A plethora of products now exist that make it almost possible to operate a paperless maintenance & engineering organisation. OEMs' manuals can be accessed and viewed electronically, while maintenance records can be stored on DVD or CD.

MRO IT systems for managing technical documents

Maintenance operations are highly regulated. Regulations apply control which inevitably leads to large amounts of documentation, both reference material and resulting auditable mandatory records. This documentation can be handled in a variety of ways, which have different overhead costs and features in terms of safety and quality. Technology has standardised formats and file structures which facilitate the application of computer technology to this area of airline maintenance.

This article examines the various technologies for the management of documentation that are offered by original equipment manufacturers (OEMs) or third-party software vendors. It will also examine how technology could make maintenance totally paperless and the options for operations that are still largely paper-based.

Types of documentation

The mountain of paper facing airline maintenance departments falls into two main categories: reference material and records. Various other smaller document categories are also used to oil the wheels of a maintenance operation.

● Reference material

Reference material includes all the technical guides and references to ensure consistent, safe and approved actions or decisions are taken during the time-pressured technological environment of aircraft maintenance. Without these multi-layered references and traceability, centralised control is lost and quality standards can be compromised. Typical reference material starts with the OEMs issuing the illustrated parts catalogue (IPC) and aircraft maintenance manual (AMM). These reference guides are used during the different stages of the maintenance process, and can have complex inter-relationships.

To add to this complexity, various sections or paragraphs only apply to certain part numbers or aircraft configurations, as was previously analysed *(see IT strategies for aircraft configuration management, Aircraft Commerce, page 47, February/March 2005)*. MRO systems must be able to handle this detailed complexity for an airline to realise the potential cost savings.

Beyond the standard reference manuals, mechanics need to follow instructions to accomplish maintenance tasks. Airlines have a choice of customising their own task/job cards or using the standard cards published by the OEM. The job instruction card (JIC) will have a set of directions for the mechanic and most will reference the AMM (and some other manuals) with paragraph or sub-paragraph reference points. Some may also incorporate graphics from the AMM. The old way was to list the tasks for a hangar 'input', and then laboriously pull out the AMM pages, and photocopy and attach them to the task cards. The mechanic also had to go to the library and use a microfilm reader, spooling through to the correct manual reference, and print the reference document.

Most modern aircraft now come with a complete set of reference manuals on electronic media (CD or DVD). More MRO software vendors can incorporate this electronic material into their software packages. This simply replaces a microfilm reader with a mouse click on a hyperlink. Versioning, revisions and updates can be centrally controlled, avoiding costly paper distribution and manual updates to paper libraries or microfilms. It also avoids human error or delay in the update process that can give a mechanic an incorrect set of instructions. The process is more complicated for third-party maintenance

organisations, which have to hold and reference the correct version and applicability for specific customers' documents.

● Maintenance Records

The second main by-product of regulation is the large volume of mandatory maintenance records. Every completed maintenance task has to be signed, and counter-signed in some cases, and this record forms part of the history of a tracked component, assembly or aircraft. Most tracked components (sometimes called rotables) also require an airworthiness document in their own right (JAR Form1 or Form 8130 under FAA) to show that a component is allowed to be fitted to an aircraft.

Added to this is the large volume of paper documents accompanying repaired components, usually including strip reports that record initial findings, and then a full repair report detailing the action taken to return the component to serviceability. Major components can return from a major overhaul with a mountain of paperwork.

Airlines also need to record and keep work accomplishment documents for unscheduled hangar and line work. These technical log entries, pilot reports (PIREPs), maintenance reports (MAREPs), or non-routine cards (NRCs) will be raised and signed off by mechanics. An airline must retain these paper records as audit trails for checks by the regulator. Records are also vital for aircraft and engine sales or lease return conditions.

● Other documents

Airline maintenance operations are also likely to generate other generic paperwork. This includes purchase orders, repair orders, receipts, shipping documents, training and personnel records, vendor certification, quality reports, and management reports.

The latest technology also means that

Avexus's system can pick up tagged SGML or tagged XML data from a DVD or CD and bring it into its system at the right point. Avexus already has an interface to the Jouve Aviation Solutions product.

these documents can be easily and quickly searched to find important references or information that otherwise would require laborious desk research in a paper-based system.

Maintenance vice presidents, directors and managers would like to replace all paper with a centralised electronic system that works with, or as an integral part of, their MRO software system.

OEM data

● Airbus

Most manuals and engineering documentation originate with the OEM. Airbus has evolved its products over the years and offers the ADOC suite of software tools. It has also evolved its commercial approach to ensure that customers have the best opportunity to maintain their aircraft efficiently and safely.

Hubert Dehase, marketing and business development director at Airbus explains: "We want to do everything we can to give our operators the best tools and service so they can fly and maintain aircraft more cost-effectively and to the highest quality and safety standards. Our approach to digital engineering and maintenance documentation supports this. ADOC is a suite of modules from which our customers can pick to fit their needs.

"There are five modules: Revision Manager, Content Manager, Electronic Publisher, N@vigator and Job Card Publisher," continues Dehase. "The modular system means that airlines can also add on and expand capabilities as they grow their infrastructure. AirN@v is the ADOC N@vigator tool combined with the Airbus technical data package, which becomes the airline's technical data consultation tool. This replaces our old standard ADRES CDs. AirN@v is available on a DVD for airlines to load and use, but in January this year we added AirN@v to the Airbus portal, which made it available over the web. In 2007 we will add the capability to customise this data.

"We are calling the next phase of our evolution 'FLYSMART with Airbus'. This will integrate data both on the ground and in the air, and offer a standard framework and set of services that an airline can fit solutions to. It will have a
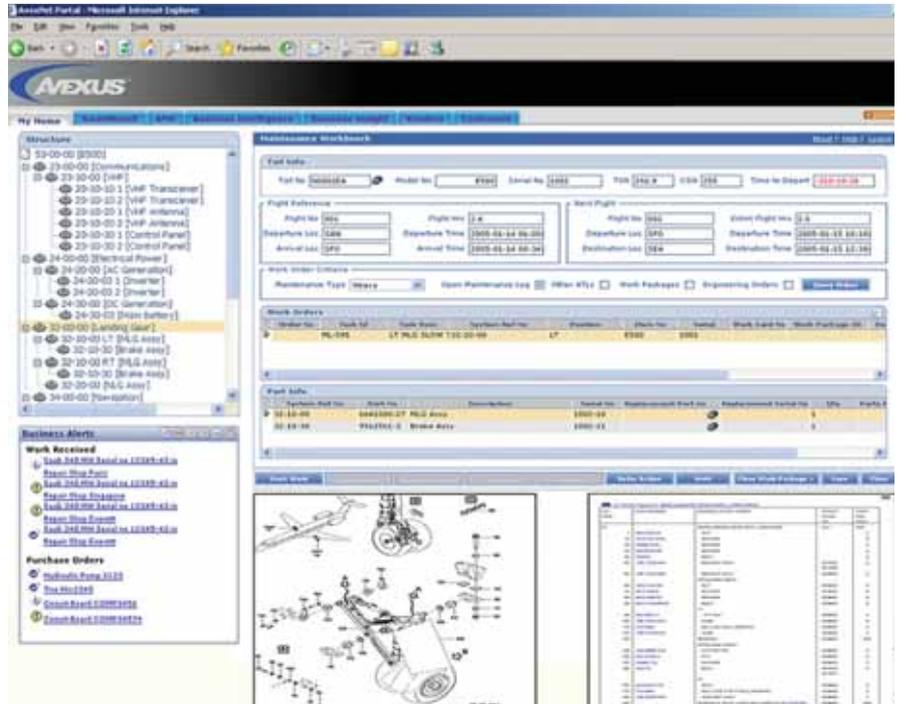
ground piece and an aircraft piece," explains Dehase. "One objective is to move as close as possible to a paperless aircraft and have commonality across all our fly-by-wire fleets. We make the concept work as well as possible with the A380 and then apply elements back across other types. We are adding additional data packages for the A380 for AirN@v for the end of 2005. These now include browsing for repair, shop and planning data."

From 2005 Airbus is charging a simple one-off fee for AirN@v, with customers then getting free data updates and technical upgrades to the functionality. Indeed all the AirN@v options are now included in the one-off fee, rather than as costed extras. Eight airlines use the full ADOC suite.

Significant benefits

The main benefit from easy access to inter-linked digital documentation is productivity. "Engineering and production planning can reduce their overhead cost by up to 30%," claims Dehase. "The production of JICs is easier with the ADOC suite. Larger operators get larger benefits. An airline can expect to save about one man-year of labour for a fleet of 100 aircraft. The system also takes care of revision control for them thereby saving an additional man-year. We also see a 20% reduction in distribution and printing costs. Job card publisher (JCP) is a specific example of our software working in conjunction with the airline's MRO software. Our strategy is to leave control and choice with the airlines. We have made JCP open to all the many MRO software systems, including some very old legacy

mainframe systems like Merlin and Sceptre. We have also assessed the MRO software market and all the available software, and intend to form closer alliances with a few vendors to enhance integration and inter-operability. The chosen vendors will be announced at the end of 2005. This is in marked contrast to Boeing, which bought a software company several years ago and then formed a unilateral relationship with only one vendor. We prefer to leave the decision on MRO software to the airlines. JCP can organise and publish/print JICs directly from the MRO software, using effectivity criteria to pull the correct AMM references and graphics from the digital manuals. JICs can be formatted and laid out to suit a customers needs."

Boeing's new toolbox

Boeing has previously led the field in electronic documentation. The Portable Maintenance Aid (PMA) is widely used by airlines as a back-office tool and in its portable form to bring reference material to the point of maintenance, either in the hangar or on the flight line.

Airbus overtook Boeing with the ADOC suite, but Boeing has responded with a new suite called the Maintenance Performance Toolbox (MPT). MPT is an integrated set of productivity tools that unifies maintenance activities from start to finish. This includes technical publications, training, maintenance, and engineering in one product suite. Technical publications departments use the Toolbox to customise airline documents, modify OEM manuals, and create task cards. Built-in workflow tracking ensures that the document audit
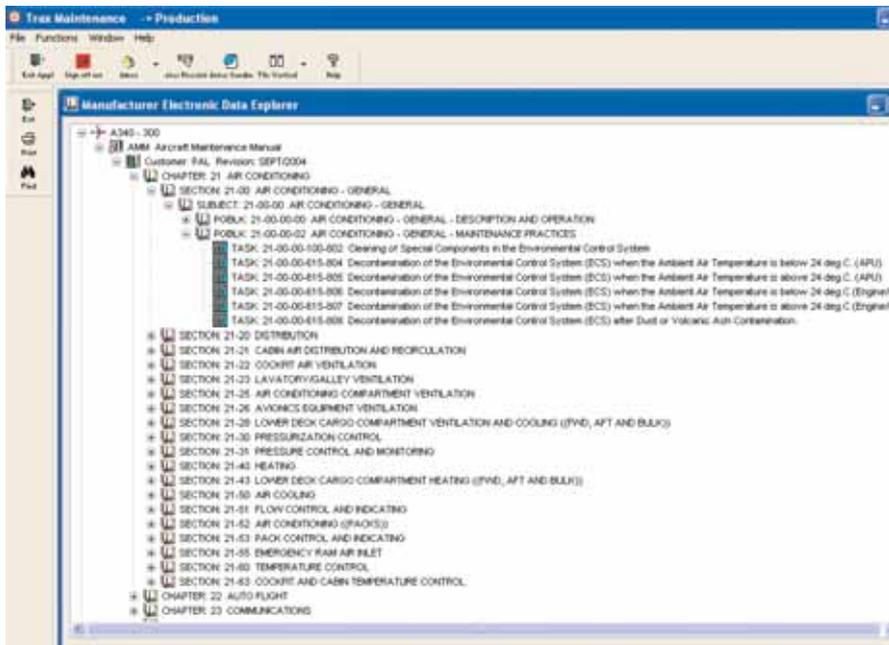
trail is complete and approved before release to the users.

Trainers use the MPT as a teaching aid and to supplement their own multimedia materials. Students learn aircraft systems with the same tool that they use on the job at the work site. The MPT gives mechanics on the flight line, in the hangar, and at the maintenance operations centre fast and efficient access to the information they need. The new 3-D Structural Repair Database tool helps engineers comply with upcoming requirements. Engineers can save successful solutions for re-use on recurrent tasks. Embedded support tools facilitate innumerable everyday tasks, including Service Bulletin (SB) evaluation.

Boeing claims that an advantage of MPT is that it is available on-line, anytime, anywhere. According to Boeing, synoptics streamline systems troubleshooting to boost job performance. Collaborative workspace and re-use of successful engineering solutions reduce maintenance operations costs. Intuitive navigation helps the user construct a mental image of the solution and takes the user directly to the applicable information. Real-time information updates ensure access to the most current technical information. Hosting on MyBoeingFleet, another Boeing reference system available over the web, relieves operators of the systems burden and ensures 24/7 access. Integrated publications, training, maintenance and engineering promote efficiency across functional organisations.

Regional aircraft manufacturer ATR uses the same underlying Airbus ADOC technology and releases its publications as ATRN@v. It is not clear what strategic direction Embraer is taking, but it does have some electronic publication technology available to customers.

Formats old & new

One of the key issues in digital documentation management is format and file layout. Over the years there has been a progression of standards, competing formats and technologies.

There has been considerable anticipation in recent years about Extensible Markup Language (XML), which is expected to revolutionise the way in which information is used, managed, exchanged and presented. There is a range of popular formats that most software systems can handle, and in which the OEMs distribute digital technical data. Portable Document Format (PDF), created by Adobe, is a proprietary print format intended to reproduce documents as originally composed. The big benefit of PDF is that it only requires the free Adobe Acrobat Reader to view, print, and search, making it inexpensive and convenient.

Next is Hypertext Markup Language (HTML). This is a set of 'markup tags', modelled on Standard Generalized Markup Language (SGML), and specifically intended to support files for display on the web. This markup tells the web browser how to display a web page's text and images. SGML is an internationally agreed standard for information representation. It provides an architecture for defining document tag sets for a wide variety of applications. The tag sets allow the appearance and text to be separated and reformatted for different uses. SGML is used by most of the OEMs for distributing and handling raw technical data. Finally there is XML, a streamlined version of SGML, which makes it possible to use and display information in different ways by defining its structure and elements.

"ADOC is based upon tagged SGML

data format," says Dehase. "It will remain SGML-based until 2007 when we will convert to XML. However we have an external module to import data into the ADOC suite from an XML source. So, for example, if an operator has a mixed fleet and has data from Boeing or Bombardier in XML, the data can be sucked into ADOC."

Documentation management

"Our product has always had a document management aspect," says Chris Reed, managing director at TRAX. "However, this year we are adding a new suite of functionality developed for Lufthansa Technics Philippines (LTP). They asked us to replace their old way of working with microfilm, paper and an older documentation software system, and exploit the electronic availability of OEM data to fully integrate the MRO software application with technical reference material. The old documentation software took three days just to load the aircraft AMM. Simply put, LTP wanted the ability to view the technical documentation on-line. Part of the business case was based on the fact that the microfilm readers in the hangar were old and broke down quite often. They were facing a $1,500 repair about once a month so the repair saving alone substantially paid for the modification we made to our software.

"The integration was relatively simple for us since the OEM data is usually available in SGML format," continues Reed. "So we made an SGML import function and gave LTP the ability to suck in the technical documentation. The challenge for LTP was that the OEMs usually try to adjust the price of technical documentation depending upon format to nudge airlines towards their own documentation software. Usually the SGML version of data is about twice the cost of the 'flat' PDF format. The TRAX modification obviates the need to buy and continue to pay for OEM technical documentation software products such as Boeing's PMA and Airbus's AirN@v. The biggest savings from documentation management come in the form of productivity improvements. This is most effective in the hangar environment, but also on the line. Our customers say that it has an effect on aircraft-on-ground (AOG) situations and out of service times by helping mechanics more quickly

pinpoint and diagnose sometimes complex technical complaints. Indeed, our software has a feature where standard troubleshooting manual references can be attached to ATA chapters. When a mechanic is raising a PIREP, the form dynamically adds a troubleshooting tab for the specific ATA that the mechanic is logging the fault against. This tab contains the hyperlink to the fault isolation (FIM) documents for reading in our SGML browser.

"Another big saving is the overhead time for production control in the hangar to produce the work package for the maintenance visit," continues Reed. "Planning defines the workscope ahead of maintenance, but Production normally has to take the related AMM sections or pages from the resulting task cards and append them to the workpackage. TRAX can import these references, and the task cards and AMM pages, together with graphics, are printed in the correct sequence."

A third saving comes from library management and distribution costs of paper, adds Reed. If an airline has 50 line stations, they all have to receive copies and revisions of all the technical manuals. This costs time and money to produce and manage. A paper-based system has a big time-lag in the update process, and the inevitability that human error may lead to a revision not being filed correctly or at all. It is therefore possible that maintenance is working with the wrong technical instructions. A final benefit of the TRAXdoc module is that the airline does not have to pay for the OEM software like PMA or AirN@v, or indeed for a third-party product like Jouve or Corena.

"There are two main parts of our product that help an airline deal with documentation, largely on the reference side," explains Reed. "We have a library function for non-electronic documentation and we have the new TRAXdoc module. We can open a tree and look across geographic locations in our library module to see which station or work centre has which document, and which revision each has received. A final feature used by our customers replaces the manual 'read-and-sign' sticker on the front of general publications. This allows engineering or management to distribute internal publications or general information and force users to register that they have read the document. Indeed when they log in next they will have a pop-up icon saying that they have a read-and-sign item queuing for their attention."

"Our newest addition, continues Reed, is TRAXdoc, part of release 7.0 that came out in June 2005. For the documentation administrator, this has a 'point-and-select' loading function to

upload any document that the airline can access electronically. For raw OEM reference data we currently support only SGML, but we can handle other file formats, such as PDF, HTML, and URL link to websites, and import entire folder structures. We also support the pass out of a statement to another piece of software, for example AirN@v from Airbus, that will fire up the external application and execute this statement. Documents can also be linked in a parent-child relationship, and have a basic Temporary Revision function to edit and update the original documents, for example inserting additional pages into a PDF document."

With regard to handling resulting records, Reed concludes that airlines and regulators will continue to be paper-based long time. TRAX does not yet support bulk scanning and indexing of manual records, he says. Although they can be individually scanned and linked through a manually established URL, this is time consuming. All in all, the document management module is a good starting

point for many airlines. It can be working within two months from start of implementation, helping to speed up the overall return on investment.

Bigger systems

SAP and Oracle have never really attempted to integrate document management into their MRO-specific product, apart from having simple hyperlinks into electronic sources, which is a cumbersome and inefficient system.

Lufthansa Systems augmented the SAP systems for Lufthansa and developed DocSurf, an electronic document retrieval solution. DocSurf is an electronic document library for standard internet browsers. It offers comfortable and fast retrieval for a variety of documents. DocSurf is based on standard products and a sophisticated functionality, which can easily be adapted to the individual needs of the customer. Based upon XML/HTML and standard software using MS Internet Explorer and Netscape, it is platform independent and
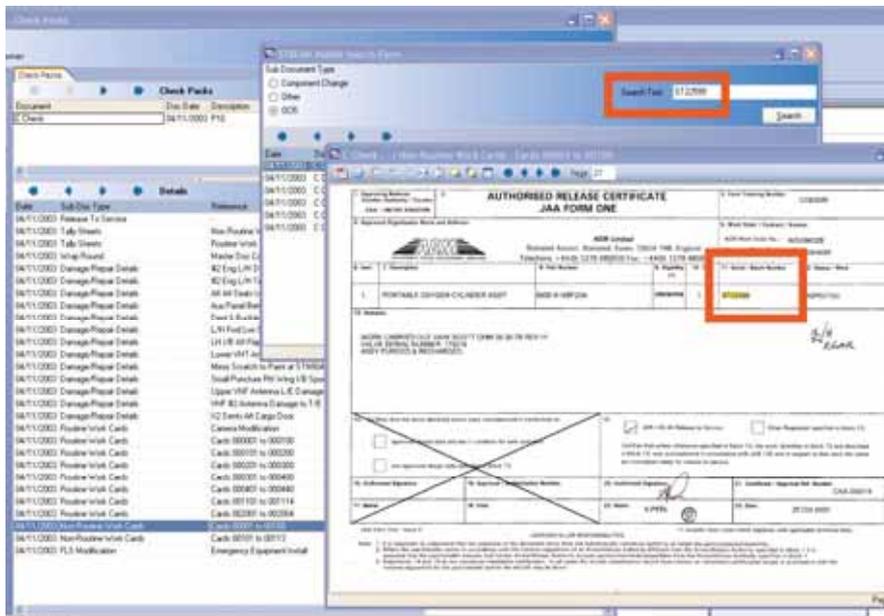
very easy to administer.

Most larger software vendors, however, rely on integration to third-party tools like the French Jouve solution. Jouve Aviation Solutions is a data integrator to airlines and aerospace OEMs, and offers a fully integrated and comprehensive information management solution. The system includes authoring and change management, publishing and distributing aircraft technical documentation to allow customers to efficiently manage their information to ensure configuration control and regulatory compliance. Jouve provides a full range of publication services to the aerospace market, including data conversion, imaging, e-content management solutions, systems integration, maintenance compliance programme tools and web-based technical document delivery. AirGTI is a suite of tools for browsing OEM reference documents. Jouve also offers a scanning and imaging solution called Alchemy to archive and replace old paper records.

MRO software capabilities

Avexus has been a player in the MRO software market for a number of years and is seen as a third-party maintenance company solution. Not any more, according to Richard Bergmann, president and chief executive officer. "We are aggressively going after the airline market now, he says. We believe our strong MRO background brings added value to the airline sector. We are trying to achieve interconnectivity in the network. Airline maintenance is still heavily paper-oriented and changing this means changing the way people access the data they maintain". But according to Bergmann, change is not happening fast enough. With regard to document

management, Avexus sees its solution as more than a passive system for automating card production. "We enable a visibility solution from a web portal," explains Bergmann. "This can be accessed from a desktop or indeed a mobile device like a PDA. We also have an initiative with an OEM to take IPC, AMM and SB data in XLM and pass it into the Avexus solution. The financial and safety benefits to this are large because we can build the configuration reference data automatically from the IPC data source."

Avexus claims that the Asset Management and Operations solution provides discrete control and information at a particular asset level. "The system can pick up tagged SGML or tagged XML data from a DVD or CD and plumb it into the Avexus solution at the right point," says Paul Dibble, director of solutions management at Avexus. "We have a trial going on at the moment with an engine customer to do this. We have had some discussion with Airbus on ADOC integration, and we already interface to the Jouve Aviation Solutions product. On the subject of technical records, Avexus already has electronic signatures working at Dallas Airmotive and the system already produces electronic 8130 serviceable tags. Going forward we are already working with some Radio Frequency Identification (RFID) manufacturers to remove all paper from their operations."

Another main player in the MRO software arena is MIRO Technologies with the AuRA integrated solution. "Paper is one of the big areas of potential cost savings for our clients," according to Mark Ogren, vice president of commercial sales and marketing at MIRO Technologies. "OEM and regulatory technical documents are managed, revised, tracked, monitored and audited

with respect to engineering changes and instructions within a controlled environment in AuRA. This process is also supported by a corresponding AuRA technical reference library where revisions and other change directives can be logged. The AuRA library enables revision management, publishing and drafting modes for change directives. Our customers like this function and use it in AuRA with excellent results.

"AuRA also facilitates document management with the ability to attach documents to most item records in the database," continues Ogren. "AuRA establishes URL links to documents or applications on the network. Throughout the application, AuRA makes extensive use of the paperclip feature that allows the user to attach documents, such as a strip report or digital photograph of an aircraft or component damage, to an item record."

Ogren also hints that MIRO soon plans to announce an enhancement to AuRA that will enable SGML-tagged technical documentation from OEMs such as Airbus and Boeing to be linked and viewed in a native browser. MIRO continues to support linking to third-party technical document applications such as those provided by Jouve Aviation Solutions and the Airbus AirN@v family, as required by customers.

Remaining paper

All that remains to be replaced is the plethora of auditable, traceable maintenance and technical records for aircraft and components. This represents most of the paper inside a maintenance organisation, and is the most difficult to replace with an electronic solution.

However, a number of fledgling companies have spotted an opportunity in the airline maintenance market. They have developed innovative solutions to help an airline make the transition to an all-electronic world, and simplify the life of maintenance and engineering departments that wade through reams of paper every day.

One such company is Century Computers in Hawaii, which has developed a solution called Fileyard to turn paper aircraft records into an indexed electronic library. It also offers an efficient scanning service where paper is delivered and electronic records are

returned. Accuracy is guaranteed in terms of readability and Optical Character Recognition (OCR) technology to find keywords in the scanned text.

In the UK, a small company called Waviatech has been leading the revolution. Started in 1997 to scan technical records for ORIX leasing company, the founders could see the market potential. "We embarked on a five-year design and development exercise to slowly evolve an airline-specific solution," says Karl Scanlon, manager of technical operations at Waviatech. "There were lots of general scanning solutions on the market, but we decided that we had to do it ourselves. One reason was our own experience of sending paper records to be scanned, only to have them come back in a mess and totally unusable. This created more work than the scanning saved. We developed a new product called Secure Technical Records for Electronic Asset Management (STREAM). Typically an airline or leasing company will be faced with 85,000-90,000 documents per aircraft. At Waviatech, we go through a multi-step process. First, our airline-experienced staff assess the documents and identify what is in the pile of paper. We then identify the major constituents of the records and index the data. Then we scan, using standard OCR software. Importantly, we do not re-categorise or re-name any documents. This would create mayhem and is something most scanning solutions miss out. STREAM takes care of all of this at the point of scanning. Indeed, we have made a mobile scanning rig which we can deploy on site to an airline or MRO facility if they do not want to ship their paper to us."

What electronic format?

"We scan all documents to TIF format," says Scanlon. "This is actually more of an industry standard than PDF and is much more flexible with volumes of data. We distribute the final files on a DVD or CD with a viewer that can output to PDF, because it is such a popular viewer. We have full OCR and text search capabilities with the electronic records and we are in discussions with vendors about an interface to an MRO software solution. As far as price is concerned, we match any third-party scanning cost per page, with all the added value of STREAM. The only other cost is to ship the 50kg portable rig if we are on site. We are meticulous about leaving the records in the original usable state. We avoid causing a secondary problem for technical record departments and they are all grateful to us for this at every engagement we have had. We can also take data from microfilm. Indeed we are taking nine ex-United Airlines aircraft records into the system right now from that media. STREAM's performance is also exceptional. For example, we have a six-year old aircraft with 53,000 pages, for which it takes less than five seconds to look up a specific part and serial number combination."

What are the big benefits of scanning paper like this for an airline? Scanlon is clear from real-life experience at Aer Lingus. "Organisation of records, rapid access and location of critical pages and the costs saved for lessees and lessors during a re-delivery transition," he says. Oversight of invoices from maintenance facilities is another benefit. $60,000 was recently saved for a C check invoice using STREAM to double-check charges made by the MRO. Errors in the invoice were quickly identified and proof was supplied by exporting images to back up the claims. All this was performed remotely, since the actual check pack had already been sent to the new operator. Last year a courier company lost a complete set of engine records that were being sent as the final part of its sale, which would have held up the sale indefinitely, and perhaps lost the customer completely. Fortunately, all the records, including the logbooks, were immediately reproduced from STREAM, and the sale went ahead as planned. Another of the many benefits lies in the re-marketing of aircraft. STREAM disks were recently sent to three potential lessees at the same time, allowing the owner complete flexibility in marketing and advertising, without infringing on the current operator, and while discreetly allowing simultaneous inspection of the records by multiple potential lessees.

Jouve has a similar system called Alchemy, which it installed for Frontier, JetBlue and Chautauqua about 12 months ago. All three airlines praise it for management of technical records, 8130s and repair reports.

The future?

The ideal is for every last scrap of paper to be removed from the reference library, and records, supply and stores departments. This is not likely to happen yet. Line offices will be crammed with manuals, books and files of handwritten forms for years, if not decades. This is simply a fact that airline management must face. However, some emerging technologies are offering a route to a paperless future.

OEMs are playing their part by developing new software, harmonising file structures and technology transfer standards. Display and portability solutions are advancing, with companies like Xybernaught already deploying document imaging 'backpack' computers that are wirelessly networked to MRO systems. Airbus foresees an electronic display 'page' that can literally be stuck to anything around the hangar or office, like an electronic PostIt note. Companies like Waviatech can help the painful transition from paper to electronic documents. The future for paperless document management is promising but only if airlines develop a clear and coherent strategy to make the change. **AC**