Cyon Research™

Intellectual Capital and Interoperability

A Cyon Research Interoperability White Paper
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Cyon Research Corporation
8220 Stone Trail Drive
Bethesda, MD 20817-4556 USA

phone: 301-365-9085
fax: 301-365-4586
Web: www.cyonresearch.com

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Executive Summary

For many companies, the most significant repository for their product-related intellectual capital are CAD data files. The ability to disseminate and reuse the information in these CAD data files is key to reaping the greatest benefit from it.

Product data interoperability tools allow CAD data to be reused, whether in downstream processes, or in other CAD systems. Yet growth in the complexity of CAD data files, as well as market dynamics, have made interoperability more difficult than it used to be. This has given rise to the product data interoperability industry.

Interoperability is not a one-size-fits-all proposition. There are many common use scenarios which require that the product data be treated differently. There are also significant interoperability challenges, including continuing difficulties in translating basic geometric and topological information, complexities in translating semantic information, lack of information on common file formats, limited information content in some file formats, and uncertainty about the needs of the ultimate data user.

Interoperability projects can be carried out in-house, using IGES or STEP translation, or third party direct translators. They can also be contracted to a service bureau, which may either use software based direct translation or re-mastering (where the project files are created from scratch in the new system.) The most appropriate choice is a function of the nature of the project. There are no hard and fast rules about which way is best.

Successful interoperability projects first require an understanding of the ultimate use of the data. They also require the use of capable software tools, sophisticated processes, careful validation, and, guidance from people with expertise and experience in interoperability.

Intellectual Capital and Interoperability

There's a story I was told when I went to college, that the United States couldn't send another man to the moon, because the plans and tooling for the Saturn V rocket had been lost. Whether or not this story is apocryphal, it points out an important truth—that intellectual capital can be ephemeral.

In today's manufacturing world, the most significant repository of product-related intellectual capital are CAD data files. Though, with careful backup procedures, CAD data files are more permanent than the paper plans of the Saturn V rocket, that says nothing about their long term value.

It may seem patently obvious that CAD data files are of much greater value than paper plans, as they contain the essential definition of a product. However as a practical matter, few organizations ever get close to leveraging the full value of the product data contained in their CAD files. A set of CAD data files might contain the results of millions of dollars in engineering and design work—but if those data files remain locked up in the design engineering department, the organization is not going to get the most value out of them. It is in the careful dissemination and reuse of intellectual capital that an organization reaps the greatest benefit.

Interoperability

Reuse of data is nothing new to CAD vendors. For as long as CAD has existed, CAD vendors have recognized that their value proposition revolves around the reuse of data. In a traditional linear sense, CAD data has flowed to CAE, CAM, ERP, technical documentation, and other downstream processes. CAD data has also flowed to other CAD systems, either for further processing, or because the organization has decided to migrate to that other system.

This flow of information, or interoperability, has commonly been supported by internal data formats (proprietary to a particular vendor), CAD industry standard data formats (such as IGES and STEP), de facto standards (such as DWG), and broadly used standards (such as PDF, CGM, JPG, and TIFF), depending on the needs of the process. Yet in today's world, the complexity of information flow within product development and manufacturing processes is anything but linear, and the interoperability tools of the past have become inadequate to the task.

There are four factors that have really changed the landscape in interoperability in the last few years:

- There has been a dramatic growth in the semantic information contained in CAD data files. Today's CAD files not only contain the geometric and topological definition of a product, but also may include feature definitions, multiple configurations, scripts, knowledge based engineering tools, tolerance data, manufacturing information, engineering data, functional requirements, and more.

- No two vendors represent the data in their files in the same way. There is no one-to-one mapping of information between CAD systems, and there is never likely to be. This is

not a conspiracy—it's simply an side-effect of innovation. CAD vendors spend tens (if not hundreds) of millions of dollars on building innovation—and they generally don't contact their competitors ahead of time to make sure what they are doing is compatible. (This being said, there are certain areas, including basic model construction, where CAD vendors could benefit from improved consistency, yet market forces—and customer demands—often make it hard to change.)

- It's unlikely that one CAD vendor will gain market dominance in the foreseeable future. Despite changes in the fortunes of many CAD vendors, we're still in a situation where the market is split between a number of very competent suppliers. Products such as CATIA, Unigraphics, I-DEAS, Pro/Engineer, SolidWorks, Solid Edge, and Inventor all have their staunch adherents. And despite some products approaching end-of-life (CATIA V4 and I-DEAS in particular), the data associated with these will not disappear any time in the foreseeable future.

- Users of CAD software have moved, if not formally then informally, to a multi-CAD environment, where they use a variety of CAD tools. In some cases, this is by design (for example, where an automotive manufacturer uses one CAD tool for powertrain design, and another for body-in-white), and in other cases, it is an artifact of corporate reorganization (such as when one aerospace manufacturer acquires another, and they use different primary CAD tools.)

These changes have had the effect of making perfect interoperability a practical impossibility. But sometimes perfect is not as important as "good enough." As a result of the complex nature of the problem, a product data interoperability industry has emerged, with a variety of companies offering tools and services geared to almost any need.

The players in this industry include all the major CAD companies (they're smart enough to see the writing on the wall), a number of related companies which produce interoperability tools in support of their primary product lines, and several companies which are specifically dedicated to the interoperability market.

Types of Interoperability

By its nature, CAD (or, more broadly speaking, product data) interoperability is not a one-size-fits all proposition. There are a number of common use scenarios which require that the data be treated differently. Some of these include:

- Technical publications
- Analysis
- Tooling design
- Manufacturing planning
- Assembly instructions
- Maintenance
- Extended Enterprise Collaboration
- Digital mockup
- Web viewing
- CAD system migration

- Live project translation
- Legacy project translation
- Subcontractor collaboration
- Archival storage
- CAD/PDM integration
- ERP/SCM/CRM integration
- Management/Sales presentations

Even within these areas, there are varying needs. Consider web viewing, for example. Some of the important parameters in this area are speed of access, level of detail, accuracy, internal structure, and metadata content (such as would be used in ERP or SCM). Different web viewing projects may have dissimilar requirements for each of these parameters. A consumer looking on a web site for a replacement part will be wanting completely different information than would a design engineer looking for components to specify.

Challenges to Interoperability

In the general computer market, there are many types of data files, including document files, spreadsheets, databases, and more. Yet, even with these file types (which are much less complex than CAD files), there are still fundamental problems in interoperability. If its so hard to make Microsoft Word work cleanly with Corel WordPerfect without compromise, there's little hope to make programs as complex as CATIA, Unigraphics and Pro/E work together without compromise.

Consider these factors:

- Translation of basic geometry and topology between dissimilar CAD systems is still difficult and not always reliable. IGES and STEP provide a good framework, but don't address issues such as model tolerance or quality.

- Much of the deep semantic information in CAD files is stored in a proprietary fashion, optimized for the needs of the user, rather than for the needs of interoperability. Every major CAD system includes feature types which have no direct analogy in other CAD systems.

- Major CAD vendors rarely provide third-parties with detailed information on the structure of their native data files.

- Interoperability oriented data formats (including XML variants) provided by most vendors have limited semantic content, and may not provide all that is necessary to fulfill the needs of a scenario.

- API based translation, where an application program uses the source CAD system's API to create a metafile which is used by a matching application program using the destination CAD system's API to create a new model, shows promise, but suffers from inconsistencies and weaknesses in the APIs of even mature CAD systems.

- It's often hard to know the ultimate use of the data ahead of time. Not knowing this, it's impossible to make informed decisions about what compromises in translation are acceptable.

- Even if everything is known ahead of time, the complexity of the data involved can make developing a satisfactory interoperability solution very difficult.

Options for Interoperability Projects

There are a variety of approaches to tackling interoperability projects, and no one way is more correct than another. The factors that tend to indicate one approach or another include the scope and duration of a project, use of the resulting data, and complexity of the source data.

One of the simplest approaches to interoperability is to use the built-in IGES, STEP or DWG translation tools included in all major CAD programs. This has some real limitations. Much of the semantic information in the original files is lost in translation, and the process is inherently manual. But in some scenarios, the results are acceptable.

A step beyond IGES or STEP is to use third-party direct translation software. This will invariably provide a better result, as it reduces the process from potentially four steps (exporting, flavoring, importing and validating) to two steps (translating and validating.) Some third-party software vendors are offering tools which support feature-level translation—a capability of great value if the translated data is ever to be modified. (Yet, high-fidelity feature-level translation requires two CAD systems which represent data in mutually compatible ways. This isn't always the case.)

Both of these approaches assume that interoperability projects are done in- house. There are cases where it makes more sense to use service bureaus, particularly with larger projects where preserving semantic information is important, in fast-turnaround projects where there is no time for mistakes, and in low-volume environments, where the cost of translation software would be unacceptable.

Service bureaus fall into two broad categories: Those which use software, and those which re-master the files.

The major software-based service bureaus use proprietary tools to automate their processes, and have some form of data validation. There is a trend towards supporting feature-level translation, with several companies offering advanced translation between the major CAD systems.

Software-based feature-level translation is not perfect, but depending on the requirements of the project, may be acceptable, or even better than acceptable. The success of feature-based translation is related to the structure of the original data, and how well that structure can be translated to the other system. For prismatic parts, or parts which are well structured, it's possible to achieve excellent results. For parts which are inherently difficult to represent in a standard three-view drawing, the results may not be so good. Fortunately, all of the suppliers in

this market space are constantly improving their tools, and have proven responsive to customer input.

Re-mastering is the process of recreating the data in the new system, based on the intent inherent in the original data. This is a mostly manual process, though it's possible to use some geometry (including feature profiles) from the old files. Re-mastering is a common practice in nearly all manufacturing companies—although those who do it usually resort to it as a last recourse, and prefer to call "recreating the stupid CAD files."

It's generally more efficient, when re-mastering more than a few files, to send the work to a service bureau. Off-shore service bureaus, particularly those in India, are often quite cost effective for this type of work, and generally provide similar quality to that which can be obtained domestically—however, because service bureaus often don't know the ultimate use of the files they are creating, there is a potential that the work they produce may not be ideal. And, with any re-mastering effort, there is the potential for human error. (This is where careful data validation becomes important.) Finally, there is the issue of confidentiality. Some companies are understandably reticent about sending their valuable intellectual capital out of the country. (To their credit, most major off-shore service bureaus have excellent security records. However, as you might imagine, Iraqi service bureaus have had real difficulty of recent in attracting work from U.S. defense contractors.)

Requirements for Successful Interoperability Projects

It would be marvelous if, in a simple paper, we could present a solution to the challenges of product data interoperability—however, there is no universal solution. There are, however, a few factors which, if optimized, can make the process of interoperability tractable.

1) **Understand of the ultimate use of the data.** This seems pretty obvious, however data can potentially have multiple uses, and unless all the parties involved are in consensus on what they are trying to accomplish, the results may not be satisfactory.

   Consider a scenario where a company is migrating live project data from CATIA V4 to CATIA V5—something which is very common these days. Many CATIA V4 users have built a variety of tools to improve their productivity, but only a limited number of these tools are relevant to CATIA V5. It is a next-generation system, and just doesn't work the same as V4. A successful migration from V4 to V5 would involve not just moving the CAD data, but also recreating a limited number of the users' relevant V4 tools. The challenge here would be in expedience—understanding what to migrate, and in what form, so that the project schedule could move forward without undue delay.

   In many cases, both the original and the translated data are used within a project. This can create a problem, if there is no way to manage the relationship between the data. Often, it is critical that both sets of data are managed by a PDM system, and changes are made to only one set. This might require that non-geometric information in the data files—for example, manufacturing process information, be translated and loaded into the PDM system.

2) **Use capable software.** With the growth of the product data interoperability market in the last few years, there is no shortage of very competent software. It's actually an embarrassment of riches, with some excellent tools from a broad cross-section of vendors. But, if the ultimate use of the data is well understood, it's possible to make a reasonable evaluation of the available tools.

   But there is one catch in the software area. And that is the little matter that there actually may be no tools which do exactly what is needed. This may seem paradoxical, but it's just a fact of life. CAD is complex. If the folks who created the original CAD data were particularly Machiavellian (intentionally or unintentionally), it actually might be necessary to write some software from scratch to deal with it.

3) **Develop well thought-out processes.** If all that is required is to translate one file from format A to format B, the process involved need not be particularly sophisticated. However, if multiple companies are collaborating on a complex project, using a variety of tools (not just CAD), with a variety of destinations for the data, then the process must be very well thought out, and very sophisticated. If not, the entire project might be endangered, due to people getting the wrong data at the wrong time.

4) **Validate the Results.** How do you know that the data you have is good? It's not a trivial question. There are a variety of validation tools that can help—the important thing is to develop processes that assure the validation is actually done.

5) Get expert guidance. For manufacturing companies, product data interoperability is not a primary business activity. It's just overhead. Because of this, it is often left as an ad-hoc task, to be handled as best possible by those who can't help but deal with it. This is not fundamentally a bad thing—but without expert guidance, the results may not be as good as they could otherwise be.

Peter Marks, a highly-regarded consultant and one of the deep-thinkers in the area of product development, has described a concept of "knowledge turns." One of the postulates of this concept is that the more often one uses a particular knowledge, the better they are at it. For example, an engineer who works on one complete project per year, and who does the stress analysis on that project, may only have a few knowledge turns per year (essentially, the number of parts he or she has analyzed.) A stress consultant, who analyzes parts full time, might have literally hundreds of knowledge turns per year—and will not only be faster, but will understand potential problems better, and deliver a better result. (This is not to say that there isn't a place for go/no-go analysis. In fact, quickie FEA programs are a major boon, letting companies reserve their use of "rocket scientists" for the more critical problems.)

The same dynamic applies in interoperability. The early involvement of experts—who have worked on many types of interoperability projects—can make all the difference in getting the best results.

About Cyon Research…

Cyon Research Corporation was formed by CAD industry consultants Brad Holtz, Joel Orr, and Evan Yares to foster clarity and provide vision to users and vendors of CAD and PLM tools. Current products include: CADwire.net, a leading provider of online news and analysis; COFES: The Congress on the Future of Engineering Software; Engineering Automation Report, A-E-C Automation Newsletter, Extranet News, and The CAD Rating Guide™. More information can be found at: www.cyonresearch.com, 301-365-9085.

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