More operators are recognising the benefits of electronic operational and maintenance based processes. In order to achieve this, a software that supports and streamlines these procedures is essential. The process of selecting and implementing this software is explored in this article.

ETLs & paperless line maintenance

To maximise operational and maintenance efficiencies, fleet reliability, and ultimately cost savings, airlines are gradually moving from traditional paper-based data collection and maintenance towards electronic processes throughout their day-to-day activities. This has introduced the concept of 'paperless' maintenance and airline operations in recent years.

Transferring a company's standard operating procedure (SOP), both operational and maintenance-based, from paper methods to advanced industry solutions is a lengthy and complex process. The airline must ensure that its entire paper documentation process for every aircraft, including manuals (both flight and maintenance), technical logs, and maintenance tasks cards, can be converted and integrated electronically into a maintenance and engineering (M&E) IT system, which has to interface with the rest of the airline's systems.

All data from the base maintenance hangar where maintenance tasks are performed, the flightdeck and flight operations, and line maintenance activities, need to be reliably captured and collected. The operator must also demonstrate to its local aviation authority that it is reinforcing this capability. These data then need to be distributed and filtered throughout the company's relevant departments as quickly and efficiently as possible. For example, an airline's flight operations department has to communicate all the data that must be recorded during a flight, as the flight occurs, to the flight operations and M&E systems. These data will include block times, take-off and landing times, and cumulative flight hours (FH), landings and flight cycles (FC) to date, alongside defects raised and other discrepancies and measurements. This information must be automatically fed into the operator's maintenance control centre (MCC), and M&E system.

M&E systems are a core repository in which to store, analyse and record the manuals and original data provided by the original equipment manufacturers (OEMs), technical data fed in by a techlog, and shop floor data collection (SFDC) information contributed by mechanics working on the aircraft. M&E systems can also interface with HR and native accounting systems to further increase efficiencies.

M&E systems receive OEM and regulatory authority updates, such as service bulletins (SBs), thereby making maintenance planners and engineers more efficient, since they no longer have to carry out update and revision tasks manually.

However, regulatory authorities need to be convinced of the reliability of electronic techlogs (ETLs) and paperless maintenance, with respect to data integrity, and maintaining and proving compliance.

Alongside the software subscription and hardware costs involved, this can make presenting the case for switching to electronic operations too challenging for an airline to pursue. "As the European authorities have become more at ease with the concept of paperless operations, the European Aviation and Safety Agency (EASA) has published EASA – AMC 2025. This is a standard to outline the requirements for ETLs and electronic flight bags (EFBs)," explains Steve Russell, chief executive officer, at Conduce. "Fundamentally, the processes when using an ETL or EFB have to mirror a paper system. Ultimately, it is the process by which the airline captures its data, rather than the techlog itself, that requires approval by the regulators."

Traditional techlogs

The techlog provides a single point source of communication between the crew leaving and arriving at an aircraft that is between sectors. It displays the maintenance and operational status of the aircraft.

Traditional, paper-based technical logs have three copies in duplicate paper. One of these is kept on the aircraft as a first-hand reference, while the other two are distributed to: maintenance control, which monitors the status of each aircraft and co-ordinates the resolution of defects; and the line maintenance department, which diagnoses faults arising and determines whether they can or cannot be deferred. Involving so many different people to manually handle these techlog copies used to present problems. For example, by the time information from the paper techlog had been keyed into a computer system, many defects had often been diagnosed and resolved, and so their status had changed. This could make it hard to monitor the aircraft's true maintenance status.

Typically, a fault that is located can be categorised by the line mechanic as: (i) a Category A fault, which can be deferred for one flight; (ii) a Category B fault, which can be deferred for up to three days, so that the defect can be swiftly rectified; (iii) a Category C fault, which can be deferred for 10 days; and iv) a Category D fault, which can be deferred for 120 days.

The remaining defects will be aircraft-on-ground (AOG) faults, which must be rectified before the aircraft can be released back to service. The sooner information on these defects can be received by a line mechanic, diagnosed, and rectification planned, the better the aircraft's efficiency and reliability.

The other data traditionally captured in a techlog include arrival fuel, departure fuel, cumulative hours, and checks on oil levels, temperature and pressure, together with notes and observations recorded by the crew during flight. Other content varies from airline to airline.

When an aircraft has completed a

An ETL is an interactive software application that is designed to completely replace an airline's paper techlog.

sector and arrived at its arrival airport, the crew will fill in arrival information, including the oil and fuel information, alongside the FH, landings and block time of the aircraft. The crew taking over will then have to corroborate the information set out in this techlog by the previous crew, and 'accept' the information set out in this techlog.

The information in this techlog affects each aircraft's maintenance requirements going forward. It is therefore essential that all data are recorded accurately, and filtered through an airline's operational, line maintenance and central M&E systems as quickly and as efficiently as possible. Speed is rarely achieved with a manual, paper techlog system, however.

Reasons for paperless

Aircraft are performing a growing number of sectors daily as operational demand grows. Fewer maintenance tasks share the same interval, making it more difficult to group and manage pre-arranged checks. An M&E system helps plan and group a range of tasks, and makes it easier to keep a record of cumulative FH, FC and landings for aircraft.

The airline industry has long recognised the need for an intuitive and fully supportive M&E system. This has led to the development of paperless line maintenance activities. However, as it is the techlog that captures the initial information that feeds into the line maintenance control centre, a demand for fully functional ETLs has emerged.

A number of vendors has developed solutions to support the paperless techlog and line maintenance initiative. For example, an airline would traditionally have been unable to report many of the faults that arise during flight to maintenance control until the aircraft had arrived at an airport, reached the stand, and the crew physically handed over the handwritten techlog to the line mechanic. The information can now be either automatically synchronised as soon as the aircraft lands, or transferred through a ground-to-air datalink system, such as ACARS in modern aircraft. ETLs have therefore revolutionised fault reporting, and minimised the risk of error or data misuse, while maximising efficiency.

Electronic Techlogs

Techlogs, both paper and electronic, are a minimum equipment list (MEL) item. This means that the techlog is a mandatory and legal document that must be on board the aircraft at all times it is operational. Without a functioning techlog, the aircraft is not allowed to fly. While a piece of paper is relatively reliable in that it cannot 'break down' or default, an electronic device carries that potential risk. To mitigate this risk, an ETL device may mirror the data both on the hard drive and on a backup SD card or USB. In the unlikely event of a device failure, the SD card can then simply be slotted into a spare device, and the ETL is immediately back in action.

An ETL is an interactive software application that is designed to completely replace an airline's paper techlog. The ETL application is hosted on a hardware device that is an electronic flight bag (EFB). The hardware device can only be termed an EFB when it has various flight operations and maintenance applications installed on it. Other than ETL, applications can include aeronautical charts, performance calculation tools, and operating manuals.

Several airlines have a fully approved ETL in service *(see ETLs in operation - airline case studies, page 13 Aircraft Commerce, October/November 2014)*, where they have eliminated the paper log. One option is for airlines to have the ETL hosted on a separate EFB hardware device to the other applications. Operationally this facilitates faster turnaround times, because engineers, mechanics and pilots are competing for access to the EFB.

ETL capability will be standard on modern aircraft models, such as the 787 and A350, but has to be retrofitted to many older types.

There are three classes of EFB that an airline can opt to use. A Class I EFB operates entirely independently of the aircraft, so it does not plug in or interface with the aircraft in any way. This is most commonly a portable electronic device (PED). It may be charged on board via an ad-hoc AC power outlet provided for such purposes.

A Class II EFB will be mounted on the flightdeck, and will integrate/interface into the aircraft in some way, perhaps by using the aircraft's power source to charge up. It may therefore be able to read data from the aircraft bus, or even use aircraft communications systems such as ACARS or satcom.

Third, a Class III EFB will be fully built into the aircraft's systems. Modern aircraft such as the 787 Dreamliner, and the A380, have Class III ETLs as part of their flightdeck configurations. Although a Class III ETL is considered the most advanced and integrated, it can be costly and difficult for airlines to rely on it.

An ETL can take information from the aircraft's systems and avionics, as long as it is hosted on a Class II or III EFB.

The classification of EFBs used here are the original definitions. These definitions have recently been revised by some regulatory authorities.

"Software is constantly evolving and improving," outlines Russell. "For airlines with Class III EFB/ETLs, the software may already be more than five years old when the aircraft is received from the OEM. It is difficult and costly to update software developed by the OEM, which is impractical in a fast-changing industry. It is also well known that although OEMs are excellent at building aircraft, their knowledge of operating them is surprisingly poor.

In all cases to date, operators of Class III EFB/ETLs continue to use paper techlogs, especially for defect management, in parallel to the ETLs. "This defeats the point," adds Russell. "Class I is the most practical option for

Conduce has developed the eTechLog8 ETL, which is a Windows 8/10 Touch application for the Panasonic ToughPad. It is trialling the software with several operators.

operators, because it allows them to eliminate inefficient paper records, and benefit from regular software updates and commercially beneficial upgrades to the communication processes."

Implementing ETL software

Conduce recognised the industry's need to move into paperless operations, when it originally started developing ETL software 10 years ago. Conduce maintains the OSyS system, an ETL application originally implemented by Rolls-Royce before it exited the market in 2011, for Thomas Cook.

Using Panasonic ToughBooks, Conduce has worked to strengthen its reputation as a leading provider in the ETL market by developing eTechLog8, a Windows 8/10 Touch application for the new Panasonic ToughPad. Conduce is trialling the eTechlog8 software with several operators.

It can be difficult for an airline to interface all the different requirements for ETLs, when it has flight operations, crew, and maintenance department engineers and mechanics all involved in line maintenance in one way or another.

"Integrating a variety of systems can complicate procedures, and in an airline there is an operational and engineering cross-over," says Russell. "Typically, the first phase of integration will take over three months. This includes tweaking the software to best fit the airline's operational procedures. For example, each airline may record slightly different items on its techlog, so extra fields may have to be added. Many operators also see ETL implementation as an ideal opportunity to collect additional information, and may use the trial process to test this.

"Conduce will also interface its eTechLog 8 application using eGIS (generic integration system), which communicates with the airline's core MRO system," adds Russell.

During this phase the eTechLog 8 application may be integrated with several different recipients via the device used by the crew and line mechanics (in this instance, a Panasonic ToughPad) and the website portal, which will be used to access the ETL data.

The next step is to get the ETL working in a test environment. These trials can vary from airline to airline. "We integrate the application into the airline's technical and operational procedures," continues Russell. "Meanwhile, the airline revises its SOPs for its flight and operations manuals to include the addition of an ETL. These are reviewed by its Quality Assurance department, before being taken to its regulatory authority. EASA may also want to approve these revisions."

After the regulator approves it, it can take a further six to nine months to complete the implementation and have the software running live. "The logistics of installing the software requires the least amount of time," explains Russell. "It is ironing out the operational processes, conducting training and rewriting procedures that takes more time for the operator."

Regarding the trials currently under way, Conduce has tested the software in two stages. "With one operator, eTechlog8 has undergone an office-based functional trial for one aircraft flying six sectors a day for one month. It is a single point, system stress test ensuring that all data are accurately captured," explains Russell. The next step is to undergo a live trial with the device in use on an aircraft by the pilots and engineers. This provides enough data for subsequent approval by the local regulatory authority. At the moment Conduce has several clients at this stage that plan to roll out eTechLog 8 live over the winter period when the operators are at their quietest.

Conduce also has several clients in the Middle East in Bahrain and the United Arab Emirates (UAE) where trials are also being planned with the local regulators ahead of rolling the software across the respective fleets. Although a month seems the average length of time to trial the software, it is the operator's regulatory authority that will determine the duration. "The aviation authorities may specify a minimum time during which the airline must run the system in parallel to the paper techlog," Russell concludes. "We have seen it vary from two weeks to six months."

Several airlines have moved towards full reliance on ETLs. Their experiences and reasons for opting for the modern initiative are outlined here.

BA CityFlyer and NVable

British Airways CityFlyer (BACF) is a wholly-owned subsidiary of British Airways. It is headquartered at Manchester, and its fleet of Embraer E-170 and E-190 aircraft operates domestic and European routes from fleet bases at London City and Edinburgh.

The operational demands of London City have led to significant operational benefits for this regional airline as a result of implementing ETLs. "Turnaround times at London City airport are incredibly short; sometimes as little as 30 minutes," explains Dave Cooper, line maintenance manager at BACF. "This requires quick and efficient data reporting, to get the aircraft status monitored, and subsequently released and accepted by the outbound crew, to make its next departure on time. This turnaround time has to accommodate the arrival crew signing off the status of the aircraft and handing it to the flightcrew taking over. The captain then has to officially 'accept' the aircraft by signing the techlog ahead of departure, which signifies the crew is satisfied with the status of the aircraft. An ETL enables this process to be speeded up."

Since 2012 BACF has been using the Appixo Techlog, developed by NVable, on a Panasonic FZ-G1 ToughPad. This is a ruggedised tablet that is categorised as a

Class I solution.

For BACF, the opportunity to make the transition from paper to ETLs came when it decided to modernise its fleet. "Upgrading our BAE-146 aircraft to a fleet of 12 E-170 and E-190s in 2009 provided us with an ideal chance to upgrade our operating processes," explains Cooper. BACF has since further increased the size of its E-jet fleet to 17.

Overall, demonstrating the validity of integrating an ETL to the UK Civil Aviation Authority (CAA) took about three months. "We had three, one-month phases of simulation and demonstration," says Cooper. "Initially, we had a desktop testing phase, in which we simulated a dummy aircraft registration into a test server. This initial testing verified the transmission and data accuracy and lasted for one month.

"After this was approved, we had a live trial using both an ETL and a paper techlog on a single aircraft. We ran these systems in parallel for one month," continues Cooper. "Even though we had both types of techlog to input, we had no delays in our day-to-day operation.

"Last, we removed the paper techlog and ran the ETL on a single aircraft for another month. We continuously monitored these phases and reported to the CAA. During the three-month period various bugs, minor development and enhancement fixes were recorded and implemented prior to seeking final approval from the CAA. The detailed submission for roll-out across the whole fleet was initially granted for a 6 week period with full unrestricted approval following."

The Appixo platform used by BACF on the ToughPad operates a 'traffic light system' to indicate outstanding information needed; making it relatively simple for the crew to see where additional information is required.

A red section means that an action is required by the crew or mechanic, or that a defect is still open. An amber tab means the ADDs must be reviewed by the crew. Icons adjacent to the acceptable deferred defects (ADDs) and out-of-phase (OOP) items indicate the status of those individual tasks. The status ranges from unrestricted operation to nearing expiry to expired, so users do not have to read text to determine the status. As each section is completed satisfactorily, the tab for that section turns from red or amber to green. The ETL cannot be transmitted until every section has been reviewed and completed by the crew. Once sent, a green acknowledgment of transmission will signify successful delivery of the data to the BACF MRO system.

For a crew waiting to depart, the captain will check the defects listed and the colour associated with each defect. The captain will then fill in the fuel and oil details during pre-flight checks, and then sign off and attempt a transmission. During flight, defects can be raised and filled in via the ETL, which will transmit them once the aircraft is back on the ground and data connection is available. The arrival captain will fill in the relevant flight and block times, oil and fuel levels post flight, before signing off and transmitting the techlog again.

To gain the regulatory approval, BACF has had to demonstrate that back-up procedures are ready and accessible in the event of no data transmission, or hardware failure. "We have redundancies built into our SOPs," explains Cooper. "If there is no data transmission when the aircraft lands at an airport, we have a small plug-in printer to print off the techlog to hand to the mechanics. If the hardware is broken, we have a pad of 20 paper techlog pages aboard every aircraft.

"There are few printed sectors made however, and even fewer reversions to the hard copy paper techlog," says Cooper. "To date, we have had no hardware failures."

In fact, over a two-and-a-half year period, only 38 sectors out of 54,000 have had to use the paper techlog. "The transmission failures have largely been due to the aircraft being parked at shielded stands at certain airports, rather than system or hardware issues," adds Cooper. "First-time transmission success

By using Empowermx's Fleet Cycle suite, Delta Tech Ops has found that paperwork errors were reduced by 10%, and overall efficiency was improved by 20%.

of the ETL data back to maintenance control is 97.4%. Overall transmission success is 99.9%."

BACF would like the MRO systems to provide the ETL system with additional data, such as component data, and to provide robust verification processes. "It is something we are looking at but we want to ensure that ETL performance is not compromised with the additional exchange of data with the MRO system," concludes Cooper. "For example, on 30-minute turnarounds one would not want the ETL process to be delayed by the transfer of excessive data, so timing of this transfer and improved network infrastructure will be the prime consideration."

Alongside the ETL, BACF has partly introduced paperless line maintenance into its operations. The data captured through the Appixo ETL is filtered into a web-based portal that interfaces with BACF's maintenance planning systems on the line. Maintenance control then accesses and reviews the techlog information, including any defects found, and therefore plans line maintenance activities accordingly. These are then filtered back and delivered directly to the ETL, along with the workpack, to keep the line mechanics and crew informed.

NVable, as provider of the Appixo platform, has supported its integration into BACF's operation. Ahead of installing and integrating its product with a customer, the team research how to maximise the benefits the software can offer. "We talk to customers to gain insight into their processes ahead of implementation," explains Cameron Hood, chief executive officer at Nvable. "There is a perceived barrier in Europe, since the ETL presence is currently less established. Operators feel there are challenges in trying to convince the aviation authorities to approve an ETL. Although it can take less than a month to configure and customise our software for the customer, it is the acceptance by the aviation authority that takes time. Therefore, a gradual phasing in of the software makes it far more acceptable and manageable in the regulators' eyes, while also ensuring the process for the airline is as easy as possible."

The Appixo software can transfer data through WiFi or a GSM sim card connection; meaning the ETL will update the aircraft's maintenance status once the aircraft lands after a flight. Interfacing with a datalink, such as ACARS is to follow, so that defects arising during flight could be communicated in real-time to the ground and maintenance control.

Cathay Pacific & Ultramain

Cathay Pacific is the largest airline in Hong Kong. Its fleet comprises A330s, A340s, 747s and 777s operating to more than 200 destinations.

Although Cathay has used its M&E system since 2002, it has recently contracted Ultramain to provide ETL software for all of Cathay's fleet. This uses the Ultramain ETL for Cathay's technical and cabin logbooks. Ultramain also provides the ETL software on Boeing's optional Class 3 EFBs for the 777 and 787. Its ETL software can also be used on Class 1 and 2 EFBs for other aircraft types.

Cathay initiated the installation of Ultramain's ETL in April 2014. It now has three 777-300ERs operating with ETLs in parallel with paper techlogs that are awaiting operational approval from the regulator, so that paperless operations can be rolled out across the fleet. The intention is that the whole fleet will adopt ETL processes over the next 18 months.

Cathay's techlog captures the usual operational data required by its aviation authority. "We use a spec 2000 Chapter 17 compliant ETL to capture all the standard data points of the techlog," explains Robert Saunders, head of engineering business improvement at Cathay Pacific. "Defect number and type, pilot report (PIREP)/maintenance report (MAREP), MEL category, e-signatures and fuel and fluid uplifts are examples of other items. We capture other operational events such as weekly, transit and extended range twin-engine operations (ETOPs) checks that will directly update the M&E system records."

Like other operators, a phase-in approach is required by Cathay's local aviation authority to gain its approval and confidence in the reliability of an ETL. "Each activity is phased differently, depending on the impact of the implementation stage," says Saunders. "This takes longer than expected in most cases. Seemingly straightforward paper processes can be replaced in theory. Complications, however, come with the exceptions to the norm, which all need to be addressed in order for the system to become truly automated.

"Adoption of new electronic processes, after a clearly defined and approved procedure, will typically take six months to stabilise," continues Saunders. "Before we can continue to the next stage, our regulator is informed of any procedural change through updates of procedures manuals. As e-signature and paperless processes are at the forefront of new and changing regulations, there is particular interest from the regulators, and this leads to more requirements to seek approval."

External connectivity for Ultramain's ETL can be via a range of methods, so that it can interact with Cathay's fleet, and allow for full-time global communications between the aircraft and Cathay's ground systems. Data connections include Iridium satcom, VHF, HF, and ACARS, while WiFi & cellular data connections are used when the aircraft is on the ground. An important use for this continuing connection is when a fault arises during flight. "A series of procedures take place," explains Saunders. "The crew raises the defect via the ETL and sends it. The defect is then immediately visible in the ETL ground system dashboard for the maintenance control department to see.

"All defects are pre-prioritised (in the ETL background tables) to indicate operational importance," continues Saunders. "Ground staff in both the mechanics and defect management team,

BA CityFlyer has been using NVable's Appixo ETL since 2012. The Appixo ETL can transfer data via WiFi or cellular connections when the aircraft lands.

can review the defect report and assess its impact. The defect is then loaded as an appropriate maintenance opportunity in the 'Line Planner' module in Ultramain according to its severity, together with any other maintenance due. This can be next arrival or to a dedicated input. Resources are planned and a work package is assigned to the mechanic on duty, who works on the defect, and then updates it or clears it in the ETL. This ETL entry closes the loop by interfacing back to our central M&E system, which is the Ultramain Line Planner."

Of course this all relies on a solid data connection. Cathay has implemented its own procedures to ensure against lost or missed in-flight transmissions or defects and other ETL entries. "The ETL has a 'paper sign' function to accommodate communications failure," says Saunders. "This prints the sector information and work carried out during the transit to meet the legal and regulatory requirement for a 'Station Copy'. The ETL can be run in this mode for a number of sectors with data entry available through the ground system. The airborne and ground systems realign records when connectivity is restored."

Altogether, Cathay has identified a significant increase in data accuracy and integrity in the ETLs of the aircraft under operational approval. Saunders foresees further benefits. "New opportunities will arise as people become more familiar and confident with data, rather than paper," he says. "Right now, our local regulators and quality departments have difficulty in accepting data over electronic scans of paper because of the industry's legacy view of dirty fingerprint originals. Also, auditors are not necessarily experts in IT processes, data management or security, so it is likely that third parties will be consulted during our audit processes, which may become stricter or more complex. As confidence grows, however, regulators will become more willing and able to adopt data-based processes."

Alongside the ETL implementation, Cathay has started to address its line maintenance processes. "We are not yet paperless for processes outside of ETLs, but we have a paperless strategy for work card production and technical records," explains Saunders. "The approach has been to clean up the past first, streamline our processes, and implement a sustainable electronic technical records repository. In 2014 we finished scanning and indexing 34 million paper records. These have been loaded into a system by Flydocs; a company providing electronic document management specifically for aviation technical records. The reality at the moment is that, even if the internal production of paper is eradicated, component suppliers and repairers show little sign of adopting paperless operations, so we still need to scan."

"The next stage is to look at paperless workcards for base maintenance, which will require cooperation with our MRO suppliers," adds Saunders. "HAECO, as a major supplier, are moving toward paperless work card sign-off which aligns with Cathay's strategy."

Finnair & Skypaq

As one of the most experienced users of ETLs, Finnair began installing the software into its daily operations in 2008. Finnair uses Skypaq's 'eLog' for its ETL data capture, alongside some line maintenance activities that include handling defects arising mid-flight. "We use Swiss AMOS software for our line and base maintenance operations," explains Juha Hiissa, head of maintenance control at Finnair.

The type of data that gets captured in Finnair's ETL includes: PIREPS, cabin reports (CAREPs), MEL items, certificate of release to service (CRS), ETOPs status, oil, and generic service checks.

Overall, the integration process for both line maintenance and ETL data capture has been similar for Finnair. "We typically base integration around three separate phases, each lasting up to two months," explains Hiissa. "The authorities approve and sign off each phase before we progress to the next one. We therefore expect full implementation to take about six months."

For Finnair, eLog transmits the ETL data captured during flight by GSM, as opposed to wireless internet. It will therefore only automatically synchronise and transfer the data to Finnair's M&E systems once the aircraft has landed. "It is possible for the pilot to notify our systems of new defects through ACARS during flight, however," continues Hiissa.

"If there is no data connection available because, for instance, the aircraft has landed in a remote location without a GSM or WiFi signal, Finnair resorts to a paper back-up log to record flight information," confirms Hiissa.

Finnair has seen many benefits since implementing ETLs. "We are saving on manual work and making fewer errors," explains Hiissa. "Our reports are easier to understand and better categorised. All the data are updated immediately to all backend systems, so there are no delays caused by manual processes.

"An improvement we would like to see," continues Hiissa, "is more checks for typing errors in the front-end application, so that there is more redundancy built in when checking for basic flight information syntax, such as flight number, and departure and destination airports.

"Also, bi-directional data transmission between IT-systems would be a further benefit. We have the eLog in a read-only format. If the aircraft avionics could be somehow integrated to provide further data to the ETL system, that would also be a benefit," explains Hiissa.

Finnair is well on its way to becoming fully paperless in its line maintenance operations as well."While the ETL

NVable's Appixo ETL operates a traffic light system to indicate the outstanding information needed. A red section means action is required by the crew or mechanic, or that a defect is still open. An amber section means that deferred defects must be reviewed by the crew.

process is already paperless, " concludes Hiissa, "we will have completed our integration of defect management across our maintenance facilities within the next couple of years."

ETL benefits

Cost savings and operational reliability are driving the initiative for airlines to make the move into paperless flight operations. "Short-haul airlines, with aircraft flying more sectors, on a daily basis, see the quickest return on their investment into ETLs," sums up Russell at Conduce. "These airlines see the shortest turnaround requirements, and more operational movements on an aircraft in one day, because they enjoy maximised efficiency, and get the flight information over to maintenance control as quickly as possible."

"The ability to plan ahead, keep the line maintenance mechanics in the loop and have the visibility of real-time data, is priceless to an airline," adds Hood at NVable.

The relative ease with which redundancy can be installed into the operating procedures for using an ETL, enhances the attraction for operators. The back-up option of reverting to paper in the event of data transmission failure, seems to be used rarely, but it provides regulators and users with a straightforward and reliable solution to be used in the event of ETL breakdown, and instils confidence.

Traditional line maintenance

The demand for electronic, paperless aircraft maintenance was present in the industry even before the ETL initiative. An aircraft remaining on the ground due to a technical fault loses an airline a great deal of money, so mitigating against this scenario is obviously attractive to an operator. Aircraft records, including OEM manuals, illustrated parts catalogue (IPC), MELs, flight manuals, maintenance programmes, task cards, work packs and other mandatory items, all involve a large amount of paper, which could get lost in the activity of a shop floor or hangar.

Every task, whether for a scheduled, non-scheduled, in-phase or OOP item, would traditionally require a handwritten task card that would have to be attached to the pages from the relevant technical manual to which the task is related. This is another exercise that uses time to locate the relevant pages, further keeping a mechanic off the shop floor. All findings would have to be handwritten, and once completed the task card would have to be manually signed.

Maintaining the reliability of the data on a task card, when looking to move into paperless maintenance, is critical for an operator. Also, the cost of assigning every mechanic a portable electronic device (PED) such as an iPad or Toughbook, must be taken into account. One of the processes preventing most operators from becoming 100% paperless is digital sign-off an electronic task card. The regulatory authorities need to be convinced that an electronic task card has secure, tamper-proof signatures that keep the data protected and incorruptible.

Headquartered in Ottawa Ontario, Canada, Mxi Technologies is one of the market leaders providing web-based line and base management solutions to airlines and MRO shops. It counts among its clients global operators such as Qantas, Air France Industries and KLM, as well as regional operators and those with smaller fleets. Mxi's software suite Maintenix, specifically the Maintenix Operator edition, is a web-enabled solution that manages both line and heavy maintenance activities.

Mxi has long recognised the importance for operators to sign off electronically on maintenance tasks via a tablet or device. "For an operator to achieve its operational goals, aircraft availability to fit the flight schedule set by the airline is key," says Andrew Floyd, product marketing manager at Mxi. "Having information instantly ready, ensures rapid return to service for the aircraft. Our clients want the needs of the aircraft considered throughout the maintenance chain efficiently. Our central website portal sends information to all departments instantly, so that we can maximise efficiency throughout the chain."

One issue is the occasional aircraft lessors' demand for paper task cards, which may reduce the need to install fully paperless operations. An example is Air Canada Jazz, which has been using tablet and laptop computers since 2009, and generates electronic task cards for 90% of its maintenance. However, the other 10% uses paper cards because some of its fleet lessors require any airworthiness directives (ADs) performed on the aircraft to be recorded on paper.

Delta TechOps & Empowermx

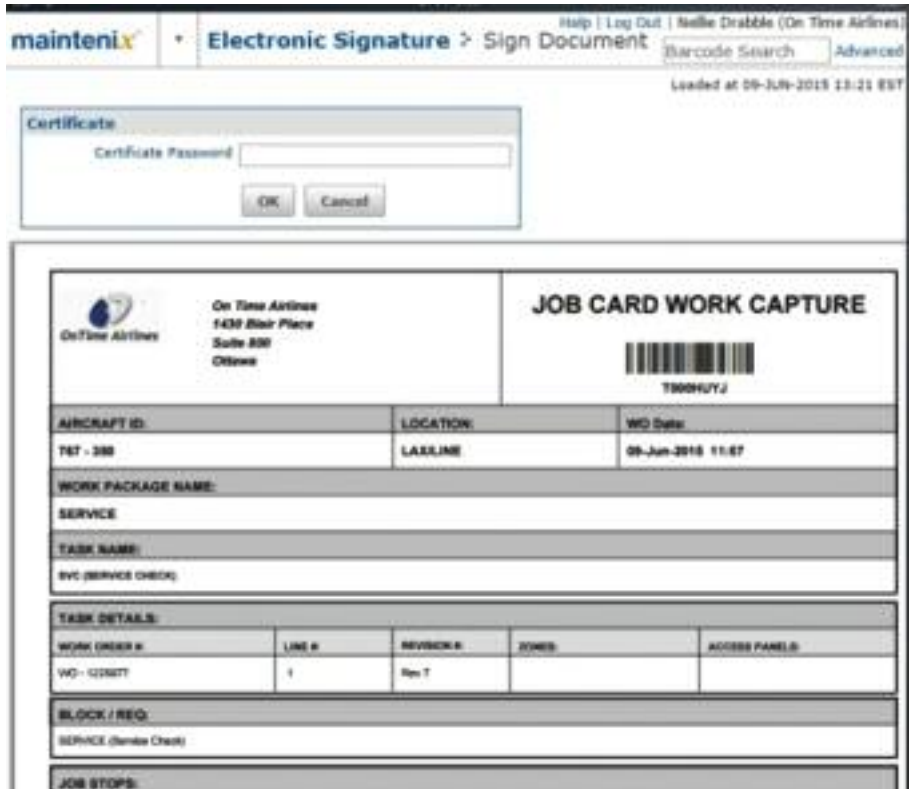
Based in Atlanta Georgia, Delta TechOps is the maintenance, repair and overhaul (MRO) division of Delta Air Lines. It maintains 24 aircraft types; including a fleet of more than 800 mainline aircraft and 400 regional jets. These have an average age of 16 years.

Delta TechOps uses the Fleet Cycle suite developed by Empowermx. This software comprises several different modules including the Line Manager and Electronic Logbook editions. Delta uses the Line Manager module, which filters information into Delta's core M&E system from its line maintenance activities.

Speaking at the *Aircraft Commerce* MRO IT conference at Heathrow Airport, June 2015, Lorraine diMarco, general manager of base maintenance for Delta, outlined Delta's experiences in implementing paperless operations across its line and base maintenance processes.

"Delta started with an overall paper system," explains diMarco. "Some processes were automated, but they were mostly manual. We wanted to improve efficiency in the line and base maintenance processes, and install a system that supports electronic non-routines. We also wanted a mobile-ready application and an intuitive system that was relatively easy to integrate."

Delta began this process by adopting



Mxi Technologies provides web-based line maintenance and base management solutions. Its Maintenix Operator edition is a web-enabled solution that manages line and heavy maintenance activities.

a phase-in approach. Phase one involved implementing an MRO software system that would improve efficiencies in base maintenance. This was followed by buying software that would support the planning and execution of phase checks in both the airline and MRO environment. Delta also had to ensure that the software would grow with the company by supporting fully paperless maintenance in base, line, and component maintenance. Last, Delta wanted to ensure full integration with its native accounting system, so that man-hour (MH) and shop floor data could be sent to it automatically in order to track efficiency during shifts.

Delta TechOps had completed this by the third quarter of 2013; ahead of schedule. It also received Federal Aviation Administration (FAA) Approval for Part 121 and Part 145 electronic signature on non-routine maintenance. The operational disruption experienced was minimal, and already they found that paperwork errors were reduced by 10%, with overall efficiency improved by 20%, through using the Empowermx software.

Delta's long-term goal was to maximise its efficiencies across line, base and shop floor environments by using one maintenance support software to collate and distribute data across all departments. They also wanted to unify the layout of electronic routines and non-routines across all these departments, enable mechanics to work in a completely paperless environment, and ensure seamless integration to all current software through one point of data entry.

The second phase of implementation began in January 2015. Delta and Empowermx developed and trialled an automated link between non-routine maintenance tasks, and the system of record which eliminates the requirement for mechanics working on the aircraft to complete sign-offs in two locations. They also introduced a single sign-on into the software, which enables the mechanic or engineer to access all systems by accessing only one..

Phase three of the process is expected to be signed off in the coming weeks. It will include the use of tablets to produce and fill in ad-hoc routine cards in Delta's line maintenance activities, and the electronic sign-off of routine cards, which will be automated back into the system of record for the aircraft.

Delta is then preparing for the final two phases of its implementation into paperless maintenance activities.

Phase four is due to be completed by the end of the third quarter this year. This will include raising and generating work packs in the system of record to be electronically sent to line and base maintenance for the mechanics to work from. It is also expected that this stage will involve line and base maintenance mechanics using autogenerated electronic routine task cards, all of which will automatically link back into the system of record for entire work packages.

The final phase will involve engine and component shops using electronic routine task cards, alongside automatic distribution of work packages to the shops.

Last, sign-offs in the system of record will be automated with completion of the work on a routine or a non-routine task card. "Most of the efficiency gains are through automating the task assignment and completion cycle, which starts with the crew scheduling and is completed with the automated sign-off in the system of record," explains diMarco. To complete a routine task card, Delta ensures that all work steps are contained within the electronic work card so that there is a single point of entry for all the maintenance execution data. This includes completing the maintenance task and authorisations that are checked during task sign-off. "The mechanic simply places a check mark in the task(s) that require a signature, and then enters a PIN to capture a secure electronic signature," explains DiMarco.

To date, Delta TechOps has seen marked improvements in its day-to-day operations since going paperless. These include a 20% improvement in maintenance check efficiency at base maintenance and airframe MRO, and a 10% improvement in audit findings. Delta finds that it has better visibility of the maintenance check process, and the ability to plan maintenance events better by using information gathered on current checks as it hits their M&E systems.

Much like ETLs, the main potential issue that can arise in line maintenance is lack of data connection to transmit or receive task updates and work packages. For Mxi, ensuring the software is structured to support connectivity as often as possible is important. "Our software is architected to scale," explains Floyd. "Some customers will still need to include a modicum of paper-based activities in their operations. We can build the system to support data connectivity 99.9% of the time for those wishing to become completely paperless. Maintenix is web-based, and transmits data over a very low bandwidth. It can operate over any network: public internet, cellular network, or satellite phone."

Overall, the benefits of moving from a paper to an electronic system are becoming increasingly proven through case studies and company statistics. This will further instil regulator confidence, as well as improve the logistics for an operator to pursue both ETL and paperless line maintenance initiatives. AC