**The main tasks of component management include aircraft configuration management, tracking rotables and repairables, monitoring repairs, and determining the inventory stock of rotable and repairable components. The functionalities of IT systems to perform these tasks is examined.**

# Configuring IT systems for all functions of component management

Managing repairable and rotable components from cradle to grave, or from delivery to final disposal or retirement, is an intricate process. This is because thousands of parts are installed on aircraft and held as spares in an airline's stock, and each part goes through hundreds of transactions in its lifetime, with technical records of all authorised repairs having to be kept.

Managing components involves several main functions: monitoring aircraft configuration; tracking the movements and locations of components at all stages of installation and repair; compiling reliability reports and data; determining appropriate quantities of rotable inventory stock; managing repairs; monitoring costs of repairs; keeping all technical records; and keeping track of all financial records and calculating depreciation and book values.

An added complexity is that components have to be located at a large number of locations across an airline's route network. They can also be sent for repair to as many as hundreds of different agencies, sometimes between different countries, so transport and customs logistics need to be taken into account.

## IT configuration

Several IT systems are able to perform most of these main functions. Most are within the core pureplay maintenance and engineering (M&E) and ERP systems used by airlines. Some specialist point solutions may be required for some functions. The capability of IT systems has evolved, and this has improved the overall component management process.

The configuration and functionality of the IT systems, and the relevant hardware that allows all these functions to be managed from a part's first entry into an airline's system to its exit is examined.

## Configuration management

Tracking the component configuration of each aircraft in a fleet is the first step of component management.

Each aircraft type in a user's fleet can be defined in a tree structure, which is based on Air Transport Association (ATA) chapters. Each ATA chapter is treated as a main branch in the aircraft's structure, and each point where a component can be installed will be defined in the system. The tree structure in an M&E system will have all the relevant information of each part installed at each possible point. This will include the part number (P/N) and the unique serial number (S/N) of the actual part installed on the aircraft.

The first main objective of any aircraft configuration system is to show the user all the P/Ns and S/Ns that are installed at the time. This will be updated every time a part is installed or removed. French supplier AD Software has a screen on its AIRPACK M&E system that lists all the P/N and S/N of components installed on the aircraft, and the ATA location for each component. A line is highlighted in pale grey if a part is not installed. The absence of a part is permitted for some locations.

Several functionalities can be added to a system's capability.

The first is a mechanism to ensure that incorrect P/Ns, and related dash numbers, cannot be installed at each installation point. Data on allowed and non-allowed P/Ns and dash numbers are loaded into the M&E system to provide a list of the P/Ns that are permitted and not permitted for each installation point.

All of this is ultimately based on the approved P/N and dash number configuration for each aircraft in the fleet. The approved configuration is updated each time the aircraft is modified.

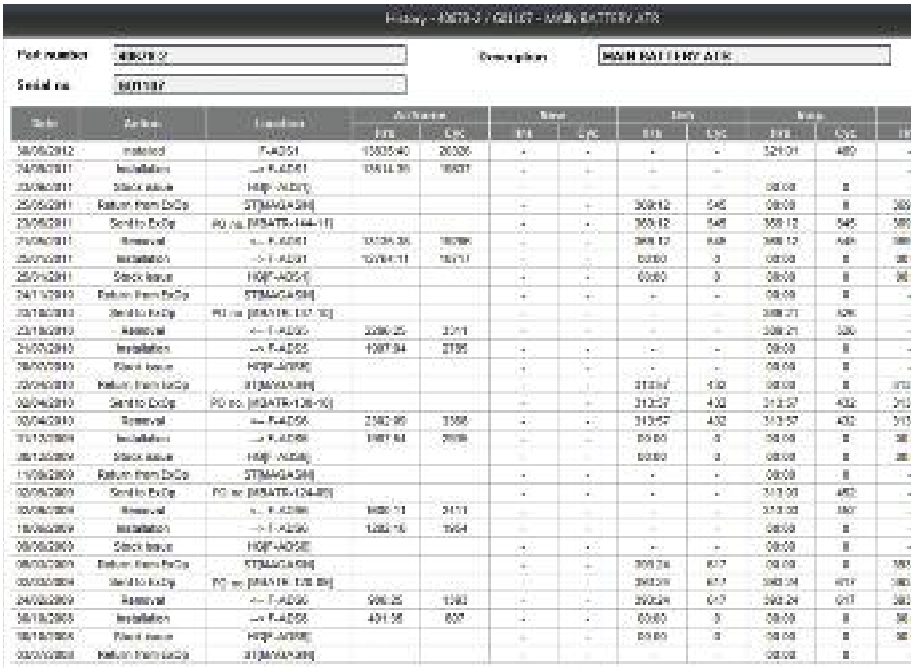
The information on which P/Ns and dash numbers are permitted will partly come from the original equipment manufacturer's (OEM's) illustrated parts catalogue (IPC).

For example, the line number (L/N) or the group of L/Ns that a P/N belongs to, affects whether it is permitted on an aircraft, as certain P/Ns or dash numbers are not compatible with particular aircraft L/Ns. The permitted P/Ns change with batches of L/Ns as production of the aircraft progresses over the years. Some older P/Ns can be permitted on younger aircraft L/Ns if the component is modified and upgraded to a certain dash number or group of dash numbers, while other dash numbers are not permitted.

The P/Ns and dash numbers allowed at each location change on a regular basis because of modifications to the aircraft resulting from airworthiness directives (ADs) and service bulletins (SBs) being incorporated on the aircraft, or on the components.

"AIRPACK works by connecting with the OEM's IPC, to list the alternative P/Ns for the system user," says Fred Ulrich, sales director at AD Software. "The system can also be programmed to tell the user on which L/Ns of that aircraft type the part can be fitted, and what other aircraft types and L/Ns in the fleet can use the P/N. There is also a warning function to alert the user if the wrong P/N has been chosen for installation."

Another issue of the approved configuration is the interdependency of P/Ns on an aircraft. That is, one P/N can only work together with certain P/Ns but not with others. Interdependency includes




*Through individual component tracking, AD Software's AIRPACK system can generate the life history of each individual component. This includes every movement, installation, removal, and repair. The user can drill down to acquire further information.*

some P/Ns being used on both sides of the aircraft, or being installed as duplicates or triplicates.

"The approved P/Ns include the loadable software components that are used in the central maintenance computer (CMC), the electronic flight bag (EFB) and the electronic technical log (ETL)," explains Ronald Schauffele, chief executive officer at Swiss Aviation Software. "The software on the aircraft has to be kept up to date in relation to the P/Ns installed on the aircraft, because mechanics and others use it while the aircraft is in operation to troubleshoot and diagnose faults.

"The user's engineering department builds up a configuration template of a generic aircraft," continues Schauffele. "The approved configuration of each aircraft changes regularly, and the engineering department is responsible for managing this dynamic process. Initially the approved configuration does not have to be changed too frequently. From this point the system informs the user if the selected parts or components are unacceptable."

An M&E system also needs to have all the parts and components used on the structure of assemblies, such as a landing gear leg or an auxiliary power unit (APU).

The approved component and part configuration for each aircraft should be set prior to, or at, aircraft delivery. The installed part and component list on each aircraft should be loaded onto the M&E system at aircraft delivery. This may be more difficult if a used aircraft is acquired.

## Component tracking

Once the approved P/N list, and all P/Ns and S/Ns have been entered into the M&E system, additional functionalities can be developed to assist the user. One example is AIRPACK's ability to list all S/Ns and their location after the user has typed in a P/N. "Once the user has asked for a list of all S/Ns of a particular P/N, they can drill down to get the full status of each S/N, such as the number of flight hours (FH) and flight cycles (FC) it has accumulated since being installed on the aircraft, and the date and details of the last repair or overhaul," says Ulrich.

This information can only be provided, however, if each component is tracked and the FH and FC recorded while it is installed on an aircraft.

Each of the thousands of repairable and rotable components used on a fleet has to be tracked through all the steps it goes through once it has been installed on the aircraft: being removed due to malfunction; being sent for inspection; being repaired; being transported; and being held in stock as a serviceable item before installation on an aircraft.

This tracking is necessary to perform the many steps involved in component management, including: the legal requirement to generate reliability reports for regulatory authorities; monitoring removal intervals, repair times and stock levels for each P/N to determine the correct spare inventory level; monitoring the progress of repairs; and monitoring the cost of ownership, repairs and maintenance.

Tracking means the M&E system is informed of each change of location and status, and all the steps a part takes in its rotation cycle.

The first step in component tracking is to inform the M&E system of a part's induction to the system. The relevant information is manually entered into most M&E systems. "This initial entry is usually either when the part is received into stock, or when the user takes delivery of an aircraft. The relevant information for each part is first its P/N and S/N," says David Pusey, projects director at Commsoft. "The other data will include its maintenance condition, whether the part is serviceable, and the part's location. From this point on, an entry into our OASES M&E system is required. The next main event for a part in storage will be installation on the aircraft."

Tracking also records the FH and FC each S/N has accumulated after being installed on the aircraft. The M&E system is informed as soon as the part is installed on the aircraft, usually by the line mechanic responsible. From this point, FH and FC data, taken from flight logs following each flight, will be entered into the M&E system so that each part's FH and FC accumulated while it is installed on the aircraft will automatically be monitored and recorded. The accumulated number of FH and FC for an S/N will be halted if the part is removed due to malfunction or expiry. This transaction will also be recorded in the M&E system by the line mechanic.

## Reliability data

Tracking the FH and FC data accumulated by each part while installed on the aircraft provides a database of removal intervals, mean time between removals (MTBR), and mean time between unscheduled removals (MTBUR) for each S/N and P/N. Automatically tracking these data means that the user can be alerted to a life-limited part (LLP) coming close to expiry so that removal and replacement can be planned in advance.

The removal interval, MTBR and MTBUR data automatically generated by M&E systems allow the airline user to compile the legally required monthly reliability reports that its regulatory authority requires, as well as useful reliability data and information for its own management purposes. AIRPACK, for example, has its AirStat module to monitor, archive and report this data.

After removal, a part is typically held in a staging area, while a decision is made about where to send it for repair or overhaul. The part's physical location will have to be entered into the M&E system.

## Tracking in-house repairs

Parts can then be sent for repair to an airline's in-house repair shop, or to a third-party supplier. Tracking parts is simpler if they go to an in-house facility.

A repair will be identified by a repair order or work order number, and this will have to be entered into the M&E system.

Once repaired, a part must have a serviceability form for it to be logged as being serviceable and fit for installation on an aircraft. The US Federal Aviation Administration (FAA) requires an 8130 form or airworthiness release certificate (ARC). The European Aviation Safety Agency (EASA) uses a Form 1.

The 8130/Form 1 will have the P/N and S/N, but importantly details of the repair made will be recorded in section 13 of the 8130 form, plus information on who made the repair, and their signature. The 8130/Form 1 is the technical record of maintenance for the component.

When a component is returned from an in-house repair shop, the 8130 form is sent to technical records as a hard copy, a scan of the hard copy, or an electronically signed encrypted PDF file. If a scan or a PDF, the 8130 form can also be entered into the M&E system, along with a reference to the repair order.

"Scans of 8130s/Form 1s are often made, and can be stored in the AMOS M&E system," says Schauffele. "AMOS has the full repair history for each part and its P/N and S/N. When a part returns from the repair shop the only updates made in the M&E system relate to changes such as to the warranty information, modification status, and its remaining life. If a repair is made on a part that has an installation FH or FC limit, this can be taken back up to the maximum limit. Among the biggest changes are if an airworthiness directive (AD) or service bulletin (SB) is performed on a part, since this changes its P/N and S/N."

Each time a component is moved around the operational cycle, and repairs are made, its history is updated. "AIRPACK can show the user a part's entire history via a summary page, and the user can drill down for further information, including details about which aircraft it was installed on, what failures and repairs it had, and logbook entries," says Ulrich.

Each movement, change of location, repair, or any other change to a part has historically been made manually in the M&E system.

Some of this manual entry can be replaced by using barcodes to input data automatically. "When a part is first received into stock, and all the relevant data have been manually entered into OASES, and a scan of any 8130/Form 1 is added to the system, a serviceable 100mm X 75mm barcoded label is printed," says Pusey. "All data that are pertinent to the part are then linked to a system-generated batch number and the barcode. Each time a movement has to be recorded, the barcode on the tag is swiped, and the relevant information is manually entered. This may be something simple, such as change of storage location or shipping for repair."

Mxi Technologies has a similar system for its Maintenix M&E application. "Components are tagged with an A6-sized serviceability tag, which has a barcode printed on it," says James Elliott, product marketing manager at Mxi Technologies. "The removal of a component from an aircraft is captured electronically in Maintenix. The tag is printed at this point, and it will include the removal cause and reasons on it. The barcode is then scanned at each movement, such as turn-in and transfer to the repair shop. This eliminates manual entry of component details and provides real-time online status of each component, including its location.

"A new serviceability tag is automatically printed later in the cycle after the inspection and repair," continues Elliott. "When the part is installed on the aircraft, the tag is removed and sent to technical records for archiving. The barcode system allows many of the manual steps to be eliminated. The main requirements for manual intervention of inputting data into the M&E system are when abnormal findings are made during inspection. These have to be entered manually into Maintenix. However, it is actually possible now for the technician to enter these findings into Maintenix automatically by sending an XML message."

## Tracking external repairs

Tracking components is more complicated for repairs that are sub-contracted to outside shops, because parts can rarely be tracked by an airline user's M&E system when they are passing through another company's facilities. An airline can only know the status of its own part by having some integration between its own M&E system and the third-party's IT system.

"If an airline sends a component out for repairs, it informs its own M&E system that it has been sent to a specific repair shop. This information is coupled with the repair order, and other pertinent details," says Schauffele. "In many cases an airline has to wait until the repaired part is back from the repair shop, together with its 8130/Form 1, before it can track the part's movements again. This break in a component's cycle is one example of when manual intervention and input are needed when tracking a part.

"Our AMOS system has integration with Lufthansa Technik's IT system. This allows the data for a component to be synchronised between the two systems, so that an AMOS user can see into Lufthansa Technik's IT systems and view the status of its component while it is being repaired," continues Schauffele. "This is useful, especially when anticipated return dates of parts under repair are important. Users can also see what different repairs are available from Lufthansa Technik, and how much they cost. There is some integration with the IT systems of other repair shops, but most just state the target return date. Most M&E systems are not interfaced with a repair shop's IT systems."

As with internal repairs, Mxi Technologies has set up Maintenix to receive findings made during inspection and repair in XML messages from the external repair shop. These can be automatically populated in Maintenix.

## Monitoring repairs

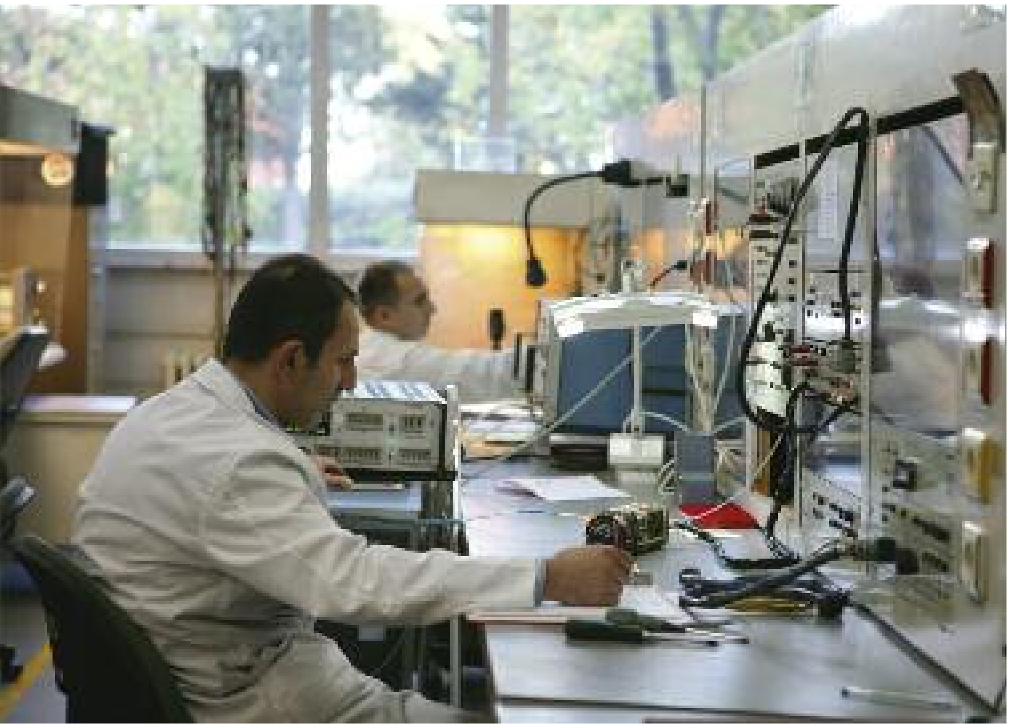
A core issue of overall component management is managing repairs. In the case of in-house repairs, this includes: sourcing the relevant manuals and documents with the repair instructions; issuing a repair and work order; generating the correct repair instructions; planning all the required resources; recording all the labour and material inputs; signing off the repair; and generating the 8130/Form 1.

The first step is the management of all repair manuals and documents. Unlike airframe manufacturers, which now issue manuals in SGML or XML formats, most component and part OEMs still issue their repair manuals as hard copies or in PDF format. The component OEMs do generate the manuals in SGML or XML, but then issue them to the airlines in hard copy or PDF.

"Manuals that are kept in hard copy mean that the users have to carry out updates and revisions in the traditional way of changing all pages in all the manuals held," says Schauffele.

The use of manuals in a PDF format means that library management can be made easier and faster, since new pages can be e-mailed to all relevant parties in an organisation. Obsolete pages can be archived in the M&E system.

Each step of a repair is planned and tracked in M&E systems. The generation of a repair or work order involves producing an order of repair instructions, and collating all the relevant repair manual pages that provide these instructions. These instructions include



*One main task for a component management IT system is to monitor the progress of component repairs. Most data and information can be transferred electronically, and in PDF format.*

the amount of labour and associated skills, the tools, parts, and type of repair shop required to make the repair. All of this can be produced on hard copy, but can also be held within an M&E system in an electronic format. "This means the whole repair order will be a seamless set of instructions for the Maintenix user," says Elliott. "The system can then record all labour, material and parts inputs. The technician has to manually inform the system, however, when the repair was started and stopped."

To continue automatically tracking the component or part, OASES will generate a barcode once a repair order has been initiated. "This means that all the associated information can be recorded against the order. This includes labour and material inputs," says Pusey.

Once the repair is finished, the technician has to complete details on the 8130/Form 1 and sign off. Several M&E systems that generate repair orders and instructions in PDF format allow the user to sign off for the repair electronically. "This will be with an electronic signature, where the technician uses an identification number and an electronic tag. This is satisfactory for the regulatory authorities," says Elliott. "This means that the 8130/Form 1 can be generated electronically as a PDF file, which can then be archived as a technical record."

Few airlines are signing component repair orders electronically, and the repair statement is signed manually in most cases. "The hard copies are scanned into the M&E system, and kept together with the part's history, while the hard copies are archived," says Schauffele.

Besides generating the 8130/Form 1, a serviceable tag has to be generated for use as an airline's internal certificate.

## Managing external repairs

Although larger airlines have their own internal component repair shops, they still use external shops for a large portion of component repairs. Smaller airlines sub-contact all their repairs to third parties, and can use a large number of providers. There are several hundred specialist component repair shops. Component Control of San Diego, California provides its Quantum Control system to a large number of independent component repair shops. A large percentage of part repairs that are sub-contracted by airlines are managed by Quantum Control, which is a specialist solution for managing the repair process of components and sub-assemblies.

"One problem when managing repairs is that the way repairs are described on 8130 forms is not consistent with all repair shops," says Andrew Valley, vice president of sales at Component Control. "This is a problem when airlines deal with hundreds of different repair shops. Another problem is that many shops still have technicians filling in paper 8130 forms by hand.

"When a component is sent for repair to a shop that uses Quantum Control, two documents are used to monitor the part's progress," says Valley. "The first is a 'router' or 'traveller', similar to a repair or work order. The traveller form follows the part at each stage of its repair in the shop, and carries all the repair instructions and references to the pages of the manuals to be used. The mechanics record their times on this form, either by handwriting on a hard copy form, or on screen in the case of a electronic form."

The repair instructions ultimately come from the component maintenance manual (CMM) or component repair manual (CRM), which are issued by the OEMs, in hard copy or in PDF format. "When a work order is being created it is important to have up-to-date manuals," says Valley. "Component Control has an imaging system to scan pages of a hard copy manual, and these are produced in PDF format. Most shops are still using paperwork, while a few now are viewing everything on screen."

Before the repair starts, a quote has to be generated and approved. "This is only possible if Quantum Control has the part's repair history and projection of costs. This is available because the system has the historical data to support this," explains Valley. "The system can forecast all the materials required, and other logistical requirements such as shipping."

Valley comments that an increasing number of airlines want to have an interface between their M&E systems and Quantum Control used by the repair shops. "This allows an airline to monitor how a shop is progressing with the repair of its components, but it is only worth it if the airline is sending a large volume of parts to the repair shop," says Valley. "One issue with establishing an interface or integration between Quantum Control and various M&E systems is data formats. Aeroxchange specialises in integrating and interfacing between systems used by airlines and the large number of component repair shops."

Where there is an interface, Quantum Control shows the status of a part's repair via a web browser.

Valley explains that Quantum Control has been built to fully manage component repairs. "The system takes into full consideration the cost of each repair, so it builds a database of all of the costs of repairing each P/N," explains Valley. "It also manages the costs of each shop to allow the user, which is often a third-party repair shop, to carry out component repairs at a profit. We believe that Quantum Control provides a lot more detail on the actual costs of repairing the components and parts."

Quantum Control's attention to costs is reflected by Embraer's use of the system at its maintenance facility in Nashville. Here the system is also used for check-planning and generating task cards.

Shop-floor data collection (SFDC) of all cost inputs into a component repair is Quantum Control's core functionality. "A

*One essential functionality an IT system must have in relation to component repair management is the recording of all shop floor inputs with respect to labour, materials and parts.*

system is needed to record the use of all labour, materials and parts; and provide the barcode technology," says Valley. "The system can log the labour used, update the component's repair status, check in and check out the tools used, and monitor the parts and materials used. The technicians update the information in real-time, and use tablets or computer kiosks to monitor the inputs in the shop. They can also report findings, order parts, and create extra work orders.

"With the documents and manuals in PDF format, the work order instructions can be presented on tablets or desktop computers," continues Valley. "Electronic signatures can then be used on screen to complete the 8130 form. A component's second main document is the 8130 form, produced at the end of the repair process. Almost all users of Quantum Control generate this form electronically."

Valley explains that the more proactive airlines will send parts together with paperwork to a third-party shop. "These documents will be the airline's own work order, and will include the reason for the removal or the symptoms that the part is showing," says Valley. "The paperwork can even include an older 8130 from the last repair. The repair shop will generate a new 8130 form when the repair is finished, usually as a PDF. An electronic signature can be accepted by airlines on the 8130, but they will also receive a hard copy of the traveller form. The issue is complicated by each airline having its own set of paperwork standards for receiving repaired parts. The standard package of paperwork we send to the airlines comprises the 8130/Form 1, the teardown and inspection report, the traveller form, and the invoice. These are printed as hard copies, which some airlines are still required to keep for technical records."

## Electronic management?

The need for several manual steps when updating a M&E system of a component's movements or maintenance status raises the issue of whether it is possible to have a completely electronic system for tagging, tracking and managing parts and components.

Manual steps are required for events such as entering particular findings and non-routines.

There have been several attempts to reduce or even eliminate the manual interventions required in the whole component management process. This would require a system in which all information was autopopulated in the IT system at each stop of a part's life.

One option is the use of radio frequency identification (RFID) tags on each component. "The information included would be the P/N, S/N, accumulated FH and FC, and whether the part was unserviceable or serviceable," says Elliott. "The RFID would only serve as an ID tag, however, and there are still security issues relating to the data on the tag being tampered with. The information on repairs made to the part would still have to be kept in the M&E system. The repair instructions could still be kept in an electronic format, and sign-off could be electronic."

Some still expect that RFID tags will be used to carry P/N and S/N, and other data, which will help reduce the number of manual steps. "The regulatory authorities are very wary of data moving around without some sort of manual intervention," says Pusey. "There are concerns that even though it may be possible to have data autopopulated, it may be prudent to have some manual intervention as a way of auditing the data periodically to ensure that they have not been edited, or mistakes made."

The whole system of managing parts and components would be easier if all the data relating to them was available in XML format. "If everything was in a structured format, such as XML, then several manual steps in the entire process would be removed," says Elliott. "The most important ones are inputting data when a part is first received by the airline or MRO, managing the library of CRMs, CMMs and other manuals when updates and revisions are issued, manually capturing work completed by external repair shops, and several of the manual steps made by mechanics and technicians during the repair process. These include manually digging through manuals. The problem is that only a minority of component OEMs are providing manuals and documents in XML, while most are only issuing them in PDF or hard copy."

## Component inventory

Another important aspect of component management is determining the inventory of rotables and repairables required to keep a fleet operational. Delays caused by component unavailability would ideally be avoided.

The number of spare items that needs to be held for each rotable and repairable P/N has to be calculated. This is made complex by several issues. First there is the distinction between 'Go', 'Go-if', and 'No-go' parts. The categorisation of each part is held within the aircraft's minimum equipment list (MEL). This is the configuration of parts that have to be serviceable on the aircraft to permit operation.

Only 'No-go' parts must be replaced before the aircraft can operate. Parts that are classified as 'Go' can remain unserviceable for certain periods of time, from one day to a few weeks, before a replacement is required. 'Go-if' parts are those that can fail without disrupting aircraft operation if particular related parts are still serviceable. All these classifications, and the MEL, have to be held in the M&E system or point solution used to calculate the inventory required.

Other issues that further complicate the calculation of the number of rotables that have to be held in stock are that 'No-go' components and parts have to be held at all locations to which an airline operates. A large inventory will be held for each fleet at the carrier's main operating base, but a smaller inventory of parts will also be needed at each outstation. These inventories can be adjusted downwards if the airline has established borrowing or pooling agreements with other operators at these outstations. These details have to be taken into consideration as a fine-tuning process, and will require specialist knowledge or even an application.

Several additional pieces of information are required to make this calculation. The first of these is the reliability and MTBR/MTBUR data that are automatically produced by tracking parts and the installed FH and FC they achieve between removals.

Other parameters have to be calculated. "The first of these is the historical and predicted fleet FH and FC," says Elliott. "This is because the MTBR/MTBUR of each component have to be matched with the fleet utilisation, so that the number of removals over a given period and probability of a P/N being removed at any one point in time can be calculated.

"The age of the components installed on the aircraft, in terms of the FH and FC they have accumulated since their last repair also has to be known," adds Elliott. "The total number of parts installed on the active fleet is also part of the calculation. This will come from the aircraft configuration functionality in the M&E system."

Another factor affecting the quantity of spares held will be the average repair turn time for each P/N. "This varies with each shop used by the airline, and again these data are held as historical information in the M&E system's database," says Ulrich.

The quantity of inventory required will be fine-tuned at several levels, starting with the serviceability policy the airline follows. This is the percentage of occasions a part is available in stock when required. A minimum serviceability level of 90% is the policy of most airlines, but having a higher level will significantly increase the amount of stock that has to be held.

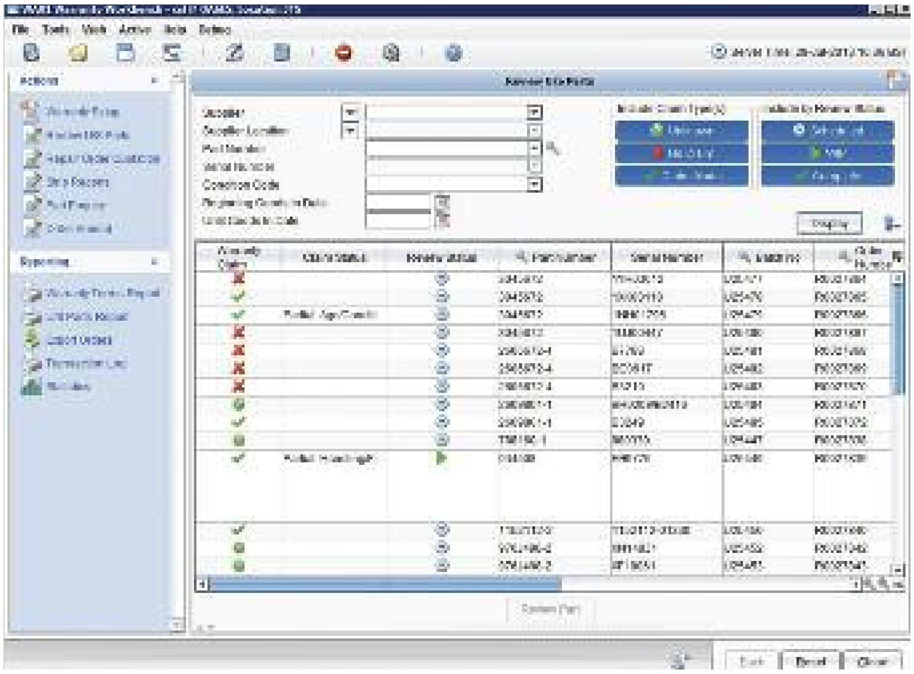
"Most M&E and ERP systems have the data, but they do not have the algorithms to calculate inventory required," says Michael Armstrong, chief executive officer at ARMAC. "Some M&E and ERP systems tend to calculate inventory stock on a re-order stock level. That is, a system that is designed to calculate how much to purchase to keep stock levels more or less constant. This is really for a system where the items are consumed.

"Determining the inventory of rotables and repairables that are not consumed, but get repaired and re-used requires the use of a specialist or point solution," continues Armstrong. "The main issue is that the failures of rotable and repairable components are uncertain, but not random. An airline needs to hold an inventory of thousands of P/Ns, and calculating the optimal amount of stock for each one is a giant mathematical problem, that can only be made with a specialist algorithm.

"Our RIOsys application is designed to optimise the inventory required at an airline's main hubs and outstations, as well as main and sub-fleets," continues Armstrong. The system uses a large number of criteria to optimise stock levels. In addition to the ones described it also uses a part's initial cost, its repair cost, purchase lead and transit times, and several financial and commercial factors. "There is also the need for a lot of data from an airline's flight scheduling system. Aircraft utilisation and the number of services to each destination with each aircraft type is also a necessary element of calculating inventory going forward," says Armstrong.

With all these data, RIOsys calculates an optimal amount of stock to be held at each location for each P/N. The inventory that is available from other suppliers, such as the International Airline Technical Pool (IATP), is then deducted.

One of the most important aspects of



*Commsoft's OASES has recently introduced an automatic warranty claim functionality. This includes a database of the warranty terms for each part.*

RIOsys' algorithm is that it optimises the target service level, while taking investment into consideration, to deliver the required operational performance.

RIOsys fine-tunes the quantity to be held at each location, as well as deciding the best place to send a part after it has been repaired. Further optimisation is performed by taking into account the price of each part. "For example, RIOsys' algorithm is detailed enough to weight up the cost of buying an additional item of a particular P/N, versus the cost of acquiring one through an OEM's exchange programme," says Armstrong. "It also weighs up the cost of repairing a unit, which increases each time as it gets older, with buying a new one. This is aided by the system knowing what the part's book value is, which comes from a module that has a database of the purchase date and price of each part, and calculates its annual depreciation."

Other fine-tuning by RIOsys comes with adjusting the amount held at each location by the number of flights served by the fleet type. Other issues can affect the quantity of parts held, including the local environmental effects at an outstation on certain components.

## Fine-tuning inventory

Fine-tuning the quantity of stock required is a constant process as the fleet continues to be operated. Aircraft utilisation patterns change, route networks and service frequencies change, and aircraft and parts are modified. "RIOsys has a 'what if' scenario-planning capability, and so can analyse what adjustments need to be made to stock levels following a major fleet change. Other examples are analysing the costs and risks of buying and managing rotable inventory, or outsourcing the complete process," explains Armstrong.

It also takes several years of fleet operation to get a good data sample of reliability statistics. RIOsys can calculate the stock required. It tells the user what the current stock is, recommends a stock level, and indicates the financial investment needed to get it.

A benefit of constantly fine-tuning the calculated inventory required by the airline is that surplus stock can be identified. Parts become surplus because fleet utilisation can change or parts become more reliable. A common problem has been that aircraft are modified through the implementation of ADs and SBs, and components are modified during their operational lives to later dash numbers. Aircraft modification can mean that unmodified parts become unusable on aircraft, or only applicable to a smaller portion of the fleet.

"The warehousing and insurance costs of keeping a part are about a quarter of the list price of a new part, so identifying surplus and unusable stock is important," says Elliott. "Using the M&E system to identify surplus stock can provide appreciable savings. We have a customer that reduced its inventory by 10% while its fleet was still growing."

AMOS can identify slow-moving parts, overstocked parts, and parts that never get used. "Once these have been identified, AMOS gives the user the option of using its existing stock on either a first in, first out (FIFO) basis, or on a last in, first out (LIFO) basis," says Schauffele. "The system the airline uses depends on the shelf-life of the parts."

OASES also lists parts that are close to expiry. When a picking ticket of parts is compiled, it lists available parts in a FIFO order so that the mechanic is likely to use the parts that have been on the shelf for the longest amount of time.

Parts can also reach their shelf expiry. "AIRPACK has a dead stock function," says Ulrich. "The part's shelf-life expiry date can be input, and the system will raise an alert. The system can also list all the S/Ns that have not moved since a particular date, and so will effectively indicate the number of parts that are surplus to requirements. If this process is done every two months then the amount of dead stock should shrink each time."

The issue of surpluses and shortages of stock goes further. "RIOsys can calculate and compare the benefits to the airline of not repairing, selling, loaning or liquidating surplus parts," says Armstrong. "It can evaluate the implications of re-allocating stock when there is a shortage of certain P/Ns in a particular location, as well as analysing the costs of reactivating an old or retired part. The system may analyse that $1 million of expenditure is needed on stock to get all locations to the required service level. The system may then reveal that if $0.5 million is spent, the service level may be increased to 90%. RIOsys can analyse which parts to invest in to get the best improvement in service level across the airline's route network, and how to get the best improvement in service level across a network for the lowest investment. This is only possible with a complex algorithm. RIOsys managed to reduce the rotable and repairable stock held by SR Technics, which supports up to about 1,000 aircraft for several airlines, by 40%, over a two-year period, while also improving service levels."

## Warranty claims

Tracking the accumulated installed FH and FC, the time since their last repair or overhaul, and calendar life of parts makes it possible for users to automatically claim warranties for parts that are removed prematurely.

OASES has just released a new warranty module that holds a database of the standard warranty terms for each supplier. When a part is received as unserviceable, after removal from an aircraft, the system interrogates the warranty database. A warranty will be automatically claimed if the part has been removed prematurely or after repair. AC