

# Strategies in Re-Purposing Graphics for Interactive Intelligent Delivery

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## Abstract

In the domain of aerospace/defense, a products life cycle may likely span up to 30 years. The amount of technical data required to manufacture, operate, and maintain those products is immense. The graphic representation of that data facilitates the communication of operational and maintenance instructions. This paper outlines issues with creating, authoring, revising, and delivering intelligence with graphics and the associated meta-data. Topics to be addressed include:

- access to design engineering source data
- capturing existing component configuration and effectivity data
- CGM standards compliance versus 'goodness'
- best-practices and interoperability
- and exploiting existing SGML/XML link to textual content

Also to be examined are issues with both product change management, and the organizational change management required by redefined functions, roles, and business processes, necessary to take advantage of emerging technologies in this area.

## 1. Overview

Intelligent graphics is the name given to graphic data that is responsive to user - generated or external events. There are two main benefits in its use; the interactive

enhancement of the graphic content within Interactive Electronic Technical Manuals (IETMs) and the automated generation of illustrations and updates. This paper also discusses some of the challenges in re-purposing graphics-from 3D CAD/CAM part data to non-intelligent legacy graphics, for intelligent delivery within the aerospace industry. This paper discusses these issues within the context of Bombardier Aerospace and what can be done to resolve these issues.

## **1.1. Use of Technical Illustrations**

In the Product and Customer Support context, pictorial technical illustrations provide visualization of written operational and maintenance procedures through isometric pictorial line art. The illustrations provide the correct spatial orientation of the optimal vantagepoint, as well as the optimal sequence of steps required to accomplish the task. Dimensional accuracy is not tantamount, as long as the information is depicted clearly.

Other types of illustration used are system schematics and wiring diagrams, which depict routing and logic. These orthographic drawings facilitate electrical and avionics troubleshooting.

In relation to the Life Cycle of an aircraft, Methods needs to deliver Graphical Manufacturing Aid illustrations before Tech Pubs and Training; therefore Graphical Manufacturing Aids are illustrated first. Such illustrations are quite different in context and visualization - Graphical Manufacturing Aids depict fabrication and assembly tasks, Tech Pubs and Training depict primarily disassembly and operational tasks, the task context and visualization are therefore quite different. There is; however, complete compatibility and opportunity for re-use at the component or illustration fragment level.

It is clear then that Technical Publications, Manufacturing, and Training all share the need for illustrated views of common components and fragments within their own unique context.

Within Bombardier Aerospace there are current initiatives to use intelligent graphic objects within the illustrations to interactively link to relevant data. In Tech Pubs, there is an initiative to be able to navigate within the different manuals, e.g. from

Aircraft Maintenance Manual (AMM) to the Illustrated Parts Catalogue (IPC); and, also to navigate externally, to the spares and on-line parts order database. There is an ATA initiative underway, which Bombardier Aerospace is participating in, to establish a standard for capturing basic part removal information. This proposed Component Reliability Data Collection (CDRC) Standard have been discussed as forming the basis of an Electronic Notebook for maintenance personnel in an electronic Part Removal and Installation Tag. This notebook may be deployed using the AMM and IPC as a graphical front-end in capturing and validating part removal/installation data.

The Technical Publications and Training departments at Bombardier have started an initiative to jointly develop a common illustration database to support training material and related technical manuals. This will result in an illustrate-once-use-many approach. Currently this will involve the use of the ATA profile CGM and will develop to full version 4 interactivity and the use of the Scalable Vector Graphics (SVG) Standard. It is noteworthy, that without the development of the ATA Graphic Style Guide, detailed corporate exchange standards and the recent initiative for an ATA Colour standard, this initiative would have been too risky a venture.

The use of interactive animated illustrations in Manufacturing, Training and Technical Publications is being explored as a mutual requirement. The same project will provide the framework for linking by maintaining component intelligence upon extraction and conversion from the light 3D CAD model to illustrations. Initial requirements are to link back to the original source context of the configured digital mock-up, from which the illustration was created, and the 'best-so-far' instance of that context.

With the integration of these initiatives with the Bombardier e-Business application and the availability of electronic parts removal tools engineering, customer support and manufacturing will all share the benefits of a complete As-Maintained digital database.

## **1.2. Why deliver intelligent graphics?**

With intelligent graphics many of the constraints of static paper publishing in particular - those of static illustrated images are eliminated. Instead we find intuitive

access to a multitude of data from graphic details. For example: links from illustrated components to information on supplier, part numbers, ordering tools, or animated sequences may be provided. Rapid access to a precise illustrated detail, may be provided by supplying known parameters, such as part number or keywords.

It is the presentation of associated text data and graphic data that provides optimal efficiency in user understanding. Text data presents precise and detailed information but sequential and spatial information is more easily understood through graphics. It is the opportunity to present the combination of text and graphic data in a cohesive whole that is intelligent graphics major advantage to the end user.

The usability of digital wiring manuals is very low with static diagrams. The format is based entirely on a paper paradigm and most users prefer to print out a digital version. A dramatic improvement in usability can be realized by enabling intelligent functions such as highlighted wiring runs and direct links to and from wiring to wiring lists to provide the display of information at the click of a mouse.

The use of intelligent graphics extends paper publishing using the technical manual paradigm as a platform to more rapid information retrieval. Users are able to access data in an interactive, intuitive manner as well as via the traditional page layout. Physically separate manuals become a cohesive dynamically connected information set and reduce inter manual searching.

This approach is central to an effective Customer Support e-business strategy where access to various company information centres is provided via on-line access. In this scenario interactive graphics not only provide bridges between various technical manuals but also enables links to electronic part removal tracking, maintenance analysis, removal procedures, part ordering and animated training sequences. Thus the information value of the technical manual is significantly enhanced, as is the capability of a technician to perform a task. In many e-business user scenarios the Technical manual becomes the keystone to accessing the customer support data set.

### **1.3. What efficiencies can be gained internally?**

The introduction of a graphic database management system enables the control and

management of graphic objects and their attributes. This provides the ability to maximize on illustration reuse by focussing on the re use of components and illustrated details rather than entire graphics. Each component can be 'made intelligent' in accordance with attributes extracted from external sources such as engineering or supplier data. Once such relationships are established engineering data and illustrated component and views become synchronized making published data retrievable on the fly, more accurate and more efficiently produced.

The essential integration between engineering database, the publications database and the e-business interface will ultimately enable the engineering systems to maintain an accurate engineering model of the as-maintained state of every aircraft in the fleet. This will provide dramatic reductions in research time - currently as much as 50% of illustrating and writing time is spent in researching engineering. Without knowing which components have been previously illustrated in other illustrations and where, there can be a significant amount of redundant work.

Such a system is also valuable far beyond the traditional technical publications paradigm since many other departments will be able to benefit from what is in effect a customer view of As-Maintained Engineering.

The existence of an industry graphic style guide enables certain engineering extraction technologies to auto-create graphic components to the style guide. This enables the creation of illustrations to be streamlined dramatically and also assures consistent presentation, not only across the manual; but also ultimately across the entire industry. The automated application of a style guide, in effect, converts precise, complex engineering views to approximate, clearly understood customer views.

## **1.4. Downsides**

Adding intelligence to non-intelligent graphics can be a substantial effort in manpower, depending on the amount and quality of legacy graphics. The more structured and consistent the data, the more automated routines can be developed to add some intelligence, reducing the amount of manual intervention. Authoring and delivery systems may be required to be upgraded to support new XML and Web CGM capabilities.

## **1.5. Primary Types of Intelligent Graphics Modes**

### **1.5.1. Overlay and Embedded modes**

Developers have two distinct ways to store intelligence within CGM files, internal to the image or as an overlay within the file.

The overlay mode is achieved primarily by utilizing a layer to map the 'real estate' or regions of the illustration to their Cartesian co-ordinates. This overlay, navigation-layer approach is suited for legacy graphics that are comprised of raster data or early versions CGM with low-level data graphic primitives. Due to the disconnection between the intelligence and the objects image this method is most useful when the rate of change to the graphics is low. This is a good fit to legacy data where the rate of engineering change in a product is particularly high in first several years but reaches a stable lower change rate at a time when more customers require the information. Thus the cost / benefit equation makes the additional effort worthwhile.

The embedded mode is far more efficient since it transports the meta data with the image and requires little manual intervention. With this method the reuse of component images can be optimized and the transfer of metadata from engineering data can be integrated to standard processes. The further development of support for CGMv4 by CAD systems is a critical element otherwise the tactical deployment of secondary conversions will continue to be necessary.

### **1.5.2. Web CGM**

Web CGM enables web based behavioral support of CGMv4 and thus enables application independent delivery of interactive graphics to the web.

Web CGM was developed as a joint effort of the CGM Open Consortium, in collaboration the W3C. The W3C has been working on integrating CGM with the Web since 1996. Web CGM, became a Recommendation of the W3C on January 21, 1999. Web CGM was based on the ATA (Air Transport Association) CGM profile, "GREXCHANGE 2.4". This profile is recognized as the best defined and most widely implemented in industry, and it has the valuable attribute that there is already an

associated product certification testing.

### **1.5.3. CGM ISO Standard**

The CGM Standard is a format defined by the International standard ISO/IEC 8632:1999 for digitally describing vector, raster, and hybrid (raster and vector) graphic pictures. It has proven to be well suited for technical illustrations in electronic documentation, geophysical data visualization, and other demanding 2-dimensional graphics presentation applications. There are 4 versions:

- Version 1 is the original 1992 standard,
- Version 2 added basic improvements, the most important being segments.
- Version 3 added many new drawing primitives, including b-spline curves, better raster support and more colour models.
- Version 4 adds support for application structures.

### **1.5.4. Profiles**

Profiles have been developed independently by several industries to enable industry specific data transfer needs to be addressed. In using profiles options, elements, and parameters of ISO 8632 are defined maximizing interchange success between systems implementing the profile. Most notable are the Air Transport Association (ATA), U.S. Department of Defense (CALS) and Petroleum Industry (PIP) profiles.

The aerospace community has benefited from outstanding work by the ATA in developing their robust and leading profile. In part their success has been the result of a years of cooperation between vendors and industry corporations.

## **2. Intelligent Graphics Creation & Authoring**

### **2.1. Capturing Intelligence at Design Engineering Source**

All the graphics and intelligence on component parts and assemblies is not created in Customer Support. At the source, Design Engineering, there is, for the most part

3D geometry and meta-data (data about data) on the parts such as: part number, CAGE code, material specification, manufacturer, etc...

Meta-data elements to be captured from the source, is at least those listed for commercial aviation in the ATA Specification 2000 Data Elements, and for military aviation in the Logistics Support Analysis Record (LSAR). Part data is also found in engineering data from part suppliers and partners. Data coming into Design Engineering from partners engineering is captured and entered into the data flow. Strategies in consideration to accomplish this include STEP and/or XML.

While 3D CAD/CAM models are an excellent source of both geometry and meta-data (if a PDM system is in place), rarely is 100% of the data present. Not all suppliers necessarily provide 3D geometry, for reasons of intellectual property or because of limited technology infrastructure. Similarly small components, fixtures and fittings are usually not represented to prevent design data overload. In all such cases the publication graphic database needs to compensate and render every replaceable component without exception.

When strategizing the extraction and addition of intelligence there is a clear limitation to the amount of intelligence that can be added to legacy data without incurring undue processing costs. This is particularly true when considering that 20% of wiring diagrams may be revised at four intervals per year. If a strategy is particularly laden with manual work costs are prohibitive.



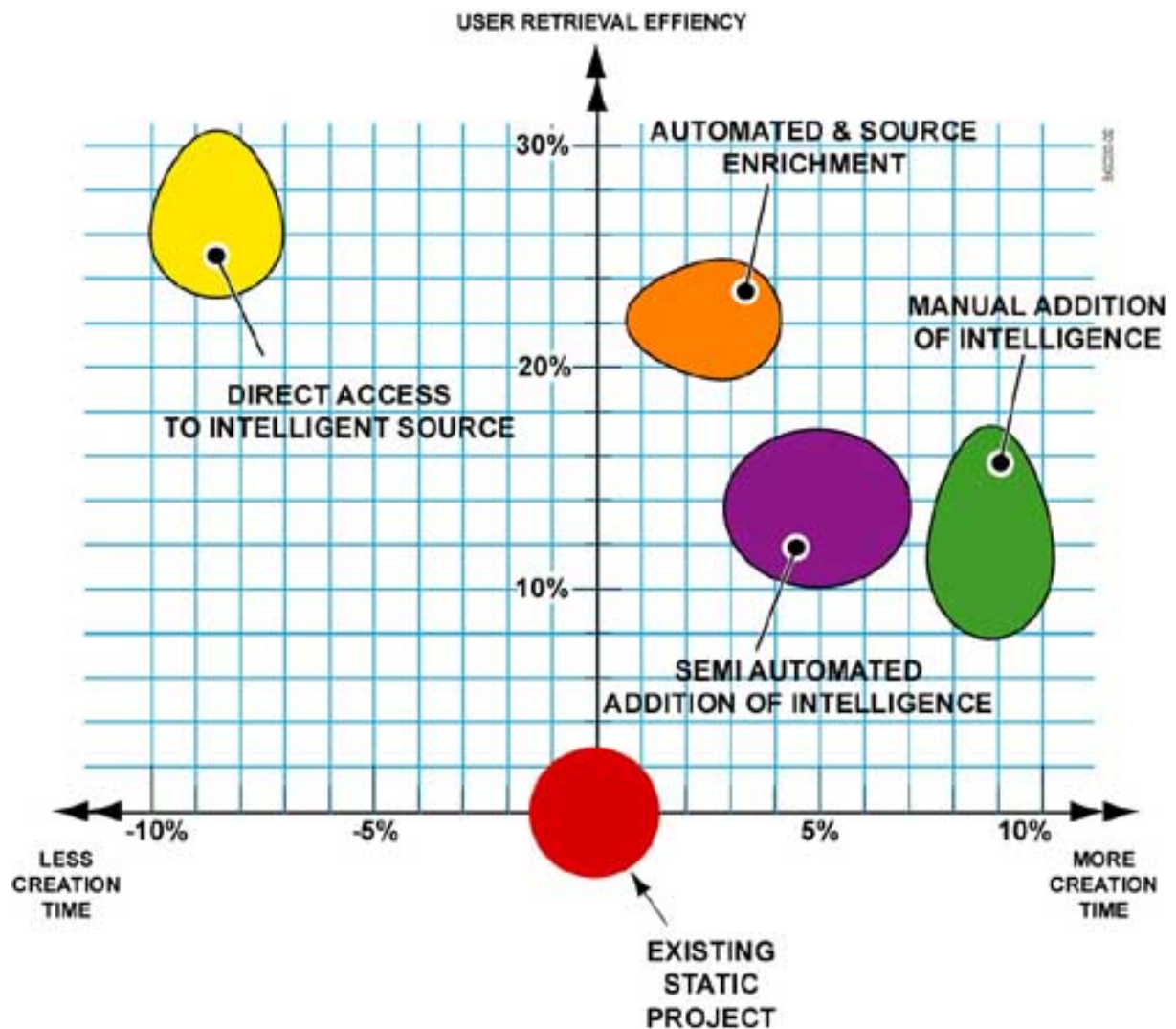


Figure 1. User Retrieval / Creation Time Comparison

## 2.2. Capturing Geometry & Meta-data from Partner Illustrations

An organization challenged to publish complex interactive technical data is unlikely to operate in an isolated environment. In fact the majority of new ventures involve close collaboration with other internal and external organizations. This presents some challenges to the exchange of graphic data and these challenges are amplified once associated metadata is involved.

## 2.3. Vector Line Art

Fortunately the exchange of line art illustrations has become significantly more reliable over the past five years. The maturing of the CGM standard and the related industry profiles has played a significant role in promoting reliable graphic data exchange of vector data independent of application.

In the aerospace industry The Air Transport Association (ATA) developed and promoted its own CGM profile to address the specific needs of aerospace. The profile is supported adopted by several key vendors, and the use of their software, almost universally accepted within the ATA community.

This has resulted in relatively successful graphic data exchange providing graphic software that supports the ATA CGM profile is used. The latest standard from the ATA has combined the previous, paper format focused, - ATA 100, with the digital data standard - ATA 2100 to form a combined and revised standard, - ATA 2200. This means that the new Graphic style standard and the digital data standards are under the same cover. This is a reflection of the efforts that ATA have made to synchronize graphic style issues with digital data issues. This is a key success factor in the ATA standards success story. From Bombardier's perspective these standards have been a key success factor in the exchange of supplier data. The recent proliferation throughout the industry of a common set of ATA profile CGM graphic library items that conform to the ATA Graphic Style guide is further evidence of the growing success of this combined strategy.

## **2.4. Raster Images, Photographs, Colour and Renderings**

Even though the ATA CGM standard requires raster data to be embedded within a CGM to conform to the standard. The flexibility to support the mass of different raster formats presents a challenge. This is particularly true considering that the sources for much raster data varies considerably:

- Engineering CAD CAM renderings
- Training Visual Aid graphic 3D programs
- Graphic applications

- Digital photographs
- Scanned images

Typically such data will not be CGM compliant in any form. Data may be supplied in CMYK or RGB models proving difficult to map to a consistent color representation.

Current ways of dealing with this diverse source is to accept the data 'as is' or to re-purpose it manually to a configured application with colour maps set up. Neither way achieves the objective of reliable interchange of data.

Fortunately the ATA are addressing this issue through their new color data exchange standard that is currently in review. The standard proposes common industry standards for color use including a proposal to use CGM based RGB only as the exchange model for raster data since it is more consistently represented throughout applications. The draft also proposes the establishment of mapping tables from RGB to Pantone colour definitions for printing. The draft of this standard is now in use at Bombardier and is forming a key element in developments bringing about the common use of graphics between suppliers, training modules and support manuals.

## **2.5. Task Simulations and Animation**

Two-dimensional technical illustrations are only one type of visualization object or graphic used to depict a sequence of operations or tasks. In engineering the optimum sequence of assembly and disassembly is determined in simulation, these task kinematics or animations are also valuable in task descriptions as they go through Manufacturing Review and approval. The kinematics objects could be distributed electronically for review just as the paper version is currently. The kinematics objects could be revised and inherit the same maturity levels (e.g. Submitted, For Approval, Approved, etc...) as the task. There are certain regulatory dependencies, such as electronic signature that would need to be addressed to fully support this.

When the task along with its attached animated visualizations is approved, the same animated sequences could be re-used by making it available to the end user performing the task---whether that is personnel in fabrication, assembly, maintenance or the flight crew. These animated sequences would have to be

integrated with current and planned delivery mechanisms in graphical assembly instructions, electronic technical publications, and computer-based training, which could include integration with the corporate e-Business internet and intranets.

The current functionality and packaging of the visualization tools in use will need some revision. This will in turn precipitate the revision of industry standards, and new business processes to support it. ATA are currently assessing the various standards of multimedia for an upcoming ATA multimedia standard.

### **2.5.1. Engineering, Manufacturing & Support Contexts**

Currently the creation of illustrations for visualization of tasks comes at the tail end of the definitions, descriptions, and approval of tasks. The simulation and validation of the tasks occur many times on the physical aircraft or mock-up, given an aircraft exists at that point, or is available. The use of the physical aircraft is done with an impact on production. Iterations are made more on a trial-and-error basis than wanted.

The process of defining assembly, maintenance, and operational tasks, and approving them is currently done for the most part with textual descriptions on paper. The task validations are done with physical representations. There are also benefits in using the 3D CAD Models in simulating and validating tasks. Task simulations and validations can be earlier in an aircraft's life cycle, not waiting on the production of a physical instance, and not having to interrupt production as often. Using the 3D Models to perform interference checking coupled with kinematics explosion and implosion of parts, early visibility of access restrictions, manufacturing and maintainability consequences are seen. Once captured in the system, a body of knowledge is built and used to refine the design-for-manufacturing concepts. Concurrent knowledge can 'train' the process to improve the fidelity of the simulations.

Maintenance Steering Groups (MSG-3) create the Maintenance Program Plan for a new model of aircraft. There is an ATA initiative underway to develop an industry MSG-3 Document Type Definition to standardize some of the elements and attributes in use. This initiative may assist in normalizing data elements and may facilitate use by the downstream AMTOSS instances of MSG-3 tasks.

Historically in the design, manufacturing, and support of complex electromechanical products, part traceability through the complete Product Life Cycle has been a recurring issue. This occurs because different departments typically have different uses of the data, and subsequently different databases. Multiply this by all the departments that handle, enhancements, and modify the part data; and its clear why there is a multitude of databases-usually not connected, populated by manual re-entry, and subsequent data integrity issues. Studies completed by the Lean Aircraft Manufacturing Initiative (L.A.I) indicates that the existence of a single source product data can result in savings of over 22% over the life of a typical aircraft program.

To communicate between the multitude of databases in a large company, requires the behavior of data objects to be somewhat normalized. In addition to CORBA, XML provides another possible strategy, to at least structure and validate the data traveling between departments and databases. By de-serializing the object data elements on exports, and serializing the elements on import, data objects can be translated between databases without the performance issues and re-engineering requirements inherent with CORBA technology.

In engineering the design context emphasizes the best-so-far configuration with little focus on the revision history of the products that have been completed previously. Paradoxically, Customer Support must service every configuration in the field, and knowledge of the specific configuration and revision history of every product is critical.

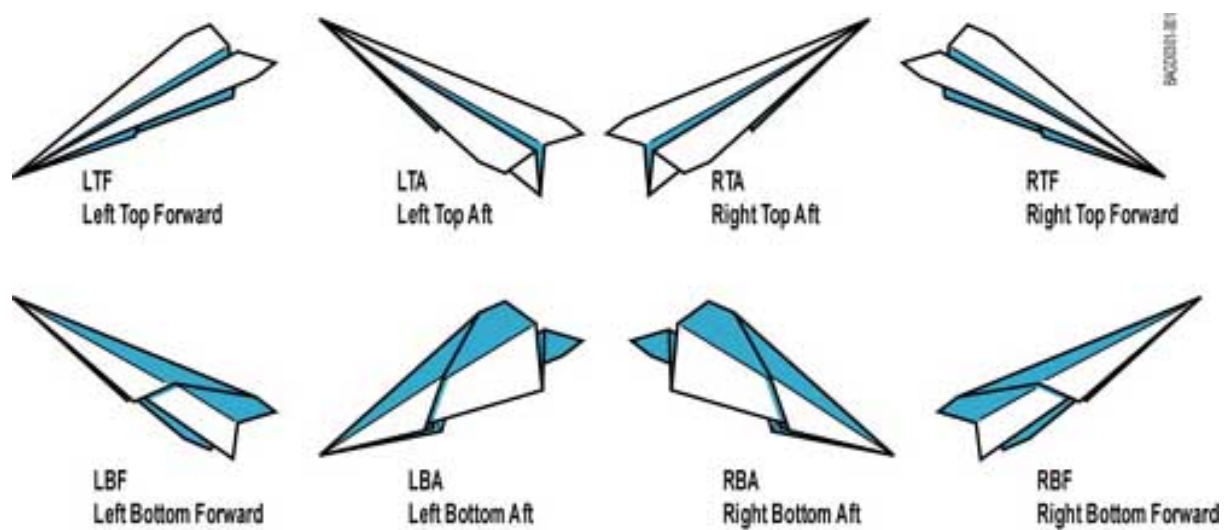
Technical illustrations are one type of visualization used to support the understanding of written tasks (assembly, fabrication, operation, and maintenance) to be performed on the product. The content, view and configuration is different both functionally and pictorially in each case. For example:

- The assembled components are at a different state of completeness.
- Not all parts assembled in manufacturing are a replaceable item for maintenance.
- Product Support views are an as-maintained view; including optional & changed

parts.

- Attaching parts are not always rendered but are critical for maintenance.

In the visualization of a task, a visual orientation is needed that is both specific to the task at hand and visually consistent with the depictions of other tasks. The standard isometric views, as illustrated below, could be an attribute on the intelligent component, so queries could be made without the necessity for a visual check for every search result.



**Figure 2. Eight Standard Isometric Views**

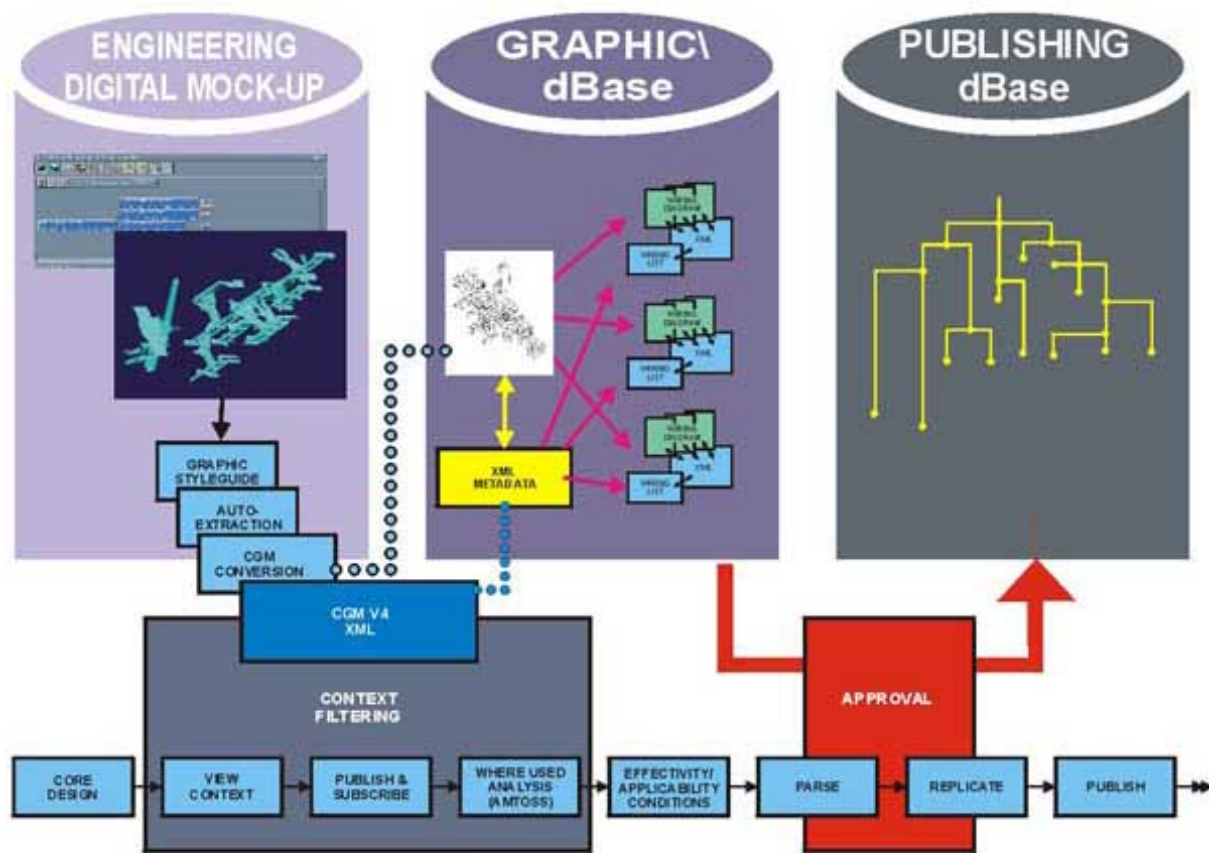


Figure 3. Simplified Engineering Source Data Extraction

## 2.6. Legacy Data

No matter how stringent a company's demands for standards conformance may be, it is impossible to avoid the reality that with a product of a 30-year life cycle it will be necessary to deal with non-standard legacy data. This raises issues of geometric goodness, lacking meta-data and complex conversions. Strategies for batch automation to infuse meta-data intelligence and to raise goodness levels of older graphic formats can be critical to leverage previous investment in that data creation.

Nowhere is this more of an issue than with wiring data. Since this information is normally first created at the design phase of an aircraft the data and the ability to revise it needs to exist for more than 30 years. An interesting paradox is that support for engineering applications and the rate of engineering change dwindles as the

aircraft matures, yet, as the aircraft matures the requirements from customers expand increasingly. This fact means that the legacy data can be re-purposed for intelligent content at a key moment in the aircraft lifecycle when the rate of engineering change is low enough and the number of customers to support is high enough. This is a basic cost per customer consideration that can be significant considering the unpredictable costs of converting non-intelligent graphic data to intelligent data.

Problematic legacy data will generally be in a format that is difficult to convert to CGM. It is usually possible to find or create a conversion route but the issue then becomes one of achieving a satisfactory level of goodness.

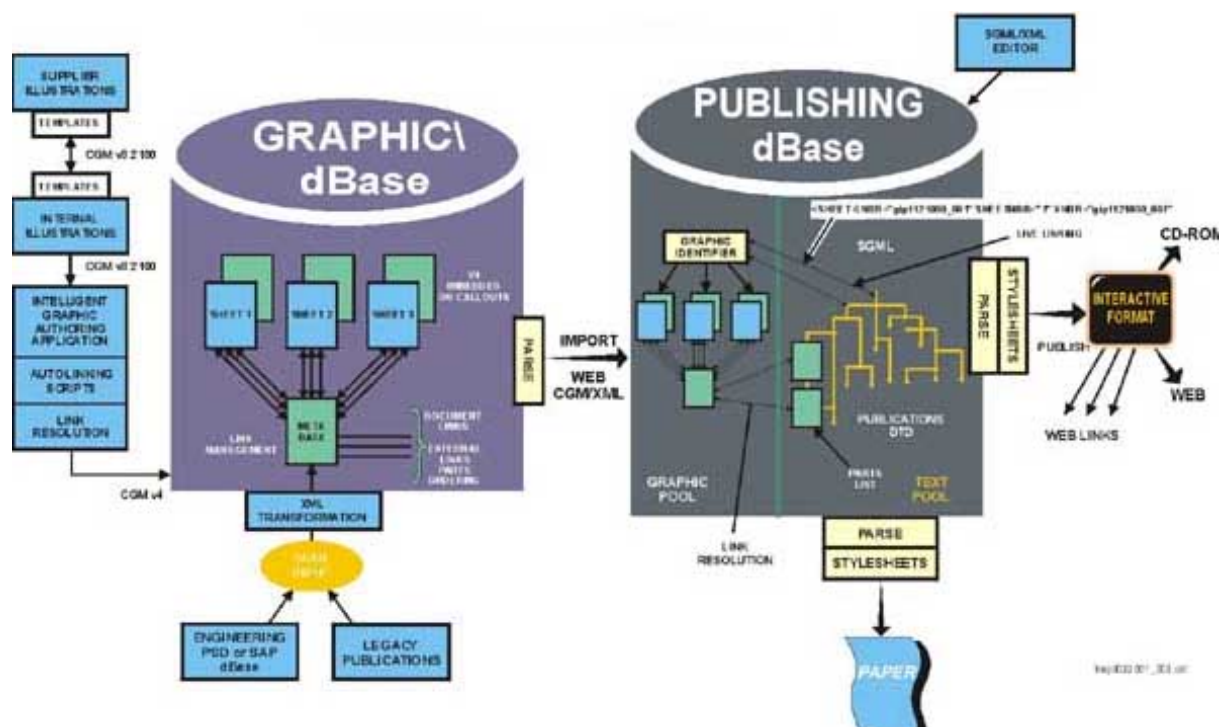
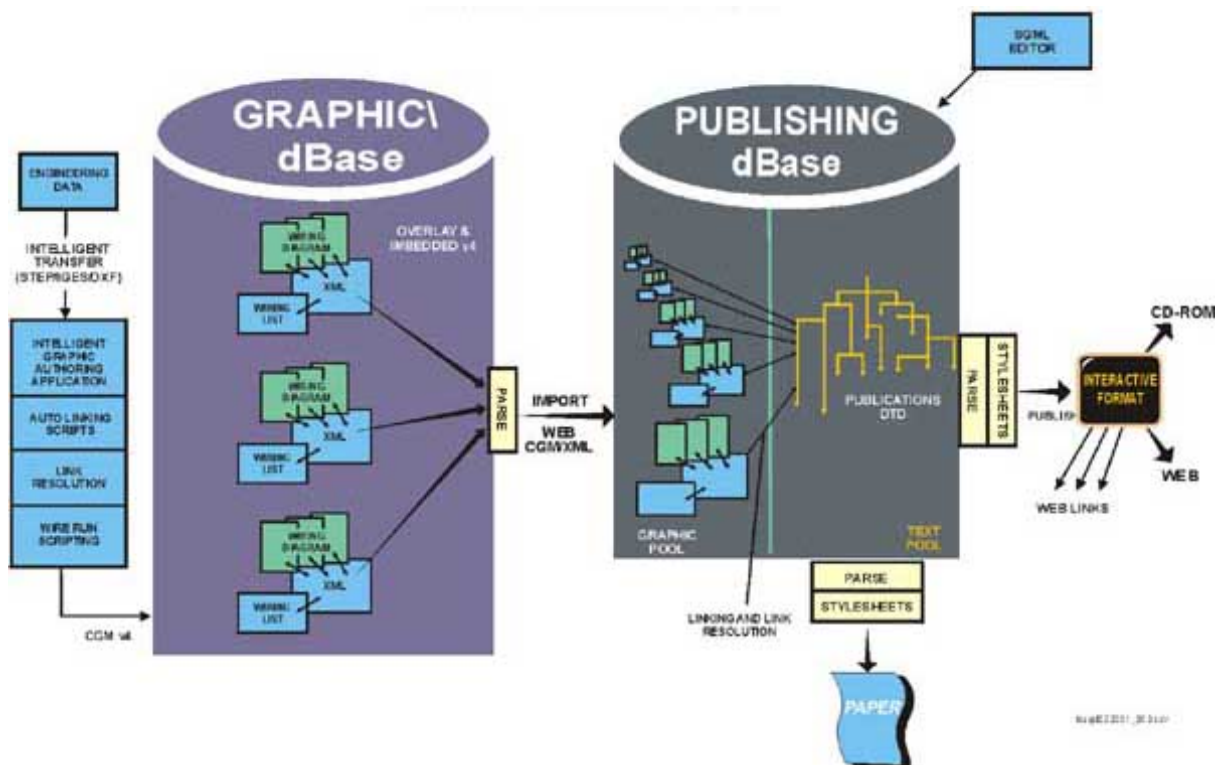


Figure 4. High Level IPC Architecture





**Figure 5. High Level Wiring Architecture**

## 2.7. Standards, Usability and Goodness

When checking that CGM files conform to the core standard or a specific profile the syntax and rules of construction are validated. The intent is to flag CGM that cannot be relied upon to provide graphics that will be consistently interpreted. Syntax checkers and certification of conforming CGM have significantly improved the reliability of CGM products considerably by clearly defining syntax and rules based errors. Just as they have improved a further problem has risen - that of goodness.

Goodness is independent of standards conformance and is a product of the CGM's usability within the revision and interchange environment. Because different graphic applications create geometry in many different ways any interchange standard needs to 'dumb down' the geometry to make sure it can be correctly interpreted by other applications. This means that the reusability and geometric intelligence of a graphic may be significantly reduced even though the graphic may well conform to the syntactic rules of CGM and look fine when printed. What may have started as a

graphic primitive of the type Closed Polygon; has instead, in the conversion process, been stroked to a disconnected bunch of vectors that cannot be selected or re-edited as a whole. Additionally, this may create a much larger file size, requiring more storage media (CD-ROM, DVD) and slowing graphics display times.

To resolve this issue it has been necessary for corporations to add a more precise corporate set of quality rules to data interchange that include line type definitions and performance expectations when transferred to other applications.

At Bombardier the standards for data exchange have been taken a stage further so that version 3 CGM is now expected in conformance to a specific template that assigns content to specific colour layers. This strategy enables superior round trip exchange between supplier and receiver since it increases the goodness capacity to one that is close to the applications. Layering rules also help organise and isolate categories of data; and prepares the data for more effective conversion to intelligent content.

With the exchange of intelligent content in non-legacy data the challenge is further complicated. Here it is even more critical to establish specific rules of interchange. As a fundamental starting point companies need to resolve which of the three core intelligent CGM standards to adopt for creation, storage, interchange and delivery:

*ATA GREX, ATA IGEX, Web CGM*

It is not in the scope of this paper to discuss the pros and cons of each of these alternatives. The processes of intelligent content creation, storage and interchange vary considerably depending on the history of the legacy data and the systems in place. It is therefore necessary to analyze each unique situation and consider the judicious use of each of the standards at each unique stage.

### **3. Intelligent Graphics Revision**

A primary issue in Technical Publications is the ability to incorporate product changes, which affect the technical manuals, in time to meet publishing deadlines. Ideally, the technical manuals should reflect the up-to-date configuration of the individual aircraft. This is a difficult task given: the volume of change drivers issued,

unique applicability by aircraft, and the reliable recording of those changes as they are made.

Typically, the illustrations in the Tech Pubs illustration repository or database do not know what components are represented in it, the interrelationships between illustrations, or the source context of the configuration they were created from. This essentially breaks the link to the source configuration and any resultant changes. It makes the analysis of which change drivers affect which illustrations a lengthy and manual, process. Current activity at Bombardier is underway to develop a mechanism to automatically resolve the reference components and their graphical representation when new components are added. Digital data and industry standards will be critical factors in the successful translation of objects and data between different business units holding the data.

The activity at Bombardier seeks to enable the tracking of components within the illustration and to link to the context from which they were created in order to be more promptly notified of changes, and to perform "where-used" queries on the document set. Intelligent graphics allow what was once an illustration 'blob' to become 'component-aware'.

Design changes are being made on a continual basis to improve reliability and performance; therefore downstream Product Change Management is a challenge for both Manufacturing and Product Support. To ensure the impact of design changes are reflected in the As-Maintained view of the aircraft, intradepartmental Configuration Management must be rigorous. The primary component of Configuration Management is the tracking of effectivity from engineering validity, to production and service effectivity.

## **4. Intelligent Graphics Delivery**

Currently technical publications are available in paper for all aircraft including the oldest legacy data. For more recent aircraft CD-ROM is the preferred media for customer and manufacturer alike. Most recent aircraft are also often supported by a web presence.

### **4.1. Variations in paper and digital delivery**

It can be a challenge to support paper when the primary deliverable is an interactive one.

Paper is the easiest media to support in all legacy cases. Legacy publishing systems were designed to support paper either via desktop publishing or even more primitive technology but usually carry little in the way of interactive content. Since the intelligence needs to be added it is often worthwhile converting from the older technology to structured content such as SGML or XML. In general if there is sufficient life left in the product to justify adding intelligence to the data it is almost certainly worthwhile converting to structured content.

With SGML database solutions the application of style sheets to produce reliably rendered printed output has been quite involved but is now a pretty much routine exercise. Once the publications move to an intelligent graphics paradigm new issues come to the fore in synchronizing the paper and digital version:

- The application of style sheets to structured text data has worked effectively but graphics remain nothing more than unintelligent blobs unless CGM version 4 browsers are used to view the intelligent graphics.
- The various views and changing contexts of an intelligent graphic are impossible to reproduce in a paper paradigm.
- The printed version of the manual cannot contain the same amount of information as the digital version.
- The paper version of the manual will need to continue to be supported due to needs of remote sites - particularly in business aircraft. For regulatory reason the paper version must then be 'in sync' with the interactive digital version. This paradox can be solved by two different ways:
- Use the digital version as the master and publish the paper version from it. This requires creating a DTD that structures interactive content so that style sheets remove data impossible to create on paper.
- Use a DTD designed for paper creating a regulatory master in both the paper and digital versions. Interactive intelligence would then be added to provide,

potentially unlimited, extended data to the digital user. This solution enables the extended data set to be highly flexible in keeping with evolving e-business needs.

## **4.2. On line delivery of paper and digital deliveries**

Once these issues are understood it is possible to make the next step and integrate the interactive manuals to an e-business web application. In this context the paper version is still a supported document but the digital version of the manual is electronically integrated to many other approved pieces of information.

The digital version has various intricacies to resolve in designing how it will behave reliably and efficiently. Some examples:

- How will multi hit searches resolve?
- How will the targeted view of a component or sub assembly centre and enlarge?
- How will reused components be sensitive to the unique context?
- How will the CD-ROM and web versions be published at the same time with absolute and relative path / link variances resolved.

The definition of behavior of intelligent content tends to be specific to the unique data of the corporation and the corporate requirements. This is a significant effort for the corporation. It is hoped that current efforts of CGM Open to develop a CGM Document Object Model (DOM) will streamline the development process by providing a standards base point.

## **4.3. Opening the door to other data**

Once the manuals are loaded to an e-business application the door is opened to linking to other maintenance data. Such links become communication channels in both directions transporting maintenance data to and from the operator and support organization. The manuals provide the central navigation hub to data such as:

- Parts ordering
- Parts removals
- Maintenance Management Systems
- Reliability data
- Animated training procedures.
- 3D simulations.

These extended data are a primary advantage of an e-business application. The information is usually produced as the result of different but related business processes the information already existing in a different context. To support this, the corporation is analyzing business processes to redefine the data relationships in accordance with the new business rules. Even though the core manual remains the basic, and well-understood delivery, the extended data set provides huge additional value to the user.

## **5. Organizational Change**

These changes in the use and structure of graphics by embedding non graphic data with graphics is having a subtle but profound effect on the work of the illustrator and writer. The impact of such systems go beyond those directly involved and at least force the use of more stringent style guides. For those more directly involved traditional roles are expanded to include a greater knowledge and expertise in the wide range of data related subjects inherent to the technology. For all concerned, a more rigorous and disciplined way of working is a necessity. In addition to visual acuity, content and navigational accuracy is required to ensure proper link resolution. With thousands of links to manage in a typical Illustrated Parts Catalog accuracy and rigor are essential. In a sampled manual at Bombardier 2,000 graphics are compiled of 4,000 sheets comprised of 80,000 components which results in almost 250,000 link nodes. Clearly error-checking routines will resolve inaccuracies as the work is processed but correction activities are always a detriment to production.

Despite the constraints of additional rules and standards the traditional skills of a

visual communicator cannot be lost. Indeed attempts to automatically create illustrations from engineering have, in the past, repeatedly failed due to the different communication needs of engineering data versus support data. It is the requirement of engineering data to be completely accurate whereas support data has to be accurate only within very specific data. It is a paradox to realize that illustrations need to communicate clearly a specific idea (maintenance procedure or breakdown); but the best way to clearly communicate is very often not via the most dimensionally accurate or 'realistic' representation. This is one of the underlying concepts of the ATA Graphic Style Guide that enables the visual communicator to communicate in a consistent standards based manner.

These changes are at least as significant as the migration from the drawing board to the computer. Traditional 'artistic license' may be somewhat restricted, yet those with a creative mind now have opportunities to test their capabilities in a new frontier.

## **6. Summary**

### **6.1. Technological Convergence**

With various key technologies maturing a technological convergence has developed providing tangible business opportunities to those with the opportunity and vision to leverage them. For Bombardier Aerospace the opportunities are particularly significant.

At the regulatory level the Air Transport Association have made a major contribution to the reliability of graphic data exchange by leading the definition and development of the ATA profile for CGM. As a result the aerospace industry is now benefiting from reliable supplier graphic data.

Within Bombardier several corporate projects are well on the way to providing interfaces to configured engineering data, real time spares inventories and an e-business portal.

The 1999 agreement within all Bombardier Aerospace publications groups to use a common graphics style guide developed in line with the ATA now makes it possible to use common components illustrated in a common style across all aircraft

programs. The graphic style guide is also in line with the AECMA standard making it compatible for European military work.

At the same time several commercial vendors have developed intelligent graphics tools in accordance with the requirements of the Web CGM profile developed under W3C. This new profile brings the benefits of interactive vector graphics to the web environment.

The final convergence is the emerging business requirements driven by an increasing demand from customers replace the paper paradigm with more interactive, immediate and accurate information.

## **6.2. Supplying Value to Customers**

The increasingly complex nature of aircraft and the resulting complexity of the manuals necessary to support those aircraft; requires levels of usability in excess of those possible by traditional paper means. Interactive documentation provides the customer with efficiencies in troubleshooting and maintenance that have been reported as providing a 35% increase in troubleshooting accuracy as well as reduced research time.

## **6.3. Standards-based Solution**

With projected life cycles of aircraft of 30 years it is critical that any system designed to support the customer base is based on portable standards rather than proprietary systems. Even though several proprietary systems exist, the emergence and maturity of the ATA CGM profile, XML and the W3C profile have provided a software independent route that will be sustainable through the life cycle of the fleet. While supplemental multi-media graphics formats should be allowed, the minimum required graphic format should be Web CGM, because it best supports simultaneous delivery of paper, electronic, and interactive media to an operator community with varying degrees of technology infrastructures.

The Life Cycle of an aircraft involves many processes. It is important that these processes are not looked at in isolation. Design engineering, manufacturing, maintenance planning, maintenance instruction & execution are highly interrelated



and linking those processes and the data traveling through them, is tantamount.

The on-going goal of the industry is to have the most current snapshot of an aircraft's service configuration, so that highly customized technical manuals can be published that are specific not only to a fleet; but to a single aircraft. To accomplish this will require the operator to provide accurate and up-to-date part removal information.

The emerging technologies are not enough in themselves; but must be supported by new, modified, and more relevant processes. Additionally it is important that industry does not look at the emerging standards in isolation; but in the interrelated and synergistic nature in which they are applied. The strategic use of the standards discussed here should contribute to the continual improvement in operational safety of the industry and produce increases in efficiency in both the creation and usability of its technical manuals.

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