A rational approach to CAD standardization

Author's biography

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Introduction

In May, 2008, Industry Market Trends* published an article outlining how sections of a major new aircraft had reached the assembly plant with wiring flaws, which caused a production halt. Executives at the aircraft manufacturer blamed the fiasco on the failure of different plants to use the same design software. It was an expensive lesson, costing thousands of jobs, and forcing the company not only to reduce its profit forecasts by $6 billion, but also to close multiple plants.[1]

While this is an extreme example, it demonstrates the risks that arise when a manufacturing project relies on multiple CAD systems for modeling, configuration management, test, analysis, and other important product development functions.

Today, many manufacturers, both large and small, use multiple 2D and 3D authoring systems – sometimes within a single design project or function. This approach works well enough, as long as users are familiar with their preferred CAD software, and as long as customers – and deadlines – are not too demanding. The airliner example above was an obvious case where using multiple 3D CAD systems presented major issues. But, each day, there are many less obvious cases where the use of multiple authoring systems causes added process complexity, higher costs, and wasted time, especially where users must spend time translating files back and forth between CAD tools. And, in cases where multiple CAD tools are used either in the same project or for the same customer, then costs, complexities and wasted time can increase exponentially, as engineers endeavor to smooth out the incongruities of the different systems.

Today's global economy means that many companies have no choice but to employ multiple CAD systems, and, thankfully, there are solutions available that support interoperability between different CAD systems. These solutions include robust data exchange capabilities, data repair, feature recognition, direct modeling, and heterogeneous design-in-context (HDIC), which lets users create, view and modify assemblies built with components created in different CAD systems. However, for a growing number of manufacturers, the solution is to standardize on a single CAD-authoring platform. This paper will discuss why a company should consider embarking on such a course.

Challenges of the multi-platform CAD design company

In the past 20 years, the capabilities and performance of CAD software and related applications, from machining to testing solutions and analysis software, have skyrocketed. Thanks to both the downward migration of functions originally developed for high-end systems, and steadily decreasing costs for both software and hardware, the decision to purchase CAD tools can be made at a business level lower in the organization than ever before. Consequently, individual design groups have purchased CAD tools without gaining consensus from the rest of the engineering organization. As a result, product development companies often end up installing many CAD tools that aren't file-to-file compatible. The following are two examples of such companies.

A tale of two multi-CAD companies

An appliance manufacturer in the Midwest produces washers, dryers, ovens and other products for retailers across North America and the world. Throughout its history, the company's design engineers have used a variety of tools within their product development processes. Today, they have designs that are documented in paper drawings, 2D stand-alone electronic drawings, 3D wireframe and/or surface-models, and 3D parametric models with associative 2D drawings.

This particular company was an early adopter of CAD technology in the 1960s. Company designers used first-generation CAD software to generate 2D engineering drawings, and eventually moved to 3D wireframe models. Later, the company, like many others, started looking at 3D parametric solid modelers, such as PTC's Creo Elements/Pro (formerly Pro/ENGINEER), and eventually added 3D parametric software to its CAD repertoire of solid modeling and surface modeling tools.

Each upgrade delivered enhanced capabilities that allowed the company to be more competitive and to win new business. New projects were done in the latest 3D parametric design software. Occasionally, parts were re-used from their older design formats. Those part objects were either imported into their latest CAD tool or rebuilt from scratch by novice designers or interns. The company maintained an archive of old hardware and software tools as a means of making simple edits to older data when necessary. For the sustaining end of the business, engineers' time was spent entirely on the legacy tools. While new product development was focused on using the newest technology, many engineers were forced to "straddle the fence" between the old CAD tools and the new.

As new appliance designs became more complex, and as the engineering organization was reduced in size, the company began to rely on subcontractors. These subcontractors, chosen on the basis of cost and design expertise, sometimes tended to use CAD tools other than the standard tools used by the appliance manufacturer's designers.

Because of the extra time and effort required to rationalize the different data formats, design and manufacturing costs began to rise, and deadlines began to slip.

In a different scenario, an auto-parts supplier, starting up in the early 2000s, bypassed the need for early generation CAD tools. Still, this company created a different set of problems when it began purchasing 3D CAD tools that were different from those used by its suppliers, rather than standardizing on a single CAD platform.

The company purchased a variety of CAD tools either to placate the requests of their individual users, or to work with certain customers or suppliers who wanted to transfer data in specific file formats. And, to further complicate matters, the auto-parts supplier also acquired new business units that were already using several different CAD platforms.

Multi-CAD problems

For both companies, the problems resulting from multi-vendor CAD platforms are the same. Instead of becoming experts in one CAD platform, design engineers had to operate as novices in multiple platforms. As well, they had difficulty using and sharing data with co-workers. For the auto-parts supplier, personnel in administration and purchasing could not take advantage of economies of scale to reduce costs, while both companies in these examples found themselves wasting time and money translating files back and forth between systems.

Feature-poor file transfers

In fact, the most critical problem for each company had to do with just that: translating files between different CAD systems. Today, there are currently no global CAD standards for user interface or geometry construction, so file transfers work mostly at the level of boundary geometry. These translators leave out information about the construction of geometric features and their dimensions, so the design-intent is either lost or, at best, unclear. Why is this a critical issue? The fact is, more than ever before, feature-rich models have become a vital representation of the design itself. Much of the 'richness' in this information is lost because multi-CAD file transfers can leave out critical feature information. In addition, today's 3D models are used to generate associative 2D drawings for all downstream processes; after a file transfer between CAD tools, the 3D-2D relationship is lost. While some forward-thinking companies have embarked on 3D annotations in conformance with ASME Y14.41 to reduce the need for 2D drawings, the transfer of these 3D notes, dimensions and symbols are not yet supported by all CAD platforms and, therefore, cannot be instituted throughout industry until a future date.

"I guess" and neutral translators

Historically, de-facto standard neutral translators, IGES and STEP, have done little to solve the overall CAD interoperability problem.

The Initial Graphics Exchange Specification (IGES) – developed by a consortium of manufacturers, CAD companies, the National Bureau of Standards, and the US Department of Defense – was the first neutral medium for translating 2D and 3D data between CAD tools. It wasn't long before the IGES method of 3D translation was fondly called "I guess" because of inaccuracies found in the final geometry after migration. IGES was followed by numerous versions of the Standard for the Exchange of Product Model Data (STEP) which, until only recently, offered little more than IGES.

After migration and cleanup, translated 3D models had none of the feature intelligence that was once embedded into the original models. Even if two CAD products were built from the same modeling kernel, or delivered from the same vendor, there was little more intelligence transferred between the two than was transferred with a neutral file exchange.

To make matters worse, no neutral translator existed to re-create the association between 2D drawings and their original 3D models. This disconnect forced design engineers to re-create 2D drawings – still the most common method for communicating designs in every aspect of the product development process. Drawings are important because they also serve as legal documents. Re-creations must be highly accurate, otherwise the company could risk substantial damages in lawsuits pertaining to defective products, recalls, or other issues.

There is technology invented by PTC that exists today to address the migration of CAD data. This technology, called the Legacy Migration Extension (LMX), provides a suite of tools to assist in migrating data from one CAD system to another. A big part of LMX is a tool for re-association of imported 3D models to otherwise un-associative 2D drawings. This tool, known as the Legacy Drawing Associator, maps 3D model geometry (either parts or assemblies) to a separately-imported 2D drawing. It then re-maps dimensions and notes to the 3D solid geometry on that same drawing so that model modifications are reflected with drawing dimension updates. The result is a 2D drawing that is, once again, fully associative to a 3D model.

Working towards standardization: intermediate solutions

For many companies working with disparate CAD platforms, the first and best step toward CAD standardization involves using tools that will facilitate multi-CAD collaboration and file transfers. Some of these tools can help to recover feature information and other intellectual property that may have been lost during transfer.

Here are four examples of such tools:

1. Visualization technology

Using visualization technology and multi-CAD data management, a designer can place model geometry from more than one CAD tool in a single viewing environment. The design engineer can superimpose the models coming from two or more CAD tools into one assembly to check for clearances and interferences, and can access mass property information and actually "fly through" this assembly.

Visualization technology can serve a multitude of uses – for comparing product designs, for reviewing ergonomics, for presenting to management for project review, or for previewing to customers or prospects.

But visualization only goes so far, and there's a vast difference between a visualization tool and an authoring tool. A visualization tool enables viewing – both 2D and 3D, while an authoring tool lets the design engineer perform actual design modifications. If design modification is what's needed, then a system that supports HDIC, which permits both, is a better choice.

2. Heterogeneous design

Heterogeneous Design in Context (HDIC) tools are a recent development. They typically work in conjunction with data management products to allow the co-existence of dissimilar CAD data within a single authoring environment. For example, the design engineer would use a primary CAD authoring tool to control the top-level assembly with drawings, and a co-worker would use a secondary CAD tool to supply subassemblies and to document the corresponding subassembly 2D drawings.

In this scenario, the primary CAD tool reads the models from the secondary CAD tool and uses them within the context of the top-level assembly design. When changes are made to the subassembly model geometry in the secondary CAD tool, that geometry is updated in the primary CAD tool's top-level assembly. This way, the feature-rich designs stay in their original native form. Design engineers can make changes quickly in both native CAD platforms by using the authoring tools that created the models in the first place.

While HDIC delivers an elegant solution in certain scenarios, having to refer back to each independent CAD tool to make a major change may present a challenge. There is also the issue of determining which CAD tool is considered primary, and which is secondary within a particular project. If there are more than two CAD products used by the company's designers, the decision gets even more complicated. In the end, design engineers are still required to maintain multiple CAD tools, along with the overhead associated with each.

3. Feature recognition (FR) technology

Feature recognition tools can detect engineering features such as extrudes, chamfers, rounds, slots, holes, and patterns, and then restore them after the data transfer. The goal here would be to make a few small changes to a model and not change everything else. Good feature recognition (FR) tools will remove geometry on a static, imported model and replace it with intelligent, dimension-driven native features. This approach lets the engineer proactively pick on the geometry that he or she wishes to change, and only change what is necessary.

Feature recognition tools come in a variety of flavors: some are more vendor-specific than others; some are limited to single-feature migration – which is valuable for saving time if the engineer knows the specific feature needing modification; and some offer full-scale feature recognition for entire parts and assemblies. These solutions are effective if changes are major, or if the engineer is unsure about which changes will be required in the future.

But feature recognition is not an exact science. There will be situations where feature recognition fails to produce the desired features; FR tools can migrate a good portion of the data, but some user intervention is inevitable. Remember, too, that conversion tools are not design engineers, and cannot interpret or make designer-like decisions. Expect to take control of the migration process, and to make the necessary corrections in geometry – keeping in mind that using a migration tool as a "black box" is dangerous.

4. Direct modeling tools

Direct modeling, or the ability to modify 3D geometry without the use of parameters or features, represents another way to facilitate file conversions. In direct modeling, the engineer makes changes by working directly with the geometry in question – by pushing, pulling, and rotating surfaces of the model – without having to update any dimensions or features that would be related to the model, as is the case in a feature-base, or parametric-based CAD platform.

Some parametric platforms also incorporate direct modeling tools, so users can choose which approach to use based on application needs. Following a conversion of a parametric file, for example, the designer sees that the features of one imported part were not included in the migration. S/he would then highlight the surfaces to be modified and make the changes directly on the model, for instance, by increasing a dimension, rotating to change an angle, and dragging to modify hole diameters. By contrast, the parametric approach would require the designer to fill in a number of related dimensions and other information that the correct feature and dimension scheme for the edit exists for, and then regenerate the model.

Call to action: Steps toward a full migration

The most important step toward CAD standardization, however, is to move toward a primary file format – the format of the main CAD authoring system. To do that requires effort in the following three areas.

Determine the standard

A number of considerations fall into this topic. Most important is to analyze the tools you're using now, and assess which ones are likely to survive in the market for the next 10 to 15 years. Another consideration: one platform may have already become the de-facto standard, having attracted more users than any other in the company. The degree of data reuse is also important; one project area may have a greater need for data reuse than any other, so this might be the best place to locate the company-standard CAD system.

Further, a particular CAD tool might bring more revenue to a company than another, if significant contracts are riding on it. A large customer may represent a significant portion of your revenue, and may require your data to be created in their native CAD format. Cost is another criterion, and it can include everything from software license costs and maintenance costs, to costs for user training, additional hardware, and data migration.

The availability of trained users on a particular platform can be important, too. This is a compelling situation that would force a company to avoid an end-of-life CAD tool. Professionally speaking, nobody wants to bet a career on expertise they've developed for a CAD product that will no longer be maintained. Even the vendor of an end-of-life CAD tool does not want to train new users on the tool because that will make it harder to sell customers a replacement product. If there are no users available to operate a particular CAD tool, your company has to foot the bill for training for all new hires that need to use it.

Communicate the platform change

Leadership begins with management and flows out to all product stakeholders – design engineers, manufacturing engineers, test experts, and others who will be moving to the new standard. Planning, too, is essential, and begins with an understanding of users' exact roles in the product development process. The better you understand their needs, data sources, deliverables – even their frustrations, the better the chance of gaining user buy-in.

In fact, probing for user frustrations can help you find ways to improve their day-to-day experiences, and can help you gain their buy-in by designing improvements into the new regime. Users might complain about the time it takes to work with large assemblies, where a model regeneration might take multiple minutes or more. Or, they might have difficulty using third-party applications for cabling or electronic design, and then integrating the results with their CAD model. As part of the effort to win users to the standardized authoring system, you can then demonstrate faster performance with assemblies, or show them the value of integrated applications.

Execute the migration

If you're fortunate, you may be able to migrate to a new, standardized 3D CAD platform by simply starting all new projects on the new software. For most companies, however, migration will require the careful coordination of moving both data and people to the newly standard platform. Since some 80 percent of the work that design engineers do involves modifying or leveraging existing designs, it's critical that the old system's data be moved carefully into the new format and, if the company's business warrants it, into a data management vault. Tactics for transferring data include using HDIC or other tools mentioned earlier, as well as installing standard or custom data translators.

Importantly, the data should be vetted, moved, tested, and ready by the time the people – that is, the users – are moved to the new CAD system, so they encounter a minimum of disruption. And, it nearly goes without saying that user training, documentation, and support must be in place to help users become acclimated and productive as quickly as possible with the new software.

Conclusion – what to expect

Working with a standardized CAD platform has many merits, mainly that users can easily share software licenses, training, data, and best practices. CAD standardization gives the product development company a single, unambiguous data platform where information can be shared with all disciplines in the product development process, thereby reducing design complexities. Instead of repairing and re-creating data, engineers can spend their valuable time optimizing designs. A single CAD tool will better facilitate initiatives like concurrent engineering, design for assembly, and design for manufacturability, as well as design anywhere/build anywhere initiatives. The time and effort saved in product development may also result in capturing more sales revenue by helping you get products to market sooner than your multi-CAD competitors.

Likewise, migrating toward CAD standardization brings significant benefits in design efficiencies, specifically in reduced costs of training, documentation, and system administration; faster product-development cycles; and improved product quality. For large companies as well as small, the rewards can be substantial within the first year, and the benefits of efficiency will continue to support company growth into the future.

*About Industry Market Trends (IMT):
From industry at large, to the shop floor, to the cubicle, Industry Market Trends delivers the latest developments, best practices and trends in the marketplace daily.
http://news.thomasnet.com/IMT/

[1] David R. Butcher
Industry Market Trends, May 8, 2008
http://news.thomasnet.com/IMT/archives/2008/05/airbus-to-review-a380-delivery-schedule-tells-customers-in-letter-possible-delays.html

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