When taking delivery of new-generation aircraft, operators will face the challenge of handling S1000D document & manual content. Users can take advantage of the enhanced functionalities that S1000D provides. To benefit, however, airlines have to adapt their IT systems to extract the full potential. The considerations for IT systems are summarised.

The challenges of S1000D data management

There has been a progression in standardised data formats, content and standards for technical documentation. This originated from ATA 100 content, which is the specification for paper format, and progressed to iSpec2200 specification. This can be published in standard general markup language (SGML).

iSpec2200 signified the start of the digital age in document management for airlines. Maintenance and engineering (M&E) and content management (CMS) systems became a common element of the document and engineering and maintenance management processes. iSpec2200 allowed maintenance providers to transfer maintenance publications into digital formats. This subject is covered extensively *(see M&E and CMS systems' ability to manage data for new generation aircraft, Aircraft Commerce, April/May 2016, page 72)*. With S1000D content, maintenance documentation is provided to customers in electronic format.

New-generation aircraft, such as the 787 and A350, have adopted an initiative that publishes technical documents in accordance with S1000D specification. This content is written in an eXtensible Markup Language (XML) format. To realise the full potential of this content, the industry and its supply chain needs to recognise and process S1000D content.

S1000D content is more intelligent to use and has a different structure to traditional aircraft documents, so it is easier for operators to access, update and revise. It is designed with digital documentation and electronic processes in mind, rather than iSpec2200, which was a transitionary format whereby a few electronic processes could be achieved.

The use of S1000D content in an XML format helps to streamline wider processes within an operation, such as the updating of maintenance task cards, and the revision of manuals.

Maintenance systems that can process S1000D content, written in XML, provide enhanced functionality for the user, because they allow relationships to be developed between pieces of content. This capability relates well with the reusable data allowed in S1000D content, as will be explored.

Transmitted data

There are several types of data transmitted by new-generation aircraft. The types of data are described below.

Aircraft health monitoring (AHM) data

AHM is aircraft-generated data that supports remote diagnostics and predictive maintenance activity. "This fits broadly into two categories," explains David Kinney, technical fellow at Boeing Digital Aviation Maintenance and Commercial Airplanes. "The first is fault data, which is generated by central processing functions on the aircraft, known primarily as flightdeck effects (FDE) reporting and the central maintenance computing (CMC) function."

The second is parametric data. "This is often referred to as sensor data, and relates to the operation of the aircraft systems," continues Kinney. "This data is captured by on-board recording systems, including the airplane condition monitoring system (ACMS), flight data recorder (FDR), and quick access recorder (QAR), among others.

According to Boeing, AHM data formats are defined by the on-board systems that record and transmit the data. In general, the data format is controlled and defined by the specifications of the system, and is proprietary in nature. "For example, the 787 records and transmits fault and parametric data according to the Boeing and supplier specifications for the ACMS, FDR and CMC systems," says Kinney. "Once the data is sent to the ground, and into a system like Boeing's AHM, it can be shared and integrated with other ground-based systems. This is typically done using an application programming interface (API), web services, and industry-defined XML schemas, such as ATA Spec2000 chapter 17.

Maintenance execution data

Maintenance execution data is aircraft technical logbook data, which is used by maintenance and flightcrew personnel to record and rectify aircraft defects. "Although most airlines still use a paper logbook, once logbook entries are digitised, maintenance execution data is typically exchanged between systems, according to ATA Spec 2000, Ch 17," says Kinney. "This specification, created by the ATA e-Business Program Maintenance Execution Working Group (MEWG) includes data structures for logbook records, resource requirements, parts requests and documenting completion of maintenance actions addressing maintenance requirements." The data exchange methods and record structure are designed to be usable by maintenance history recordkeeping and archive systems. "The MEWG has used XML schema to define the Spec 2000, Ch 17 data exchange format, which includes flight log data, maintenance log data (including airplane faults, maintenance actions, maintenance release and servicing) and fuelling information," adds Kinney.

Maintenance technical data

"Maintenance technical data is generated by the original equipment manufacturer (OEM) to support the

Paper manuals have traditionally meant lengthy fault diagnostic processes in line maintenance. New generation aircraft, such as Boeing's 787, are now publishing technical records in digitised, S1000D format. This helps make the use of electronic documentation more intelligent.

maintenance of an aircraft through its lifecycle," says Kinney. "This includes data that is traditionally incorporated into technical documentation."

It is this data that has made the leap from ATA iSpec2200 to S1000D XML data. Boeing provides a range of products and services that interface with the maintenance technical data provided to customers. These include the Boeing AHM system, electronic logbook and Maintenance Performance Toolbox. "The data formats and standards integrated in these products allow mechanics to view a technical logbook entry from the flightcrew for an aircraft, relate it directly to an AHM recorded fault, and easily navigate on a mobile device to investigate fault history, fault isolation and maintenance manual procedures, and the parts needed to rectify the fault and return the aircraft to service," says Kinney.

S1000D content & XML data

S1000D has revolutionised the way that aircraft data can be used. It goes beyond the capabilities of iSpec2200, which allowed some basic relationships between technical documentation to be established. For instance, using iSpec2200 allowed hyperlinks to connect references between an aircraft's technical publications, such as the aircraft maintenance manual (AMM), and its illustrated parts catalogue (IPC). While these links streamline the process for mechanics to cross-refer between manuals, it remains time-consuming as some manual application is still required. iSpec2200 was developed in the early days of digitalisation, whereas S1000D, and its development in XML, is geared towards achieving an electronic standard in maintenance. It can contextualise content and data. S1000D is developed for electronic devices, such as an iPad or laptop, rather than paper manuals.

Unlike ATA 100, S1000D does not develop content that follows the layout of a document page. Instead, it constructs pages for viewing on a screen from blocks of information, called data modules (DM).

This means that IT systems need to be configured to read these DMs correctly, and in a different way to previous standards. Previous data specifications outlined the detail within technical publications rather like chapters in a book, which enabled operators to translate to paper (as has been the expected format of technical publications) with relative ease.

Each chapter, or in the instance of an maintenance planning document (MPD), each maintenance section such as structural or zonal inspections, was written in a linear fashion. This meant that each section gave each task and its description separately. Particular descriptions for a task were then used several times throughout the document. For example, a single maintenance document in iSpec2200 content may have had hundreds of tasks that required a general visual inspection (GVI). This meant that the GVI was described and written hundreds of times, whether for a landing gear, flaps or cockpit windows.

S1000D instead allows the task description of a GVI, a particular DM, to be written once and 'reused' in all the relevant tasks. Each DM can therefore be re-used in any number of viewed pages through the use of data tags. These allow reference between the DMs. Each DM has associated meta data, which details particulars, such as the effectivity and applicability of a task, as will be explained later. All DMs are then managed within a common source database (CSDB).

More rules and detail can be added into the structure of S1000D content, allowing more dynamic relationships between publication references. "XML data in S1000D has the potential to provide less ambiguous, more part-specific data than SGML-structured data has historically provided," explains Todd Young, vice president and general manager, customer services and Q400 program, at Bombardier Commercial Aircraft.

S1000D, and its use of DMs, therefore streamlines procedures in aircraft operations, compared to iSpec2200 predecessors. If a document is edited, then by changing the relevant DM the description of a GVI, for example, will be changed wherever it is used across the entire publication. Task cards will automatically reflect this change, so the document management engineer does not have to manually edit every single reference to a GVI within a technical publication. Managing document revisions and updates therefore becomes more efficient for operators and MRO.

A number of questions are raised by the use of S1000D- and XML-configured content. What options do airlines have when taking delivery of aircraft with these electronic manuals? To what degree are they reliant on the OEM to provide the means of rendering this data in a readable or printable format? How can this content be customised? Can the OEM customise this content, or is it more cost- and time-efficient to invest in a maintenance system that can author this content? Last, does being a smaller, single-fleet operator affect these decisions?

Utilising S1000D

Reading and rendering XML-written S1000D content is relatively straightforward. Most M&E systems have some support for S1000D, but typically only for extracting task data. Operators need to establish how much information they want to extract from this content, especially since S1000D is designed to make the maintenance

Customers taking delivery of the majority of new aircraft will receive technical data in S1000D. Other types of data transmitted by aircraft today include AHM, which comprises fault and sensor data, maintenance execution data, which consists of ETL information.

information contained within publications more effective. If operators are unable to filter maintenance tasks by an aircraft's specific engine configuration, for example, then they are unlikely to be taking full advantage of S1000D.

Technical data requires stringent monitoring. Upgrades must be performed as soon as they arise to ensure the operator is up to date and compliant. Airworthiness directive (AD) and service bulletin (SB) updates happen regularly, and often require amendments to an operator's aircraft maintenance publication (AMP). An aircraft's maintenance programme requirements will vary from operator to operator, because it includes elements in the maintenance operation that are specific to their own requirements. Most operators therefore require a level of customisation when handling S1000D data.

For example, OEM maintenance data will need to be adapted to include the operator's own additional maintenance standards and requirements. This could include, in addition to the full content of an MPD, engine washes, cosmetic inspections, and other maintenance tasks that are derived from in-house experience of operating the aircraft type. Some operators will need a degree of authoring ability when managing their fleet documentation, which may fall outside the scope of an OEM's provisions to its customer. To date, very few have fully developed this capability.

Key examples of aircraft that use S1000D content and XML-formatted data for their technical publications include the A350, 787, and Bombardier C Series.

The process by which operators can fully benefit from the increased functionalities provided by S1000D is constantly evolving, and depends on the IT system used to manage documentation. Experience and ease in processing this data will further improve as more operators require this level of functionality of their systems.

So what makes S1000D content the industry standard of choice? While S1000D is not mandatory, the OEMs of new aircraft types being manufactured today have chosen to incorporate it when compiling and issuing technical content.

Typical technical and maintenance publications and documents that are delivered with an aircraft to the operator include the minimum equipment list (MEL), MPD, engine maintenance manual (EMM), AMM, IPC, fault isolation manual (FIM), wire diagram manual (WDM), and system schematic manual.

"S1000D is the specification of choice for the industry to support new-generation IT systems more so than for new-generation aircraft," says Kinney. "Aircraft OEMs have taken advantage of the opportunity to move to S1000D during new-generation aircraft design, partly because of the large amount of new maintenance technical information that is created during the design.

"S1000D methodology is data-centric, meaning that it supports the creation of new information and allows the data to constantly evolve," continues Kinney. "This differs from previous specifications such as ATA ispec2200, which have been document-centric." This means that for previous specifications, upgrades to small portions of a document such as the AMM would have required revisions of the entire manual. "S1000D supports creating modules of information or data, instead of manuals."

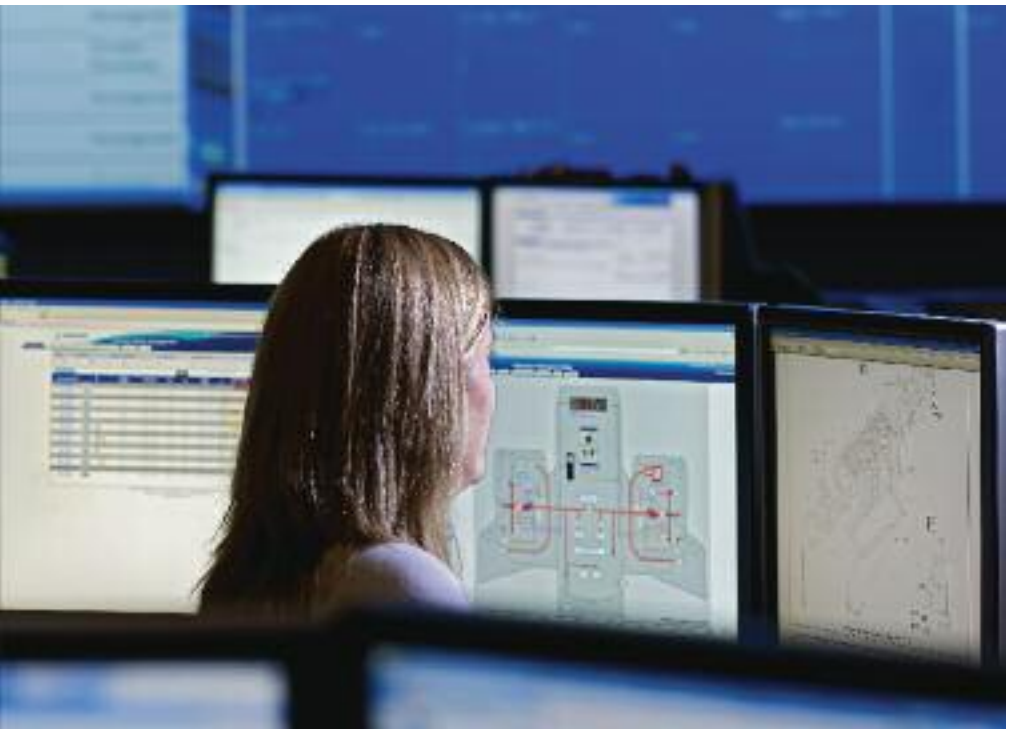
Whereas historic IT systems have become adept at processing ATA iSpec2200 data, they are limited in processing S1000D data. "There are inherent problems for legacy systems, built on decades-old platforms, to adapt to the new standards," confirms Kinney. "Historically airlines and M&E systems have experience and knowledge of ATA iSpec2200, so IT system upgrades will be needed to support evolution to, and correct processing of, S1000D."

"S1000D XML represents a significant departure from the typical book and chapter structure used for many years in ATA documentation," adds Young. "Instead, with S1000D, the breakdown is by system, subsystem, and equipment. Since the data is stored as DMs in a CSDB it means that it can be 're-used' on many pages throughout a manual. Each DM is attributed a data module code (DMC), which is used to create data tags and manage DMs within the CSDB. It enables access to, and retrieval of, relevant data as and when needed.

"S1000D facilitates a modular approach to data generation rather than the traditional linear approach," continues Young. "A user can traverse dynamically 'across' the data set and therefore access all the tasks relating to a particular aircraft system in a single view without having to search in various locations." This is in comparison to the fixed nature of documentation associated with ATA iSpec2200, where a maintenance manual page is presented in a rigid PDF file that allows minimal interaction.

"S1000D as a specification is built around the component part at a granular level," adds Young. "This affords the opportunity to repurpose and group small data 'packages' targeted for a specific component on an aircraft. The specification also expects the data to be exchanged and used in electronic form. This differs from the ATA specification, which is evolving from a paper specification and format to digital. In S1000D, the default delivery is an interactive electronic technical publication (IETP), from which a PDF or printed page can be produced if needed." The emphasis is therefore on digital manual use, rather than paper.

Young explains that the main value of S1000D is that operators can render and



Boeing's Maintenance Performance Toolbox provides an IETP to its customers in addition to authoring software for XML data. While the IETP may be accessed and used by thousands in an airline, the authoring capability will only be required by those customising the airline's technical documentation.

arrange the data on a screen in ways not possible with a printed page. The publication data is intelligent, because the specification tags and structures the data in ways that allow repurposing, as well as defining when data is applicable to a procedure, part, component or aircraft.

Bombardier provides its C Series data in two separate formats to customers: first, via its Bombardier Commercial Aircraft Navigator IETP viewer, which is a cloud-based system that is accessed by customers via an online portal. Second, data is provided via an XML exchange data platform, which can be interfaced with operator M&E systems in the event that they need independent document management capabilities.

Versions of S1000D

S1000D is a specification that has evolved over time, so several versions are being used by new-generation aircraft that have entered service in recent years. The 787, for example, uses a version of S1000D 3.0, whereas the C Series' maintenance publication data is authored and supported in S1000D version 4.0.1.

"Specifications like S1000D are an evolving set of business rules and functional requirements," says Young. "These specifications are complex and undergo industry and peer review cycles that can take several years. When the C Series programme selected S1000D as the standard, the specification was at version 3.0 (released on 31st July 2007), with version 4.0 released shortly afterwards on 1st September 2008. Since then, the specification has been 'up issued' twice, and is currently at version 4.2 (version 4.1 was released on 12th December 2012, and version 4.2 on 12th December 2016)."

"In general, aircraft OEMs do not change the version of the specification used for a given aircraft type," says Kinney. "Especially not between major versions, such as from version 3.0 to version 4.0. Changing between these versions could disrupt downstream processing, due to the major impact of changes. Minor changes to the original designated version may be made with updates to data formats.

"The version of S1000D data used will be typically decided during the aircraft's design phase," says Wayne Enis, VP solution management at Flatirons Solutions. "The new data content has to allow for developments, such as the applicability and effectivity of maintenance tasks." These are two main elements that show how the functionality of S1000D allows maintenance management to be optimised. This will be explored further in the CMS section.

"The way that OEMs can adopt and structure the S1000D data specification is actually quite flexible," continues Enis. "This leads to very different interpretations between the manufacturers. The data construction can be very different, between the A350 and 787 for example. Some OEMs build in extensions to the DMs for instance, to appropriately map the layout of their maintenance documentation. These layouts vary from manufacturer to manufacturer."

Kinney explains that each aircraft is likely to use the most current S1000D version present at the time its design programme was initiated. In addition, each OEM may implement specific capabilities or unique information to support their systems, and these customisations might also cause some variance. Each version of S1000D is designed to add further capabilities and improved interaction with the XML schema. "S1000D incorporated a major schema overhaul at version 4.0, which included removing dependencies on SGML processes. This overhaul made S1000D incompatible with earlier versions," adds Kinney.

"Version changes can be a result of many things, such as clarification of a DM definition, expanding the scope of the specification to include new DM definitions, or technical considerations and evolving user and industry requirements," explains Young.

An IT system needs to adapt to each S1000D version to become fully S1000D-configured. "Although data structures may vary between versions of the specification, the main concepts, such as the DM structure, can be supported across different versions of the specification," adds Kinney.

OEM support & portals

The OEM provides a number of web-based and software services agreements to support the delivery of new-generation aircraft. Customers can, for example, commonly use any electronic device to view all technical documentation via a portal on a server. "Using the OEM's online portal makes the airline dependent on the data presented, so it will have no control over the revision or enhancement of the data it intends to use," says Christian Eickhoff, IT project manager and focus for the introduction of S1000D at Lufthansa Technik (LHT).

"LHT uses structured data to streamline work processes like job card creation," continues Eickhoff. "The content of technical data is linked to a job card, and the job card only needs to be updated if the respective content has changed."

"Imported structured data facilitate an efficient way of integrating technical data in our maintenance documents," says Dr. Andreas Roth, director technical data management at LHT. "Furthermore, the data can be enhanced by links to other documents or by customised content that can be filtered in or out on demand."

According to Boeing, virtually all 787 customers have opted to use Boeing's

AHM for aircraft monitoring and its Toolbox software for viewing and managing maintenance technical data. Furthermore, the Toolbox Records module integrates AerData's secure technical records for electronic asset management (STREAM) product into the toolbox suite. The Boeing Maintenance Performance Toolbox suite can also be used for the management of technical documentation for other aircraft types. This suite of tools includes authoring capability, which consists of an XML editor. Updates to Boeing source information, such as the AMM, are provided to the airline's technical publications personnel, who then incorporate in into their documentation using the tools within Toolbox.

If they are not using these products, however, an airline or M&E system provider would need to implement adapters to process the S1000D data formats, in addition to a software that can render and display this data.

Customers taking delivery of the C Series can access technical publication data via a portal. It is granted on a subscription basis, and accessed via username and password on www2.iflybombardier.com. "The portal supports our Navigator IETP viewing application," says Young. "Customers can also install a local Navigator IETP hosted in their local server environment, or subscribe to receiving technical publications as S1000D exchange data for use within their own MRO tools." Navigator IETP content is published on a regular schedule, and promoted to the portal. Concurrently, this same data is pushed to customers utilising the locally-installed Navigator IETP. A separate service is also offered to author S1000D content.

According to Bombardier, most customers have opted to use its Navigator IETP. "Some customers have robust systems that are being evolved to support S1000D for Technical Publications delivery to their end users, line mechanics and engineers," adds Young. "Therefore, on these occasions they import our exchange data into their own systems."

Undertaking manual revisions can be a complex process if users rely on OEM portals. "Manual revisions are one of the most difficult intelligent processes to achieve using XML documentation," explains Eickhoff. "If an airline uses the OEM portal for this, it gets a notification on a new issue and then the planning engineers manually check if any of the written job cards need updates. OEM portals display HTML files and are generally read-only.

"To make life easier, some airlines use job cards provided by the OEM, which should reflect the latest manual revision," continues Eickhoff. "In this case, however, they cannot adapt the job cards to their specific requirements. This may not be of any concern for a small airline, but it definitely is for any larger one. Last, the airline may have contracted to download the XML or SGML 'raw data' from the OEM portal. In this event, it may import the XML into its own configured system. This is what most large airlines do, including Lufthansa. This system then checks for any changes in the technical data," adds Eickhoff. "Any reference to another document is checked to see if the new issue carries any relevant changes. If, for example, a job card system is connected (as it is in Lufthansa Technik's case), a planner gets very specific alerts for a specific job card if a referenced DM has been changed. This only works with structured data, however. With PDF this cannot be achieved, because the functionality and intelligence is lost."

The choice depends on each operator's needs and available IT resources. "The data for maintenance publications in its 'raw' S1000D form needs to be made ready to view by human users, while at the same time integrated with the M&E systems used by that operator," explains Young. "For technical publications, some form of

Building in-house, independent capability to handle S1000D content is a complex process with many considerations to take into account. An operator or MRO will need to establish how it will import, author, publish and view S1000D an XML data. This requires several elements to a CMS.

online viewing tool, such as an IETP, is required. The S1000D specification defines the minimum required features for this type of software."

Young says that vendors of M&E systems should be able to support their customers to some level in the transformation and use of S1000D. "While S1000D is a relatively new specification for commercial aviation, it has been around for more than 20 years in other sectors," says Young. "Most M&E system providers have already made the effort to accommodate this new specification."

System requirements

Interactive electronic technical manual (IETM) software was developed to correctly display SGML content. This is what translates SGML coding to look like a page on a computer screen. The IETM renders the data coded in SGML to the HTML format that any web browser can display. Many IETMs use a specific viewer to be independent of browser development cycles. OEM portals use a similar technology, but the IETM is generally an internal module of the software suite an airline needs to display structured data. Customers taking delivery of most aircraft today will be given access to the portal to view their technical publications in page format. For aircraft such as the 737NG, for example, customers can access online electronic manuals via portable electronic devices (PEDs). These publications are 'read only', however, and cannot be edited. To perform in-house manual revisions or make improvements to a publication, a CMS with authoring capabilities is needed, as will be explored.

IETP software is the next iteration of an IETM, and captures the ability of the IETP to render and display all maintenance publications, not just technical manuals. Wider documentation includes ADs and SBs, for example.

Given that rendering XML data into readable formats is complex, many users will opt for the portal access granted by OEMs. An IETP allows users to look up AMM references and information quickly.

An IETP allows users to filter tasks by applicability and effectivity, which reduces the time needed to identify relevant tasks per aircraft. Delivering S1000D content via an IETP enables some functionality of the data to be realised. This includes intelligent graphics and diagrams in the e-manuals, which provide users with a more dynamic level of information than a page in a paper manual, or hyperlinked PDF.

If taking delivery of an aircraft that supplies technical documents in S1000D, operators must either rely on the OEM's portal, or pursue their own appropriately configured IT solution that can support document revisions and AMP customisation. If the latter, then raw and non-rendered XML data will be provided to the customer by the OEM. Customers that perform their own in-house S1000D document management will require a software that can provide the following:

- A means to display CSDB data in an IETP
- Access to a database with basic CSDB functionality
- A Data Management Module (DMM) that can facilitate revisions
- PDF generating capabilities for selective print-outs
- Authoring capabilities for creating new XML files in S1000D to make amendments when necessary.

While customers can use the OEM to perform amendments, Enis explains that this can be time-consuming. "This is not efficient for a large airline with a diverse or growing fleet of new-generation aircraft, where revisions are frequent," he says. If the operator can use an appropriate system, than all authoring responsibility for amendments is in-house and they can be performed immediately by the end-user.

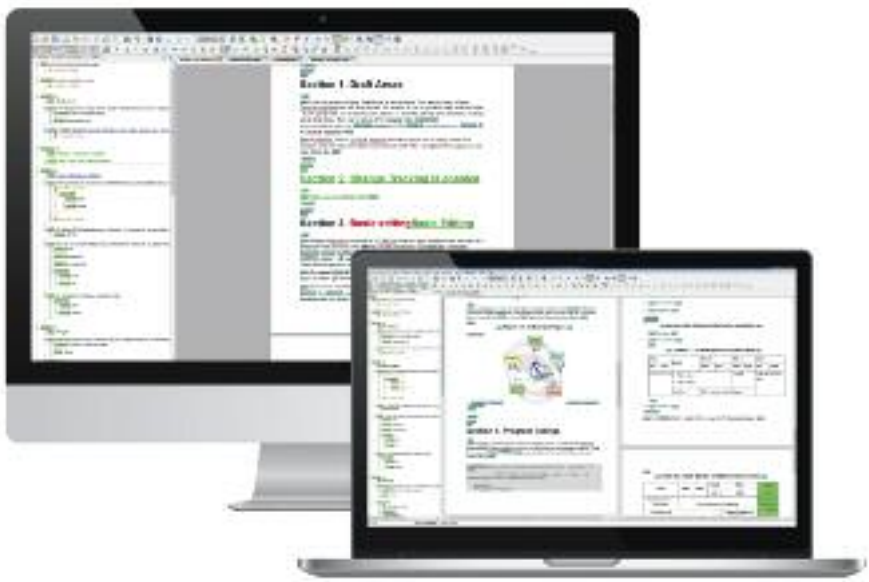
A small airline may request the OEM to perform all revisions. Enis highlights that this option is expensive and slow.

"Airframe OEM systems also focus on supporting the airframe's publications, and often do not provide the same level of capability for other documentation," adds Enis. "This includes engine, avionics and component maintenance manuals. While these are supported to some extent, it is usually via PDF documents that are also accessed on the OEM portal. The relationships for these documents are therefore not as intelligent, which detracts from the primary benefit of XML-coded technical data. By taking advantage of an independent solution, not only can the user write and author documents itself, but it can use one system to search across all manuals, whether airframe engine or component, and consolidate tasks in the AMP. For instance, if the AMP references an engine removal or inspection task, it can then establish a single task based on data from the AMM, EMM and MPD," says Enis.

IETP integration

As highlighted by Boeing, airlines seek an integrated solution where mechanics can view maintenance manuals, diagnose faults and establish the configuration status of an aircraft. It is the ability to take advantage of the complex functionality of S1000D content and XML data, however, that poses the biggest challenge for operators. This functionality can only be achieved by a sophisticated level of integration between a maintenance IT system and the XML-generated S1000D content.

An operator establishing its own IETP must define the level of functionality it wants, including: creation of business



CORENA Suite comprises a range of XML and S1000D specialised software. Its products include a CMS, an XML editor, and an IETP called Pinpoint. This can be accessed by either desktop or mobile device.

rules, authoring guidelines and DM requirements; defining how diagrams should be displayed to the users; and whether it requires modules to be printed in paper or translated into PDF. All these specification requirements are laid out in a functionality matrix.

Once an operator has rendered and published its S1000D and XML data, if it chooses not to rely on portal access and has received raw XML data from the OEM, the main challenges come from the day-to-day operation of the aircraft. Task and manual revisions are the prime example. Data uploads arrive from the OEM, once again in S1000D. A system's reaction to this is important in terms of establishing its level of functionality with S1000D.

A high level of IETP integration with the CDSB, which contains the S1000D data, allows airlines to instantly update and revise the AMP, following a manual amendment from the OEM, or an SB or AD from a regulatory authority. "Most OEMs send full deliveries and no incrementals," says Eickhoff. "When updates arise for S1000D technical data, the airline must discard all DMs that are known already, and then only process the new ones." A system should be able to recognise if the update sent by an OEM relates to already updated content, or to DMs that have been customised by the operator. The system should be able to highlight the changes required, or automatically update the DM.

"If the DM being replaced carries a link to a job card or other customised enhancement, these links and content need to be checked for changes, usually manually. Once the changes have been finished, the new data package can be released," adds Eickhoff.

The addition of new SB information follows a similar process for airlines using XML data. "SBs are not as complex as AMM revisions, because SBs usually cover a smaller work area," explains Eickhoff. "Engineering evaluates an SB to determine whether it makes sense for the fleet, or is mandatory, and then forwards it to the maintenance planners for integration into job cards. SB content is not always transformed into AMM content, so the document may stay on its own for the lifetime of the aircraft without requiring integration into the AMM," says Eickhoff.

"Amendments to an AMP can be handled in two ways by customers of S1000D aircraft," says Eickhoff. "One is that the airline requests a supplement from the OEM, to be used alongside the AMM when maintaining the aircraft. This is a standalone document. Alternatively, the airline can request the OEM to modify the customised content of its data to reflect the change. This is an area where Lufthansa Technik is working closely with our OEM partners to find new, efficient and safe ways to ensure that our mechanics see the most up-to-date data as quickly as possible."

Without a sophisticated level of integration, operators are unable to make full use of S1000D data. True rendering of this data goes beyond the ability to see technical publications online, and establishing links between diagrams and the maintenance manuals.

Role of the M&E system

As the front-end system used by mechanics, an M&E system does not have obvious system requirements for quickly and easily updating S1000D manuals in an XML format. When it comes to interfacing directly with this content, an M&E system has minimal involvement in renewing data, and is not dynamic towards S1000D data. In fact, the only data a M&E system will lift from an AMM is the AMM references for each task, rather than the detail of the task itself. This is left to the CMS.

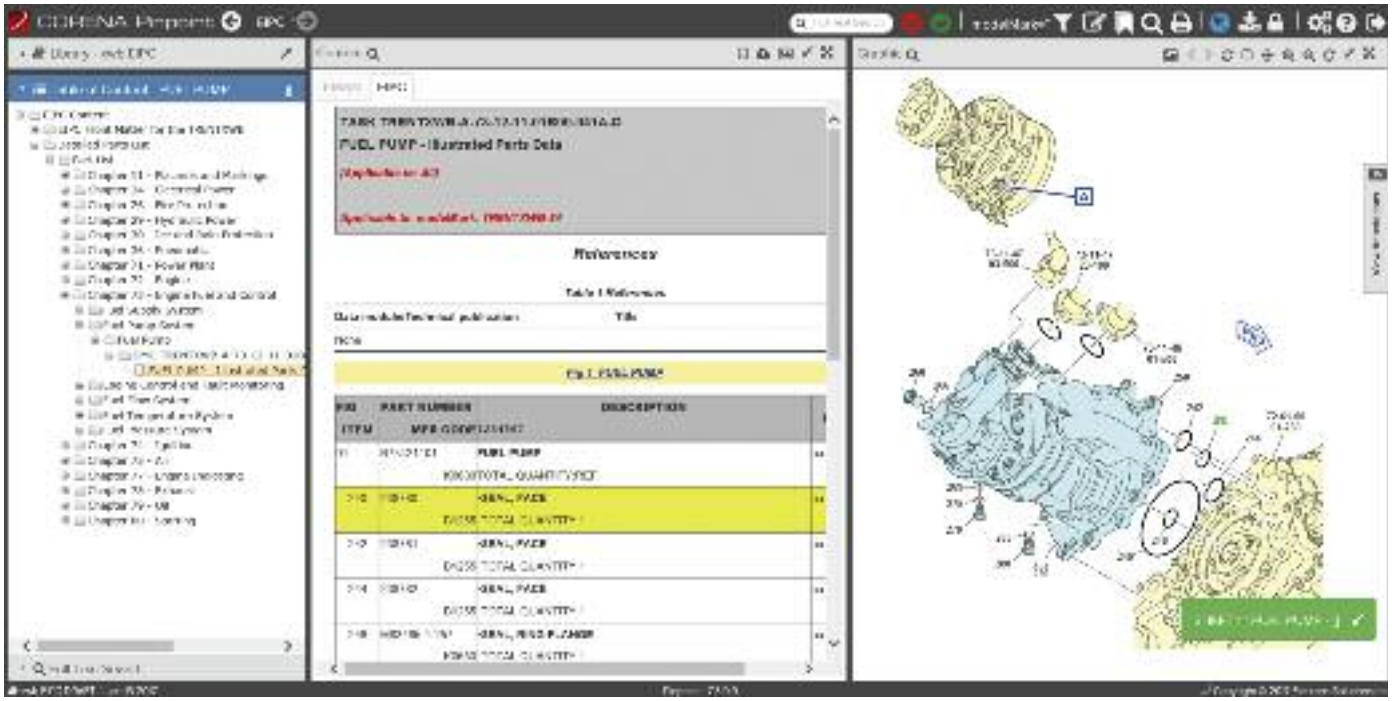
An M&E system should be able to process AMM references in XML, as long as the M&E system has been configured to import and map S1000D content from the IETP to its DM module. It will therefore need to interface with the IETP. An M&E system alone is inherently unable to fully appreciate this S1000D content, however. It is the CMS, instead, that adds intelligence. "M&E systems deal with only a very small section of the technical manual content," says Enis. "The purpose of this system is to track and manage tasks, and discern whether the proximity to any given task is within acceptable limits. It is not designed to facilitate and recognise a new AD or an AMM revision, and then implement it into the MPD or AMP. That is the function of a CMS."

The M&E system is driven by reference data, which is placed in a database within the CMS. This is what drives its scheduling capabilities. Recognising tasks due, and currency and recency of a mechanic, are the extent of an M&E system's capability to liaise with XML data. It cannot handle manual revisions. Instead it can recognise the physical configuration of an aircraft, such as all part numbers relating to it, track FH and flight cycles, and store information regarding components. It can also be configured to incorporate an operator's AMP. Adaptation of this AMP is, however, authored, edited and customised via a CMS that has XML editing capabilities built in.

"There is technically nothing preventing an M&E system vendor from building in complete XML editing and processing capability," says Enis. "It is just a matter of time and money. Similarly, a CMS could expand to process the M&E side of things. There are, however, different priorities and focuses for each system. While a CMS needs to consume, manage and review content, a M&E system needs to focus on the reliable output and management of workpacks and due tasks."

CMS system functionality

As described, it is the CMS where the true functionality of S1000D data can be realised. The onus is therefore on the CMS and its relationship with the IETP.



Pinpoint allows mechanics to access technical publications via a PED. The S1000D content enables sophisticated links to be established between an aircraft's technical publications.

An M&E system can extract its required maintenance data from the processed and extracted technical data that is stored in the CMS's database. "The CMS has to manage the complex relationships in the XML data," explains Young. "The IETP then transforms the XML data to the end user as HTML. There is no S1000D-specific CMS, therefore, but instead a CMS that is suited for structured data and can therefore be configured to manage S1000D data correctly." Essentially, a CMS has to manage the S1000D content to a level that is required by the operator.

Flatirons Solutions offers a comprehensive suite of XML and S1000D specialised software, known as CORENA Suite. CORENA Suite is available in a number of editions to support the requirements of both OEMs and airline/MROs. In addition, Flatirons also offers outsourced management and authoring capabilities under the banner of CORENA Managed Content Services, which facilitates the authoring of S1000D content.

The structure of a CMS that can facilitate manual revisions and XML editing capabilities for AMP customisation comprises two systems: the main CMS; and the IETP that holds the publication content. The CMS then interfaces with the M&E system. CORENA includes a CMS, which is made up of three core components to allow this to be achieved. Via its CMS module it imports, stores and manages XML data.

CORENA's authoring module, which is an XML editor, allows XML and S1000D content to be altered as and when needed by the user. Last, the publishing module publishes the new content out of the CMS and back into the IETP. Because the IETP is web-based, M&E Systems can retrieve content as and when needed. AMM references are tracked and information reverted back through the IETP. Both the IETP and the CMS are located on servers that can be accessed by authorised users. Whereas the IETP may be used by thousands of people in an organisation, such as engineers, planners, flight crew and line maintenance staff, the CMS may only be used by 20-30 people, who are responsible for making adjustments to the AMP and performing manual revisions.

The effectivity and applicability of each maintenance task can be assessed and distributed so that each tail number has its relevant tasks attributed in its individual maintenance programme. "Whereas iSpec2200 established the effectivity content of each task within the ETP, a CMS and IETP that are fully interfaced with S1000D content will discern the applicability of these tasks," says Enis. "Determining effectivity has been a relatively straightforward process for CMSs. Effectivity has been allocated by manufacturer serial number (msn), which makes it easy to identify which aircraft the task is relevant to.

"Applicability is a far more sophisticated determinant for maintenance tasks. Modern day MPDs, for which there are thousands of tasks, can apply and designate tasks by aircraft modification status and even operator utilisation. The process of designating each task is therefore far more complex for S1000D data, although once achieved it means that each aircraft has its own customised AMP, so only the relevant tasks are allocated." This is different to historic processes where planning engineers have to manually determine whether each task applies to an aircraft. Appropriate tasks are then fed into an M&E system; it cannot process these tasks independently of the CMS.

If an airline can carry out manual revisions to documents in S1000D, in accordance with task applicability, it can start building additional parameters into each task card. "The user can then start to build further intelligence into its CMS, because the extensible nature of XML is dynamic," says Enis. "For example, by determining whether a task is being performed in a base maintenance hangar or a line station, the operator can use the XML format to bring up instructions specific to its surroundings." Enis has seen business cases suggesting that the time saving for large-scale airlines due to built-in effectivity control within a CMS is worth more than $20 million, because planning engineers no longer have to work out which task is relevant for each aircraft.

Using an XML editor within a CMS can author and publish amended content into the CMS, which an M&E system can interface with and extract accordingly. "Smaller airlines are less likely to implement XML editing-capable systems, because they will not be customising maintenance programmes to the same extent as larger carriers," adds Enis. "It is not difficult to configure an M&E system to pull in and implement manual revisions in this situation, as long as the system already recognises and supports S1000D." Version two of an AMM revision, for example, should override its

Bombardier's IETP is called Navigator, and can be accessed via its portal www2.iflybombardier.com. The IETP can also be hosted on an operators local server. Alternatively, the airline can subscribe to receiving technical publications as exchange data to manage independently.

preceding version, and the existing task card should link to the new file created. Assuming the AMP is not customised, this process is not difficult to achieve. If there is independently authored and customised content, however, the import and reconciliation process becomes much more complex."

In summary, an operator that wishes to author and customise S1000D content independently from the OEM will require the following three main elements;

- An S1000D specific CMS and CSDB
- Authoring capability
- Viewing capability, such as an IETP

Other, wider aspects that complete an operator's ability to fully manage its S1000D data include the capability to import XML data, and publish its edited content back to the IETP.

Document management

Lufthansa has commenced A350 operations, taking delivery of the first aircraft in late 2016. The airline has substantial in-house capability to configure its maintenance systems, having developed and used its own pureplay MRO software, which displays, filters and uses references to other documents in S1000D. It is currently developing its capability to author and edit S1000D content by working with OEMs. Its MRO subsidiary, Lufthansa Technik (LHT), is working towards being able to make amendments and additions to its AMP independently of the OEM, publishing these changes in an IETP once done.

LHT has subsequently configured its systems to process S1000D content, and XML data. "Lufthansa Technik uses its own proprietary system for processing technical data for all aircraft," explains Eickhoff. "For S1000D data, it helps to have a relational database to store data in, and a CMS to edit and present the data. The database retrieves data fast and the CMS prepares only the DM for rendering that is needed for the task at hand.

"S1000D allows DMs to be combined in customised publications for specific purposes," continues Eickhoff. "As each DM is released individually by the type certificate holder, the modules can be combined. LHT has created a structure which it has used for Lufthansa, whereby the mechanic finds all data pertaining to the area he is working in on one single branch of the navigation tree within its engine publications. These reside in LHT's own IETP. The mechanic therefore does not have to check several manuals and IPCs to find the correct procedure. This is a structure that Airbus is already using for the A350, but that we have introduced for engines types as well, such as the V2500 and the Trent XWB."

According to LHT, airlines have three options when operating new-generation aircraft. "An airline can use the data as presented by the OEM on its website or portal, or it can contractually agree with the OEM to get the data delivered in raw format," says Eickhoff. "Once received, the data can be imported into a commercially available system or into an in-house system that is specially configured. With each step, the airline gets more independent, but has to invest more in its own IT."

"If introducing this data to its legacy IT systems, the operator will need to have discussions with the OEM about the OEM's individual interpretation of S1000D and the schema, which is defined by the S1000D version used. The operator will also require the Business Rules used for successful implementation," describes Eickhoff. This means that future created XML documents can map and follow the same format set by the OEM. "Once the specific structure is clarified, the process is straightforward: You check the data against schema and Business Rules, import them into the database and present them to the user for release to the workforce.

S1000D is clearly the specification to follow for products used in aviation. Eickhoff says that it is more strictly defined than its content specification predecessors, yet offers more possibilities for all partners to reap the benefits of structured data. All industry participants can only benefit if:

- The specification is strictly adhered to
- Robust processes for data delivery exist and are followed
- The cost for using S1000D data is manageable to all in the supply chain.

Summary

S1000D is a new specification standard for aircraft documentation. It only applies to the technical documentation of new types, however, rather than legacy types or the majority of aircraft in operation. An airline needs to carefully consider its options for managing documentation of new types. An airline needs to consider it requires a high level of customisation to its technical publications, and whether it utilises OEM software to support its business needs. In-house software solutions, or CMS vendor services, may be the most appropriate solution for carriers with large, diverse or complicated fleet requirements. Solutions are being established to assist the first operators that handle these publications, however, and the ease with which XML and S1000D content can be processed will increase as these new aircraft types become more active in the industry. - *CLD* AC