Autodesk's Digital Prototyping for Manufacturing Program

"A Review of Autodesk's Digital Manufacturing Program"

June 2010

A CIMdata Program Review

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This review provides CIMdata's perspective on Autodesk's digital manufacturing program. CIMdata's view is that Autodesk's solution offering in this area is evolving substantially by both expanding existing manufacturing and digital prototyping capabilities and incorporating capabilities from Autodesk's Architecture, Engineering & Construction Solutions group that directly address factory design. This is enabling Autodesk to provide much more substantial solutions for manufacturing companies. Currently, Autodesk's capabilities are focused on factory and plant floor layout as opposed to sophisticated factory simulation and other high-end digital manufacturing capabilities. CIMdata provides its own reflections as well as describing the experiences of Autodesk customers and their perceptions of Autodesk's technology and program.

1. Introduction

Manufacturing has become increasingly complex and challenging for companies of all sizes in all industries. Meeting these challenges is forcing companies to make changes to improve their ability to cost-effectively produce products while maintaining a high level of quality necessary to satisfy their markets. Depending on the industry, the primary pressures include reducing costs and capital expenditures on Property, Plant, and Equipment (PP&E), satisfying green and sustainability initiatives, speeding time-to-market, adopting new and more efficient manufacturing technologies, and taking advantage of global manufacturing. The challenge is to employ modern digital manufacturing processes and supporting technologies that help address these issues effectively.

Digital manufacturing is one of a number of areas that CIMdata classifies as part of a holistic Product Lifecycle Management (PLM) strategy. It is supported by, and augments other aspects of PLM such as CAD, data management, data visualization, and best-practice driven workflows.

Autodesk has been one of the largest suppliers of product development authoring tools for many years. Their design tools for architecture, buildings, and mechanical systems have been very popular and have established them as one of the leading suppliers of computer-aided design (CAD) tools in the manufacturing and architecture, engineering, and construction (AEC) industries. However, today they also provide more business solutions based on newly-developed tools. Their family of tools has grown substantially over the years through both internal development and acquisitions and they now support companies in both the manufacturing and building solutions market sectors.

Autodesk has expanded their solutions into a number of areas, including simulation and analysis, data management, and digital manufacturing. While their perceived market position has been as a provider of design-focused point solutions, they recently have undertaken a strategy of integrating multiple tools into suites that provide solutions focused at specific industry problems. This has been a key transition for them. One area in which they have been evolving is in their support of manufacturing engineering.

In this paper, we review Autodesk's program for digital prototyping for manufacturing. We have interviewed a number of their customers and provide their perspectives on Autodesk's support for digital manufacturing and the continuing evolution of their solutions by covering the following topics:

- *Industry Challenges*—The issues that companies face when trying to successfully employ manufacturing engineering capabilities to support their business.
- *Autodesk's Overall Approach*—Describes Autodesk's market position and evolving approach for manufacturing.
- *Autodesk's Manufacturing Solution Program*—A description of Autodesk's manufacturing engineering solution offering.

- *Customer Experiences*—Observations from CIMdata's discussions with Autodesk's manufacturing solutions customers.
- *Summary*—CIMdata's conclusions, observations, and comments.

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2. Industry Challenges

To provide a context in which to understand Autodesk's solution offering for manufacturing engineering, some issues and drivers facing manufacturing companies and how they design both manufacturing facilities and products need to be understood.

There is typically a great divide between the CAD and other work automation capabilities provided to product (and manufacturing equipment) designers versus those available to manufacturing engineering organizations. Product engineers are quite used to having state of the art, integrated suites of design tools that provide 3D modeling and at least semi-integrated product and process analyses capabilities, data visualization solutions, and other tools to help them do their design work. Also, Product Data Management (PDM) capabilities and their benefits have been available for product designers and engineers since the mid-1980s. These support tools allow them to be much more efficient in their design and validation processes than they would be without these tools.

Manufacturing and production engineers, on the other hand, have historically worked in 2D design environments for developing building designs and production facility layouts. Tools that help analyze their designs have, for the most part, come from third-party software solution suppliers and have been poorly integrated into their design, validation, construction, and facility and equipment maintenance processes. Due to the 2D nature of the process, there has been a pronounced lack of ability for them to leverage product design CAD data in their work. For data management, Building Information Management (BIM) tools are a relatively new concept that is still evolving and are used by far fewer manufacturing engineers than the number of product design engineers who use PDM. Lack of 3D adoption and limited use of BIM leads manufacturing engineers to be less efficient in their design activities than they could be with more up-to-date tools and processes.

This is a troubling situation when one considers that the manufacturing environment contains far more parts and assemblies than a typical product design. Admittedly, some manufacturing components, such as jigs, fixtures, and machines, are often used over and over again in the design and tend to be somewhat simpler in shape and complexity compared to the products they help manufacture. However, sometimes the manufacturing equipment is much more complex than the item being manufactured, such as a machine that produces facial tissues at very high volume. In almost all cases, the manufacturing components have to interact in very complex ways so the ability to perform functional analyses of the manufacturing environment is a very important, but often missing capability.

The lack of data compatibility and sharing between the product engineering and manufacturing engineering worlds leads to a host of problems that impact directly on manufacturing productivity, time to market, and product quality.

Designing a complete manufacturing facility can be an extremely complex problem. It may include the building that houses it; the power, HVAC, and other distribution systems; material handling systems; production machinery including robots and transfer lines; human workers; and other components. Often, factories must be capable of manufacturing more than one product, complicating the design and its simulation and analysis even further.

Various forms of simulation can help assure that a facility design works as planned before the physical facility is realized. However, in today's complex manufacturing facilities, these need to be 3D virtual simulations in order to provide the most benefit. A well-documented example of this is the improved productivity and design quality that product engineers have been able to achieve by using a 3D work process and tools. Additionally, 3D design data that defines the product and manufacturing machinery cannot be used in the 2D tools and work processes that are commonly available to manufacturing engineers, thus lessening the potential for extracting more value from the 3D product design data.

Further aggravating this situation is that the tools used by manufacturing engineers to support design, simulation, and analysis are often provided by a number of solution suppliers and thus are not integrated either in their operational or data models, leading to additional inefficiencies.

In order to address these and other manufacturing engineering issues, industrial manufacturing companies are looking for solutions that provide easy-to-use tools that streamline 3D facility design and layout. Autodesk has developed its Factory Design Suite to help companies of all sizes to design better manufacturing facilities. This suite is described in the following section.

3. Autodesk's Manufacturing Solution Program

Autodesk has launched a new program to support manufacturing and to facilitate collaborative manufacturing engineering work processes. The core of this program is the Autodesk Factory Design Suite. The suite is made up of three major components that are used in a factory design workflow as shown in Figure 1. AutoCAD Architecture provides factory layout, Autodesk Inventor supports machinery and other 3D design needs, and Navisworks allows data from other CAD solutions to be included with that from AutoCAD Architecture and Inventor to create and visualize the factory design. The suite also contains additional factory-specific functionality and integrations across these programs to address customer workflows.

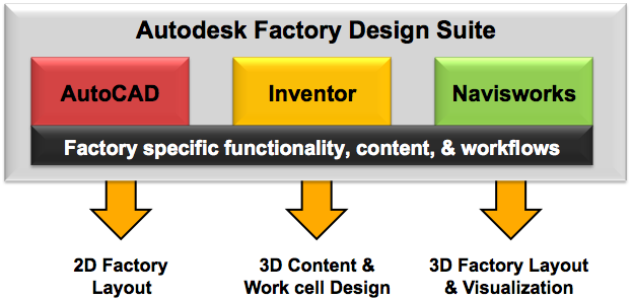

Figure 1—Factory Design Suite Components

The basic goal of the Factory Design Suite is to provide a working environment where factory equipment and facilities can be created, planned, viewed, and analyzed together, in a common workflow based on 2D and 3D environments. The combination of these capabilities into an industry-oriented solution suite instead of just a collection of interesting point capabilities is a key element of Autodesk's manufacturing strategy.

3.1 Autodesk's Factory Design Suite Tools

The following set of tools comprises Autodesk's offering at this time. Additional tools are planned or under development.

AutoCAD Architecture

AutoCAD Architecture is a 2D and 3D CAD tool that has been in use by a very large base of users who design manufacturing facilities and equipment such as assembly transfer lines. AutoCAD was first introduced in the early 1980s and has been a very popular CAD solution in the areas of Architecture, Engineering, and Construction as well as factory floor layout. The product is characterized as being easy to use, and a multitude of trained users exists throughout the world. It is very important as a primary tool used to layout manufacturing facilities. AutoCAD Architecture output data can be fed directly into the rest of the Autodesk manufacturing solution suite of products.

Inventor

Autodesk Inventor is a 3D CAD package for creating designs and digital prototypes of mechanical systems. It supports designs of large and small assemblies including complex mechanical components, plastic parts, sheet metal, piping, and routed systems including electrical cabling. It provides a large array of design, visualization, and simulation capabilities that can be used to design both complex and simple combinations of parts and assemblies. Typical applications of Inventor include the design of products as well as the tools and equipment required to create the products. In addition to its ability to read and write native files from a range of other CAD applications, Inventor interoperates with many Autodesk applications, including AutoCAD Architecture, Revit, Algor, Moldflow, Showcase, and 3ds Max.

Navisworks

Navisworks provides viewing of aggregated multi-CAD data and point clouds. This allows existing installed facilities to be audited by laser and photogrammetric scans that can be combined with CAD data to validate current conditions and plan changes. CAD formats supported in Navisworks include Autodesk (DXF, DWG), STEP, IGES, ACIS, and JT. When incorporated into the Factory Design Suite, Navisworks also supports the import of CATIA, NX, Pro/E, and SolidWorks data. Users can perform clash detection on Navisworks data including data from scanned point clouds. Output can be generated in the Navisworks NWF 3D format.

Suite Functionality

In addition to the capabilities of the individual components within the suite, Autodesk provides capabilities specifically targeted to support designers of machine work cells and factory layouts. The Factory Design Suite provides a library of commonly-used 3D factory assets such as machine tools and conveyor belts that can be quickly assembled together in a 3D layout using pre-defined "connection points." These assets are parametric in nature and can be provided in a variety of predefined and customizable configurations. For example, a single roller conveyor asset can be provided in three width increments. The suite also allows users to create or import 3D MCAD data to use as custom assets within their factory layouts.

3.2 Other Capabilities

Autodesk provides a number of additional solutions that can be applied to the digital manufacturing process. These tools are not part of the factory design suite, but provide complementary capabilities.

Revit is Autodesk's core product for authoring BIM content. It provides tools to create BIM structures. This is a key capability that enables the Autodesk factory design suite to combine the internal factory and equipment layout with the design of the building and infrastructure that house the factory. Revit extends the manufacturing suite's capabilities to create and access BIM data.

Autodesk Inventor Publisher is a product documentation tool. It helps users combine textual and graphical information into documents such as assembly instructions, work orders, operating procedures, repair manuals, etc. Inventor Publisher helps product documentation teams by giving non-CAD users the ability to leverage the digital design data to create illustrations and diagrams for publications without having to use more complex 3D CAD products. By utilizing the 3D design model, documentation can be developed concurrently so companies can begin the documentation process sooner, potentially reducing costly delays and allowing for faster time to market. It can combine data from multiple CAD systems and use templates to automatically create documentation such as shop instructions and drawings. The same publishing tool is used to embed the graphical data into the text, creating complex documents containing both elements. Inventor Publisher is designed specifically for technical communications professionals and those who have to create complex documents such as work instructions that need to contain a high-level of graphical content.

AutoCAD P&ID and Plant 3D provide routed system schematic layout in a form that is quite familiar to facility, building, and process plant designers. For example, its output can be used to validate that piping system layouts actually match the facility design's requirements and that all required piping is accounted for in the factory layout.

Simulation and analysis products such as **Moldflow** and **Algor** are available to evaluate manufacturing processes as well as interactions and structural soundness in the factory and equipment design.

GIS products such as AutoCAD Civil 3D can be applied to planning and designing the site in which a manufacturing facility is positioned.

3.3 Business and Marketing Program

Although sales and customer relationships are maintained as direct relationships between Autodesk and its largest customers, the majority of Autodesk's customers are handled by their extensive partner channel.

Some of Autodesk's partners focus more on training users of tools, rather than on process capabilities, re-design and re-engineering. Their focus is not so much on helping customers learn how to improve their business processes by leveraging tools, but more on how individuals can use tools more effectively for design activities. These partners provide customers with relatively limited levels of services and are typically not able to support larger or more extensive implementations.

However, Autodesk's channel partner program does include a number of partners that offer a more substantial suite of services that help customers implement Autodesk's manufacturing solution suite and integrate it into their business processes. These partners are often differentiated by their unique knowledge of certain industry segments, and frequently take the lead in developing unique industry-focused solutions based on the Autodesk solution suite.

While the factory solutions are not specifically limited to use by any particular industrial segments, within their manufacturing-focused business, Autodesk primarily focuses on a selected set of industry segments:

- Industrial Machinery
- Automotive and Transportation
- Aerospace and Defense
- Consumer Products
- Medical and Life Sciences
- Building Products and Equipment

This is a fairly wide spectrum of industries in which Autodesk already has a large number of customers, as witnessed in the following section. These industries are all substantial users of PLM solutions and companies in each sector have or should be considering a process-oriented approach to digital manufacturing.

4. Customer Experiences

CIMdata interviewed a number of Autodesk customers who are using the manufacturing solutions. Their relationship to, and history with Autodesk, the focus of their Autodesk manufacturing solution usage, and their overall perceptions of the Autodesk solution suite are presented below.

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Ghafari Associates

Ghafari Associates is an engineering services firm that provides facility services throughout the planning, design, construction, and commissioning of manufacturing and other types of facilities. Their annual revenue is in the 50 million dollar range and they have more than 600 employees. Their projects range from relatively small to very large. They use a number of Autodesk manufacturing engineering products including Navisworks, Revit, and Inventor.

A key factor for business success at Ghafari is data interoperability and transportability. They have successfully used Navisworks to allow them to view data sets consolidated from disparate sources, thus streamlining their design processes. They state that being able to integrate data from many sources into the overall manufacturing facility design is a substantial benefit in terms of streamlining the process, alleviating data translations, and saving time.

In addition to Navisworks, Ghafari employs Autodesk Revit to help them incorporate BIM data into their design process. They believe this is an important capability that improves their overall design efficiency.

They report that for some projects, the Autodesk suite has helped them virtually create the facility design, allowing them to nearly eliminate drawings. This provides both cost and productivity benefits.

They cited the lack of integration among Ghafari's Autodesk tools and other tools they use as being a problem that needs to be resolved.

Electronics Manufacturer

This company uses Autodesk products as the basis of their Building Information Management (BIM) strategy. While the buildings that house their manufacturing facilities are designed by third parties, the company takes an active role in designing the plant layout and some of the equipment used in their plants. For them, AutoCAD is the essential layout tool, but their drive is to move to 3D plant layouts. A major factor in this strategy is that the building design and the design of all of the equipment contained in it have to be coordinated very closely, as they operate as a complete entity with many interactions between the two designs.

To validate the design of the complete facility, they use Navisworks as a digital assembly tool that allows them to import building and equipment design data from multiple sources into a complete design that is held in Navisworks' compressed file format. Navisworks allows critical interference checking to be done regardless of the data source. It is very difficult to capture the as-built configuration of existing facilities. The most convenient method is to use large-scale laser scanning. Navisworks also allows the resulting point cloud to be imported and used during visualization and interference check. An issue is that the size of point cloud that can be imported is limited and they have to artificially divide it into regions. They anticipate that this restriction will be alleviated in a newer version of Navisworks. They also use Navisworks' ability to output files with a digital rights-managed time stamp that causes the file to become inaccessible after a particular date. This is used to assure that people in the design and build teams are not using out-of-date data, especially during the highly iterative design process.

One capability embedded within Inventor that is quite helpful is its ability to import data from other CAD tools and apply a shrink wrap to that data. The shrink wrap removes a lot of detail from the data and effectively hides any proprietary data that is inside assemblies. Thus, while the assembly (e.g., a manufacturing workstation) can be used to support layouts, the supplier's intellectual property is protected.

5. Summary

The Autodesk Factory Design Suite has capabilities that help companies create factory building designs and layout the equipment that goes in the factory. AutoCAD is arguably the most popular factory layout solution in use today. The vision of expanding on AutoCAD with Navisworks and the other tools in the suite is very well conceived.

There are opportunities to incorporate additional functionality in the future to expand the capabilities of this suite. These include ergonomic analysis (inserting people into the factory design to examine strength and safety issues), discrete event simulation, optimization of factory processes, and a data management solution that can manage all of the information produced in complex factory designs and layouts.

There is also opportunity for further integration with products not in the suite. For example, Revit uses a different data structure from tools in the Factory Design Suite, making it more difficult to incorporate into a consistent work process. However, on the plus side, the Autodesk Factory Design Suite is a straightforward solution compared to competitive offerings—which will appeal to smaller companies as well as large. It is expected that Autodesk will continue to increase the capabilities and interoperability of this suite, since their digital manufacturing journey has only just begun.

Few other solutions can link BIM to equipment, facility layout, and product designs the way the Autodesk suite does. It also supports the 2D to 3D evolution, bridging the two by allowing relatively easy use of 2D data in a 3D design environment. Users can approach their design needs from either direction, tying together these two design paradigms.

The potential exists for Autodesk to expand its suite of capabilities further to utilize direct knowledge of the facility assets (e.g., machines, controllers, lines, etc.) to support manufacturing planning. While this isn't a solution that Autodesk has specifically addressed, the capabilities are clearly possible; pointing to another potential for their expanding suite of solutions.

Autodesk has significantly expanded the breadth and depth of their suite of manufacturing offerings. The development of a broader suite of Autodesk technologies for the manufacturing market significantly extends Autodesk's reach and solution set. The transition from providing a collection of interesting features and functions to delivering a manufacturing solution suite expands Autodesk's overall market breadth.

About CIMdata

CIMdata, a leading independent worldwide firm, provides strategic consulting to maximize an enterprise's ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM) solutions. Since its founding more than 25 years ago, CIMdata has delivered world-class knowledge, expertise, and best-practice methods on PLM solutions. These solutions incorporate both business processes and a wide-ranging set of PLM enabling technologies.

CIMdata works with both industrial organizations and suppliers of technologies and services seeking competitive advantage in the global economy. CIMdata helps industrial organizations establish effective PLM strategies, assists in the identification of requirements and selection of PLM technologies, helps organizations optimize their operational structure and processes to implement solutions, and assists in the deployment of these solutions. For PLM solution suppliers, CIMdata helps define business and market strategies, delivers worldwide market information and analyses, provides education and support for internal sales and marketing teams, as well as overall support at all stages of business and product programs to make them optimally effective in their markets.

In addition to consulting, CIMdata conducts research, provides PLM-focused subscription services, and produces several commercial publications. The company also provides industry education through PLM certificate programs, seminars, and conferences worldwide. CIMdata serves clients around the world from offices in North America, Europe, and Asia Pacific.

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