As well as base maintenance, there are complex issues to be considered when configuring IT systems for line & component maintenance. Transitioning line maintenance & defect management to a paperless system has been a long process, but has the potential to save large costs.

Configuring an MRO's IT system: line & component maintenance

Configuring an IT system for an airline is relatively simple compared to configuring it with many of the same functions as a specialist third-party maintenance provider's. The issues that must be considered by a specialist third-party airframe maintenance provider have been examined *(see Considerations for configuring an MRO's IT system: base checks, Aircraft Commerce, February/March 2021, page 40)*. The complexities of configuring a system for third-party providers of line maintenance, and rotable and repairable components, are considered here.

Specialist third-party line maintenance providers, and component repair shops are different entities, so each is considered separately.

Line maintenance providers

Line maintenance capability has to be provided across an airline's entire route network, and is essential to maintaining on-time performance, and minimising delays. The nature of line maintenance is that defects and system or component failures randomly occur as a result of operating the aircraft. Most defects that have to be dealt with are unrelated to routine line maintenance tasks.

The random nature of component and system defects and failures complicates line maintenance for both an airline that carries out its own maintenance at its bases and outstations, but even more so for third-party providers at most of an airline's outstations.

Routine line maintenance tasks are all relatively simple to perform, because they require little access and specialist tooling, and can be completed relatively quickly, especially for pre-flight and daily checks. Weekly checks and A checks have some tasks that are more complex. These can all, however, be performed relatively easily by third-party providers if required.

Technical defect management

The traditional system for dealing with component and system defects has inherent inefficiencies. Most airlines still operate with traditional paper aircraft tech logs.

Many defects and failures that occur with components or systems are first notified to the aircrew either via a central maintenance computer (CMC) fault code, or as a flightdeck effect (FDE). For faults that are notified via a CMC fault code, further information can be found in the CMC on the flightdeck. The crew report FDEs and observed faults/situations in the Tech Log, along with a brief description.

The first long-term inherent difficulty with the traditional paper system is that only limited information about the fault can be relayed to the airline's maintenance control centre (MCC), flight operations and engineering departments while the aircraft is in the air.

The tech log will be manually written by the flightcrew, referred to as pilot reports/write-ups (PIREPs). These will only have a brief description of a defect.

The second difficulty of a paper tech log system is that the aircraft must land before the line mechanic can view the aircraft's paper tech log. The advent of the aircraft communications addressing and reporting system (ACARS) allowed a minimal form of data communication over long distances from the flightdeck. The information that can be transmitted by the crew during flight is CMC codes and additional brief text information relating to a fault or defect, so that airline staff can analyse it and start making preparations to fix the fault before the aircraft lands. ACARS on its own, however, can only relay a limited amount of information relating to a defect. In reality, not all of this information will find its way to the mechanic meeting the aircraft.

Another difficulty is that the line mechanic is only able to diagnose reported faults when the aircraft lands, and they have been able to examine the paper tech log. The process often requires consulting large printed technical manuals, including the fault isolation manual (FIM) or the troubleshooting manual (TSM). This can mean leaving the flightdeck to go to an office to consult manuals and communicate with other parties, sometimes travelling a long distance between an aircraft at a remote stand and their office.

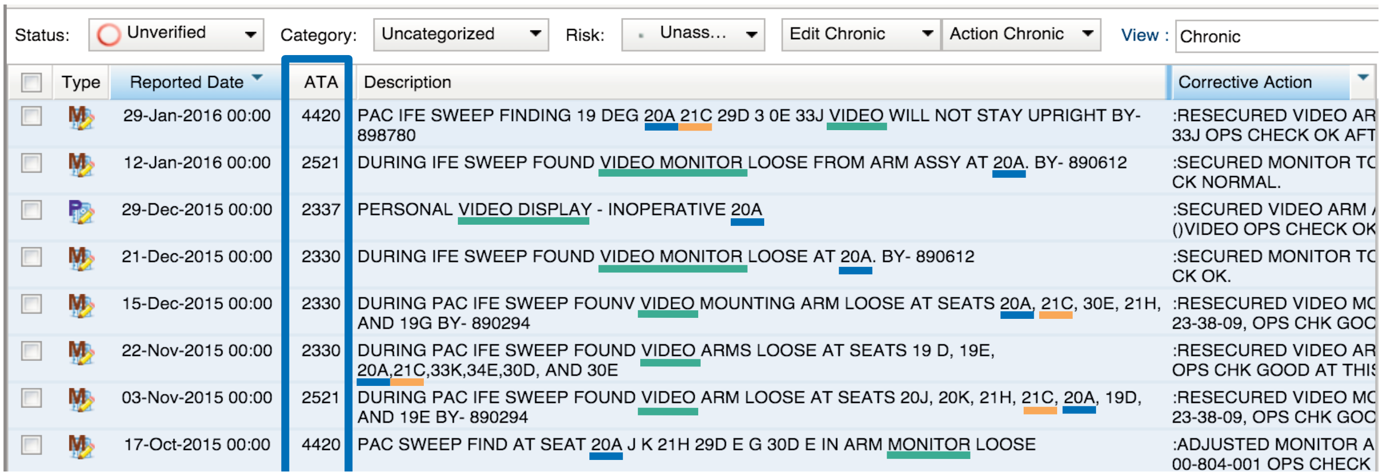
The mechanic is required to record some sort of response against each defect on the paper tech log. This relates to the issue of first having to divide faults between those that are categorised as being 'Go' and 'No-go' on the minimum equipment list (MEL). Faults classed as 'Go' can be deferred, and allow the aircraft to operate until they can be fixed at a more appropriate time or location; while 'No-go' faults must be rectified before the aircraft can depart, and so result in aircraft-on-ground (AOG) incidents while they are rectified.

The line mechanic has three main choices when writing a response. The first will be that the defect has been deferred in the case of a 'Go' defect being diagnosed.

The second choice is a brief written description of the rectification, with references to part and component changes, in the case of a defect being either a 'No go' item, or a 'Go' defect that was rectified.

The third situation is where the mechanic finds that the defect is no longer evident, and the relevant system passes the

Find Hidden Chronics with Mixed ATAs



Status: Unverified | Category: Uncategorized | Risk: Unass... | Edit Chronic | Action Chronic | View : Chronic

	Type	Reported Date	ATA	Description	Corrective Action
	M	29-Jan-2016 00:00	4420	PAC IFE SWEEP FINDING 19 DEG 20A 21C 29D 3 0E 33J VIDEO WILL NOT STAY UPRIGHT BY-898780	:RESECURED VIDEO AR 33J OPS CHECK OK AFT
	M	12-Jan-2016 00:00	2521	DURING IFE SWEEP FOUND VIDEO MONITOR LOOSE FROM ARM ASSY AT 20A. BY- 890612	:SECURED MONITOR TC CK NORMAL.
	P	29-Dec-2015 00:00	2337	PERSONAL VIDEO DISPLAY - INOPERATIVE 20A	:SECURED VIDEO ARM / ()VIDEO OPS CHECK OK
	M	21-Dec-2015 00:00	2330	DURING IFE SWEEP FOUND VIDEO MONITOR LOOSE AT 20A. BY- 890612	:SECURED MONITOR TC CK OK.
	M	15-Dec-2015 00:00	2330	DURING PAC IFE SWEEP FOUNV VIDEO MOUNTING ARM LOOSE AT SEATS 20A, 21C, 30E, 21H, AND 19G BY- 890294	:RESECURED VIDEO MC 23-38-09, OPS CHK GOC
	M	22-Nov-2015 00:00	2330	DURING PAC IFE SWEEP FOUND VIDEO ARMS LOOSE AT SEATS 19 D, 19E, 20A,21C,33K,34E,30D, AND 30E	:RESECURED VIDEO AR OPS CHK GOOD AT THIS
	M	03-Nov-2015 00:00	2521	DURING PAC IFE SWEEP FOUND VIDEO ARM LOOSE AT SEATS 20J, 20K, 21H, 21C, 20A, 19D, AND 19E BY- 890294	:RESECURED VIDEO MC 23-38-09, OPS CHK GOC
	M	17-Oct-2015 00:00	4420	PAC SWEEP FIND AT SEAT 20A J K 21H 29D E G 30D E IN ARM MONITOR LOOSE	:ADJUSTED MONITOR A 00-804-001 OPS CHECK

ATP Software's ChronicX system is programmed to quickly identify repetitive defects by using a dictionary and database of phrase and synonyms used by mechanics to manually report and describe technical defects.

test. The PIREP can be closed with a description of troubleshooting carried out and a statement that no fault was found. Aircraft are made up of complicated systems, so there are times where faults can often be hard to find, and then reoccur intermittently several flights or days later.

Following this Tech Log 'Action Taken' entry, the line mechanic or an authorised superior has to sign a certificate of release to service (CRS) on the tech log. The aircraft captain then has to examine the tech log, and the line mechanic's entries before the next departure, so that they are aware of what defects have been deferred, what rectifications have been made to other defects, and which defects the mechanic was unable to find.

The tech log page is typically a 3-ply paper, with a unique serial number. The first page stays on the aircraft in the technical log.

The second page is removed from the tech log when the aircraft arrives at its home base, and the information is later manually entered into the M&E system to update the aircraft's maintenance status. While this can be within a few hours of the aircraft returning to base, it can take up to two days in some cases for the information to be entered.

The third page is removed by the line mechanic at the outstation before the aircraft departs. This is the Station Copy, and is the record of maintenance activity and certifications required to be available in the case of an incident investigation.

There is also the regulatory requirement to ensure the secure storage of this paper copy, in many cases. The line mechanic will also fax or email the copy to the airline's Tech Records department for data entry.

This process creates a fundamental problem in today's dynamic operating environment. With a paper maintenance log, the systems used for the defect management do not get updated before the aircraft has departed and often not before arrival at the next airport.

Having established that the maintenance system used for decision-making is essentially out of date, the next issue is the quality and completeness of the defects and write-up being reported.

Fault reporting

With flightcrew and line mechanics manually writing tech logs, this creates various difficulties. The first is that each person writing a manual tech log will describe a fault in their own way, instead of using a standard, pre-defined description. As an example, a fault reported on the number 1 engine could be described as number '1', 'No.1', 'LH', 'L/H', 'Port - Eng', or 'LH - Engine'. This has several implications for identifying and analysing the fault for the mechanic attending the aircraft on arrival as well as downline analytical systems.

Handwriting can be illegible, while the description of the defect can be inadequate or even misleading or vague on a paper tech log.

These issues can be exacerbated by the fact that English is not the first language of many line mechanics around the world, and they can use colloquial or non-official technical terms to describe faults.

Another frequent issue is that line mechanics enter errors on the tech log using the air transport association (ATA) system of chapter numbers, as well as two sub-digits to describe the sub-chapter relating to the fault. While all mechanics generally know the first two digits for the main ATA chapters, few know the two digits for the sub-chapters. Examples are defects in the cabin or with the auxiliary power unit (APU). The digits for the cabin and APU chapters are 25 and 49. A fault with a toilet door or oven in the galley requires the correct digits for the sub-chapter, as does a fault with the electric starting system on the APU. The problem is that few pilots and mechanics know these two sub-digits, so the faults described may often be written as 25-00 or 49-00.

This problem is further exacerbated by the fact that pilots who fill in the tech log and make PIREPs, and cabin crew members who write the cabin technical log, are rarely familiar with ATA chapter digits when reporting defects. This is because a different system for describing and reporting faults is used in the flightcrew operations manual (FCOM) provided by the aircraft manufacturer.

All these factors can make it difficult to correctly diagnose a fault, or can even cause an incorrect diagnosis, which can result in the defect reoccurring at a later date.

Another issue is that errors occur when faults are keyed into the M&E system, and can lead to them being incorrectly described.

When using a paper tech log, a particular difficulty arises when the line mechanic records a defect as being a 'No-go' item. A third-party line maintenance provider may not have direct access to each of its customer airlines' M&E systems, so it must relay the limited information it has to the airline by telephone, sending faxes, or scanning pages and sending emails. The airline's MCC or line maintenance department may be able to assist the line mechanic. "This will involve communications between the line maintenance provider at the outstation and the airline's MCC and line maintenance departments, which can be many time zones away," says Alejandro Bravo, senior vice president of production control and chief operating officer at AISG. "Reporting the fault can in fact start with the flightcrew sending a message to its MCC at its homebase via flightdeck connectivity systems. The information is then relayed to the line maintenance provider at the outstation, so that it can work on a diagnosis according to the resources it has available."

The lack of access to the M&E system with the aircraft's maintenance status and history makes it more difficult for the line mechanic to diagnose the fault.

Third-party line maintenance providers are especially concerned with the 'No-go' faults that cause AOGs at the outstations. These can also include some 'Go' defects with particular operational implications that affect, for example, the aircraft's ability to operate extended-range twin-engine operations (ETOPS) missions.

Once the fault has been diagnosed, the third-party line maintenance provider must prepare for its rectification. In some cases, the service order or non-routine (NR) work order is prepared by the airline, and sent to the line maintenance provider.

IT configuration

Third-party line maintenance providers can perform routine checks and line maintenance tasks with relative ease. Some specialised IT capability will be required for several management purposes. AISG is a specialised third-party line maintenance provider in Mexico. It operates at 35 different airports in Mexico, and provides line maintenance for more than 80 airlines, including from the US and Canada, Europe, Russia, Japan, Korea, China and Hong Kong.

"We deal with a large number of aircraft types, and many arrive in Mexico from long-haul missions," says Bravo. "We use several modules of the Ultramain M&E system to manage the line maintenance process. One of the functions performed is to schedule all the line maintenance checks that are coming due at each line maintenance station. With this schedule we then use the system to plan and calculate the labour required for each day at each outstation. This includes the number of line mechanics required at each outstation for each shift, and the licences they require. The system can then be used to assign checks to the mechanics."

When used by a third-party MRO, Ultramain's Line Maintenance mobility apps allow the MRO to manage all the various customers' arriving and departing flights across its route network in one system. This allows the provider to centrally schedule and balance labour of the appropriately certified mechanics in a dynamic environment. The Mobile Mechanic app will handle customer workcard files in multiple formats with real time electronic signature. Being able to manage multiple customer formats and processes in a single system simplifies completion records and accurately consolidates billing information.

Repetitive defects

A particular problem is the issue of repetitive or recurring defects. As described, when using a traditional paper tech log system, writing and reporting defects can lead to the incorrect use of digits for ATA sub-chapters, and the poor description by pilots, cabin crew and line mechanics of the defect. "This arises from an inconsistent use of ATA chapter and sub-chapter codes, and poorly and illegibly written descriptions of the defects and technical faults," says Steve Lightstone, vice president of sales at ATP Software. "Another issue is the inconsistent use of terminology and phrases used to describe a technical fault. This inevitably leads to recurring and repetitive faults because the inadequate description of the defect results in an incorrect diagnosis and rectification, or the mechanic recording 'nothing found' against a fault in the corrective action column on the paper tech log."

An incorrect rectification action will often include the replacement of operational components, as well as incorrect maintenance action. "The inevitable consequence of this is that the fault will reoccur a few flights or several days later. This will be recorded on the paper tech log by a different crew member, and because of the causes described, it will be logged poorly," explains Lightstone. "This will often include the two digits for the ATA sub-chapters being different to the previous report of the fault, which will make it appear to be a different fault to the one reported on the first tech log entry. The two digits for the main ATA chapter can even be incorrectly used, which increases confusion such that the fault is not properly diagnosed and isolated. This process can continue for several weeks or even months, and the fault or defect can occur as many as 10 times.

"The correct identification of the fault can take several months, and is often down to chance," continues Lightstone.

The cost implications of repetitive defects are large when all the elements of NR line maintenance and related factors are taken into consideration. These clearly include the unnecessary use of labour and replacement of rotable and repairable components. They also include the costs and economic consequences of delays and AOGs. The operational efficiency of a paper tech log system can therefore be increased by being able to correctly identify the tech faults and defects that are manually written in the tech log.

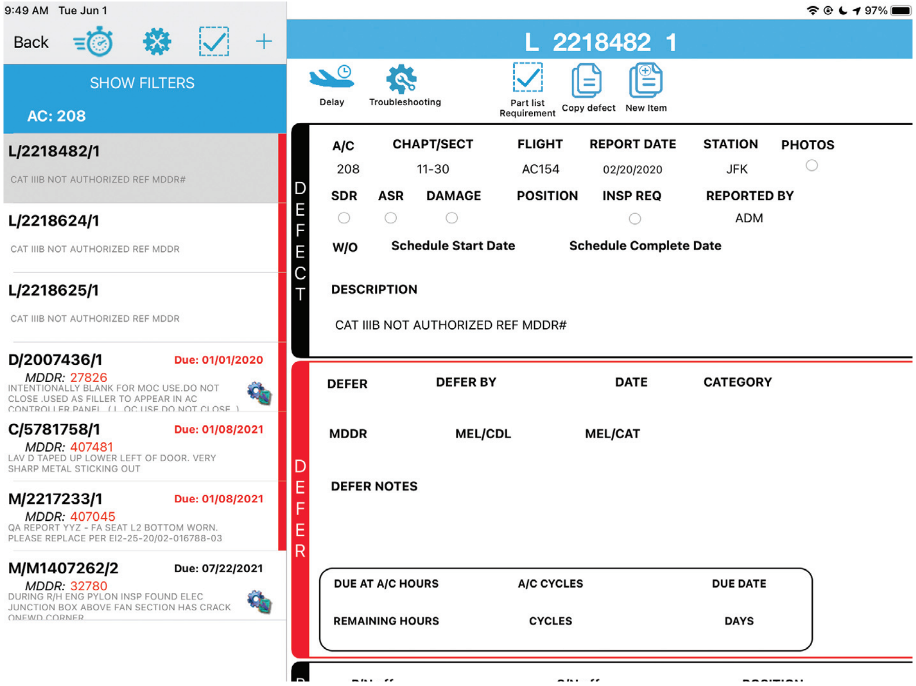
Casebank Technologies, a division of ATP Software, offers its ChronicX system, which uses a dictionary to analyse all the entries of the tech log that have been entered into the airline operator's M&E system. "The system is programmed to find consistency among all the recorded defects for each aircraft when inconsistent terms and ATA codes have been used," explains Lightstone. "ChronicX also has the capability to find the physical location of the defect. An example, as already given, is the door handle for the toilet, under ATA Chapter 29 for the passenger cabin. This is because although the ATA sub-chapter codes may be used incorrectly or even be missing, the text description of the defect can help use the correct codes.

"Another example is an APU over-temperature warning," continues Lightstone. "The APU is ATA chapter 49, but such a fault can often be described using several other chapters than 49, as well as other description types and synonyms used by mechanics and pilots to log the defect. An example is using 'leaks' or 'hydraulic fluid' to describe a leak of fluid appearing, which is either too vague, or an incorrect description of the defect.

"The issue with repetitive defects is getting control of the defect earlier," continues Lightstone. "It is possible to identify a recurring defect after just a second or third occurrence, rather than on the 10th or 12th over an extended period."

ChronicX is used as a point solution within an M&E system. "ChronicX uses extracts of defects recorded in the tech logs on a regular basis. It can be used by line mechanics on PEDs, or by the MCC or line maintenance departments, as well as the reliability department within engineering," says Lightstone.

The cornerstone of ChronicX's technology is the dictionary of technical and engineering terms and synonyms. "We have optimised the system so that it can identify a recurring defect as early as the second time it happens," says Lightstone. "It is up to the airline's standard operating procedure to act on the information ChronicX providers. Once the airline has got used to operating it, it allows a shift in mindset in dealing with repeat defects, with personnel learning to report defects more clearly, and being motivated to identify repeat defects much earlier."



An example of the Line Control mobile maintenance function on Trax's ETL. This allows the ETL and defect management function to be combined with routine line maintenance.

Electronic FIM/TSM

As with tech logs for reporting faults, the traditional system of fault diagnosis is via the printed TSM or FIM provided by the aircraft OEM. "These manuals are written on the basis of what the OEM expected to see when designing the aircraft, and they do not reflect what the airlines operating that aircraft type actually experience," says Lightstone. "We have a solution for fault and defect diagnosis that works in the same way as a FIM called Spotlight. If a fault or failure is discovered that is not in the OEM's FIM or TSM it gets written into Spotlight.

"The system is further enhanced by reporting the fault or defect to our central database for the several aircraft types that the Spotlight system works from," continues Lightstone.

The solution's capability has been so extensively proven that Airbus uses Spotlight for FIM instead of the traditional e-FIM or printed FIM manual. Spotlight is available for the A220, 737NG, CRJ, Q400 and Gulfstream aircraft. It can be used on a desktop or laptop computer, and is migrating tablet devices.

Electronic tech log

"While the most recognised reason to adopt an ETL is to avoid the need for paper, this alone is not a compelling case," says Robert Saunders, director of business development, ELB at Ultramain Systems. "It certainly makes sense, but we need to consider the operational issues that paper creates. We need to consider two main areas. The first is the time delay for data entry, and the second is the quality and completeness of the data being written and then transposed into the M&E system by non-technical staff."

A first issue is the time delay in data entry. With a paper Technical Log, the maintenance system is not updated until after the aircraft has departed on its next flight. The maintenance system and, therefore, departments affected are largely blind to the defects written up during the transit. The only people aware of the maintenance activity are the mechanic attending the aircraft and the departing crew.

The introduction of an ETL should address this problem and provide significant efficiency improvements. The design of an application to achieve this, which is an electronic version of the log page with the ability to send the data to the maintenance system, is relatively straight forward.

A second issue relates to completeness and errors. Manual data entry is open to error and misinterpretation. The accuracy completeness of data collected is essential for correct and effective troubleshooting in order to rectify defects as quickly as possible.

Building an ETL that leads users (mechanics, pilots and cabin crew) through a simple process, while ensuring accuracy, requires a more intelligent application design. ETL applications should ensure ease of workflows by user role, intelligent validation of data entry, alerts and prompts to the user. Of key importance is that the application should cater for abnormal situations encountered in a dynamic operational environment. This includes disconnected resilience.

The main benefit for line mechanics is having access to more information than the traditional paper tech log system provides, especially when dealing with defects and technical faults. While there are efficiencies achieved by not requiring data entry from paper, access to structured information for review of maintenance history can highlight repeat occurrences of similar defects.

There are two main categories of ETL, those installed on equipment that stays with the aircraft (installed EFBs); and those that can be used to host an ETL, which can be the pilot's personal EFB or a mobile device dedicated to stay with the aircraft. There are few ETL systems commercially available on the market, and the two first options on the market were Ultramain and Conduce.

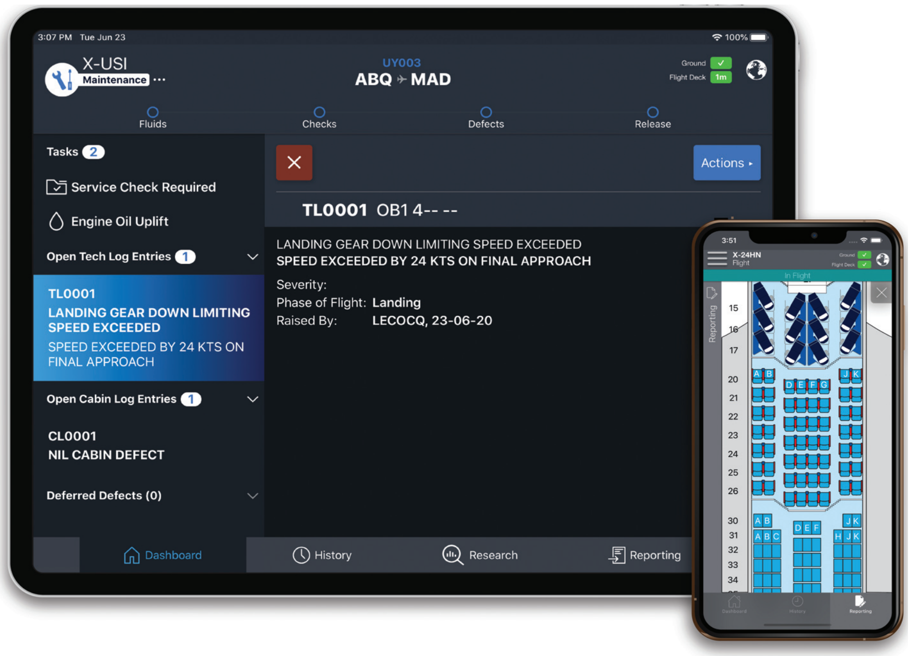
There are now more vendors of ETL systems, and Trax now has its first two airline customers. "One is US carrier Breeze Airways, which has recently started operating with the ETL. We also have other airlines in the process of implementing our system," says Chris Reed, managing director at Trax. "The ETL system can be used together with Line Control mobile app for performing scheduled line maintenance."

ETL connectivity

The first purpose of the ETL is for the pilots to record PIREPs and any other reports, including those of defects, during the flight. Whereas OEM-installed (Class 3) EFBs are considered avionic equipment, and will typically have connections to the ACARS via VHF or SATCOM, mobile EFB devices are still largely independent and only offer cellular connectivity. They therefore do not have airborne connectivity. Ultramain's mobile ETL is one of very few to have capability to connect to an Aircraft Interface Device (AID), directly from the pilot's iPads via a WiFi access point. These integrations with FOMAX and Teledyne Comm+ provide comparable capability to that of an ETL on an installed device, such as those seen on the 787, 777 and A350, but at a fraction of the cost.

Saunders explains that Ultramain ETL customers, with passenger WiFi available, have found this to be a convenient and cost-effective channel to send and receive data while airborne. The net effect is that Pilot & Cabin reports are relayed to the ETL fleet dashboard in MCC, and then immediately seen in the Maintenance System.

It is this ability to have immediate M&E system data population that makes data integrity so important. Four-digit



Ultramain's ETL/ELB system can be used on an iPad or an iPhone. All items relating to technical defects and routine line maintenance can both be accessed and displayed on the system.

ATA system codes entered on paper logs can have up to a 50% error rate. The ATA code is used for reliability analysis and to support accurate troubleshooting. These large paper process errors create misleading results, so airlines have to spend time and effort making corrections. An ETL with in-built fault menus and associated pre-defined four-digit ATA system codes, will remove the margin of error and the need for corrections.

ETL operation

These ETL features make it easier for line mechanics to identify and diagnose faults. The connectivity means the airline can relay the information to the line maintenance provider at an outstation, and the line mechanic can also start a diagnosis while the aircraft is inbound.

"A particular feature of the Ultramain ETL is that it can be installed on existing pilot EFBs (as a companion app to the electronic flight folder (EFF) if required), on mechanic devices and /or smartphones as well as on cabin crew devices. Devices synchronise when in range of each other, or when they have a connection to the ground system. The app can also be opened on a desktop when using the Fleet Dashboard. This new capability, which provides all the features of the mobile app, is sure to be popular with MCC and operational departments," says Saunders.

"With so many deployment options, we asked what customers preferred: viewed via a desktop; or via a tablet device, such as an iPad," says Saunders. "In the case of airlines that use the Ultramain ETL system, including Cathay Pacific, British Airways and Japan Airlines, they have chosen to keep one iPad on the flightdeck and one in the cabin. These two devices stay with the aircraft as loose equipment, just like the old paper Tech & Cabin logs did. This means that there is always a device available on the aircraft, even when the crew are not present. This 'aircraft attached' deployment is common to most customers," says Saunders. "Of course, the ETL can also be installed on personal devices, including pilot EFBs and third-party staff devices in the case of MRO service providers.

"The ETL can use a variety of connectivity systems that include WiFi and 3G/4G when on the ground, and SATCOM if required," continues Saunders. "All four ETL devices are synchronised with the airline's maintenance & engineering (M&E) system when connectivity is established. This therefore allows the line mechanic to view the aircraft's maintenance history on the airline's M&E system after they have received notification of a defect and technical fault on the inbound aircraft. This of course makes diagnosis easier."

Another feature of the ETL is that it hosts electronic versions of the FIM, TSM, aircraft maintenance manual (AMM) and other manuals to make it easier for the line mechanic to diagnose faults and defects, and prepare rectifications.

"When configured correctly, an ETL allows a line mechanic, either employed by the airline or a third-party maintenance provider, to perform all maintenance and defect diagnosis and rectification electronically, without any use of paper," says Paul Boyd, director at Conduce. "This also means the mechanic can work on the aircraft, such as on the flightdeck, with all the information they need on the host device, and without having to leave the aircraft to go to the office to consult manuals or communicate with someone. The line mechanic should be able to view all relevant manuals, write NR work cards, communicate with airline departments, record data on the ETL device, and synchronise it with the airline's central depository."

In addition to clearing defects on the aircraft during the turnaround period, the ETL can be used to host all the information required to perform a routine line check using electronic task cards and an electronic work order. As with technical defects, the ETL can also be used to sign off the routine line maintenance tasks and checks. "Moreover, the line mechanic can use the ETL to plan high-frequency line checks. That is, routine line checks can be combined with work or service orders to clear defects," says Saunders.

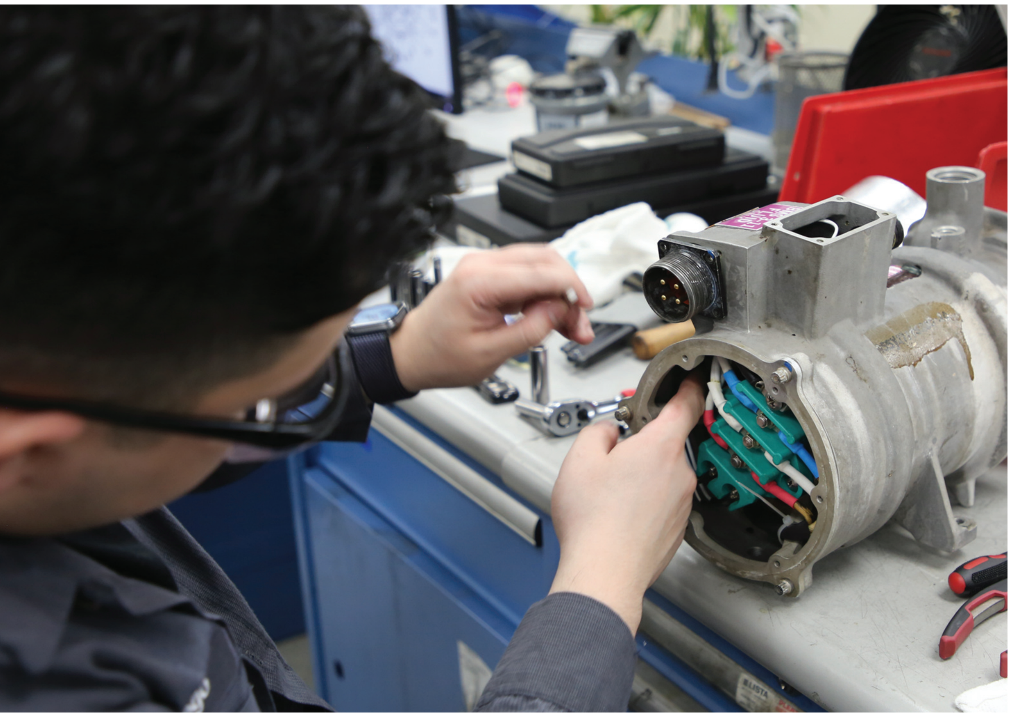
The Trax ETL system, as used by Frontier Airlines, uses iPads and has the Trax line maintenance app hosted on it. "The system allows the line mechanic to see the outstanding defects on the aircraft, provides access to eManuals, gives the mechanic the job cards, and allows the mechanic to record actions on the ETL," says Reed. "The eManuals feature includes a library module to handle all manual and document revisions issued by the aircraft manufacturers.

"The hosting of the line maintenance app on the same device as the ETL, if the airline selects this option, means the mechanic can remain on the flightdeck while performing the majority of the line maintenance," continues Reed. "Another feature we can provide is an app for fleet status and management. This is used to indicate whether or not the aircraft are operable or inoperable, and where each aircraft in the fleet is located. Some defects that arise can automatically trigger an alert through this function."

Data management

As a consequence of being used for performing paperless routine and non-routine line maintenance, the ETL must be capable of accepting electronic signatures. True electronic signature requires a system to authenticate the mechanic signing for a task, check or workpackage. This means the ETL must have an in-built facility for signature verification, taking into account the fact that the tablet devices being used by line mechanics, as well as pilots, can frequently switch from being online and connected to offline and unconnected.

The EASA and FAA guidance for ETL signatures allows a signature to be captured on screen. This can be used in the case of connectivity, but it is not a



A long-term difficulty of third party and subcontracted rotable and repairable component repairs and overhaul has been the airline customer having no access to information or data while the item is out of its control.

validated CRS signature. "The Ultramain ETL system uses encrypted data and a technology, similar to that used by the banking industry, to validate CRS e-signatures without the need for connectivity," says Saunders.

The next issue is in the situation of connectivity not being available. In this case it has to be ensured that there is a record of all maintenance activity left at the departure station before the aircraft departs. This record is termed the Station Copy, and is a regulatory requirement.

If there is no connection available then the station copy cannot be transmitted, so the aircraft cannot depart. A back-up system is therefore required, such as the line mechanic manually writing a paper copy, and using this as the CRS, or carrying a printer onto the aircraft to print from the ETL. "Another option is to have a peer-to-peer system, where the iPad's own WiFi or Bluetooth signal is used to synchronise with the line maintenance provider's and the pilots' ETL devices. A Station Copy is therefore replicated on a device that will not depart with the aircraft.

"As all defects are recorded and diagnosed, and rectification maintenance tasks are completed, the relevant data can be autopopulated in the airline's M&E system," says Boyd. "The aircraft's tech log can also be automatically updated, as well as the aircraft's maintenance status. This will include the aircraft's CRS, so that it can return to operations. The advantages of this include a big reduction in errors because data entry is no longer manual, which has implications for cost savings, and makes it much easier for different people within the organisation to understand the entries made by others."

Synchronisation with the M&E system is important for ensuring up-to-date maintenance status information for the aircraft. "Fortunately, there is a mature standard for ETL/M&E systems integration. This is ATA Spec 2000 Chapter 17, the latest version of which supports two-way data exchange" says Saunders.

The implications of this are that a specialist third-party provider will need to have at least one separate device for each of its airline customers at each of its stations that operate an ETL system that is configured this way. The ETL device for each airline customer will require security clearance data and information for each mechanic that is expected to use it. The device will also require all the related information for mechanic verification for electronic signature.

The overall implications for the configuration of the ETL system means it is more complicated for an airline to use the system across just part of its fleet operation and route network. "This is because you cannot have some aircraft types using it, and their pilots and line mechanics being trained to use it, while other aircraft types continue to use the traditional paper tech log. This is especially the case when the different aircraft types operate from the same hubs and fly to the same outstations. It is much easier for the system to be implemented across the whole operation and route network. It is all or nothing," explains Boyd. "The airline therefore has to train its own pilots and maintenance and operations personnel, as well as line maintenance providers at outstations."

The first main benefit of line mechanics being given more time to diagnose faults and prepare rectifications has several advantages. Ultramain, for example, says that one of its customers reports that since implementation, they have seen an improvement as a result of changing the way line maintenance can be managed with real-time, up-to-date information for all. The particular A350 fleet has seen a 44% reduction in defect-related delays and a 29% reduction in PIREPs. Preparedness and accurate information has led to more first time fixes on arrival. That is, fewer deferrals that need to be planned into the schedule for later rectification. This has further led to an increase in aircraft availability.

"When building a business case for an ETL, it is usual to focus on the direct savings of paper handling, data entry and weight savings," says Saunders. "But the improvements we are now seeing with the maturity of ETL operators far exceeds just the removal of paper. It is not defects that cause aircraft delays, it is the inability to manage the impact of a defect before the next departure that causes the delay. This is what ETL fixes."

This will lead to associated benefits of higher aircraft utilisation, in particular the effect of the cost of aircraft financing per available seat-mile. An improvement in fleet reliability and a reduction in delays and AOG situations will also help reduce related costs.

These benefits have to be considered against the costs of installation and implementation. The approximate cost is less than half that related to an AOG situation. This includes ferrying additional aircraft, the consumption of aircraft components, and providing hotel rooms to dissatisfied passengers. In the long term there are also the costs related to no-fault found (NFF) with components removed following the reporting of a defect or technical fault.

Component repairs

The management and maintenance of rotable and repairable components accounts for a large percentage of overall aircraft M&E. Airlines can use their M&E systems to manage their components when they are under their control, but they do not have access to information on the status of these components while they are in transit or being repaired by a third-party repair agency. This means that components sent to third-party repair shops are in a 'blind spot' for the airline until they are returned.

Internal management

Airlines can use M&E systems to manage components when they are within the airline's own internal system, whether they are installed on aircraft, in their own in-house repair shops, held in inventory stores, or in transit. Components can be labelled with barcodes, and scanned at every main event, such as installation on an aircraft, removal from stores, entry into a test facility, or exit from a workshop.

If this tracking is complete for each part and item, the reliability and removal interval data for each part number (P/N) can be compiled for engineering management to file the necessary component reliability data. This information is also necessary when assessing and re-assessing rotable inventory requirements, and to locate components.

This tracking will also include those components that leave the airline's jurisdiction when being sent for repair to a specialist subcontractor, and when being received back into stores afterwards.

The M&E system can also be used to monitor the airline's internal costs of operating its own repair shops, logistics and transport of items, maintaining stores, and other costs such as staff and salaries, and external component repairs.

There are several technical details an M&E system is required to monitor and follow. First, the airline must issue a repair order for any component sent for test and repair. The information included will be the individual serial number (S/N) and the P/N, and any pertinent information relating to the repair, such as the condition of the component, and the reason for removal or suspected failure. The airline can also include a required or preferred return date for the part. The repair shop may also require specific shipping and transport or logistics information.

When the component is returned after repair, it must be accompanied by an 8130 or Form 1 document, which acts as the maintenance record and a CRS. There will also be the final teardown, bill of materials used, and inspection report; and any specific repairs or modifications required. These forms also have to be signed by the repair technician responsible. All this information and a scan of the 8130 or Form 1 is kept on the airline's M&E system. The information returned must also include the expiry dates of new warranties issued, the remaining life limits of the component, and a packing slip.

One of the main elements of outsourcing component repairs relates to arranging transport, import and customs duties, taxes, and all related paperwork and information. These issues are related to INCO terms; the internationally agreed commercial terms of cross-border trade.

Many components have to be spent for repair to highly specialised shops, and there are often only a few in specific global locations for certain types of component. "A component can be imported using the repair shop's inward processing and repair (IPR) number, which is issued to the repair shop by the relevant government," explains Ralph Perkins, chief executive officer at Aviation Logistics Network. "The IPR number allows a component to be imported without any duties being applied. This is only permitted, however, if strict record-keeping is maintained, and the return of the part to its original airline customer is recorded against the IPR number, so that it reconciles with the original import. If the component repair shop fails to keep accurate records and a validated audit trail of these imports and exports, this will lead to penalties and a withdrawal of the IPR number, and the application of import duties later."

Perkins adds that a common problem is what is the correct classification for an aircraft part, since some parts can be used for other applications such as a toilet or galley oven.

"Parts that arrive in a usable condition, and have a certificate of airworthiness (CoA) can be cleared as aircraft parts, and in the case of the UK, attract an import duty of 2.7%," says Perkins. "On low value items, the importer may actually decide to pay the import duty, since the duty rates in many countries are low for aircraft parts. This can especially apply to

The AJW Group includes AJW Aviation, which provides rotable support contracts; and AJW Technique, which is a specialist component repair and overhaul provider.

aircraft parts traders that do not have access to IPR authorisation."

One of the most commonly used set of INCO terms for shipping aircraft parts for repair and then back to the airlines, is a system of 'door to arrival named place' (DAP). The sender of the part, an airline, will pay for the freight charges from their facility to an agreed named place, which is usually the delivery address of the repair shop. The repair shop will instruct its local customs broker how to clear the part for customs. Once customs has been cleared, the repair shop bears the cost of customs charges.

Another common set of INCO terms is cost, insurance and freight (CIF). The shipment made by the airline to the repair shop is prepaid by the airline sender, so the air freight and associated charges all the way to the arrival point are controlled by the sender. The repair centre then appoints a broker to clear and deliver the component package to them. This means the recipient, the repair shop, will pay the cost of delivery, and re-charge this to the airline.

External management

As with all other sectors of aircraft maintenance, the information sent a repair shop is transferred in a paper format. Clearly, a lot of data entry and errors and time could be avoided or reduced if this information were prepared and transferred electronically. "Most airlines continue to use the traditional hard copy paper system, but some airlines are starting to use new technologies," says Sajedah Rustom, chief executive officer at AJW Technique. "These include API connections between the various IT systems in use. These allow shops and airlines to transfer information between each other. This is now becoming more common as many maintenance providers and repair shops create customer portals that allow the direct transmission of this information."

Rustom adds that more airline IT systems are placing data on the part's repair into radio frequency identification (RFID) chips. The data can easily be read by the repair shop and transferred into its IT system when the RFID chip is scanned. This includes all relevant documentation.

Among the several problems inherent with a paper system, are: the lack of visibility the airline has while the component is outsourced; the absence of a seamless flow of data between the airline and component repair shop; and the fragmented data sent to an airline from the component repair shops.

An airline's main interests are to reduce repair-related costs and increase parts availability. Many airlines only receive emails from repair shops and have limited information. What an airline needs to know promptly is whether or not it is economic to repair a part, and when it can expect to receive it back from repairs.

Management solutions

Several solutions have evolved to track or manage components as they pass through the repair and transit cycle.

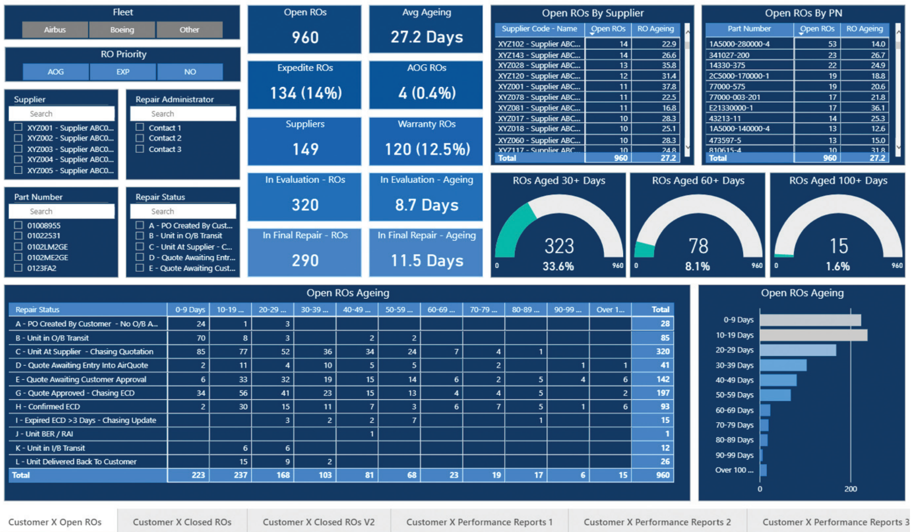
One example is an electronic data interchange (EDI) connection between AJW Aviation and AJW Technique, AJW's component repair and overhaul service. "This gives AJW Technique advance notice of when units are coming in for repair, and it builds the framework for the repair order to reduce the manual input required when the component comes into the shop," says Rustom. "In return, the EDI connection allows all the repair work to be monitored. We also have GATE reports, which are a visual aid to help AJW Aviation see where the part is in the repair cycle process. We have API integrations for our customers, and our in-house customer portal provides the same benefits of transparency for the airlines."

One of the best known solutions in the component management process is Aeroexchange, which works as a data and information exchange platform that sits between airlines' M&E and other IT systems and the third-party specialist component repair shops' IT systems. Aeroexchange uses an EDI and web services to provide airlines with visibility on the progress of their components as they pass through the repair process.

Component Control provides an enterprise resource planning (ERP) solution for repair shops to use for the repair management process. "Component Control can be interfaced with Aeroexchange to set up communications with all the airlines that use it," says Daniel Tautges, senior vice president at Component Control. "There are different ways of configuring Component Control to manage component repairs and maintenance. A specialist repair shop, such as Aerorepair, interfaces Component Control with the M&E systems of its airline customers by utilising Aeroexchange.

"A repair order comes through to Component Control from an airline, via Aeroexchange, and gets processed into various pieces of information," explains Tautges. "Aeroexchange provides the airline with the information it requires as it monitors the progress of its component repairs. Aeroexchange has a repair status dashboard or page. The overall system autopopulates the data and information into the system, so it does not have to be manually keyed in. The data relating to each component is managed all the way through the process."

Airinmar provides a specialist IT solution for managing the component repair cycle, and has been a subsidiary of AAR since 2011. "Airinmar can be used to source repairs from a large number of specialist shops. This is one of the first stages after an airline issues a repair order for a part," says Matthew Davies, senior vice president of cost control at Airinmar. "The system provides visibility in the



AAR subsidiary Airinmar provides airline customers visibility into the progress and of the repair of its components via a portal.

repair cycle of a component via its portal. The system also manages repair quotations, once several shops have been found. The relevant information for each shop's quote can be displayed via the portal."

This is a useful tool for airlines, since most will use 200-300 specialist shops around the world for their component repairs. "The system provides detailed information that is required to make informed choices," says Davies. "An example is a repair involving hazardous procedures or chemicals. It can also advise which shops are relatively close, if an important factor is the cost of transport or date of return to the airline. The level of sophistication required varies by airline.

"The system can operate by emails, EDI, web services or file transfer protocol (FTP). There are varying levels of sophistication among airlines and providers," continues Davies. "It is therefore possible for the data flow to be electronic, and without any manual input. The data feed from the airline can be based on ATA Spec 2000 Chapter 7, for repair order management; or Chapter 14 for warranty management. The data can be in extensible mark-up language (XML). These two chapters were developed by the ATA to standardise data connectivity. Alternatively, the electronic data that is transferred can be in a bespoke format pre-agreed by the airline and the repair shops."

A specialist ERP solution is required if all the relevant data is to be managed electronically rather than on paper. "This can eliminate the traditional paper and manual processes from most of the process, but there will still be some items such as test sheets that have to be filled in by technicians," say Rustom. "These test sheets can, however, be scanned and uploaded into the ERP system, with the related repair order and other information."

AJW Technique has been working on solutions to reduce manual interventions related to administrative work, and is exploring integrations of tablet devices and software solutions that allow the direct transfer or input of documentation from the tablet to the ERP system.

Such a system would allow all technical records and serviceable tags to be produced, signed and sent to the airline electronically, if this is what is required. "A seamless flow of electronic information between airlines and multiple component repair shops is possible, if all parties are willing to adopt new processes," says Rustom. "AJW Technique has the functionality to log labour man-hours and material consumption used for the work. These can be sub-divided into the individual steps of the repair process."

Component tracking

TrackiT of India has developed several applications for managing and tracking components and engines through the repair shops. Its system is used by Emirates to track rotables and repairables that are sent to specialist third-party repair shops, as well as its own in-house shops.

TrackiT interfaces with an airline's M&E system, with the airline generating and issuing work and repair orders. "We have developed a system for the parts to be tracked with RFID tags," says Hem Pandey, business unit head MRO, at TrackiT. "This allows a component to be tracked through the entire repair process so that the location and stage of repair can be monitored at any time. This information can then be made available to the airline customer. The system also provides granular detail, so that an airline and the repair shop can see how long it took the part to pass through each stage of transport, test and repair. This tracking and monitoring process allows granular data to be collected and generated for each P/N.

"With this capability established, it is possible to compare the planned versus the actual repair progress of each part, and to calculate the financial implications of delays or time savings in the repair cycle," says Pandey. "Our system makes it possible to predict the implications of a delay in the repair process, for example."

TrackiT has customer portals or dashboards that allow an airline to view the live status of each of its components, based on the electronic data taken from the RFID tag, which is read every time it passes from one stage of the process to another. "The system can also be programmed with thresholds of where a part is supposed to be in the repair process at particular and regular intervals," says Pandey. "The system can therefore be programmed to flag up a delay to a component's repair. When a component with an RFID tag arrives at the airline's home base, it is possible to see exactly when it has been delivered, so that the airline is informed that the part is available."

In addition to tags, the TrackiT system uses RFID sticky labels, which can be read a one hundred can be read per second. "They have a circuit inside, which is activated when it gets close to a reader," says Pandey. "These sticky labels are cheap, and only cost 25-100 cents each. They can be laminated, and so are reusable.

TrackiT has also developed component tracking and monitoring using Bluetooth Low Energy (BLE) tag devices. "The BLE tag is capable of providing real-time tracking with a cellphone reading," says Pandey. "A BLE can be synchronised with Cloud data, and this allows the component to be monitored around the repair cycle and process. A BLE device is better for real-time tracking, since it can be read all the time. It can be set to bleep at set intervals of a specific number of seconds, minutes, hours and days. A BLE is the size of a wristwatch, has a battery that can last six to eight years, and is best used in a confined space."

The main difference between a BLE device and an RFID tag is that the BLE can be continuously read, while an RFID tag has to be read with a device. The availability of RFID tags and stickers, and BLE tags means that there is an appropriate device for a range of applications for tracking parts around the repair cycle. AC