ATA Graphics Working Group work: From CGM to structured graphics

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The technical documentation

Technical documentation exchanged between the aircraft, engine and equipment manufacturers and the airlines has specific characteristics. It is varied and covers several domains - aircraft operation and maintenance and also training. It contains different types of information: maintenance procedures, operational procedures, wiring diagrams, spares lists, etc. This documentation is also characterised by large quantities, numerous customisations, short revision cycles and a long life. What is more, it needs a high level of standardisation as the airlines wish to apply the same processing to the different types of technical documentation that they receive from different sources (different aircraft, engine and equipment manufacturers). All these characteristics make processing more complex and weighty.

Airlines process the documents they receive. They make minor or major changes, manage revisions, distribute them and consult them. With paper, certain limits are reached rapidly because of the large quantities, the short revision cycles, the duplication of information in the different manuals and information access times that are too long.

For all these reasons there has been a migration to electronic documentation. With this evolution, large quantities and short revision cycles can be managed. The documentary engineering that implements methodologies for the modelling, processing and handling of an organised set of composite and accessible information offers new solutions. Duplication of information is avoided, documents can be modified more efficiently by the airlines. The electronic consultation of a structured documentation offers more intelligent consultation modes with shorter access times.

But the migration to electronic documentation has increased standardisation constraints. The use of standards, independent from suppliers and platforms is necessary to guarantee that the technical documents now exchanged on electronic media are interchangeable and can be processed in an identical manner by the airlines, whatever their origin.

The ATA/AIA standards

ATA/AIA[1] is an international organisation grouping airlines, aircraft, engine and equipment manufacturers. This organisation ensures that the technical documentation corresponds to airline needs and in particular standardisation needs. It standardises the technical documentation sent by the aircraft, engine and equipment manufacturers to the airlines. It also ensures that the work performed is cost-effective.

ATA publishes different specifications standardising the technical documentation - ATA100, ATA104, ... and ATA 2100. This latter document defines the specifications for electronic data interchange. It is composed of a set of specifications, each one covering the different standards and techniques used to define the electronic data. In particular, these specifications define the SGML[2] DTDs (Document Type Definition) and the graphic applications profiles.

The ATA 2100 Graphics Working Group is in charge of standardising the exchange specifications for electronic graphics sent by the aircraft, engine and equipment manufacturers to the airlines. The group is working on two types of graphics: current graphics (TIFF [3]& CCITT[4] group IV and CGM[5]) and structured graphics, called Intelligent Graphics. These more powerful graphics give access to the new possibilities offered by electronic consultation and publishing.

Concerning current graphics, the Graphics Working Group has defined two application profiles: one TIFF & CCITT group IV, and one CGM application profile. These two profiles are based on existing standards, TIFF, CCITT group IV and CGM. TIFF graphics, including CCITT group IV raster images are widely used today. In general, there are no problems processing these graphics but their performance is limited. Files are of large size and their modification by the

[1] ATA: Air Transport Association
[2] SGML: Standard Generalized Markup Language
[3] TIFF :Tagged Image Format File
[4] CCITT : Comité Consultatif International Télégraphique et Téléphonique
[5] CGM : Computer Graphics Metafile

airlines is very difficult. Their use within the framework of electronic consultation gives poor results.

It is for this reason that the Graphics Working Group recommends the use of the CGM standard for the exchange of 2D technical graphics.

The ATA application profile

On the contrary to TIFF, CGM is an international standard. It standardises a metalanguage of 2D static graphic descriptions, independent of platforms and software. Re-issued in 1992, it now proposes a complete set of powerful functionalities via three upwardly compatible CGM versions. Version 1 corresponds to the old standard, CGM: 87 with a few corrections, Two other versions have been added, versions 2 and 3. Version 3 is the most important version. It has powerful functionalities, in particular symbol libraries, and the possibility of including raster in the CGM metafiles. The symbol libraries, avoiding the duplication of information, are particularly interesting in a context of large quantities of documentation. The inclusion of raster is useful in the technical documentation domain, where numerous graphics created in raster format are still used.

To apply the CGM standard, a first indispensable step consists in choosing an existing CGM application profile or defining your own application profile if the existing ones do not correspond to your needs. **Producing metafiles without defining the application profile used does not make sense**. If we compare CGM to SGML, the application profile can be compared with the DTD. It is not possible in SGML to produce an SGML instance without defining the DTD used. It is the same in CGM with the application profile.

The CGM standard is vast and sometimes complex. It would be expensive and very difficult to develop reliable tools implementing the totality of the CGM standard, as it is theoretical and does not set any physical limits on the CGM metafiles generated. This is the reason why application profiles have been defined. They permit the specification of a subset of the standard adapted to the needs of a specific domain. So, the CGM tools can be tested. The application profile sets limits that make it possible to test that the tool implements the specifications defined by the application profile. For example, while it is not possible to test that a tool implements an infinity of fonts, it is possible for a finite number of standardised fonts.

In addition, they define some semantic included in the, such as the name of the publication, the name of the sender or the customer and specify the behaviour of tools not covered in the standard.

Different industrial sectors have developed their profiles - petrol research with the PIP profile, CALS with the CALS profile applied to the military sector and ATA with the ATA profile, applied to the civil aviation sector.

The ATA application profile is included in ATA specification 2100 chapter 3.3.2 Graphics Exchange. This profile contains the latest updates to the CGM standard and complies with the CGM standard ISO 8632: 92. It includes the three CGM version levels defined by ISO. Specified according to the proformat method, defined by amendment 1 of the CGM standard, it is very easy to read.

The GWG is also carrying out large scale maintenance work on this profile. Work to harmonise with the CALS profile is being performed as these two profiles cover similar application domains and the multiplication of application profiles generates supplementary costs.

In addition, when interchangeability difficulties are noted, improvements are made to the ATA application profile. So, standard fonts have been adopted to improve text interchangeability. New technical change possibilities, compatible with the existing application profile are also integrated. For example, the JPEG standard that enables photos to be coded has been integrated in the ATA application profile.

Today, ATA profile maintenance work mainly concerns version 3 elements. Version 1 of this profile is stable as it is widely implemented. Version 3 on the other hand, not greatly implemented at present, is liable to evolve. Corrections or precisions will no doubt be made when it is more widely implemented. For example, details have already been added on the behaviour of symbols via the escape entity.

Certification of ATA application profile CGM tools

CGM implementations reliability

CGM implementation meets difficulties. The exchange of CGM metafiles between different tools raises problems of reliability. The graphics interpreted by different tools have different aspects. (Cf. the examples below that show problems often encountered).

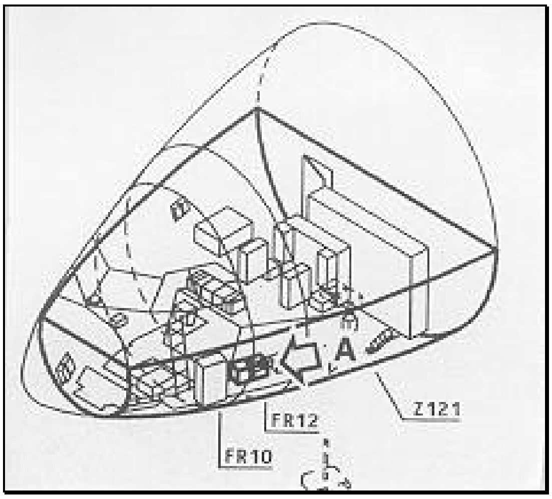

Figure 1 : The original graphic generated by tool X

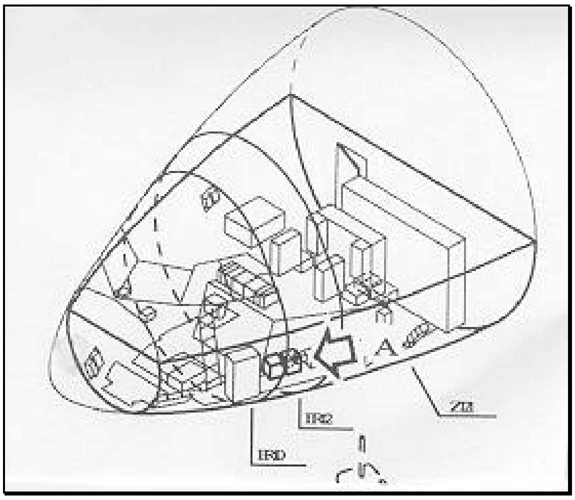

Figure 2 : Interpretation by toolY

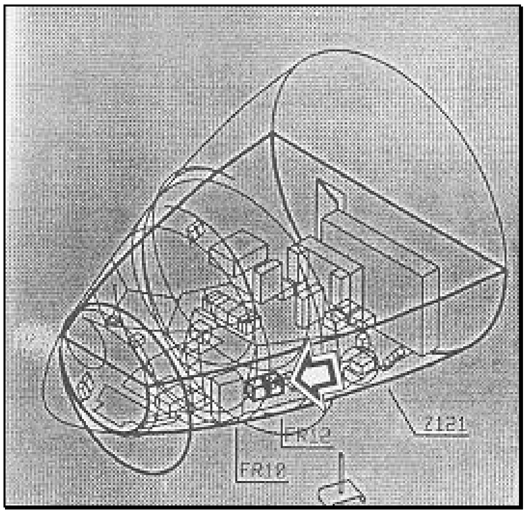

Figure 3 : Interpretation by tool Z

CGM is not to blame for the problems encountered. These are due to incorrect, or, rather, incomplete implementation of the standard by the tools. A study of the CGM market shows that certain graphics software vendors use CGM as a sales argument. The customers buy the tool then the vendor convinces them to use a proprietary format also implemented by the tool. In fact, the CGM market is not yet very widespread. Many developers are waiting to make the investments needed to obtain tools implementing CGM profiles correctly. This lack of investment explains the current state of most CGM tools and CGM exchange problems.

Among the many «CGM» tools, there are however some software developers that have already invested in CGM. «How can we recognise these tools and make sure of their reliability?» A first test consists in making sure that what the tool implements is not the CGM standard but one or more CGM application profiles. But this test is not sufficient. To detect correct tools, companies that invest in the CGM adventure carry out tool tests. The production of tests to ensure tool reliability requires time and an expert knowledge of CGM. In addition, the work carried out by each industrial company is redundant and expensive.

Tool certification by an independent organisation

To detect reliable CGM tools and ensure their total reliability there is a solution, **the certification of tools by an independent organisation** The ATA GWG is exploring this possibility with NIST - the US National Institute of Standards and Technology. In co-operation, these two organisations are developing a tool certification service in compliance with the ATA application profile. Certification will be performed when requested by the software vendor implementing the ATA application profile. The vendor will pay the cost of certification and in exchange ATA will recommend the purchase of certified tools.

To understand how CGM tools are certified, we must study the CGM model (cf.the graphic "The CGM model"). The CGM standard specifies the CGM metafiles and two functions; the generation of CGM metafiles and the interpretation of CGM metafiles. Generation is the function that creates the CGM metafiles and interpretation is the function that reads them. The certification of CGM tools is carried out on these two functions. A first certification tests the CGM application profile interpretation function. It is sufficient to certify CGM tools that only use this function, such as viewers. There is a second certification that tests the generation function. To fully certify a CGM editor, both functions must be certified.

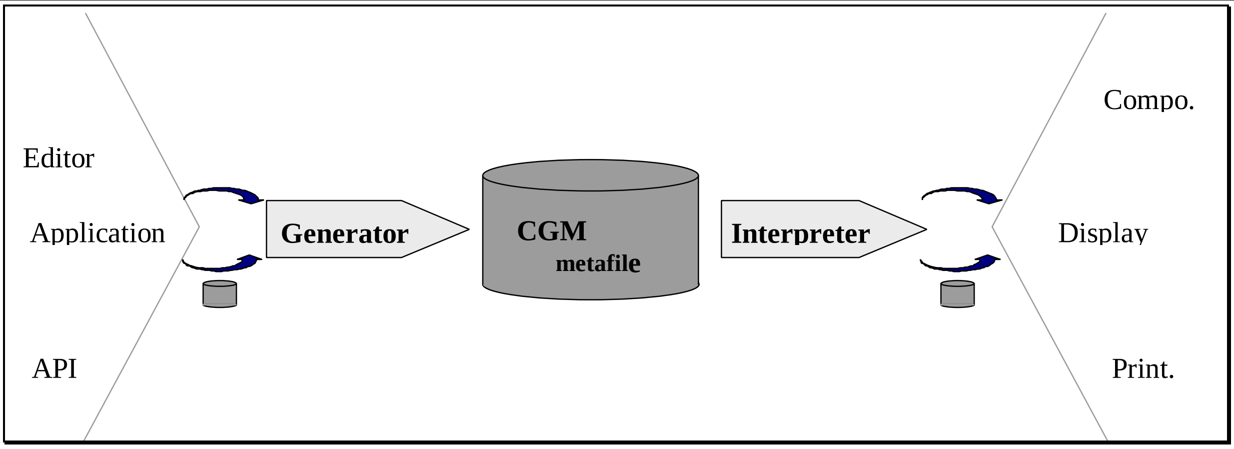

Figure 4 : The CGM model

Certification of CGM ATA profile interpreters is now available. It has taken the NIST CGM specialists five months to define the interpreter test methodology, not counting the production of a test set. The NIST now counts three days to test a tool on a given platform. Certification of a CGM interpreter by NIST costs $5000 Today, nineteen tools have been validated, under the pressure of the users. The list of these tools is available on the NIST web site. Not only has this certification enabled the identification of good quality tools, it has also permitted the correction of some errors on these tools.

Certification of CGM ATA profile generators is not yet ready. It is more complex than the certification of interpreters as each generator is a specific case requiring specific tests. Development of this certification is proving harder than expected. Eighteen months were scheduled to develop this methodology, but given the difficulties encountered, the NIST has been forced to stop development to redefine the basic principles of this methodology. This test should be available by the end of 1997. Certification of a CGM generator has been estimated at three weeks work. When this certification becomes available, companies will be able to select reliable CGM tools implementing the ATA profile, without large-scale investment.

At present, tool certification is the most efficient solution to ensure tool reliability. It is difficult to appreciate the value of this work for companies that produce or will produce technical documentation. It will permit substantial gains in time and money. This work is also important for CGM standardisation as the future of the CGM standard will only be assured on one condition - obtaining reliable tools permitting correct exchanges.

Definition of a new generation of graphics

The ATA Graphics Working Group is working on a second generation of graphics, structured and interactive, called "Intelligent Graphics". The result of this work is specified in ATA specification 2100 chapter "Intelligent Graphics Requirements" and chapter "Intelligent Graphics Exchange".

This new generation of graphics is based on a concept, the "Intelligent Graphics" concept. This concept, developed by the ATA Graphics Working Group, applies to a wider domain than simple 2D graphics. It is independent from the type of data to which it applies. Current work in this field concerns 2D graphics as these data are the only standardised data handled by technologies sufficiently mature to be industrialised. But this concept also applies to 3D graphics and on a wider scale to hypermedia.

The basic principle: structured and "intelligent" information

To understand the basic principle of intelligent graphics, the limits of a conventional electronic graphic need be explained. The term "intelligent graphic" only takes on its real meaning within a computer context.

From the computer's point of view, conventional graphics are simple "black boxes" that it does not understand. The only information managed by the machine is the name of the file. This name is often coded to include information concerning the illustration and mainly, information for illustration management.

For example, AIRBUS illustrations coding specifies data such as the aircraft type, the manual, the figure number, the revision issue, etc. But this information is limited in number and size. It can only be interpreted if the coding rules are known. Furthermore, interpretation is not immediate.

If we now look at the contents of a graphic, it is seen by the machine as a simple matrix of dots if it is a raster graphic, or a sequence of graphic entities, lines, circles, texts if it is a vectorial graphic. If we want to know the meaning of these dots or graphic entities, human intervention is necessary to view the graphic and interpret it. For example, only a human being can specify that it is the description of a wiper arm, specifying its location, and its different constituent parts. The contents of a conventional graphic have no meaning for the machine.

On the contrary, an "intelligent graphic" describes information that can be understood by the machine. It is this ability to understand, newly introduced into the machine, that is qualified by the word "intelligent". This intelligence is obtained by the structuring of the graphic into logical entities called 'graphical objects".

The complete graphic is a logical entity, for example, a description of the different parts composing a given equipment. This entity is decomposed into logical objects, representing, for example an equipment item or a detailed view of a sub-assembly. Each of these objects can also be decomposed as many times as necessary into other logical objects. An item of equipment, for example, will be decomposed into a set of detail parts or sub-assemblies. The sub-assemblies can then be decomposed into detail parts.

Each logical entity consists of a graphical representation with an associated semantic. Equipment, for example, can be described by the following information: the name of the equipment, the ATA reference, the effectivity, the date of revision of this equipment for this document unit.

Let us take an example. This graphic, that has become intelligent, will be interpreted by the machine as a logical entity describing the equipment "wiper arm" of a certain ATA, effective for all the A340s of a certain airline. The machine will also be able to specify that this graphic is composed of:

- a phantom presenting the location of the two wipers. This phantom will itself be composed of two items identified by two particular. These items are located between two particular frames and are accessed via a particular door .
- a detailed view of the wiper arm assembly that is composed of the following parts: a wiper arm, a splined shaft, a screw and a blade. This equipment is effective for all the aircraft of the manual consulted.

The evolution of the conventional graphic to the intelligent graphic can be compared to the evolution from conventional text to SGML. To enable the intelligence of the text to be interpreted by the machine, SGML has modelled the logical elements of the text and the document structure. In this way, texts and graphics are obtained whose intelligence is electronically made accessible to computer programs and applications.

The new functionalities offered by this concept

This concept defines more powerful graphics, which allow the use of the new possibilities offered by electronic consultation and electronic production. The Graphics Working Group has defined a set of functionalities that can be used within the framework of electronic consultation. This study of functionalities has been limited to electronic consultation requirements, in itself a vast domain. No study has been carried out on possible functionalities to optimise graphics production, even if this concept also gives powerful possibilities for graphics production. But graphics production is outside the scope of ATA GWG that specifies exchange standards.

It will enable an evolution from a simple "page turning" display that simulates consultation of a paper document on the screen, to a real electronic consultation using the full potential of electronic consultation. The graphics will evolve from end data that can only be visualised statically to interactive data that can be interrogated, changing from a dead data status to a living data status.

The Graphics working group has identified four types of requirements:

Navigation functionality

Navigation is the most important and the most urgent requirement in electronic consultation terms. It enables a more rapid retrieval of information and non-sequential consultation of the documentation. This navigation can be performed in different ways:

- Navigate from one graphic to another: e.g. get to an Illustrated Parts Catalog graphic from an Aircraft Maintenance Manual graphic or get the wiring diagram associated with a system schematic.
- Navigate within a graphic: e.g. get the detailed view of a sub-assembly from the general view.
- Navigate from a graphic to the text: e.g. get the nomenclature of a part by selecting the part in an Illustrated Part Catalog graphic or navigate from the Trouble Shooting Manual to the Aircraft Schematic Manual, and then from the Aircraft Schematic Manual to the aircraft schematic.

To be efficient, graphic navigation must be implemented in parallel with navigation in the textual parts. Navigation on text or on graphics only is not very user-friendly. In addition, graphics make reference to texts and texts also make reference to graphical objects.

Query functionality

This functionality enables queries to be made to select graphics. This selection is made on information contained in the graphic.

If we make a query on all the information concerning the wiper arm, it will be possible to select all the graphics that reference a certain FIN (Functional Item Number). If the operator wants to know all the systems that can be accessed via a certain access door, he can select all the graphics containing this access door. If the operator wants to know all the systems in a given zone, he can make a query selecting all the graphics concerning this zone.

To implement this functionality, it is necessary to identify all the information on which the queries will be performed and make sure that this information will be present and modelled in the intelligent graphics.

Data extraction functionality

This functionality will permit access to non-graphic information which is or is not part of the visible illustration, but associated with a graphic or graphical object, e.g. the designation or P/N of a component or a table giving the different pressures possible according to the type of part used.

Today, all the information included in the graphic is part of the visible illustration. With structured graphics, more information will be included within graphics. The graphical objects will be described by information, for example the designation of an item of equipment, its part number. This information, which may or may not be part of the visible illustrations, could be extracted to be visible or to be pasted in another document. For example, we could imagine that the Illustrated Parts Catalog (IPC) is only a set of graphics. The nomenclature will be automatically extracted with the information included in each graphical object.

Analysis functionality

This functionality will be used within the framework of test and trouble shooting. It will permit the dynamic creation of graphics according to actions or data input by the user, for example, the dynamic creation of a performance curve in function of the value entered by the user. It will also permit the animation of hydraulic, pneumatic or electrical systems. The user could, for example, act on an electrical relay to animate an electrical circuit, or enter a certain pressure value to animate a pneumatic circuit.

Intelligent graphics will only provide the input data necessary for analysis and simulation. Software will manage the dynamic creation of the graphic, or the simulation itself.

The requirements of intelligent graphics and the functionalities of intelligent graphics are frozen. On the basis of these requirements, the modelling of intelligent graphics is now developed.

Structured Graphics Standards

The Graphics Working Group today standardises the exchange of these graphics. As the exchange constraints are the same as for CGM graphics, structured graphics will only be used if they are interchangeable. This is the reason why the Intelligent Graphics specified by ATA is based on standards, CGM (ISO 8632 Version 4, and amendment 1) and SGML.

The «Intelligent graphics» will be specified within an application profile: the ATA Intelligent Profile. This profile will be compatible with the ATA CGM profile. Thus, the conventional graphics will be interpreted by Intelligent Graphics ATA tools and conventional ATA tools will interpret the graphical data of Intelligent Graphics.

CGM Version 4 is also used to define Intelligent Graphics. This version defines the Application structure. This element is based on the principle of the mark-up of the objects like SGML. Here, the objects are graphical objects. A tag “begin application structure” and a tag “end of application structure” mark up the graphical object. Each object could be defined by a type used to classify application structures into similar groups. Attributes are associated to graphical objects. They allow adding semantic on objects.

SGML is also used to model Intelligent Graphics. SGML allows the definition of a document type definition (D.T.D.) which describes the different elements of a document, the semantic associated to these elements and the structure of the document. SGML also defines links between the elements of a document.

Graphics modelling

The intelligent graphics exchange specification defines the exchange modelling of Intelligent Graphics. All the elements necessary to achieve the functionalities defined in the requirements must be identified and modelled. An Intelligent Graphic, for example, includes a “locator” which locates the item of the equipment on the aircraft, a “detail” which presents a view of the equipment, etc.…

To each element type, the associated semantic is described. For example, a detail is described by an identifier, a name, a revision date, the reference of the assembly which includes this item, etc…

The structure is also described. For example, an Intelligent Graphic is composed of an optional element “effectivity” and a repeatable sequence of “locator”, “detail” and “paragraph”.

These data are modelling via a graphics type definition (GTD), in fact a DTD applied to graphics. This DTD permits the check of the structure by a parser.

These data are also modelling via the ATA CGM Version 4 profile which permits the exchange of a single file with the graphic and its intelligence.

Tools which implement Intelligent Graphics concepts are starting to appear. Vendors involved in ATA, HSI, INTERCAP, ITEDO, already sell Intelligent Graphics tools.

Conclusion

The ATA CGM Application Profile is now a stable and advanced application profile. But work still remains:

- the maintenance of the profile
- the tool certification service

Concerning the ATA Intelligent Graphics profile, a specification of an exchange specification standard is now available. This first release of the specification focuses on links. The Graphics Working Group is now working on an evolution to include all the functionalities defined to obtain a really powerful electronic consultation.

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