Tablet computers look set to provide new benefits and efficiencies to the line maintenance process. Increased mobility, wireless and cellular connectivity, built-in camera and video functionality, and relatively low cost set tablets apart from ruggedized laptops. The benefits, problems, and implementation of tablets to line maintenance are analysed here.

Using tablet computers in line maintenance & maintenance control

With line maintenance accounting for a high percentage of total aircraft maintenance costs, airlines are continuing to look for ways to streamline line maintenance, and so reduce costs. Tablet computers are one technology that could bring a new level of efficiency to line maintenance.

New-generation on-board maintenance systems on aircraft such as the A380, 787 and forthcoming Bombardier CSeries are helping operators to streamline the line maintenance process *(see Rectifying faults with new-generation on-board maintenance systems, Aircraft Commerce, April/May 2012, page 51)*. Operators of many older aircraft types are looking at other ways in which they can improve the efficiency of line maintenance and maintenance control.

Tablet computers such as iPads and PDAs have the potential to provide new benefits and efficiencies to line maintenance and maintenance control for all generations of aircraft.

A distinction must be made between tablets and traditional laptops, which have been widely used in line maintenance for some time now. Tablets are smaller and more compact, and therefore more portable than laptops. In addition they offer users wireless and cellular connectivity, as well as built-in camera and video functionality. These are the main benefits of using them in line maintenance and maintenance control.

The advantages and disadvantages of using tablet computers in line maintenance are reviewed and analysed here.

Traditional defect process

Under a traditional line maintenance process, still used by many airlines, pilots record defects on handwritten pilot reports (PIREPS) into a logbook. The logbook is reviewed by the arriving line mechanic, who, depending on the nature of the faults, may debrief the pilot further to better understand the nature of the defect. The line mechanic assesses inbound defect log entries, and looks back through previous log pages to search for any related defect history. The mechanic also reviews the list of deferred defects to prioritise those that affect the subsequent flight, and so which of them require immediate attention.

The minimum equipment list (MEL) and configuration deviation list (CDL) are considered at this time to preclude operational disruption, subject to the fault confirmation and compliance with the MEL and the airline limitations.

The line mechanic is required to manually enter all relevant details of a fault or defect into the airline's maintenance and engineering (M&E) IT system. There are delays, however, of up to several days between the mechanic initially seeing the reported fault and it being entered into the M&E IT system. Once it has been entered, it allows all relevant departments to see the defects outstanding on each aircraft. Until the information is entered in the M&E system, maintenance control lacks the scope of detail required to understand the defect and schedule all the necessary action to rectify it.

The mechanic may consult maintenance control or travel back to the line maintenance office, with handwritten logbooks in hand, if deeper investigation, tooling, equipment or spares are necessary. The line mechanic will then search the appropriate documents for instructions on how to rectify the fault. These documents include the aircraft maintenance manual (AMM), fault isolation manual (FIM), illustrated parts catalogue (IPC) or troubleshooting manual (TSM).

Once the fault has been identified, a paper task card and/or maintenance manual pages are printed. The line mechanic then takes the appropriate action to rectify the fault. For a basic fault, the line mechanic may only require common tools, but more complex faults may need more than this. If a part is required, the line mechanic has to locate the appropriate part in the stock of spare parts on site, or order the part if it is not in stock.

Once the line mechanic has all of the appropriate tools and parts, he can go back to the aircraft and repair the fault. Once the fault is repaired, the line mechanic signs off on the repair on a paper document, and then records and certifies the repair details into the logbook. Later on, this repair is manually entered into the airline's M&E system, which is updated accordingly.

In some airlines, the sheer volume of log pages to be entered into the M&E system can lead to a delay in this updating process of several hours or even days.

Through an airline's M&E system many, if not all, of the aforementioned manuals may be available in PDF or another electronic format via a computer

Tablet computers and iPads have the potential to transform many of the different stages and processes in traditional line maintenance. The benefits that can ultimately be gained include reduced time diagnosing faults, searching for parts, and preparing work orders.

workstation, usually located in the line mechanics' office area. Instead of searching paper manuals, therefore, the line mechanic can find the appropriate details electronically. These maintenance procedures are usually printed off as a hard copy, and physically taken to the aircraft, together with the required tools and parts.

Where it has not been possible to rectify all of the defects between flights, a maintenance deferral is put in place. "If there is not enough time to resolve a problem, the line mechanic will defer," says John Warren, senior vice-president at Ultramain systems. "The MEL criteria have to be fulfilled before a flight can depart. Other faults or malfunctions can be deferred to a later time. Depending on the airline's own policies, and the nature of the fault or malfunction, mechanics will have the authority to defer themselves, or will have to get authority from maintenance control."

Allan Geall, specialist, AHMS Ground Systems, CSeries Customer Services at Bombardier, adds, "The MEL often presents issues of interpretation to pilots and mechanics alike where the fleet consists of aircraft with various 'as-maintained' configurations." This means that each aircraft can have its unique MEL, so deferral decisions will differ accordingly. "Digital MELs can be customised to a specific aircraft ensuring that the correct MEL is applied for a given aircraft modification status," adds Geall.

"Another current issue, growing even more complicated on the next generation aircraft, is maintaining a synchronised and accurate record of the approved list of loadable software aircraft parts (LSAP)," continues Geall. "Traditionally, this record of approved LSAP parts has often been maintained as part of the aircraft log as a paper document, so updates and synchronisations are not timely. This leads to confusion in determining the approved software required for a given aircraft configuration when software load is required for maintenance."

ACARS

The aforementioned process assumed that no advance information about any fault or malfunction was available to maintenance control, or to line mechanics prior to the aircraft landing. Since many aircraft now use the Aircraft Communications Addressing and Reporting System (ACARS) to transmit messages to ground stations during flights, certain faults or malfunctions will often be known before the aircraft has landed. "Maintenance control will know about certain problems with the aircraft directly from ACARS, and may even get advance notice from the pilots as well," says Warren. "This means that maintenance control can give line mechanics advance notice of what is wrong, and the line mechanic can be suitably prepared to deal with it when the aircraft lands."

When the aircraft lands, however, the line mechanic must still inspect the handwritten technical logs, assuming that the airline still uses paper technical logs in the traditional line maintenance process. This may have faults or malfunctions not reported during the flight via ACARS. The process of diagnosing and rectifying a fault is then the same as previously described, with the line mechanic returning to the office to check the manuals (either as paper or pdf/other digital format), devise a rectification procedure, acquire paper task cards and get the required parts and tools. ACARS, therefore, only saves time where faults are reported in advance.

Electronic Technical Log (ETL)

If the aircraft is installed with an electronic technical log (ETL), line mechanics do not have handwritten technical logs to check. On the few aircraft that operate with ETLs, pilots are able to electronically record faults and defects that are not automatically sent to maintenance control ground stations by ACARS. Faults and defects can be sent to ground stations while in flight.

Mechanics can therefore spend more time diagnosing and preparing fixes for

Traditional line maintenance processes include a lot of individual steps by line mechanics between the aircraft and various ground stations. Tablet computers have the potential to eliminate these steps and so save mechanics' time and reduce aircraft delays.

faults. The line mechanic still has to sign off on the work back at the office, and manually enter data for the work carried out into the M&E system, so some manual processes are still in place even with faults reported via ACARS and an ETL.

The traditional line maintenance process therefore involves several trips to and from an aircraft by each line mechanic. Time is spent not just travelling to and from the aircraft, but also searching for faults either with paper manuals or through PDF files on a desktop workstation. If a spare part is required, time will be spent finding it in the airline's stock of spare parts, or if it is a non-routine part, it may have to be ordered, and the repair deferred. A large amount of paper is still involved in the process, therefore, with manual data entry required once the repair is carried out.

Tablet devices

Introducing tablets to the line maintenance process could eliminate much of the paper now still in use, reduce the amount of time a line mechanic spends travelling to and from the aircraft, and give line mechanics quick access to the manuals they require.

A mechanic's process of rectifying faults has five main stages, and tablet computers could ultimately be used in all of them. These are: communication and coordination with maintenance control and planning engineers and other departments; analysing faults and reviewing all outstanding faults and defects; writing repairs and rectification processes; ordering tools and parts; and performing the repair and signing for it to create a technical record.

"Using tablets in line maintenance will mean fewer deferrals, with less line maintenance work outstanding, and fewer overall delays to the airline," says Warren. "This is where an airline stands to make the most savings."

Tablet computers, such as iPads, Android devices, and the recently announced Windows Surface device, can be issued to line mechanics for use throughout the line maintenance process.

"A tablet device has a variety of uses to the line mechanic," says Dinakara Nagalla, chief executive officer at EmpowerMX. "For example, reference material such as manuals, reports and log books can be accessed electronically via the tablet. This allows the line mechanic to find fault repairs and use electronic task cards on the tablet and do the necessary work without returning to the office.

"If the line mechanic must return to the office for tools and/or parts, there is still a time saving to be realised because they do not have to search through manuals or print hard copy repair task cards. Parts and tools can be ordered via the tablet computer," says Nagalla. "These time savings may just be a few minutes per flight, but when adapted across a whole fleet, they will lead to a significant cumulative saving of man-hours, thereby leading to a large reduction in costs.

"Tablets will also allow line mechanics to spend more time at an aircraft, improving labour productivity and allowing more repairs to be done during an aircraft's turnaround," continues Nagalla. "In this digital age, we have all come to expect instant responses to our needs and we often become distracted from our objective during a pause. A tablet allows the mechanic to stay focused and concentrate on the task with fewer or no forced pauses. The consequence of this is fewer deferrals and delays to the airline, thereby reducing operating costs."

WiFi-enabled tablets

There are two scenarios where airlines can benefit from using tablets in line maintenance: in WiFi-enabled areas (online); and in non-WiFi enabled areas (offline).

"If the tablet is WiFi-enabled, the line mechanic will have access to real-time, server-based information, or even information located in the 'cloud'," says Nagalla. "This means the line mechanic can order parts electronically from the aircraft, which will be immediately processed, reducing time later in the line maintenance process. It will allow the line mechanic to see what spare parts are available instantly, reducing time spent processing this in the office.

"WiFi connectivity also allows real-time communications through the tablet with maintenance control," continues Nagalla. "This gives maintenance control more time to plan for any potential deferrals ahead of time, instead of only finding out about deferrals after the departure of the next flight, which means less time to plan and more potential for delays further along the schedule.

"This also gives other departments, such as flight operations, more advance notice on potential delays," notes Nagalla. "This allows better operational planning in terms of providing replacement aircraft and even flight crews if the delay is likely to require a flight crew change."

This highlights the potential benefits of using tablets in maintenance control. If delays due to deferrals can be planned for as early as possible, it may reduce the overall delay to a flight. This will reduce the costs of delays for the airline. It will also allow for line maintenance deferrals to be planned for and dealt with sooner, providing further cost savings to the operator.

Geall summarises: "Tablets allow operators to be proactive, rather than

One main benefit of using tablet computers in line maintenance is that all types of aircraft manuals will be available electronically to mechanics. Required pages and manuals can therefore be searched electronically and quickly. This will not only make the search process easier for mechanics, but also eliminate the need to carry traditional paper manuals.

reactive. They improve defect awareness, and facilitate a structured, planned and proactive approach to unscheduled maintenance. Reducing the stress faced by mechanics and pilots constrained by flight schedules, slot times and duty days increases safety and efficiency.

"Tablets also allow for better preparation with advance knowledge of an inbound aircraft's defects and status, as well as a current list of deferrals and the status of deferral reasons (spares, tooling, equipment, facilities, resources and certification requirements), not to mention recorded troubleshooting performed to date," continues Geall. "This leads to more first-time fixes, lower deferral rates, reduced no-fault found (NFF) rates and charges, and a reduction in aircraft-on-the-ground (AOG) spares requirements where the same spare is replaced several times as part of a troubleshooting session exhausting spare reserves for that component."

Not only do WiFi-connected tablets allow maintenance control to see where deferrals have been made sooner, but also helps plan those cases of partial deferrals. "At times the line mechanic does not have enough time during a turnaround to complete a task," says Ron Kallio, supervisor, Technical Publications CSeries Customer Services at Bombardier. "For those non-flight critical tasks, maintenance tasks will be deferred, but partially completed. By using a tablet, the line mechanic has quick access to which tasks have been completed and which have been deferred, as well as to historical records of past work done. The aircraft then departs, and both maintenance control and the line mechanic at the next station can see immediately what is left to complete on the task."

A further benefit of using WiFi-connected tablets during line maintenance is improved safety and efficiency. "Using a WiFi-connected tablet will allow for quick access to the latest maintenance and repair information," says Kallio. "Original equipment manufacturers (OEMs) regularly update the various digital technical publications, so using a tablet will allow the line mechanic to refer to the most current revised publication procedures for any task required, provided these have been synchronised to the airline's publication revision cycle.

"Airlines are also able to update the various publications with their own maintenance procedures and tips. In both cases, the line mechanic will see the latest maintenance and repair information," continues Kallio. "Updates to spare part publications also fall into this category. If the OEM issues a new part that supersedes an old part, the line mechanic will be able to instantly view the new part number applicable to the aircraft tail number he is working on because the manuals will be up to date. Previously, a superseded part number may have been ordered incorrectly, because of the time lag in updating and revising paper manuals."

Tablets with cameras fitted, such as the iPad 2 or iPad 3, can provide a new benefit to line maintenance. "Using the in-built camera allows line mechanics to take pictures of various faults, or even to record a video showing the fault," says Dave Junker, account manager at Mxi Technologies. "This is particularly useful for non-routine faults. The line mechanic can send pictures or videos, instantly via WiFi, so that both management and maintenance control can see, in detail, the problem and plan immediately for corrective action for the fault. This can be combined with a video phone call to discuss the fault should management wish to discuss the fault with the line mechanic, and then see what they need to repair it."

Offline tablets

WiFi connectivity does not have to always be available, however, for tablets to improve the line maintenance process. "In fact, the tablet is likely to be used offline most of the time, because the line mechanic is mobile and WiFi connectivity is often not available," says Paul Saunders, operations director at Conduce Consulting. "In this scenario, the line mechanic will ensure the tablet is synchronised at the start of their shift."

Although this does not give the line mechanic real-time access to manuals and information, in most cases the latest information will still be stored offline on the tablet device because updates to manuals and publications from the OEMs often happen overnight.

Even in an offline mode, therefore, the line mechanic will able to find the relevant fault or malfunction codes while at the aircraft, and use electronic task cards, saving time travelling to and from the office, and searching paper or pdf documents at the office workstation. "The line mechanic still has the information at hand in an offline mode, and still has electronic access to the relevant publications," says Warren. "For example, the line mechanic can instantly see the criteria for referrals immediately on the MEL, and has access to the FIM, along with any other document usually required during line maintenance."

The line mechanic will still be able to access useful applications on the tablet even when offline. "Using dynamic troubleshooting applications on a tablet will significantly improve the line mechanic's ability to find the most probable cause(s) and perform the most relevant solution(s) to return the aircraft to service," adds Kallio. "The line mechanic will then be able to bring up the maintenance or repair procedure for the fault immediately on the tablet."

Not all the steps of rectifying faults in the traditional line maintenance process can be easily replaced with tablet computers and iPads. The two most challenging issues are electronically creating and authoring non-routine task cards for rectifying faults, and the other is to create fully electronic task cards that can accept level 2 electronic signatures.

Since most tablets were originally designed for individual consumers, rather than aviation business applications, tablets are designed to be intuitive and easy to use. "Tablets will offer the mechanic a user-friendly experience," says Junker. "Provided the M&E solution being accessed can make full use of the mobile device, it will be quickly and easy to search for content and inventory, and find the relevant repairs. This intuitiveness will minimise retraining needed, since both the devices and applications are intended to be easy to use."

Problems with tablets

Although tablet computers look set to provide a host of benefits to the line maintenance process, they do pose some issues. The first is potential reliability and ruggedness. If the tablet fails, or breaks, the line mechanic must revert back to the traditional system and use paper, and the benefits of using a tablet disappear.

This is a particular problem if the tablet fails when a line mechanic is part-way through a task, or has even completed it, and the tablet fails. Jayson Agagnier, security specialist, eEnabled Aircraft Systems, CSeries Customer Services at Bombardier, notes, "When tablets are used as a replacement for paper and involve the use of digital signatures, the ruggedness and reliability of the tablet becomes more important. An example could be where maintenance work has been performed to return an aircraft to service, but the tablet is damaged or broken before the data can be offloaded from the tablet."

This highlights the next issue tablets are likely to face in a line maintenance environment. "Line maintenance can be a dirty environment with oil, grease and corrosive fluids involved," says Junker. "This may make tablets harder for line mechanics to use in those circumstances, and therefore reduce some of the benefits."

The cost of tablet devices is also likely to balance any concerns with reliability and ruggedness that come from the line maintenance process. "Tablets are significantly cheaper than a ruggedised laptop computer," says Saunders. "An airline can afford to purchase three or four tablets for the equivalent cost of one laptop computer, so if a tablet breaks, it is easily replaceable."

Saunders also recommends a technique to improve reliability. "When the airline issues the tablets to the mechanics, they can make the device the property of the mechanic, as their own device," says Saunders.

Although using tablets in an off-line mode offers airlines significant benefits, using tablets in an on-line way offers the most savings. WiFi connectivity is not yet common at the gate or on the aircraft on the ground, so airlines will have to invest in WiFi connectivity not only at their main hubs, but also at line stations throughout their network. Given the diversity of countries and airports around the world, this may take significant time and investment to become network-wide.

The two areas where more M&E system functionality needs to be developed so that tablet computers can realise improvements in efficiency is in the writing and creation of repair orders, and in the use of fully electronic task cards. These fully electronic task cards are those with level 2 electronic signatures. Level 2 electronic signatures would avoid the need to manually sign paper task cards *(see Assessing the 737 Classic's ageing maintenance, page 51)*. Airlines need complete M&E system functionality for the entire line maintenance process to be conducted completely electronically to completely avoid the use of paper.

Summary

Potential savings are available to an airline in both an on-line (connected) and off-line mode. Most airlines are actively pursuing this, with tablets in line maintenance set to become the 'norm' in the next five years. Warren does offer a word of caution, however. "Using tablets in line maintenance is new to everybody in the industry, so there are no benchmarks yet," says Warren. "This means we are likely to see a cautious approach to tablets initially, because airlines discover the most efficient way to use them, and what they can truly offer in terms of savings."

Given how new using tablets in line maintenance is to the industry, it is unclear how most airlines will decide to implement and use their tablets, either through managed content applications, library applications, or unique improvised solutions.

Despite this, tablet computers do look set to offer airlines large savings to line maintenance costs, with few drawbacks. "Reducing line maintenance deferrals, which therefore means less delays and cancellations is the main benefit of using tablets," says Warren. "This benefit will offer significant cost savings to an airline, which will be too large to ignore."

Junker notes, however, that the correct processes must be in place through the entire line maintenance process for the benefits of tablets to be fully realised. "It is not only the mobile device itself that provides benefits, but rather the combination of the mobile device and the maintenance, repair & overhaul (MRO) IT solution underpinning it." AC