF format."

The system has been in use with Qantas since 2012.

Mobile apps

While there has been considerable development in mobile applications and associated hardware for the main elements of line and base airframe maintenance, mobile applications and technology have inevitably spread to other elements of M&E.

Ramco Systems of India has developed what it describes as 'full blown' mobile apps for specific roles in M&E.

"Two of these relate to aircraft maintenance, but the other three relate to different elements of M&E," says Sam Jacob, vice president of aviation business unit head at Ramco.

The first of these is Mechanic Anywhere. This software is deployed on a tablet or mobile device, and allows a mechanic to perform almost all of their functions. "There are some specialised functions that cannot be performed through Mechanic Anywhere," says Jacob. "These include recording detailed parameter values, such as measurements and calibrations. The system is effectively an interactive task card, and can be used to do most maintenance task card functions. It is used to display an M&E system vendor's task cards, including electronic signature."

"Line Anywhere is a second application, and is used as an offline system by mechanics for line maintenance," says Jacob. "It needs this

capability because of intermittent connectivity on the ramp. When connected, the mechanic downloads all the relevant documentation and task card information before starting on maintenance tasks. The mechanic starts the work, and then syncs the system when the work is finished and connectivity is re-established."

The system is also used to clear or record cabin log items, as well as technical faults.

A third mobile app developed by Ramco is Customer Anywhere. This supplements the apps used in line and base check performance. "This is a system designed for an MRO performing third-party work for airlines," says Jacob. "The system allows an airline customer to keep track of the status of its aircraft with an independent MRO while a check is being performed. The system therefore supplements an interactive task card and real-time check progress system.

"Information is gathered by the Ramco M&E system being used by the MRO. This includes the utilisation of the Mechanic Anywhere application and interactive task cards," adds Jacob. "The whole mobile and interactive task card system uses data that has been converted into XML, although it will work when some of it is in SGML format.

"The airline sends the task cards to the MRO's Ramco system," continues Jacob. "There are several systems for doing this, one of which is XML data transfer. The task cards can also be sent in PDF format, and converted into responsive cards. The MRO therefore develops it own task cards. Ramco monitors the progress of the check. Customer Anywhere has a user I.P. address. The app gets check progress data from the MRO's Ramco system, and creates the page to provide graphical information about the check's progress."

A fourth app is Warehouse Anywhere, and is a material request and dispersal system. It also supplements the main systems used for line and base maintenance. "Material requests are made via Mechanic Anywhere," says Jacob. "Warehouse Anywhere is used by stores staff, and some of its functions relate to stock-taking of parts.

"Another function is the receiving of rotables removed from the aircraft, so it also has a parts-tracking facility that is used to generate removal interval and reliability data," says Jacob. "The system can also be used to view stock, and can drill down to individual part S/N, and all its other related information."

Warehouse Anywhere also monitors parts movements, and has a stock-taking function called Cycle Counting. This functionality has been brought into mobility function. The system can be used to create a shopping list of required parts, and to reconcile all the stock.

The fifth application is Approve Anywhere. "It is used by senior management for approving commercial input documents. Examples are purchase orders for high-cost rotables," says Jacob. "The system therefore complements the various mobile mechanic systems and the Warehouse Anywhere app.

"The use of Approve Anywhere means that the senior engineer using the app does not have to log into the main M&E system on a desktop," continues Jacob. "The app lets the senior engineer order parts on the spot with a mobile device, such as a smartphone. The screen on the app has all the authorised personnel required for the approval, and shows each user where they are in the approval chain, as well as which people have already given their approval.

"The app also lets the user click on a P/N, and the system will tell you how many are available and where they are," continues Jacob. "One example of the Mechanic Anywhere app is the page for recording a rotable component replacement. A photograph of a damaged part can be attached here if required. The

Ramco has developed a number of mobile applications for the various elements of maintenance and engineering. One application is Customer Anywhere, and this allows an airline customer to remotely view the porgress of a base check being performed on its aircraft by a third party maintenance provider.

Approve Anywhere app has a warehouse screen, for viewing a request for a part made by a mechanic. Some materials also require a HAZMAT compliance form."

Wearable technology

Besides mobile maintenance systems, another development in maintenance has been wearable devices. These all involve the user wearing some type of headwear, either with a viewing device to provide visual instructions, or a voice control system and audio instructions. Wearable devices are intended to provide mechanics and technicians with handsfree equipment that also gives them all the information they need to complete maintenance tasks.

For wearable and voice control devices to work, a specialised platform is required to host instructions that may relate to the performance of a maintenance task, for example. The server will host an application that converts the standard steps of a maintenance task into voice control instructions given through wearable glasses or a headset. An example is the Skylight server developed by Upskill, formerly APX labs.

"The server sits between the M&E system, which hosts the content and the steps of maintenance tasks listed in the aircraft maintenance manual (AMM); and the wearable device," explains Aaron Tate, vice president of customer solutions at Upskill (formerly APX labs). "The server we provide certainly works with the main M&E systems that include SAP, Trax and others. We can connect several systems, and have developed our server this way because many airlines work with several systems simultaneously in their maintenance and flight operations departments.

"Wearables are good for line maintenance, preventative maintenance, and shop repairs or hangar maintenance," continues Tate. "The Skylight system works for handsfree devices. Examples of wearable devices include the Vuzix M300 monocular, headworn display, and the Realwear HMT1. The Vuzix M300 gives the mechanic work instructions, allows them to contact supervisors, view images of documents and manuals, and view data feeds. The monocular device also has a microphone so that the user can inform the system that a step or sub-task has been completed. The M&E system is informed, and the server is prompted to issue the step in the process. The whole wearable system connects to the M&E system via WiFi link, although the wearable device does not have to be synced to the M&E system all the time. Our software runs on the Vuzix headwear system."

Another application for the Uplink server system is Google Glasses. "This product was slow to develop, but there has been a re-emergence with the enterprise version," says Tate. "Google has been deploying the version for the past two years, and it is now in actual industry use. The enterprise version is beginning to be used in aircraft maintenance, and GE Aviation is one of the first users. The glasses are connected to the software that is hosted on our server, and which generates the visual instructions that are viewed through the glasses. An example is the use of a wireless torque wrench, which sends data on the torque applied by the wrench to the system. The system can thus be used for maintenance tasks where values and measurements have to be recorded."

Wearables have made the first few in-roads into aircraft maintenance, and GE is using the system in its engine shops. We expect to see the use of the system expand into on-wing support in airline operations. "Overall, these monocular systems provide mechanics and technicians all the information they need through a single device, which is very convenient. No other equipment is required, and there is also no need to speak with anyone else," says Tate.

The development and use of wearable devices in aircraft maintenance involves several products. "One of the first wearable products we have been involved with is glasses," says Enis. "Functional glasses were first developed for personal use, but their application has now been expanded to industrial uses. Another issue was that the first ones to be developed were too bulky and heavy for the user. There has been a big improvement over the past 12 months, and the new systems feel more natural to wear. We will probably see a lot more vendors start to offer wearables and their applications over the next few years.

Wearable technology for maintenance is being used at increasing levels in aircraft maintenance. Various middleware platforms have been developed which sit between the M&E system and the maintenance task instructions, and the wearable hardware. Vocal and visual wearable devices are being deployed to allow mechanics to work on a handsfree basis.

"The glasses we have developed work on an Android operating system together with our technical publications viewer. These allow the user to view technical publications and manuals through the glasses, meaning both hands are free when using the system," continues Enis. "The resolution on the glasses product is not as good as on tablet devices, but this will improve. We are also looking at adding a voice recognition capability."

The particular application in line maintenance is for viewing technical manuals and publications in a handsfree system. The main advantage of this system is that it gives mechanics and technicians instant access to manuals, generating significant time savings. One US major airline estimates that such time savings can save it more than $20 million per year in line maintenance through reduced labour costs.

Similarly, there are also applications for wearable devices in base and hangar maintenance. "We are seeing that it is possible to do additional jobs simultaneously with this technology," says Enis. "This is mainly because mechanics do not have to spend time on research, such as going through pages of manuals, and instead can find what they need instantly.

"Airlines were not too sure how they could adopt wearable and portable technology," continues Enis. "Many bought large numbers of tablets and then worked out how to apply and use them. Now vendors have applications for wearable devices, but so far these only work on certain devices. Airlines ideally do not want to buy two different types of tablet for different functions in M&E. To avoid this problem, Flatirons has developed its mobile applications and software suites so that the core of the application is common to all the different types of hardware platforms available. We have achieved this by making 80-85% of the application code the same for each type of hardware system."

Ramco has also been involved in the development of some mobile hardware devices. The first is a range of robotic devices, known as chatbots, that provide a messaging and communication service. "This is used by people working on their own, and attending maintenance calls," says Jacob.

Another Ramco development is the hololens, a head-mounted wearable device that the mechanic uses to view a task card for truly handsfree work.

Voice control

Another area in mobile and wearable equipment is the development of augmented reality and virtual reality. Virtual reality is a system of computer-simulated images, useful for activities such as training mechanics.

Augmented reality is more appropriate for performing actual maintenance. This will present additional computer-generated information that is visible on the wearable device lens or screen, through which the actual aircraft, engine or component is viewed when a mechanic is performing tasks. This will allow them to perform a large portion of the work handsfree.

Voice control is another useful development. Honeywell has developed a system called VoCollect, which issues a set of aural instructions through a wearable headset for the mechanic. These instructions will be the several steps for a multifaceted maintenance task.

The basis of the system is a server that operates as middleware between the main M&E system and the headset. The mechanic also carries a small device on their belt, which has a cable connection to the headset. The belt device is linked to the middleware by WiFi.

The server is used to build up the steps in the maintenance task process. "The middlewear server ties into an existing data storage, so uses data already present," says Matthew Nichols, product marketing manager, at Honeywell Sensing & Productivity Solutions. "The middleware system can therefore create maintenance inspection steps in a workflow. This information is then used to generate the voice commands that the mechanic hears through the headset.

"The system is then integrated with a system or maintenance record," continues Nichols. "The mechanic then wears a head device to request the work that has to be performed. In many cases these will be complex components, such as an auxiliary power unit (APU). The system gives a voice command for each step at a time. The recordings and findings given by the inspecting mechanic are converted into data which is stored as value. This means that no data has to be collected, or manual data has to be entered anywhere. The system is designed to turn the data into discrete values, and from this it generates reports. An example is how often a part or assembly is found to be corroded. Reliability and finding statistics can be generated for each maintenance task, and from there data that is sent back to the OEMs is automatically generated."

The system also detects and issues alerts when steps are skipped by the mechanic, and so prevents this from happening.

"There are now several companies that have found practical uses of the VoCollect system, and it is mainly being used in APU and engine maintenance inductions. Other uses and applications in the future can include line maintenance, although this will be challenging. Structural inspections in heavy base checks, and interior inspections are two other potential uses." AC