The large number of components on aircraft means airlines use a large number of different vendors to perform component repairs and maintenance. Tracking an analysing component maintenance costs is therefore complex. IT systems' ability to record & monitor component costs are examined.

IT systems to monitor component maintenance costs

One objective that users of maintenance information technology (IT) systems have is to accurately track the inputs they are using for all levels of maintenance. For example, the cost of maintaining rotable components is often a low priority, but with these components accounting for a high portion of aircraft maintenance costs, they should be closely monitored. The ability of maintenance IT systems to accurately monitor and record and report component maintenance costs is examined here.

Tracking components

Rotables are acquired by airlines with the purchase of new or used aircraft, or with the purchase or borrowing of parts to increase or modify stock levels. On receipt, airline mechanics or engineers enter the serial number of each component into their IT systems. These data are necessary to manage aircraft configuration and track components, which allows airlines to gain reliability data and adjust stock levels. As a result the data can be used to determine the optimum rotables inventories, and airlines have the accurate and up-to-date reliability data that are required for reporting to their local authorities.

As components are removed from an aircraft, a record of this should be entered into the airline's IT system. This includes every stage the rotable goes through in the aircraft installation cycle: removal from the aircraft; being in transit; being tested; during repair; and being placed in inventory stock. Tracking the movement of a part number means it can be located at whatever stage of the cycle it is in, and allows the average time each part spends in transit, in storage and in repair to be tracked, and the number of flight hours (FH) and flight cycles (FC) that the part is installed on the aircraft to be monitored. Tracking parts this way also provides vital reliability data, such as the mean time between removal (MTBR). These data can also be used to optimise the amount of rotable inventory stock an airline should hold.

Most airlines that use their maintenance IT systems to track stock this way have their mechanics manually enter part and serial number data at each stage of the rotable cycle. A few have each item barcoded and use scanners to expedite the entry of rotable components. The use of radio frequency identification (RFID) tags could further speed up the rotable management process.

As well as tracking each component, the IT systems for managing aircraft maintenance perform various management functions in the process of dealing with rotables.

"Different airlines have different parameters they want to track when monitoring components," says John Stone, director product market management at Ramco. "Ramco Series 5.0 M&E allows you to specify these criteria. The aircraft configuration within the system is defined by a tree structure, and has parts numbered within each Air Transport Association (ATA) chapter."

Airline and component repair shop users have a range of requirements when tracking parts. "OASES has a contract database, which stores information on each part's ownership and maintenance management," says David Pusey, director at Commsoft. "This allows the user to see if the part is repaired in-house or sent to a third-party provider, and to access information on the part being repaired under a fixed-rate contract or on a time-and-material basis. This improves turn times for transit, inspection and repair, because it does not have to be looked up manually.

"If the part is repaired under contract with a third-party provider, OASES automatically raises a repair order so that the part can be sent for repair without any delay," continues Pusey. "If there is no contract, and it is repaired in-house, OASES sends an e-mail to the department responsible for creating the repair order, and one gets created straightaway. The repair department then uses OASES to e-mail the line station where the item was removed, with details of the repair shop to which to send the part."

All maintenance IT systems have a system for summarising parts that are available in stock, including the life history of each part, the removal data, part number, and other important parameters. "OASES can list all the spare rotables available in stock," says Pusey. "This can be by part number, for example. Each item is listed, with its serial number and other information, such as location and the registration of the aircraft to which it has been allocated or reserved. Each listed part is colour-coded with a traffic light system: parts highlighted in green are available, while those in red are not. OASES also lists the alternate part numbers that can be substituted if the part is unavailable. The system also gives the user information about the cost of new replacement parts."

Part history

Maintenance IT systems use their component tracking functionality to generate useful data and information about each part.

"AMOS generates a summary page for each part. This describes the component in terms of the part number and its own serial number," says Ron Schauffele, chief executive officer at Swiss Aviation Software. "It also lists the airport at which the aircraft was located when the part was removed, the aircraft's tail number, the removal date and time, and the part's current location. AMOS

can also arrange the part's removal and historical data. Parts associated with particular bases or particular fleet types, for example, can be listed.

"AMOS tracks the parts, and movements can be entered manually or by barcode reader. AMOS can create barcodes for this purpose," continues Schauffele. "It can also drill down to get an individual serial number's history. This will include all its movements, such as: all installations on aircraft and removals from aircraft, tests and repairs, and transportation. The user can drill down further to get the part's full repair history, including: detail on each repair made, its cost and other associated costs. The part's life history will also include time since new (TSN), time since overhaul (TSO) and time since installation (TSI) data at each movement, and the FH and FC it accumulated on each aircraft on which it was installed."

Other IT systems also have user-friendly features. "Each part tracked in Maintenix has a hyperlink, wherever it is viewed on the system, which is used to access all levels of information about that part," says Evan Butler-Jones, product marketing manager at Mxi Technologies. "This includes information on part and serial numbers, and a part's location, current maintenance condition, warranty status, current usage and reliability and utilisation data like TSN, TSO and TSI."

Maintenix allows the user to view a part's complete history, including details of all repairs made, all the shipments it has gone through, all warranties that have been claimed, the aircraft on which it has been installed, and the FH and FC it has accumulated on each aircraft.

Aerosoft's DigiMAINT has a summary page function for each part it tracks. This lists each event of a rotable's life, with the latest event at the top, together with the associated repair costs. "The invoice for each repair can also be accessed from this page," says Barend van de Vrande, director aviation solutions & project implementation. "From this the total cost of all repairs and number of repairs, as well as the purchase cost and the total of all costs, can be summarised for each part and serial number.

"A DigiMAINT user can select a part serial number," continues van de Vrande, "and drill down to access a cradle-to-grave history of each part, including the cost of each repair, as well as the FH and FC accumulated between each repair. The part's FH and FC utilisation statistics are integrated with the technical log system. The user can get to the technical log page, where the fault and removal were initiated. It is therefore possible to get a lot of useful information on each part number and serial number."

Reliability data

By tracking each part, recording all its movements and events, and monitoring the FH and FC accumulated by the aircraft on which they are installed, it is possible to generate a database of reliability data for each part and part number. All IT systems compile and present reliability information and data on components.

"Generating reliability data depends on accurately recording the removal and installation dates for each part on each particular tail number in the fleet, as well as each tail number's FH and FC for each flight, and entering this information into AMOS," says Schauffele. "With these data AMOS generates the MTBR, mean time between failure (MTBF), mean time between unscheduled removals (MTBUR), and the no-fault-found (NFF) rate of each part number. These can be displayed graphically over a time period. The system can be asked to indicate which part numbers are the biggest cost drivers. This is not simply the ones with the smallest removal or failure intervals or the highest repair costs. Failures and removals of different part numbers have different consequences for an airline's operation. No-go items will cause expensive delays, while parts that can be deferred in the event of a failure have

lower cost implications. Other issues include the number of spare units held in stock and cost of new replacement parts. The engineering department therefore defines an algorithm to determine the most costly components, taking all these factors into consideration."

Operators need to track components so they can continuously assess their spare inventory requirements, and understand the causes of removals to ensure that action can be taken to improve component reliability. "Airlines like to have a breakdown of the different causes of removal for each part number, and the average FH and FC interval between each removal cause," says van de Vrande. "DigiMAINT summarises these for each part number, and also provides a report of the average removal interval for all removal causes. The system gives the rate of removal for parts for a particular fleet over a specific period. A summary can list all the different part numbers; the number of failures experienced by each part number; and the average FH, FC and calendar time between the failures and removals. Using aircraft utilisation data, DigiMAINT provides the failure or removal rate per 1,000FH. It is then possible to get overall basic statistics on failure rates. All these data can be used to calculate stock levels."

Another feature of DigiMAINT is that it automatically populates removal and reliability data into an EDSE file. "This is required by Bombardier, which wants all its customers to provide it with reliability and operational data," explains van de Vrande. "The EDSE file captures these data, which are sent to Bombardier, which gets fleet-wide reliability statistics."

IT systems can also provide reliability data by ATA chapter, or for the worst 10 components, or for all the components for an individual aircraft or for a fleet.

Repair order creation

The first step in recording maintenance costs of rotable components is in defining a work order for those that are repaired in-house, and those that are sent to third-party vendors. The work order is created when the part arrives in the repair shop, and after some parts have been tested. It includes inspection and repair tasks, and estimates of man-hours (MH) required for each step, and the skills and associated parts and materials required to complete the repair.

"A repair order will first estimate the inputs required, including a split between routine and non-routine MH," says Butler-Jones. "A work order will order parts and materials from the parts store, and reserve specific tools to complete the job. When the actual work is being done, these inputs can be recorded."

Recording maintenance inputs

Recording MH and parts can be done manually by the mechanic as the work is carried out. A barcode system on the work order allows the inputs used to be recorded automatically with a barcode scanner. For parts repaired by third-party vendors, details of MH and parts can be provided if required by the airline. These data will be on the repair invoice, and then entered manually into the airline's maintenance IT system. The data can be populated electronically if the airline's system interfaces with the vendor's.

"When a repair order is created in DigiMAINT for an in-house repair, parts are assigned to it," says van de Vrande. "The system tracks the cost of the parts for the repair, and a list of the materials used is created. The mechanic identifies themselves so that the system has a record of the work they have done, and at each step of the repair indicates the number of MH used. It also tracks the work's rate of progress. All this allows the correct cost of labour to be applied to the job. A summary page for each repair is then generated, and the latest step of the process is the top line. Links to our DigiDOC system allow the user to get the associated job cards, and manual pages."

For parts repaired by third-party shops, the repair vendor can be required to send in a paper report detailing all the

inputs used. "Maintenix is updated when the repaired part is returned to the airline. The cost data will be input by the quality control inspector, who inspects the part upon receipt," explains Butler-Jones.

A main initial concern will be if the part is repaired internally or externally. OASES' database of information on which shops repair each part allows the system to create a work order for parts repaired in-house. "It will also generate a barcoded document, which is used as a medium to swipe a barcode scanner so that MH and parts consumption can be recorded. Accurate MH are captured by using the scanner to record start and stop times on maintenance tasks," says Pusey. "OASES has a page for displaying a work order, which the mechanic uses when performing the work. The same page is also used to make electronic requisitions of parts and materials. Their use and cost is automatically recorded by the system."

Ramco Series 5.0 creates a work order, with a task description, and an associated barcode. This is used to requisition materials and parts, and record the parts that are returned to store if not used. "There is also a beyond economical repair (BER) fee, which a repair vendor will charge if it has decided to scrap the component in accordance with guidelines set by the customer airline. This BER charge can be entered into Ramco, so that a record is kept," says Stone.

Associated costs

Other costs include items such as handling, surcharges for aircraft-on-ground (AOG) situations, transport, customs and component certification. It is important to get a clear picture of these, since the additional costs of repairing some parts will depend on the location of the repair vendors that have been selected by the airlines. If this information can be analysed in detail then it becomes clear which repair stations have the highest logistics costs, and transit times.

"How each of these cost elements is listed depends on the level of detail on the invoice for parts repaired by third-party agencies," says Schauffele. "It is better to have a breakdown of labour and materials, but a breakdown of additional costs is also useful. AMOS allows the user to define the number of criteria required on the invoice."

Maintenix also allows the user to add in various cost categories on the repair order, so that they can be recorded individually. "Maintenix has a menu of cost categories that can be included on the customer's invoice as required," says Butler-Jones. "These include: taxes and tariffs for each item; courier and related costs; shipping; component borrowing fees; customs; insurance; warranty claims; surcharges; documentation; and certification.

Monitoring costs

The ultimate objective is for the user to get a detailed picture of their costs for rotable components. This can be as an absolute figure for a given period. An airline is likely to want to have: component-related repair costs broken down into labour, materials, parts and other costs; costs attributed to different fleet types, rather than an entire fleet; and even to have rotable repair costs analysed on a per FH or per FC basis for each fleet or sub-fleet that an airline operates.

AMOS has a system that can report all costs associated with an individual aircraft over a defined time period. "The criteria include: aircraft type; aircraft or engine variant and model; aircraft registration, operator and owner; maintenance provider; type of repair, warranty repairs and loaned parts," says Schauffele. "AMOS can give the average cost of repairing each part number over a defined period. This can be used for budgeting purposes.

"Costs per FH or per FC for each aircraft fleet can be shown graphically, so that the user can see if costs are creeping up," says Schauffele. "Parts with rising costs can be identified, and their cause investigated, by drilling down into the data."

Component repair costs cannot be considered in isolation. "Airlines like to

have a lot of fleet utilisation and other operational data as well," explains van de Vrande. "These can be matched with component repair costs by DigiMAINT. The system can also include consumables in the same analysis, to give the user a very detailed view of the cost of all parts and components used in maintaining their aircraft.

"DigiMAINT also provides the MH used for maintenance in terms of per FH flown," continues van de Vrande. "If the labour rates for the different skill types are in the system then the overall cost can be generated for all levels of maintenance, not just component maintenance."

IT maintenance systems need a lot of detail for all costs to be attributed correctly to each fleet and sub-fleet. "Ramco does this by using the aircraft configuration tree structure," explains Stone. "If a component is shared between two types from the same family, an airline may be satisfied with knowing what the average cost of repairing and maintaining that component is for both aircraft types. However, it may want the cost per FH to be calculated separately for each aircraft type, because it suspects that the removal rate is higher for one type than the other. Ramco can do this because it has the utilisation and removal statistics data for each type from the component tracking.

"Ramco can also analyse components' repair costs according to the repair shop that maintains them," continues Stone. "Some shops could cost more purely because of transport, customs and other logistics costs."

The future

While the functionality of IT systems for monitoring rotable components has improved and allows airlines and repair shops to clearly understand costs and the causes of costs, further developments are likely to improve the process of managing aircraft components. RFID tags can be used on rotables and other components to store all a part's movement, repair and modification history, and its serial number and other information. One manufacturer of RFID tags being used in aerospace is US company Tego.

Tego has been selected as a provider of RFID tags for the A350 by Airbus. In the early years of operation 2,500-3,000 of the aircraft's components will be fitted with RFID tags. "This will increase to about 10,000 parts after a few years," explains Timothy Butler, chief executive officer at Tego. "Our chips can have a capacity of up to 100 years, and are freestanding so that they need no battery and are wireless. Initially they will have a capacity of 8kb, but this can be increased to 32kb if required. An 8kb chip can hold 80 pages of the part's history, which should be large enough for all but a few exceptional cases. As a part progress through life, information on movements, repairs, modifications and other events in its history gradually build up.

"This means components on an aircraft can become smart components, because they will be able to carry their entire history with them," continues Butler. "The RFID chip can interact with the asset it is mounted on, so data can be written to the chip, and taken off. It is simpler to have all the information required on a chip, rather than typing its serial number into a maintenance IT system and looking up information, or typing in new and additional information or data. While the information still has to be kept on the IT system, the chips can be read by handheld chip readers. The information on the chip can then be read on a tablet computer or similar device. A system can then exist to make sure the information and data on the chip and airline's IT system is the same.

"This means the process and logistics of handling rotable components through the component cycle can be automated and expedited," continues Butler. "It also avoids the creation of a lot of paperwork and documents. As a result, performing line maintenance logistics and dealing with AOG situations, for example, should be a lot faster. Most of the time dealing with delays caused by faulty or failed components relates to the administration of acquiring and transporting parts, while only a few minutes are actually needed to exchange a part on an aircraft. This time could be significantly reduced by RFID tags. Even simple tasks, such as counting life vests on the aircraft, can be reduced to a fraction of the current time taken." AC