A high degree of control in aircraft configuration management and technical records can realise large savings for airline engineering departments. Geoff Hughes analyses what airlines have to consider when developing an IT strategy for configuration management.

IT strategies for aircraft configuration management

One of the most complex tasks facing an airline engineering department today is the on-going task of configuration management, that is controlling 'which part is valid in which position on an aircraft structure or sub-assembly'. If handled well, configuration management can yield significant cost savings and contribute to airline safety management.

The world of aircraft maintenance is messy and ever-changing and leads to multiple configurations and constantly moving actual physical structures. Maintenance activity, in particular, modifies and re-modifies (and indeed de-modifies) structures and maintenance requirements on components. Tracking this on a complex aircraft structure can reach nightmarish proportions.

Configuration management is underpinned by technical records. The regulatory environment means that airline engineering departments have to keep track of these actual physical structures, and they must scrupulously record engineering and airworthiness data for major components, sub-assemblies and the aircraft itself.

Configuration management and technical records management can absorb considerable resources. These include highly paid engineers, who have to chase down discrepancies in data and untangle the puzzle of engineering information.

Configuration strategy

One of the first issues for an airline to overcome when choosing and implementing any new IT system for maintenance repair and overhaul (MRO) management, is to decide on the approach it intends to follow for engineering configuration management. In simple terms, what level of detail should an airline create and track within the IT system for an aircraft or subsystem, and why?

Several factors influence this decision. First, what level of maintenance is carried out by the airline? If the airline manages all its heavy maintenance in-house, and has backshop capabilities to repair components and major assemblies, it is likely the electronic configuration would benefit from being extremely detailed. This will enable airlines to manage the maintenance of major components and assemblies with a high degree of control. It will assist the repair shops by giving them a significant level of electronic visibility as they move through the teardown, repair and rebuild process. Engineering change management will also be simplified if the electronic data are modelled to this level. Conversely, if the airline outsources everything, aircraft configurations may be very simple, and even non-existent.

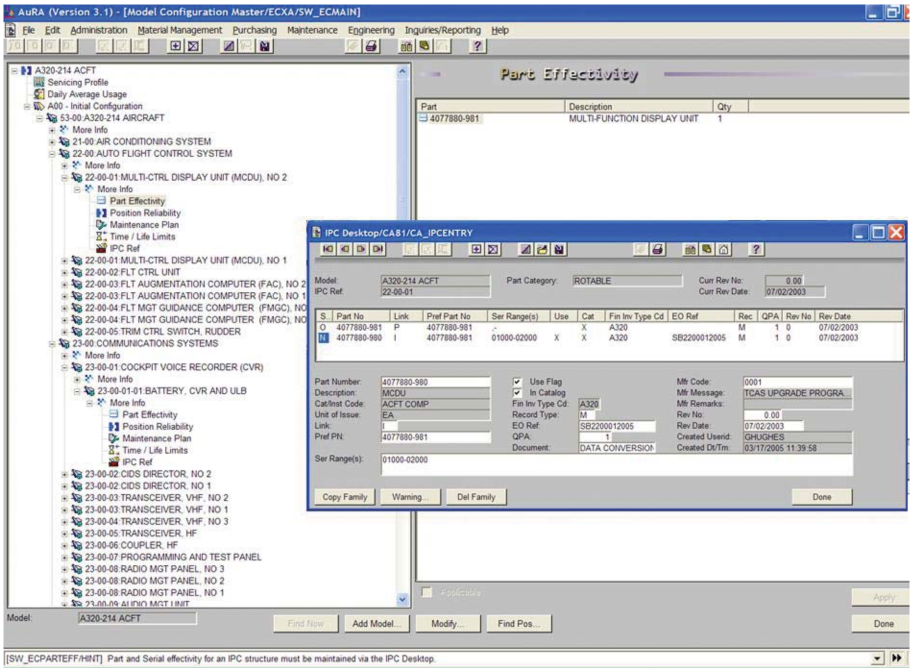
Another factor in the decision may be the type of contract the airline has in place for the aircraft. For example, the aircraft lease may contain some clauses that require the airline to track certain major components or maintain certain configurations.

Engines are an example. If an airline has a power-by-the-hour (PBH) contract for its engines, it may only need to track the installed engines. The PBH vendor may take care of everything else, such as tracking engineering data like airworthiness directives (ADs) and advising the airline when they need to take action. If there are specific clauses in the PBH contract, however, then the airline may need to track particular life limited parts (LLPs) more carefully. Even then it may not require the engine to be built electronically as a structure, since these parts are usually not replaceable on the line. If there are some high value components that can be replaced on-wing (for example the fan blades) then it may be beneficial to track these electronically in the IT system. This is because they may carry a specific warranty or guarantee, which the airline needs to track in order to implement it.

Two issues are crucial to the success of many MRO IT projects. First the airline must realise that once a decision on concept or philosophy is made it is difficult and expensive to reverse and change direction. Second, the decision can have a very wide-ranging, deep and sometimes surprising impact right across the maintenance operation. Dick Wallis, vice president sales at Software Solutions Unlimited (SSU), explains, "Configuration management is like a framework for the whole system that is established at the start of a project. An airline needs to ask itself how it wants to manage the maintenance of its aircraft and major assemblies, and what regulations and requirements it must comply with. It also needs to ask what resources it has to establish the configuration framework, populate the database, and continue to manage the configuration data.

"For any Ultramain implementation, we start by introducing the SSU configuration philosophy to the project team and management, and then give them time to absorb and reflect on the concept. They need to fully understand the capabilities of the application, the implications for data set-up and ongoing management, the benefits of different options, and the final impact across departments," continues Wallis. "They need to understand that there will inevitably be tension within the airline. For example, what is good for engineering will cause additional work and effort for maintenance mechanics. Only then can they make a decision on which philosophy they wish to adopt."

In some cases, the idea of configuration management may be all but absent. This leads to a challenge in the thought process and many organisations struggle to absorb this new approach and fully understand the implications and benefits of a new philosophy. Another issue is whether one or several models are required to cover an entire fleet.



The aircraft configuration master layout in AuRA, from MIRO, is typical of most software systems. The aircraft is modelled in a tree structure for ease of use, and positional data can be tightly controlled for interchangeability and serial effectivity rules.

Aircraft structure process

So what does a typical aircraft model look like? How many levels of structure does an airline normally track? Typically an airline will choose to model an aircraft with several hundred tracked positions (or perhaps even thousands) on a structure. These will usually go down to three or four sub-levels of substructure. The usual major assemblies that will be built as separate models are engines, APU and landing gears. In some extreme cases, airlines have built structures with several thousand tracked positions.

Hannes Sandmeirer, senior director complex MRO and depot repair at Oracle explains their perspective on configuration management. “Oracle has been evolving the complex MRO application for four and a half years, building it up to meet the needs of airlines and aerospace & defense (A&D) companies. Building the aircraft model involves a challenging series of decisions. First, which positions should be tracked? Much of this comes from how much reliability detail the airline wants to analyse. Next, should a position be modelled with a structure of its own, for example the engine? The level of detail is determined by how much control the airline wants to exert over individual components fitted to complex assemblies. In our experience, an engine is typically modelled to six or seven sub-levels. We are close to going live with our first airline and are at the implementation stage with another two.”

Having made a strategic decision on concept, the building process starts with the source data. These usually come from the OEM, although airlines may often have some data in existing IT systems scattered around the organisation. However, simply entering OEM data into the new MRO system using an electronic data loading tool can be problematic. First, the data may not be structured the an airline wants to manage aircraft maintenance. Maintenance contracts may be structured in such a way that maintenance events need to be tracked very differently to the way the OEM envisaged. Second, there simply may be too many data to load and maintain if they are taken directly from the OEM system. The airline is probably better off analysing its maintenance operation and modelling its engineering reference data accordingly.

Airlines need to realise that the data building process is not a one-time event. More than just the engineering reference data will need to be actively managed over the life-cycle of the fleet.

Using a complex line replaceable unit (LRU), such as a flight management computer as an example, if a master reference configuration data is built with a high degree of detail, this will provide a rich data source for the reliability department.

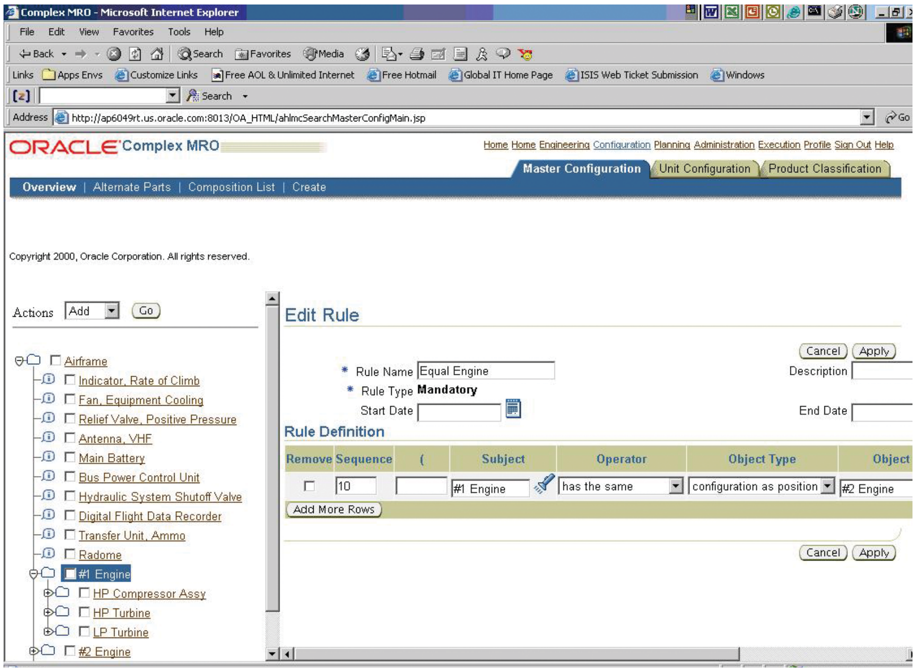
Consider what happens when an aircraft-on-ground (AOG) situation occurs. The part is received and all that data needs to be entered quickly into the computer system for that LRU, which needs to receive and assign serial numbers to the LRU, and track every position on the assembly. Warranty information and lifing counters may have to be initialised, as well as a check made for engineering change directives, such as ADs that might apply.

Sometimes, not all the data are available at the time of receipt, and in the heat of the moment some of the data may not be completed. If the aircraft needs to be put back into the air, who in the organisation will be responsible for the necessary data clean-up? If it is not completed, then much of the good work will be undone. “AuRA has been developed to deal with this issue quickly and cleanly, without disrupting the process flow of getting a part into the organisation, and out to the mechanic, and without compromising data integrity” says Mark Ogren, vice president sales and marketing at MIRO Technologies (formerly Spirent). “With AuRA’s auto-receiving function, a complex assembly can be brought in and validated, even if the data on serial numbers are incomplete. Automatic e-mail alerts within the system communicate incomplete transactions to be queued for engineering to finish off data entry. Many of our clients like Embraer, Continental Expressjet, TNT, SAS and Frontier benefit from this feature.”

Reference structure options

What types of data should be built into the structure? Structural identification data can be managed in several ways. The airline may choose to implement its own nomenclature to identify positions. Alternatively, and more usually, a configuration model will be set up using international standards such as the air transport association (ATA) system. It provides a standardised and uniform means of reference in all equipment design and maintenance related documentation/communication, such as task records, fault isolation manuals, service bulletins (SBs) and aircraft and component configuration. It provides a uniform basis for structuring maintenance performance indices, especially those related to reliability.

For Airbus operators, functional item number (FIN) may also be used, in conjunction with ATA Chapter. The equipment on the aircraft is identified by a unique identifier designated FIN. The basic element of the FIN is a two letter code indicating to which system circuit the equipment belongs. To this code are added prefixes and/or suffixes which provide the unique identification for individual items of equipment. For electrical equipment (any component with an electrical connection) the FIN is



Oracle's complex MRO software can handle extremely sophisticated configuration rule sets. Rules can be chained together or be activated on the basis of other configuration changes.

of the form 2CA1; where 2 is the second component in the circuit known as CA, CA is the two letter code for the circuit, and 1 is the suffix indicating the system number (in this case the first of several similar systems).

The FIN sequence number serves to differentiate between mechanical and electrical equipment. Sequence numbers below 5000 are reserved for electrical FINs and the sequence numbers equal to or above 5000 are reserved for mechanical FINs.

Next, the IT system must have part family data assigned to each position. The part data are the prime connection between the engineering organisation and functionality, and the material management organisation. The engineering reference data control and validate which parts the materials group issue to a job request, or load them into a bill of material kit for an aircraft check. Loading these reference data will enable an airline to more tightly control airworthiness and quality assurance on an aircraft.

The IT system also needs to be flexible enough to cope with many permutations of part attributes. For example PART A-1 can be fitted to the reference configuration of a CFM56-5C4 model and is the preferred part, whereas PART A-2 is a two-way interchangeable part, but can only be fitted to engine serial numbers from 5600 to 5670 of that engine model. Moreover, PART A-3 can also be fitted, but only if SB2003-72-00 has been applied to the engine. All this information can be loaded into most systems and rule sets can be defined. "One of the strengths of Oracle's complex MRO product suite is the flexibility to build any number of sophisticated rule sets to control allowable configuration matched and interchangeability-intermixability laws," says Sandmeier.

The next major group of reference data that most IT systems will model in the configuration is the maintenance requirements for either aircraft, major assemblies, or individual components. Normally component maintenance manual (CMM) items are attached to critical or high value parts, at the position in the structure that the component could possibly be fitted. The CMM requirement may differ, depending upon the location of fitment. This publication has already looked in depth at the various capabilities of MRO systems in use today *(see Managing maintenance plans with IT systems, Aircraft Commerce, December 2004/January 2005, page 37)*.

One of the subtleties that some systems offer is the ability to apply sophisticated lifing counters to positions and components. For example, if there is no APU counter available on the APU, the system may choose to compute APU hours, from a base life of flying hours, using a factor to account for ground running time.

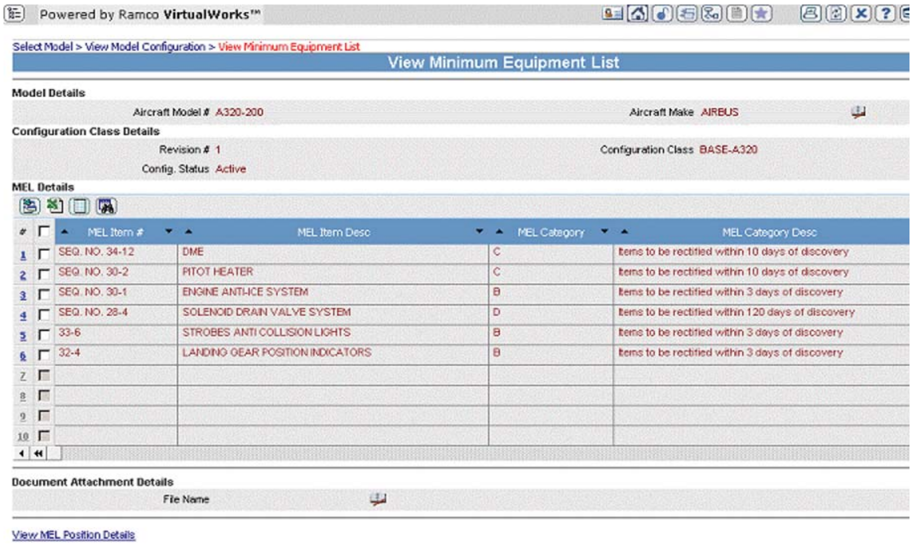
Additional reference data that could be added to the structure are specific details on warranties or performance guarantees, minimum equipment list (MEL) and configuration deviation list (CDL) information, whether the item is critical to Etops or whether it is CATII/CAT III sensitive instrument.

Most vendors have all the above features and have flexible modelling capabilities. Beyond these capabilities, there are some interesting additional functions with each vendor. For example, MIRO Technologies can ease the engineering burden for managing multiple configurations of the same basic aircraft model. Ogren goes on to explain: "AuRA tracks multiple variations in the configuration of your aircraft model with minimal user input. Once the primary configuration is entered into AuRA, the structure can be replicated, and only those changes that apply to the new model are made. The revision status of your model configurations are clearly labelled so you will never question which model is the latest. This is one of the key features that customers like Scandinavian Airlines will use to reduce their engineering costs significantly." Ulf Nystrom, head of Technical Operations at Scandinavian Airlines adds, "The AuRA implementation will give us the powerful system we need to strengthen our maintenance and engineering operations and substantially improve efficiency and lower costs. This new AuRA system solution will save us millions of dollars annually in systems operations and maintenance."

Another capability used by many AuRA customers is the local position facility. This allows a rapid modification of a basic model configuration to be made for temporary tracking of items for engineering or warranty concerns.

One of the features of the Oracle cMRO application in the configuration management area is the ability to set up sub-fleets with a main aircraft model. This is a real benefit for many airlines managing large mixed fleets. Oracle's Sandmeier comments: "This function allows customers to identify common sub-groups of tail numbers which share a common engineering master structure, but have different operating characteristics that carry specific and different maintenance requirements. For example, an airline might operate five of its aircraft in sandy desert conditions. We can set up a fleet in cMRO that either adds additional inspection tasks, or engine wash tasks, and may reduce the expected life of the hot-section HP turbine blades for this sub-fleet."

Wallis from SSU says that Ultramain can also assist planners faced with choices of multiple possible configurations. "At the touch of a button, the Ultramain application will show each possible configuration and colour the structure red to indicate components that are out of stock. The planner has a visual cue for which configurations the organisation can build with available


Powered by Ramco VirtualWorks™

Select Model > View Model Configuration > View Minimum Equipment List

View Minimum Equipment List

Model Details

Aircraft Model # A320-200 Aircraft Make AIRBUS

Configuration Class Details

Revision # 1 Configuration Class BASE-A320

Config. Status Active

MEL Details

#	MEL Item #	MEL Item Desc	MEL Category	MEL Category Desc
1	SEQ. NO. 34-12	DME	C	Items to be rectified within 10 days of discovery
2	SEQ. NO. 30-2	PITOT HEATER	C	Items to be rectified within 10 days of discovery
3	SEQ. NO. 30-1	ENGINE ANTI-ICE SYSTEM	B	Items to be rectified within 3 days of discovery
4	SEQ. NO. 28-4	SOLENOID DRAIN VALVE SYSTEM	D	Items to be rectified within 120 days of discovery
5	33-6	STROBES ANTI COLLISION LIGHTS	B	Items to be rectified within 3 days of discovery
6	32-4	LANDING GEAR POSITION INDICATORS	B	Items to be rectified within 3 days of discovery
7				
8				
9				
10				

Document Attachment Details

File Name

View MEL Position Details

The minimum equipment list (MREL) limitations can be imported into RAMCO's MRO software, to automate the process of controlling deferred defects and ensuring airworthiness and safety issues are not overlooked.

material, without having to make further queries."

New to the aviation MRO market is RAMCO from India. Originally an ERP system, RAMCO recently broke away from a relationship with Boeing (Enterprise One) to start marketing its solution independently. The RAMCO application is based upon a flexible software architecture called VirtualWorks. This is 'software to build software' and gives infinite flexibility and possible re-configuration of its MRO solution. One nice feature of the system is the ability to apply minimum equipment list (MEL) and configuration deviation list (CDL) restrictions to its structures.

"RAMCO can hold the entire MEL and CDL and relate it directly to part positions on the aircraft," claims Namrata Ahuja, UK sales manager at RAMCO. "What this means is that we can monitor the condition of a particular component and relate this condition, or indeed the presence of the component, to the MEL requirements of another component in a different position on the structure. This will immediately alert, and provide control of, the airworthiness status for deferred maintenance actions related to the MEL or CDL."

Technical records

One of the main reasons for expending so much effort on configuration management, and for installing a new software module or MRO system, is to ensure that technical records are continuously validated for accuracy and compliance with regulatory requirements.

This brings several benefits. First, if new technology is deployed across the maintenance departments, and particularly out into the areas where maintenance actions occur, then remove-install actions and engineering change embodiment actions can be validated as they happen. This will eliminate several layers of data transcription and data entry, which removes staff overhead costs. It also reduces the chance of human error during the data entry process, which again brings further benefits of overhead cost reduction by removing the need to disentangle the data corruption that is inevitably introduced when there is little or no configuration control.

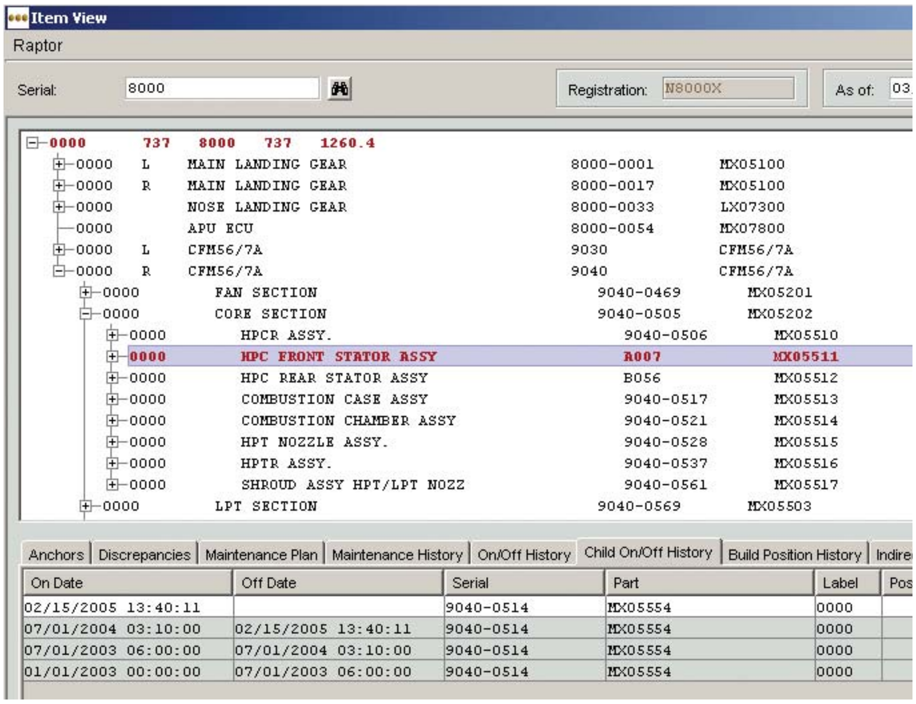
A classic example is an old legacy system that allowed 14 individual serialised nose landing gears to be electronically installed on one aircraft tail number. This raises two key questions. First, which unit is actually installed on the aircraft, what are the life counts on it, and what are the accurate maintenance requirements? The second concerns the location of the other 13 landing gear sets: are they in a supply loop, installed on another aircraft, or are they in inventory? Essentially they are totally lost as far as the airline is concerned. Soon the electronic software system falls into disrepute and is no longer trusted to help make management decisions. Expensive task forces are then needed within the airline to try and identify and find expensive components.

MRO Software Inc from the USA has its own unique approach to help solve this issue of building and correcting technical records data through configuration management technology. It recently recognised and understood the importance of strong configuration management, and rather than building it themselves, acquired the Raptor software product from Raptor Inc in 2004 to add to its MAXIMO product suite. "Raptor is based upon three key pillars," says Don Beahm, lead product manager at MRO Software. "The first pillar is the rules repository which holds the reference information on the as-built structure, with all the rules about allowable fits. The concept is based upon various industry standards, such as MIL-STD-1388 revision 2B and AECMA2000. The second pillar is the component life accounting functionality, which tracks where a serialised component has been and what are its life counts. The third and final pillar is the compliance functionality or operational status management. This compares the first and second pillars of data and reports any breaches of the rules. Our experience is that an airline will track as many positions as possible, typically around 1,000. Because Raptor is so powerful, it can easily cope with this level of complexity. Our first customer is going live, and the data population for this type of level of aircraft structure only took three months. One of our unique features is the way Raptor handles the actual structure data for remove and installs. Rather than storing each remove or install as a transaction, we hold a log of each action, and each usage update. This means that if subsequent technical record changes are needed, for example the correction to a remove or install action, all that is required is a change to the relevant log entry. It also means that an actual structure can be viewed at any point in its history. We can create an active derivation of an actual build status, and post correct it with a log of that correction. The Federal Aviation Administration (FAA) loves this capability. It also means the data conversion effort can be more tolerant of unclean legacy data and a client can start using the system and post-cleanse the database."

Financial benefits

One of the big financial winners for an airline, if they get good control of configuration management, is the materials area. Typically, parts are stocked based upon historical consumption trends, or projected usage based upon probabilistic models. The trick is to combine the demands for parts in the same basic part family, and identify those unique part numbers that are no longer usable or desirable, or are superseded and should not be used. The challenge is to control the running down of these unusable stocks as quickly as possible, and to stop restocking them inadvertently.

The rules about when a part can be



MRO software's MAXIMO is based in the system it acquired from Raptor Inc in 2004. This is based on three pillars, the first of which is the rules repository which holds the rules about allowable fits. The second is a component life accounting functionality, and the third is the compliance functionality.

used during the introduction of a mandatory change directive like an AD, or the internal airline rules about the use of parts that are superseded for engineering, reliability or economic reasons can be complex. A well managed configuration master database will not only ease this process considerably through significant automation, but it will also prevent the airline from building up obsolete stock.

The key is for the configuration management process to start with maintenance creating the demand for a part, not the point at which the remove-install happens. This will prevent the wrong part or part dash number/modification status being issued to a maintenance job in the first place. In a dynamic maintenance environment, with multiple engineering change action occurring in parallel, this is a more challenging task than it might first appear.

Paperless operation is the ultimate goal of the airline MRO environment is the paperless operation. In this concept, all maintenance action is controlled on-line by a centralised database, the correct technical documents are available in real time, data entry is validated as it happens and, in particular, mechanics' actions are regulated by a tight configuration control capability. Technical records are built in real, or near-real time, and controlled at the point of maintenance. This means that task cards can be electronically signed off, removing the need for any paper records. Historically airlines and MRO facilities have relied upon 'dirty fingerprint' copies of job cards as the master for technical records, and teams of data-entry clerks transcribing handwritten, and often illegible, technical data into the central computer system. This can introduce a two-to-four-day time lag in actually getting the data into the computer. This can severely limit the airline's ability to check that part installs have had no negative impact on airworthiness, and can also hamper efforts to control the short-term planning of maintenance tasks.

The results of introducing a paperless, all-electronic environment in maintenance can be dramatic. The first obvious impact is a decluttered, more organised work-place.

RAMCO is one of the first MRO software vendors to have successfully worked with the operator and the regulator, in this case the FAA, to introduce the full paperless working environment at Petroleum Helicopters (PHI) in the USA. PHI operates over 250 helicopters and fixed wing aircraft in support of the oil industry, transporting oil workers on and off oil rigs. Introduced last year, the RAMCO application includes the facility to electronically sign off maintenance actions on-line. The system uses a chip-and-pin concept to authenticate the user's identification. Data relating to part removals and installations are verified at the point of sign-off and lead to a more rapid identification of airworthiness issues. The database is then a true real-time reflection of the actual technical and maintenance status of each individual tail number. It also means that the mechanics are the ones performing the data entry and PHI can improve the quality of data capture, ensuring that the correct ATA Chapter, fault codes and technical write-ups are entered into the system.

Future improvements

While there are many MRO software packages around now that deal very well with the complexities of modern aircraft configuration management, they are only as good as the data they are fed with. One of the key challenges facing an airline when implementing a new MRO technology is to get the base configuration data. "Setting up the reference data is necessarily a manual process," comments Beahm. "We have various tools to assist the electronic upload, but to date OEMs have not been helpful in making this Rule Repository process easy. We do not see this changing in the near future."

In terms of hope for the future, the answer probably lies in OEMs adopting full Product Life-Cycle Management (PLM) technology to provide end-to-end electronic configuration data. "Our experience is that this type of approach is already being adopted in the military MRO market, but it is slow to be adopted for the civil arena," comments Wallis. "However, standards are being discussed and becoming available for the airline market. SAP and others are investing in this type of technology, but it needs to be adopted by the airplane makers and made available in standard formats for the aftermarket systems to use."

Summary

The importance of configuration management and how modern MRO IT systems handle and deal with its complexities and subtleties is largely overlooked. Many MRO IT implementations fail to deliver promised benefits, and going live is delayed significantly, because choices of strategy to model configurations are either rushed, or are made on poor advice. The consequences of poor choices will live in the system for a long time and can be hard to reverse. That said, the benefits of getting configuration management right in a new MRO IT system can be significant, as shown by SAS's estimate that it will save several million dollars per year saving in engineering overhead costs. The new era of truly paperless maintenance environments for airlines is becoming a reality. AC