The 787, A350 and CSeries all have their documentation issued in S1000D specification and XML language. The full functionality of this content could not be utilised if it were stored and operated on most M&E systems. The factors that affect what system capability is required are examined.

M&E and CMS systems' ability to manage data for new generation aircraft

Aircraft maintenance and operations documentation technology is evolving at an increasing speed, especially as airline processes are moving from paper to electronic ones. S1000D, the specification adopted for the documentation and data for the 787, A350 and CSeries, is intended to make it possible for the engineering management and maintenance processes to become fully electronic. However, only a limited number of maintenance and engineering (M&E) IT systems can operate with data and documents provided by the original equipment manufacturers (OEMs) in S1000D specification. The problem is exacerbated by the fact that the documentation for the 787, A350 and CSeries is provided in three different versions of S1000D. This raises the issue of what affects a system's ability to handle documentation and data for these new generation aircraft, and what options airlines and operators have for managing their fleets.

Document evolution

The evolution of aircraft documentation, manuals, and supporting data is regularly examined and analysed *(see Recent advances in documentation technology, Aircraft Commerce, February/March 2010, page 39)*. Examining the evolution from the first standards to S1000D illustrates how the requirements for handling the documentation have changed.

The Air Transport Association (ATA) 100 specification and standard for writing documents and manuals was in use for several decades, since it was first conceived in the 1950s.

The structure of the ATA 100 standard was based around two-digit chapter numbers for different sections and systems of the aircraft. Examples of ATA chapters to describe structural sections of the aircraft were 51 for structures, 52 for doors, 53 for the fuselage, 54 for engine nacelles and pylons, and 57 for wings. Examples for systems were 21 for air conditioning and pressurisation, 25 for cabin interior furnishings and emergency equipment, such as escape slides, 26 for fire protection, 27 for flight controls, 28 for fuel, 29 for hydraulics, 32 for landing gear, and 36 for pneumatics.

There were subsets for each ATA chapter. Examples of the subsets for ATA chapter 32 were 10, 11, 12, 13, 14 and 15 for the main landing gear and doors.

The ATA specification meant the parts pages of the illustrated parts catalogue (IPC) to locate tasks, and details of maintenance tasks listed in the aircraft maintenance manual (AMM), were listed as numbers with three pairs of double digits, which describe the tasks in an inverted tree structure.

The first pair of digits, the prefix of an AMM task number or an IPC parts page, was the ATA chapter number that it relates to. For example, an IPC page or AMM task with a prefix of 32 related to the landing gear.

The second pair of digits related to a section of that chapter. Two digits of 13 for ATA chapter 32 referred to the main landing gear doors.

The last two digits related to the particular component of the door to which the maintenance task or IPC page referred, for example 32-13-11. The -11 suffix referred to the removal and installation of a shock strut door on a 737 Classic in the AMM, or components to construct the door in the IPC.

An engineer could find the required part number (P/N) in the IPC by looking for 32-13-11, and then the illustration number. This listed the approved P/N.

The AMM task number, depending on aircraft type, would have extra digits at the end to indicate the type of task to be performed. Some AMM tasks were identified with an additional three digits, known as aircraft maintenance task oriented support system (AMTOSS) codes. Examples of maintenance tasks are lubrication, functional check, operational check, discard, replace and test. Other aircraft types linked the type of task to page ranges within the contents list.

The AMM and the IPC also provide details of the type of mechanic skill and tools required, the OEM's approved P/Ns, detailed instructions to perform the task, and cross-references to other manuals. These include the IPC, aircraft wiring manual (AWM), and structural repair manual (SRM). All manuals were printed in page blocks to avoid having to completely renumber all the pages when the OEM revised or added a few pages.

A mechanic performing a task or searching for a P/N had to cross-reference between manuals to complete the task, or any repairs or rectifications that arose. This meant going up and down the inverted tree structure of the two main manuals when performing tasks.

A main drawback of the inverted tree structure format was that one area of the aircraft would have associated assemblies, structures and components that comprise several ATA chapters, for example, the fuel tank and fuel pump within a wing. The fuel system and wing have different ATA chapters, so the tasks

The 787 is the first commercial aircraft in operation to have documents and manuals to be provided in S1000D structure and specification.

and parts have different six-digit codes, leading to inefficiencies.

Extensive cross-referencing between manuals to perform one task, and navigating up and down the manuals' tree structure system, was time-consuming, laborious and inefficient.

Engineering staff faced other practical difficulties in managing the document updates and revisions that are issued at regular intervals by OEMs. These changes often affected a large number of pages and sections in every copy of the manual held by the airline, and had to be made manually on every page and section affected. For example, a change of P/N or material to a new approved part in the AMM would involve a large number of different tasks. So replacement pages were issued for each one.

Further difficulties were encountered by larger airlines that wanted to edit and author the OEMs' documents, or had introduced a supplemental type certificate or an engineering order (EO). To keep its own documentation, an airline would transcribe the content of the original manuals into Word or a similar format, and then input OEM revisions manually into its transcribed files.

Airlines also created their own page and document layout and graphic design, which is required when illustrations and pictures are used.

The ATA 100 system evolved only a little in the decades that it was in use. While paper was the only possible viewing format for many years, OEMs were able to provide documentation in PDF format from the 1990s, or airlines that had transcribed the OEM content to create their own version of the manuals, could then render this into PDF.

Spec 2100 and SGML

A new ATA standard and specification was introduced in 1994 to replace ATA 100: Spec 2100. Its main feature was that it provided the same information as the paper manuals in an electronic format. The Bombardier CRJ family was the first aircraft type to use the Spec 2100 standard.

"The main aim of Spec 2100 was to make it possible for management engineers to receive documents electronically, but print the pages of the manuals, view them on a screen, or render them as portable document format (PDF)," says Mike Denis, Principal at SLM Aero.

Denis explains that the Spec 2100 standard was put in place just before the internet and hyper text mark-up language (HTML) pages came into common use, so Spec 2100 was not conceived with the aim of forming content into pages and rendering them viewable on a mechanic's mobile device or on the internet. It was still intended for airlines to print task cards and other documents on paper. It was also intended that Spec 2100 would allow transfer of electronic data between different airlines, maintenance providers, and their IT systems.

The content of Spec 2100 documents and manuals was still based on the page blocks and inverted tree structure philosophy of ATA 100, so mechanics continued to navigate the electronic manuals in the same way as the printed manuals. Mechanics still cross-referenced between electronic manuals, but this was facilitated via electronic links or hyperlinks established in the content. A link would exist, for example, between a P/N on a page in the AMM, and a page in the IPC.

"Electronic documents and content in Spec 2100 standard needed an electronic language to provide some level of intelligence to the content," explains Denis. "A new format of standard generalised mark-up language (SGML) was used." Generalised means that the format can be used for any industry or application.

Mark-up means that content is given electronic tags to describe the data and text. Documentation content, of both ATA 100 and Spec 2100 standard, is categorised into elements that have attributes. Elements are items, such as task card title, task card sub-title, pre-task description and instructions, task instructions, P/N, aircraft serial number (S/N), pictures and diagrams, and cross-references to other manuals and warnings or cautions. Each piece of content in a document falls into one of several dozen elements or categories, so the element for each piece of content is identified by the type of tag that it has.

The documentation elements of the first versions of Spec 2100 would have been the same as the number of different content categories used in written and printed ATA 100 documents. The number of elements used in Spec 2100 increased as it evolved.

"There are also rules that the author of the content has to follow when first creating the content, so that it is correctly written," says Wayne Enis, director of sales engineering at Flatirons Solutions. "These rules are contained within a file called a document type definition (DTD). For example, the DTD states that a heading cannot be followed by another heading, and must also be followed by one of several types of content elements. Another rule is that within an element related to a maintenance task, there is only a description of a maintenance task and sub-tasks that follow. The DTD, therefore, stops the author writing incorrect content.

"Each element of documentation content also has attributes, and these have to be set up as business rules. For the element of illustrations, examples of attributes are the ATA chapter it relates to or its six-digit IPC reference number," continues Enis.

The number of characters used to describe the P/N is one of the rules of the

The A350 is the second commercial aircraft type to have its documenation published in S1000D standard. Version 4.0 of S1000D was initially used, but Airbus has already increased this to version 4.2.

DTD. Another business rule in the DTD is that a warning or caution is an element used on a task card, and the associated rule is that warnings and cautions always have a yellow background.

Elements also have interrelations with other elements. Attributes have special characteristics. All of these are taken into account when a computer programme 'reads and validates' the SGML datastream that is provided to the user. This process is called parsing.

The DTD specified is the first line of the content and data, and describes what the structure of a task card should be. The DTD is written in SGML, and is held in the M&E system or content management system (CMS) database. The airline needs to acquire the correct DTD, as well as the content, from the OEM. There is a need to check that the content is valid for the DTD version when a new revision, which is a piece or section of content, is issued by an OEM.

If the content is not correct, then the user's system will not use it correctly. Any revisions, upgrades or changes have to be parsed against the DTD to ensure that the content structure has not been violated.

"While SGML only includes the content, such as text, P/Ns and diagrams, a style sheet is needed to view the content on a screen, and another style sheet is required for a printer," continues Denis.

A style sheet for Spec 2100 content interprets the SGML content and decides how it looks. "The style sheet, known as a DSSSL file, has rules for how pieces of the content appear," says Enis. An example is whether the text appears as bold, italic or underlined.

"A printed paper ATA 100 document would be laid out by the person writing the page of the manual. This is not the case in Spec 2100 in SGML," continues Denis. "Information in the style sheet determines how the content appears on a screen or a page. This is a separate issue to the content and does not concern the document writer. The content can then be printed or rendered as a PDF.

"SGML, therefore, separates the content and its qualities from what determines how it looks when viewed," continues Denis. "It has to be managed this way, since a document writer at an OEM has no way of knowing what printer or screen a user at any airline customer or maintenance facility will use to print or view the document. SGML allows the content to be agnostic to the viewing and printing device."

A style sheet is programmed separately from the content authoring, and the style sheet is usually provided by a system vendor. An exception is when an airline uses an OEM's on-line portal for managing documentation.

iSpec 2200

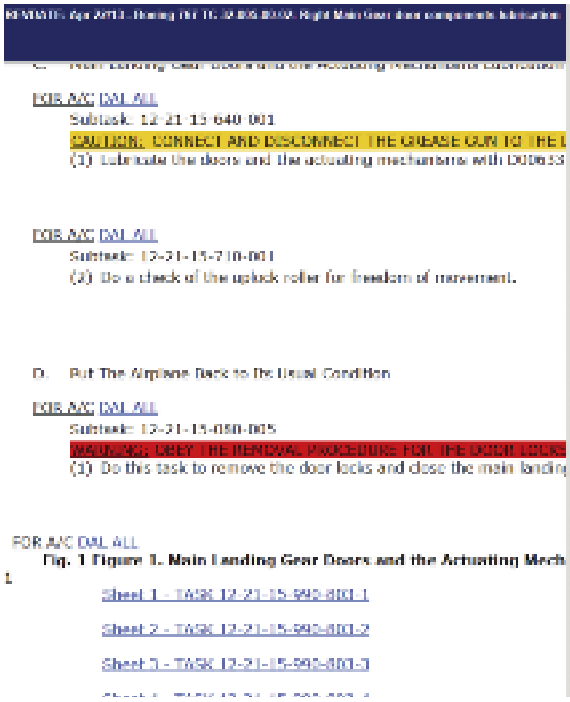
The content and data standard or specification of iSpec 2200 followed just a year or two after Spec 2100. Like ATA 100 and Spec 2100, iSpec 2200 provided an electronic version of page blocks of manuals. iSpec 2200 therefore also had the inverted tree structure of ATA 100 and Spec 2100, and had to be used by engineers and mechanics in the same way as printed manuals.

"The main issue with iSpec 2200 is that the internet and HTML pages came shortly after the introduction of Spec 2100," says Denis. "The iSpec 2200 standard was a natural evolution of Spec 2100. iSpec 2200 was set up to improve quality and expose a broader set of technical and functional concerns. The emphasis of the system was merge ATA 100 and Spec 2100 into a single specification, as well as allowing electronic interchange."

There were several differences between iSpec 2200 and Spec 2100. "One is that iSpec 2200 had broader elements and attributes," says Enis. "iSpec 2200 was more related to computers interpreting the content, and better definitions are required for computers to extract the information." The content provided in the iSpec 2200 standard was still written in SGML and required DTDs.

Another main intention of iSpec 2200 was that SGML would become the standard format, and would be agnostic between all types of IT system. iSpec 2200 was the adopted standard and specification for manuals and documents for the A320, A330, A340, A380, 737NG, 757, 767, 747, and 777, as well as several regional types that include the CRJ-700/-900/-1000.

"As the specifications evolved, and in particular with the introduction of iSpec2200, the richer functionality that was supported by the specification allowed a new mechanism to be introduced for electronic display of technical content," says Enis. "This led to development of an interaction electronic technical manual (IETM) software. This allowed publications to be displayed on a computer, and the user to navigate through them in a way that we are all familiar with nowadays via hyperlinks between different sections of a publication and between publications themselves. The hyperlinks between pages of manuals, such as one between a page in the AMM and a page in the IPC, are created by the content author. IETM, later replaced by IETP, is the software and electronic viewer that allows the user to navigate with the hyperlinks between pages. Without an IETM/IETP, SGML content would not look like a page of a manual to the user. The SGML content is, therefore, published to the IETP. As IETPs have developed, they provide a lot of value-added functionality, such as facilitating decision-making when performing troubleshooting procedures or graphical navigation through complex publications, like the AWM. IETPs need tens of thousands of man-hours (MH) to be developed, and few M&E systems have one."

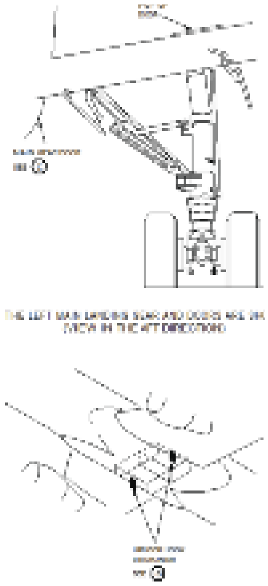

FOR A/C DAL ALL
Subtask: 12-21-15-640-001
CAUTION: CONNECT AND DISCONNECT THE GREASE GUN TO THE L
(1) Lubricate the doors and the actuating mechanisms with D00633

FOR A/C DAL ALL
Subtask: 12-21-15-710-001
(2) Do a check of the uplock roller for freedom of movement.

D. Put The Airplane Back to Its Usual Condition

FOR A/C DAL ALL
Subtask: 12-21-15-080-005
WARNING: OBEY THE REMOVAL PROCEDURE FOR THE DOOR LOCKS
(1) Do this task to remove the door locks and close the main landing

FOR A/C DAL ALL
Fig. 1 Figure 1. Main Landing Gear Doors and the Actuating Mech
Sheet 1 - TASK 12-21-15-990-801-1
Sheet 2 - TASK 12-21-15-990-801-2
Sheet 3 - TASK 12-21-15-990-801-3



Electronic and interactive task cards require information from various sources. This includes task card numbers from the AMM, P/Ns from the IPC, and illustrations from several other manuals. S1000D specification and XML language provide all this information on a single screen.

While an IETP is required to view SGML content, SGML content is also provided by OEMs with a PDF, so that it is clear what it should look like.

Trax has an IETP to view SGML content. Trax has the data in iSpec 2200 standard, and the user can view imported documents with links to cross references.

Because M&E systems do not have an IETP, airlines have to consider how to view and manage content provided by the OEMs for most aircraft types. One is to use the OEMs' on-line content management services.

A second is to acquire the publications in PDF, and just print them.

A third is to extract content in a simple text form and picture files and manage it in the M&E system.

The fourth is to use a CMS, interfaced with the M&E system, to manage the content separately from the maintenance and engineering functions.

The increased need to send data and content to portable screens and devices revealed the inherent weakness of the iSpec 2200 standard. "All content in SGML is regarded as characters," says Denis. "ASCII code converts characters to binary codes. The system does not distinguish between what is a letter, a digit, and a grammatical symbol, such as a bracket. This system is effectively one-dimensional and has limitations that include not being able to write mathematical formulae."

XML

"Extensible mark-up language (XML) was introduced to replace SGML. While XML is a sub-set of SGML, XML provides enhanced functionality that is not possible with content written in SGML. XML can be used for content that is written in the iSpec 2200 specification and standard, and XML was devised prior to iSpec 2200. The content for iSpec 2200 documentation is provided in SGML, however, and is delivered by the OEMs this way," says Denis.

While iSpec2200 SGML was largely restricted to textual content and paragraphs of ASCII characters, the adoption of XML allowed new data types to be defined and used within the technical content. "A date, for example, could be included in the technical content," says Enis. "As the system recognised it as an actual date, rather than just numbers, the date could be displayed according to regional or language variations. Knowing the type of data that is being represented in XML could also allow automated calculations, minimising the chance of error by authors or consumers of the content. A temperature authored as Celsius, for example, could automatically be converted to Fahrenheit. These powerful features can provide significant efficiency and quality benefits to both the content authors and consumers."

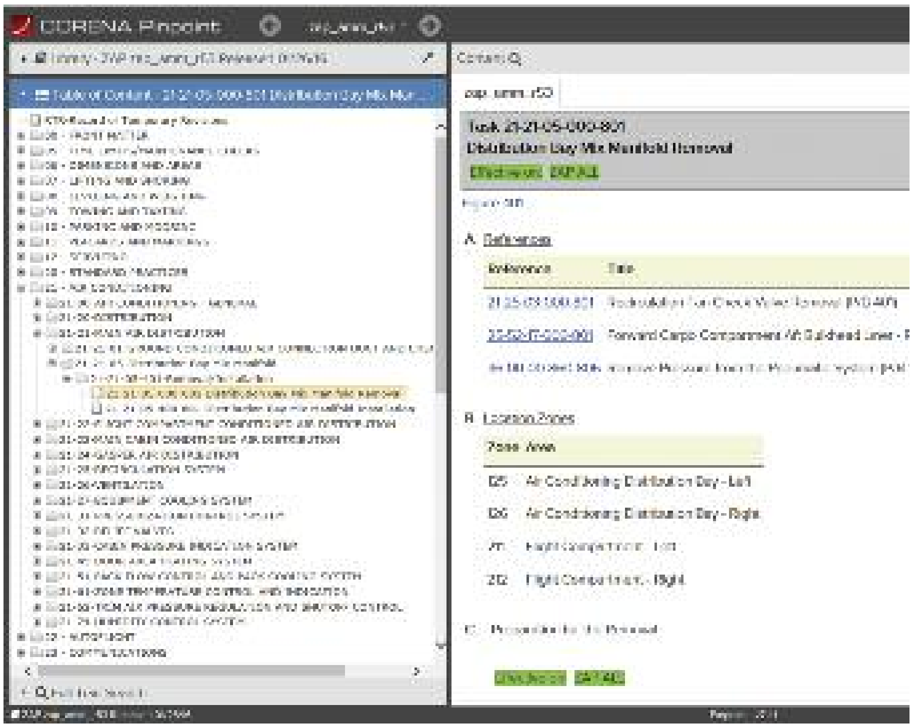
While content written in SGML used a DSSSL file as a style sheet, XML uses an XSLT file. It is the combination of the XML language and the XSLT that provides XML content with functions and calculations.

XML's improved functionality is in part due to the 'schema' that accompanies an XML file. A schema in XML has a similar, but broader, role as a DTD does to SGML. Whereas a DTD defines structural rules, such as what type of content an author can put directly after a title, or that a warning must come before the step to which it applies, a schema is a lot more powerful. A schema not only allows structural rules to be defined, but can also express constraints in relation to the XML content. An example of a constraint may be that within the AWM, when a wire is defined in content, the wire gauge is only permitted to be between an upper and lower value, or that the wire colour can only be one of a prescribed set of colours. This reduces the risk of error in the authoring process because only acceptable values can ever be included. As these rules are defined in a central place (the schema), any changes to the schema are automatically propagated across all documents that use the schema.

Another feature of XML is that it allows relationships between pieces of the content. An example of a relationship in XML content is the interchangeability of P/Ns when performing a maintenance task, that is, if one P/N is not available then alternative P/Ns can be used for the same position. SGML does not understand relationships, and there is no way it can have relationships because all the content is written as characters.

"When a page in the AMM describing a task is written in SGML, all P/Ns have to be listed on the page, and each one requires a hyperlink to the appropriate page in the IPC," continues Denis. "In turn, each page in the IPC needs a hyperlink to the relevant field in the module that lists available inventory in stores. If a mechanic chooses the first P/N and finds that it is not available in one store, the mechanic has to manually hyperlink back to the IPC and then to another store. This is because there are no relationships between pieces of the content. If the P/N is not available, the mechanic then has to hyperlink back to the AMM page to manually select a second P/N, and then manually go through the same steps again to determine if it is available in each of the parts stores. This is because there are no relationships between alternative P/Ns for the maintenance task.

"In contrast, for documents written in XML which has relationships between, in this example, the P/Ns and other content held in database fields, a mechanic can select a P/N on the AMM page and the system will indicate how many of each P/N listed are available in each store," continues Denis. "The dynamic nature of XML eliminates all the manual steps that have to be followed for content written in SGML, because it is possible to describe



An example of the functionality of S1000D documentaion is provided by Flatirons' Corena suite of CMS applications. The information provided includes a list of maintenance task card numbers, and details of maintenance task steps and other references.

the relationship between the content in database fields, which in this example hold the P/Ns and parts stores. This and many other types of relationships between pieces of content allow XML to have a variety of functions, and so improve efficiency for the user. The use of different data sets in addition to characters, and the ability to have relationships between pieces of content and to perform functions, means that rules and schemas may now be created that were not previously possible."

Another feature of content written in XML is that it is accompanied by meta data. "Meta data describes the main data," says Enis. "An example is what aircraft line number (L/N) the data belongs to or is applicable to. The main data could, for example, be a maintenance task number that only applies to particular L/Ns, and not others. The task may also only apply to aircraft that have had a modification performed. This is referred to as effectivity or applicability."

Some airlines and maintenance providers may decide to convert SGML content to XML. One reason for this is that XML is regarded as being easier to manage, and XML can use the XSLT to display the content.

Conversion can be done relatively easily, and is automatic when a CMS is used. There are specialists that provide conversion of SGML content into XML, Jana being an example.

"XML content is easier to view, and in particular it is easier to render the content, such as document pages or task cards, in HTML for displaying on computer screens," says Enis. "It is therefore preferable to convert SGML content to XML to have electronic task cards. One reason is that it is easier to incorporate lost of pieces of structure and content into a task card if it is in XML. Modern desktops and portable devices use HTML version 5, and additional formatting style information is required to display cards on these screens."

S1000D

S1000D has been chosen as a documentation standard for new generation aircraft. These include the 787, A350, and Bombardier CSeries.

The change from iSpec 2200 to S1000D is was made for several reasons. Unlike iSpec 2200, which is written in SGML, S1000D is written in XML. This means there are relationships between pieces of content, the content has a schema, and the content can have functions.

The main feature of S1000D is that content is no longer written as electronic versions of pages of books, as is the case with Spec 2100 and iSpec 2200. "Each element of a page of a manual is written as a data module (DM), or a file of information. For example, there will be DMs for titles, sub-titles, maintenance procedures, P/Ns, tools, and illustrations used in the creation of a page from the AMM. A publication module pulls the appropriate DMs so that the page can viewed on a screen.

"The philosophy is that an aircraft's manuals were written from scratch, and constructed differently to Spec 2100 and iSpec 2200," says Enis. "There are 15 types of DMs. One is a descriptive DM, which may be a paragraph of text that could be used in several pages throughout the set of engineering manuals. A procedural DM describes a series of steps, for example, in a maintenance task. There are also DMs for wiring data, parts data and information, and faults and fault codes. There will be hundreds or even thousands of files in each DM, such as all the different P/Ns used on the aircraft in the parts DM. Two other categories for DMs are repair schemas and modifications, airworthiness directives, service bulletins, and EOs.

"The content in S1000D standard, and written in XML, will also have meta data," continues Enis. "Meta data describes the other data. An example is which particular aircraft L/Ns or P/N a maintenance task is applicable to. This, therefore, gives S1000D content improved functionality, since the viewer will only see a maintenance task card that is relevant to the aircraft on which they are working."

Writing content in S1000D standard starts with writing all the different DMs, that is, all the different titles of every task card in the AMM, and each title are deposited in an individual field in the title's DM. Similarly, procedural steps for all the tasks in the AMM would be written, and held in separate fields in the procedural DM. Each P/N used on the aircraft would be held in separate fields in the parts data module.

A publication module first assembles all the relevant pieces of content (DMs) of a page or document, and validates the links between them. A formatting transformation then forms the content on a screen. This is the style sheet, so the XSLT is required to lay out and format the content. When an airline subscribes to S1000D content from an OEM, it does not get the formatting transformations (programmes). It can acquire them by using the OEM's on-line documentation service, using a CMS to do the formatting, or having an M&E system with the capability to do the formatting.

Some of the meta data that is associated with the XML data is interpreted to build the complete page.

The S1000D standard, therefore, focuses less on the inverted tree structure of the ATA system, and more on the information and pieces of content in a manual that come together in building the aircraft from the parts and configuration database. "One particular advantage is that each piece of content can be used in several places," says Enis.

"An example is where a P/N is used on 20 different task cards. The P/N is written once and put into the parts DM. The publication module and formatting transformation for each of the 20 task cards then requests the P/N whenever one of the task cards is viewed. The further advantage of this is that, if the P/N is changed, the author only has to change the P/N once in the DM, and the new P/N will be requested when any one of the 20 task cards is viewed. The advantage of using a schema in XML content is also apparent here. In the case of the changing the wiring's gauge limits, the change only has to be edited once in the relevant field of the wiring DM. Any page in the AWM or other manual will use the correct information from then onwards."

The use of XML as an intelligent language also means that the system will only show the user relevant information. There may be steps for a maintenance task that is relevant to a pre-modified aircraft, but different steps for an aircraft that has had the modification implemented. The use of XML will only show the set of appropriate maintenance steps, according to the aircraft's modification status, rather than both sets of steps and leaving the user to decide which are the appropriate steps to follow. This is possible because of the meta data and the IETP.

"An example of XML's intelligence is testing the pressure of wheel brakes, where the remaining steps depend on whether the brake is functioning correctly," says Enis.

The structure and writing philosophy of S1000D content does not use the inverted tree structure of Spec 2100 and iSpec 2200.

Although the same codes are used for AMM tasks and for locating P/Ns in the IPC, S1000D models the way the aircraft is constructed. Instead of a mechanic navigating up and down the inverted tree structure between, for example, ATA chapters 28 for fuel and 57 for wings and fuel tanks, all the content relating to adjacent related items, assemblies, and components is in the same area.

The relevant document and manual content, in this example of the wing, wing fuel tank, and fuel system components, is held as DMs. The DM structure of S1000D and the business rules provide almost everything that is ever needed to view a part or section of the aircraft in one place, or on a screen.

The documents no longer exist in the same form as the traditional manuals, such as the AMM and IPC. In the case of Airbus aircraft, the manuals are called Information Sets, and each set of information is set up as DMs. An example is a Fault Isolation information sets. All the information for each section of the aircraft is kept in a single place, and includes thousands of files. These are maintenance tasks, repairs, modifications, and the construction of the aircraft section.

The information for a specific section of the aircraft is found by the user starting with an ATA code. These link to relevant DMs, because each one has a reference called a CMC.

S1000D/XML functionality

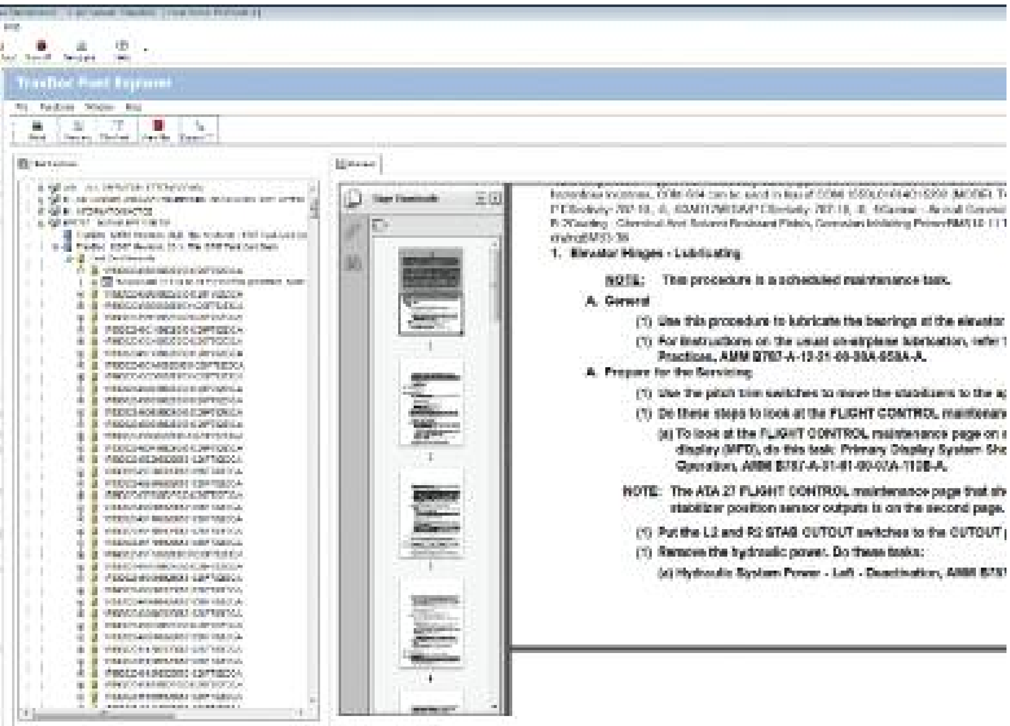
Overall, content written in S1000D standard and XML language has several levels of functionality that content in Spec 2100 and iSpec 2200 does not have.

The main issue is that, because XML uses several data types, content in S1000D has enhanced functionality that includes the ability to make calculations and use formulae, create relationships between pieces of content, and have constraints and rules because of the schema in XML. The use of meta data in XML combined with an XSLT also means that documents can have effectivity or applicability and other features built in.

The structure of S1000D means that revisions and updates to content can be performed on a cascading and automatic basis, and completed quickly.

Database requirements

An IT system's database structure affects its ability to operate with content in S1000D standard and written in XML, and to make full use of its functionality,



Trax is developing its system to be able to handle native S1000D content. Trax's Oracle database will be able to handle multiple data types, and it will have formulae, have relationships between data, and manage the DM structure of S1000D.

or operate with content in Spec 2100 or iSpec 2200 and written in SGML.

"M&E systems are designed to maintain transactional data, and perform M&E management functions," says Denis. "Transactional recordings include removal of a serial number (S/N), and installation of a replacement. An example of an M&E function is that the system will inform the user when each task or group of tasks are coming due as calendar time passes and the aircraft accumulates FH and FC. This then leads to the generation of work packs.

"M&E systems have relational databases which are really only designed to hold aircraft and transactional data, and perform these transactional functions," continues Denis.

There are two types of relational databases: the SQL Server, and an Oracle database. It should be emphasised that the relational database, and its functionality, should not be confused with the relationships that are possible between pieces of data written in XML.

"While M&E system databases are designed to hold aircraft-related data, they are not primarily designed to manage and update text files, pictures and other content," continues Denis. "Moreover, an M&E system's SQL database is incapable of having the relationships between elements and attributes, and the structure-enforcing schema that XML has."

It is possible to put S1000D/XML content into the database of a M&E system, but most of its functionality will be lost.

For the text content of manuals, such as AMM pages, it is possible to take a Word or text file from the AMM and put each one into a field of a relational database on an M&E system. There will, therefore, be thousands of fields in the database with Word or text files. The M&E system can produce the required text file whenever a user needs it, such as a mechanic performing a task or when the maintenance check planner is grouping tasks for a forthcoming check.

The first problem with this system is that each time the OEM issues an update or revision, each text or Word file has to be manually examined, and have edits applied if appropriate. The edited Word file is then saved back to the M&E system's relational database. This manual process of implementing revisions and updates consumes excessive MH, and requires months to implement a revision.

"It is also possible to put picture files into a field of a relational database of an M&E system, but this is not ideal," says Denis. "One particular reason is implementation of revisions and updates. An example is when a P/N that is used on a large number of task cards is changed. The picture file on each of these task cards would have to be changed manually when a revision is issued."

Trax, however, uses an Oracle database. Oracle added the picture storage function in 2008, with each picture field capable of holding up to 4GB of data. This has since been modified to allow an unlimited amount of data in each field.

"A second problem with using an M&E system for S1000D/XML content is that the system can only understand characters, which is only seen with content written in SGML," says Denis. "

"Although an M&E system database can handle different types of data, it focuses on text and will either lose meta data or not understand it when content is converted from native S1000D/XML. The content's ability to perform calculations, use formulae, and have functions, is therefore lost. The schema that provides XML content with all the information for data types, attributes and relationships, and, therefore, the ability to have functions and constraints, is also lost. A further issue is that most M&E systems do not have an IETP to view the content on screen, so a user must either maintain documentation on an OEM's on-line portal, or accept the documents as PDF files. These are the main reasons why a M&E system is not capable of providing the full functionality of S1000D content written in XML."

A CMS operates differently to a M&E system. A CMS does not have a relational database, and instead has a document base. A CMS has a common source database (CSDB), which is needed to manage S1000D content. A CSDB has a different construction to an SQL database, and a CSDB can support an XML schema.

A CSDB will store S1000D content as DMs, illustrations, a list of all DMs, and publication modules.

M&E systems' functions contrast with CMS functions of storing and managing the content of DMs, which is mainly text, picture and P/N files. Document management also involves regularly updating and revising them, which needs to be an automated process. This is enhanced for content written to S1000D standard because of its DM structure. "A CMS also makes the reconciliation of revisions and updates faster and easier than with a M&E system," says Enis.

A main function of a CMS is to collect the DMs and assemble them for viewing. The DMs are assembled by the publication module and formatting transformation, which renders them relative to what platform they will be displayed on.

In addition, S1000D content, written in XML, will maintain its full functionality when held on a CMS document database. This is because the content has elements, several attributes for each element, relationships established between pieces of the content and data, and meta data. These are all maintained on a CMS's CSDB document database.

Besides the structural differences of

the databases in M&E and CMS systems, the functionalities of the two systems are also designed differently. While a M&E system will record MH of labour against a particular task, aircraft and a mechanic; a CMS has not functionality or requirement to capture and record this sort of information. The CMS system only provides the documentation relating to a piece of the aircraft, and all the information relating to it.

Re-designed M&E system

It is possible to re-design an M&E system's database to handle native S1000D content, written in XML, to a level to preserve its full functionality, but this is a large and expensive task. "It is a massive undertaking, but is still likely to be more economic than using a CMS to manage content, and interfacing this with a M&E system," says Denis. "Re-designing the relational database in an M&E system means that every element would have to be re-structured. That is, the P/N element in S1000D is called a PN element. The fields for P/Ns in M&E systems may be called P/N or P_Number, for example. Every single P/N field would, therefore, have to be re-named.

"The real difference, however, is that there are a huge number of attributes and relationships in S1000D data," continues Denis. "All of these would have to be re-written and re-created manually on an M&E system relational database. What makes this even more difficult to carry out on an M&E system is that there are three different versions of S1000D for the three aircraft types that use the specification. Each version of S1000D has different and additional attributes and relationships, each set of which has to be created in the database for each of the three aircraft types operated."

Further complications arise when an OEM, such as Boeing, initially uses an early S1000D version like 3.0 for the 787, and then later decides to either upgrade it to the same functionality as 4.0 or 4.2 as used for the A350, and just improves to a version with more elements, attributes and relationships. All these changes then have to be replicated in the M&E system database.

For an M&E system to operate with native S1000D/XML, it needs a separate document database to the aircraft transactional database. The separate database could have an IETP designed and developed to view content. "The cost of this development, and time taken is prohibitive, however, when a CMS already has the functionality to handle S1000D/XML content," says Denis.

The current Microsoft SQL and Oracle databases do, however, have XML extensions for saving XML data. Reed says that the Trax now has extensions for saving XML data.

Trax is now developing its system, which has an Oracle database, to handle native S1000D/XML content for the A350 for one of its customers. The database will be able to handle multiple data types, and it is Trax's future scope to have functionality for calculations and formulae in S1000D content. Trax says it will also maintain the relationships between pieces of data and will also hold meta data, which will include functions such as effectivity filtering and applicability. The database will also manage the DM structure, and so content will be automatically updated.

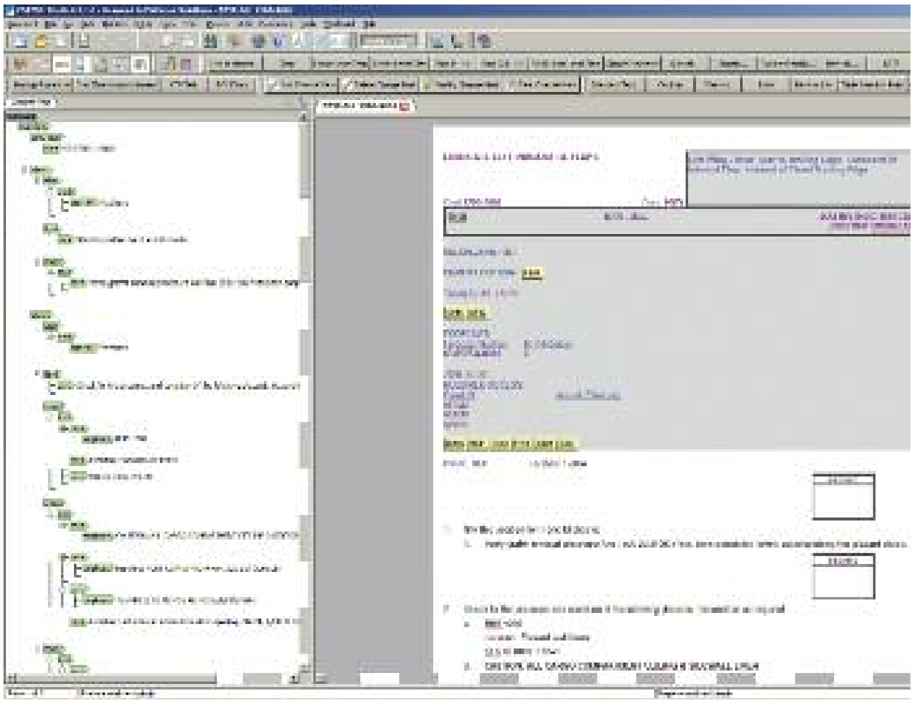
Options for airlines

There are several options for airlines that operate the 787, A350, and CSeries, and so have documentation supplied as S1000D standard and written in XML.

The first and simple solution is to convert native S1000D documentation into an extracted form of text and picture content that uses characters. An airline has to take raw content from the OEMs, and make its own edits and job cards in Word files, and apply layout. This system is basic, and one weakness is that it can take up to three months to implement a revision.

This system provides content that is no longer intelligent and loses all of its functionality. "It will instead look like another version of electronic documentation, similar to Spec 2100 or

The high expense and time-consuming process of converting a M&E system's database to be able to handle S1000D content means that many feel the best approach to handling documentation for new generation aircraft is to interface an M&E system with a CMS.



iSpec 2200," says Enis. "Of all the manuals provided, only the AMM and IPC need to be converted for loading onto the M&E system. The remaining seven or eight other manuals, such as the AWM and troubleshooting manual (TSM), can be viewed via an OEM's on-line portal. In fact, the AMM and IPC will still have to be accessed on the OEM's portal. This is because the airline still needs to have access to the issued manuals.

One example of this system is Commsoft importing XML data from Boeing's on-line portal for a 787 operator. The data is re-formatted from XML to text prior to being transferred into OASES, and is held in its Oracle database. Paper task cards can be printed from the content after being formed from the pieces of data. Content has to be re-imported after being revised by Boeing.

Similarly, Trax imports data as XML for one of its customers which also operates the 787. The extracted files are not native S1000D, but basic text files that do not have DM structure.

Such a conversion might be an acceptable solution for an airline operating a small fleet. It is likely to be expensive, however. Converting the AMM and IPC is intricate and costly, but other information will still have to be set up in the M&E system's database as fields and then have links created between them and the text. A script is needed for the conversion, and this will have to be re-written if the OEM later updates the version of S1000D. Boeing, for example, started with S1000D version 3.0 and is now using 3.2.

"Although this option may be acceptable for an airline because it avoids the investment in a CMS, there is still a lot of conversion work to do," says Enis. "The A350 has eight to nine giga bytes of data for its DMs. This gets uploaded to an operator's system quarterly, and is a huge amount compared to the data sets for an A330, for example, which is provided in iSpec 2200. The IPC is the biggest publication, and the illustrations are provided in a special format called computer graphics metafile (CGM). A CGM file has links built in that give information about the picture. These links would be preserved when converted from S1000D if the files are correctly managed. Even though conversion to a simpler format may be possible, S1000D is becoming even more complicated, since Airbus is starting to publish 3-D images.

Another drawback to this system is that documents and task cards on the M&E system have to be used manually, because the applicability or effectivity of tasks to particular L/Ns have been lost. Task cards have to be printed and read by mechanics, and decisions with respect to task applicability made manually.

A second option for airlines is to use the OEMs' portals for content and documentation management, and then use the existing M&E system for maintenance and engineering functions.

The documents on an OEM's portal would be read separately and used independently of the M&E system.

A third option is to use a CMS vendor to provide documentation and content management support. Flatirons provides three levels of support for airlines. One service level is to render content provided by the OEM without any editing or changes to the content. This will include job cards and manuals.

A second service level is to use Flatirons remotely. Content is provided as raw data from one of the OEMs, and then authored, edited and managed in Flatirons by the airline.

In addition to new generation aircraft types, an airline's other fleet types have to be considered. There are four main types of content management: Spec 2100 content for older generation types; Spec 2200 content for current generation aircraft in SGML; Spec 2200 content that has been upgraded to XML; and S1000D content for new generation aircraft types. This may result in three or four systems being required. A CMS vendor would need two versions of the same system to manage two new generation aircraft types that have content in two versions of the S1000D specification.

The fourth option is therefore for an airline or maintenance provider to interface an M&E system with a CMS.

While there is some overlap between the functionalities of M&E and CMS systems, the two types are mainly different. A CMS maintains P/Ns, revised and authored documents, links between content elements, and a database of all document data. Use of a CMS avoids all the lengthy and expensive conversion of S1000D data into a useable form if just using an M&E system. Not only does a CMS avoid this, but many can also handle different versions of S1000D. A CMS only provides information relating to maintenance requirements and tasks, but it does not drive business transactions as a M&E system does. Moreover, most M&E systems cannot view S1000D content on their own, and this is because it is pure XML. The use of XML is increasing, and is being followed to become completely electronic.

Swiss Aviation software took the option of interfacing with a CMS a stage further by acquiring Open Connect, which offered its eDoc CMS product. The result is that Swiss Aviation Software's AMOS M&E product is interfaced with a CMS. Swiss Aviation Software supports the 4.0, 4.0.1, 4.1 and 4.2 versions of S1000D, and has tested data sets for the A350 and CSeries that operate with these versions. It does not yet have a complete dataset for the 787.

Other options for CMS systems include Aerosoft's DigiDOC, IDMR's InForm system, WebManuals, and Flatirons Solutions's Corena Suite of CMS products. AC