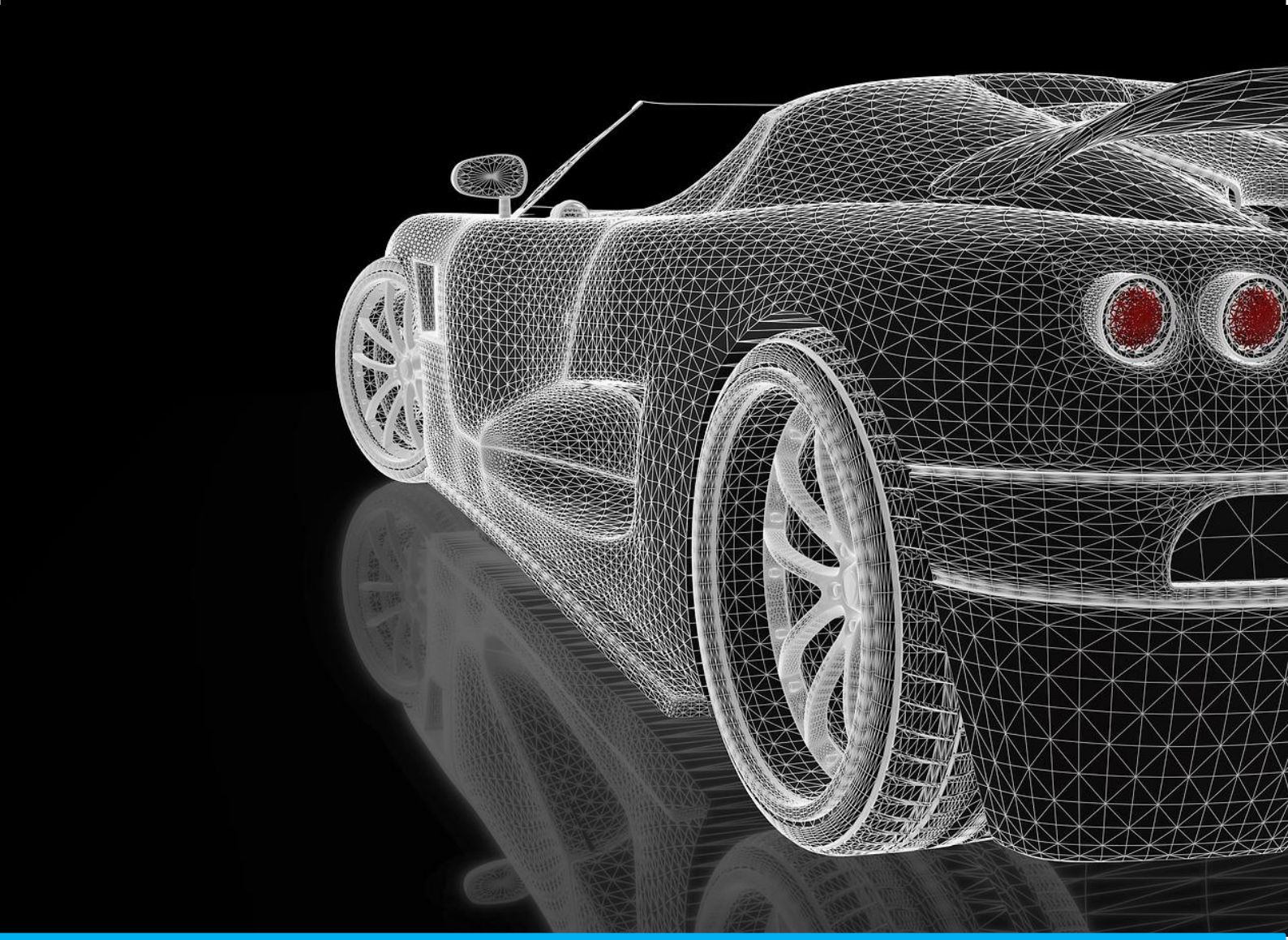
IT Manager's Guide to CAD, PDM, and PLM Applications for Manufacturing Engineering



Abstract

There are dozens of business applications on the market today for manufacturing engineering. Each with their own strengths and weaknesses. Design engineers have their favorite applications but how do those applications tie-in with other critical business systems such as enterprise resources planning (ERP), configure price quote (CPQ), additive manufacturing (3D Printing), and other technologies.

This white paper explores leading CAD, PDM, and PLM vendors and applications and provides IT management with recommendations to select the right products with integration strategies to connect data and processes across business applications.

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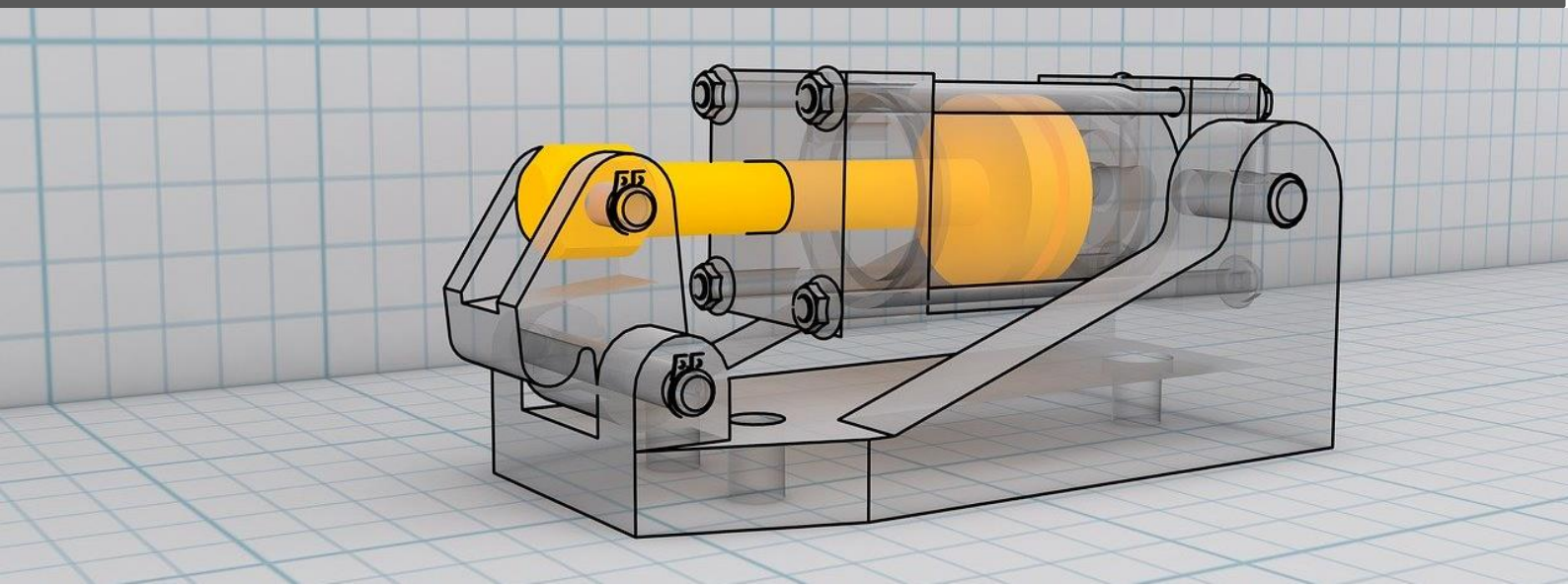


Introduction to Manufacturing Design Engineering Applications

As an IT management executive you are tasked with keeping all of your business applications in sync, up-to-date, and integrated throughout each area of your business. While you understand the underlying architecture and platforms of these applications, you may not be as familiar with specific genres of applications such as those used in manufacturing engineering and design. Nor can you evaluate these applications based on features required by your internal manufacturing design teams. This white paper is designed to help IT management to understand the broad manufacturing engineering and design business application market with an overview of various business application categories, background information on leading vendors and products, and strategies to integrate these applications into your mission critical systems such as enterprise resources planning (ERP), configure price quote (CPQ), and more.

Differences Between CAD, PDM, and PLM

Some CAD systems offer revision tracking capabilities to identify the specific design configuration for each assembly or finished good. However, most manufacturers need a bit more control over the engineering revision process and utilize CAD in conjunction with product data management (PDM) or product lifecycle management (PLM) applications which provide a lot more functionality around the revision management process (and other engineering and control functions). PDM software is popular among small to midsized manufacturers because it is more affordable and less complex providing adequate controls for many manufacturers without forcing unnecessary business processes that delay the engineering process with little value add. PDM evolved into much more sophisticated PLM applications typically utilized by larger manufacturers in complex industry segments such as automotive, aerospace and defense, industrial equipment and machinery, etc.

What is CAD Software?

CAD stands for Computer-Aided Design. It is simply software or technology enabled with functions for designing products and documenting the design process across many industries. It is highly useful in disciplines like mechanical design, industrial design, aerospace engineering, robotics, automotive design and architecture.

CAD improves designer productivity, therefore product designers use it to create unique designs, product functions and layout, and also to view their detailed designs in 2D and 3D formats from various angles. This speeds up the manufacturing process. Great CAD software should have several features including editing tools, 2D and 3D template models, customizable tool palettes. This is in addition to an accessible user interface and excellent support network.

There are probably more than a hundred different CAD applications on the market. Some are general applications used by the vast majority of the manufacturing engineering market (such as Dassault Solidworks and Autodesk Innovator or Autocad) while others are very specific to industry segments (such as Orcad for printed circuit board manufacturers and Acorn Pipe for pipe fabrication to name just a few examples).

CAD software is at the front end of the product lifecycle where new products are designed and tweaked for prototyping. CAD is also used for on-going revisions and design changes to existing products throughout the lifecycle.

CAD in and of itself is more than just a design tool. Most CAD systems also contain definitions for an engineering bill of material (eBOM) which details the items and quantities required for each unique item. The eBOM may contain additional data but is often lacking details related to the actual manufacturing of the parts. For example, an eBOM will not include manufacturing routing details with labor operations, setup or machine run times, scrap percentages, or machine or work center details. The eBOM may also utilize generic parts that are not the same as real inventory skus in your ERP system. Further, the eBOM is probably also missing information for preferred vendors and warehouse stocking locations, purchased item costs, manufacturing costs, lead times, and additional information essential for downstream production.

What is Product Data Management (PDM)?

PDM is a software solution, that manages product design and engineering data in one central location. When all the designs, bill of materials (BOM) lists, revisions and version control, change orders are all controlled in one central location, engineering teams save time and make fewer errors.

PDM Application Benefits:

- *Smooth design workflow:* Integrate with the CAD programs you use seamlessly. Search and find the data you need fast. Easily replace and reuse old files. Work on the same data with your peers without worrying about conflicts. PDM streamlines the design processes and makes them faster and easier.
- *Better collaboration:* Show the 2D and 3D views of your product, and get comments and feedback, even from people outside of your organization, like focus groups. Record the feedback directly on the PDM, to improve your design.
- *Automated processes:* Many processes, from change orders, revision management, and creating BOM lists can be automated and streamlined through PDM.

In short, a PDM system organizes and the design of the product, and manages all the product data in a central, revision-controlled environment. This improves and streamlines the design processes while reducing the potential for errors.

What is Product Lifecycle Management (PLM)?

Product Data Management (PDM) and Product Lifecycle Management (PLM) can sound similar at first, but they are two very different, albeit related solutions. While Product Data Management only deals with the design data of a product, Product Lifecycle Management deals with all the stages of a product, conception, design, production, and service.

Product Lifecycle Management (PLM) shouldn't be confused with Product Lifecyle Management (marketing), although they sound similar. PLM focuses on marketing, sales, and profit management of the product, while PLM focuses on engineering aspects. PLM is also a more enterprise-level application, like ERP and CRM. And PLM is not only a set of software tools, but also a business strategy.

PLM Application Benefits:

- *Initial conception:* This is the stage where the product is developed from a rough idea to a concept. Designers may use many different types of tools at this stage, from pencil sketches on paper to clay models, to CAD design software. Many of the major specifications, features, and defining characteristics can be developed at this stage. Without a PLM system in place, engineers come up with a design. Many times, even approvals and comments on the design has to be done unofficially, using things like email and memos. With a PLM system in place, everything is done in a central location and this streamlines the process.
- *Design:* This is the stage where the product design is detailed, tested, improved, and made ready for full-scale production. This may include prototyping and small scale pilot productions. Without a PLM, engineers design the prototypes on an ad-hoc basis, with no central procedure. When there is a PLM system in place, designers mark the initial design as ready for prototyping, managers approve the request on the system. And when the lab produces and

tests the prototype, they know the design constraints and parameters. And everything is recorded and managed in the same system.

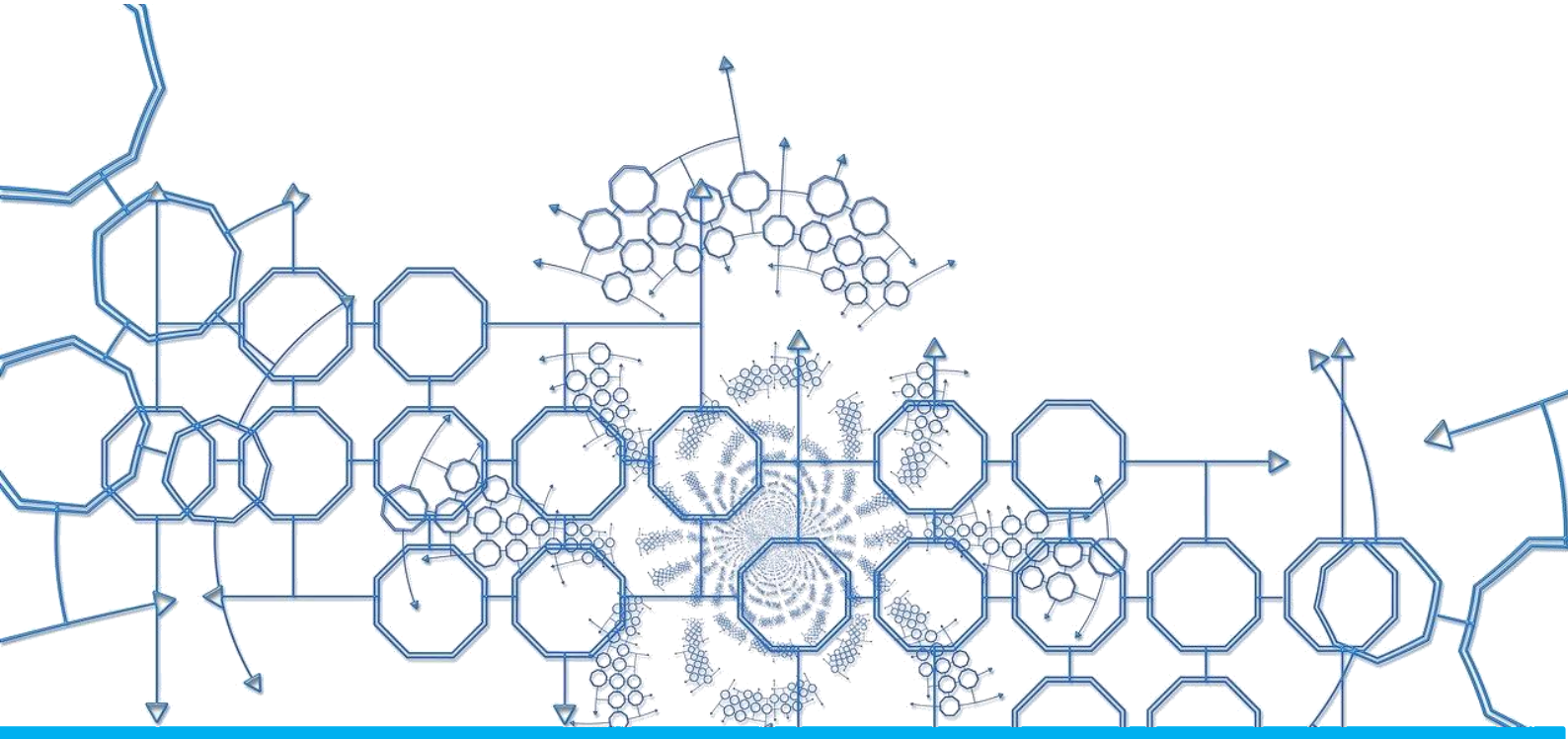
- *Production:* This is the stage where the design is ready for production. Without a PLM system in place, engineers send CAD files or printouts to management and manufacturing. Once designs are approved, manufacturing then enters items and BOM to their system manually, although sometimes there may be interfaces that facilitate the data flow. With a PLM system in place, engineers mark the design as ready for production. They can look directly into the 2D or 3D designs, and view the documents associated with the design. After the management and manufacturing approve the design, BOM is automated if PLM is also integrated into the ERP systems.
- *Service:* This is the phase where there are all kinds of information while the product is already in production. Customer service, repair, and maintenance phasing out or retiring a product, as well as waste management and recycling all belong to this phase of the project. Using a PLM, every single comment and information is stored in a central location. Service requirements of one product also become a design input for future products.

PDM vs. PLM Comparison

Obviously, PLM is a more comprehensive overall management tool compared to PDM. PDM is usually only one component of PLM. However, implementing a PLM system can also be a more costly and time-consuming project. The advantage of a PDM is that it is cheap and simple to implement. It is also generally an earlier project for a growing business. However, as a business grows, it is likely that both PDM and PLM systems would be needed.

PDM Advantages	PLM Advantages
• Cheaper and faster for initial deployment • Less sophisticated business processes • Very easy to maintain • Requires little training	• Streamlines every step of product design • Faster time to market • Designs and documents related to the design are visible to everyone involved • Reduced chance for any errors • Supports complex business processes

Overall, smaller businesses will start with CAD/CAM/CAE first, and then will implement a PDM system. Then after a certain size and complexity of operations, implementing a PLM system will also be necessary. While the implementation of a PLM is more complicated and costly compared to implementing a PDM system, in the long run, a PLM system streamlines many more processes and prevents costly manufacturing mistakes. Most businesses will likely benefit from eventually implementing both over time – PDM first and then PLM with extended functionality.



Top Manufacturing Engineering Application Vendors

There are dozens of CAD, PDM, and PLM vendors and perhaps hundreds of individual products available on the market today. We cannot begin to explore every possible business application nor can we compare specific features or industry specialties in this document. With that said, we can provide an overview of some of the leading vendors and their strategic products which you and your manufacturing engineering teams may investigate further. The following are some of the largest vendors serving the broader market. This list does not include niche players with specialization in specific industry segments.

Autodesk

Autodesk has many strong software products and services for manufacturing and engineering. The most notable, AutoCAD, remains the premier CAD software application. Originally released in 1982, this modeling application was one of the very first commercially successful CAD systems. Since then, it has undergone several improvements and upgrades by the developer.

The fact that AutoCAD has been around for some time before other CAD software makes it the industry standard CAD software. It is full of features and specific functions like 3D models that can be converted to STL files for 3D printing. It also offers excellent mobile and web-app functionality to users.

AutoCAD is designed for professionals with experience in programming models. There is a free, fully functional version that can be downloaded and used by students. Free licenses are also available for most of its entire suite of Architecture, Engineering, and Construction (AEC) vertical packages, which include AutoCAD Electrical and AutoCAD Architecture.

It is important to note that while AutoCAD may still be the gold standard and classic choice for engineers, Autodesk has introduced several other compelling products that are in some ways superior to AutoCAD. These include Autodesk Inventor and Autodesk Revit for CAD design, as well as Autodesk Fusion360 and Autodesk Vault for PLM. Most evaluations of new CAD and/or PLM application should include these powerful Autodesk offerings on the shortlist.

Dassault Systèmes

Dassault Systèmes is a true leader in the CAD/PLM space. Their Solidworks 3D modeling software is testament to their solid engineering prowess. Other popular Dassault applications include CAD applications such as CATIA and ENOVIA (collaborative design). Their PLM offering is the ever-popular and impressive SmarTeam application.

Dassault's original software product was CATIA. It launched in 1981, around the same period as AutoDesk's AutoCAD. It should also be noted that Dassault's DraftSight product remains a stalwart 2D CAD application with a loyal following and newer 3D capabilities.

Dassault's top CAD product for manufacturers is unquestionably Solidworks which it acquired in 1997. This parametric featured-based model CAD software is preferred by many designers because of its easy-to-learn user interface and advanced features such as reverse engineering and design validation tools.

Solidworks has a safety function (Faculty of Wizard) that examines your designs for structural vulnerabilities or mistakes, allowing you to isolate and fix these issues before your final design.

SolidWorks also has some special features such as a system of NURBS so you can create very thorough curvatures. This is in contrast with several CAD software offering polygonal modeling. It works with dimensional sketching making residing easier. A great thing about Solid Works is that even with all such advanced features, the cost is still low relatively compared to other CAD tools on the market. Dassault wisely continues to invest heavily in this strategic product.

CATIA is an acronym for Computer Aided Three-Dimensional Interactive Application. Developed by Dassault Systèmes, it serves as a multi-platform application with different software suites for CAD such as CAE (Computer Aided Engineering) and CAM (Computer Aided Manufacturing).

CATIA is a standard and highly advanced engineering tool used by designers in the creation, modification, analysis, and optimization of their designs. It works by innovating product design through the various approaches that leverage existing tools through the stages involved in product design.

CATIA's specialized functions is its primary appeal for creative and industrial designers, automotive designers, mechanical engineers, and so forth. It is preferred to design products relating to automotive, ship building and architecture. CATIA users are also able to collaborate and share their designs and experience to other users through the 3D design community run by Dassault Systèmes.

PTC Inc.

Formerly Parametric Technology Corporation, PTC is another major CAD technology publisher which began operations in 1985. Their premier product is PTC Creo (formerly Pro/ENGINEER and affectionately called Pro-E). It continues to be one of the darling CAD applications in the market today.

Creo's rich thirty-year history as CAD software makes it one of the leading and most functional CAD software on the market. It comes with the power of several tools for creating and editing 3D models. As a product engineering software tool, it helps designers create and interact with 3D CAD geometry, enabling them make quick engineering decisions.

Creo integrates several functionalities like motion, thermal, parametric or direct modeling, which designers can use to create or edit their designs. It is ideal for additive manufacturing because it hastens and automates the product development process, and also helps designers to seamlessly integrate technology for greater productivity.

The updated Creo 5.0 version released in 2018 is an improvement on its predecessors with upgraded features like an easily navigable user interface and more understandable layout.

PTC has several other great engineering applications including Windchill, a product lifecycle management solution that is web-based. According to a 1999 PTC announcement, there are more than 25,000 customers across industrial equipment, consumer products, aerospace, electronics, apparel, footwear, retail, automotive and high-tech industries. PTC's PLM products address products, assets, applications, processes and services.

PLM has made inroads in the Internet of Things with its preliminary IoT acquisition with the $112m takeover of ThingWorx. It has also acquired IoT connectivity management provider, Axeda Corporation, IoT predictive analytics company Coldlight, and industrial connectivity provider Kepware. They continue to signal their strong intent in the Augmented Reality space with the acquisition of Vuforia and strategic partnerships with Microsoft and ANSYS.

Siemens

The last of the big four is Siemens, the German engineering giant. They offer several products for engineers including Mentor Graphics, PADS, Xpedition/DXDesigner, SolidEdge, NX and Team Center.

NX (formerly UG) was first released in 1978 although the software has changed considerably through the decades. NX is an alternative to Creo, CATIA, Autodesk Inventor, and SolidWorks and primarily has applications in design (parametric and direct solid/surface modeling), engineering analysis (static, dynamic, electro-magnetic, thermal, using the finite element method and fluid, using the finite volume method), and manufacturing finished design by using included machining modules.

Originally Intergraph, Solid Edge is a 3D CAD, parametric feature and synchronous technology modeling software. It offers assembly modeling, solid modeling, and 2D orthographic view functionality for mechanical designers. It links to many other PLM technologies through third-party software and runs on Microsoft Windows.

For PCB design, Mentor Graphics PCB tools are integrated, flexible, scalable & easy-to-use while Teamcenter is Siemens' suite of PLM software applications. It was originally built by UGS Corporation, which is now Siemens PLM Software. Siemens PLM itself traces its roots back to 1969 pre-dating both Autodesk and Dassault Systèmes.

HEXAGON PPM

Hexagon PPM is another popular vendor in the engineering software market with several popular products including Cabinet Vision and CADworx. It is a key division is Intergraph Corporation, an American software development and services company. Businesses, governments, and organizations globally, subscribe to Intergraph's enterprise engineering and geospatially powered software.

Cabinet Vision is an award-winning design software for woodworking professionals. It is the most widely adopted design and manufacturing software for custom cabinet and room design, material optimization, photorealistic renderings, bidding and costing, bill of materials, and cutlists.

Armed with a powerful S2M center, it can automatically create machine-ready G-code for CNC flat table routers, point-to-point machines, panel saws, drill and dowel machines, chop saws, and other specialized CNC machinery.

Cabinet Vision is an accessible dialog box that shows every point measurement to take in the room. The laser in a device with Cabinet Vision should be pointed at the desired location, and the button within Cabinet Vision clicked to take the measurement.

CADWorx is an integrated series of CAD software for plant design and automation. It is either an AutoCAD-based or BricsCAD-based system. CADWorx provides intelligent drawing/database connectivity, advanced levels of automation, and easy-to-use drafting tools.

CADWorx also features the world's only intelligent link between CAD and pipe stress analysis. Capable of increasing accuracy and improving quality of deliverables for designers and engineers alike, CADWorx users report productivity improvements of nearing 75% more than previous 2D CAD software methods, and 50% over prior 3D methods. CADWorx saves time on projects.

Bentley

Bentley Systems, Incorporated develops, manufactures, licenses, sells, and supports computer software and services for infrastructure design, construction, and operation, the company's software is used extensively in architecture, engineering, construction (AEC) and operations. Bentley's software are applied in the design, engineering, building, and operations of massive constructed assets like railways, road networks, bridges, buildings, power plants, industrial plants, and utility networks. Research and development is paramount to the company that they dedicate 20% of revenues to it.

Key Bentley software product lines are MicroStation, ProjectWise, and AssetWise. Several Bentley products have been based off the Microsoft Azure cloud platform since 2014.

MicroStation is Bentley's CAD software platform to two- and three-dimensional deign and drafting. It is used widely in architecture and engineering. It is capable of generating 2D and 3D vector graphics objects and elements. It also includes BIM (Building Information Modeling) features. MicroStation CONNECT is the most recent version, and runs on the Microsoft Windows operating system.

MicroStation was initially for creating construction drawings. It has however, evolved to include advanced modeling and rendering features, including boolean solids, keyframe animating and raytracing. It offers specialized environments for architecture, civil engineering, mapping, and plant design.

Bentley revised its native DGN format in V8 to include additional features as Digital Rights and Design History. This is a revision control ability permitting reinstating previous versions globally or by selection. It also offers better support to import or export Autodesk's DWG format. Data restrictions fro earlier versions such as limited design levels and drawing area were removed by the V8 DGN file format. CONNECT uses the V8 DGN file format.

MicroStation is also able to write and read various CAD formats (DWG, DXF, SKP, OBJ, and more) and produce media output as rendered images (BMP and JPEG), animations (AVI), 3D web pages in Virtual Reality Modeling Language (VRML) and Adobe's PDF.

Altium

Altium specializes in PC-based PCB design software and robust tools for PCD designers. In other words, they provide electronics design software for engineers who design printed circuit boards. Designer is its flagship electronic design automation software package for printed circuit boards. It is the evolved version of the DOS-based PCB design tool, Protel PCB (later Autotrax and then Easytrax).

It became Altium Designer 6.0 in 2005. The first version to offer 3D visualization and clearance checking of PCBs directly within the PCB editor.

There are four main functional areas within Designer's suite:

1. Schematic capture
2. 3D PCB design
3. Field-programmable gate array (FPGA) development and
4. Release management.

Features common across reviews include:

1. Interactive 3D editing of the board and MCAD export to STEP.
2. Integration with various component distributors, allowing search for components and access to manufacturer data.
3. Cloud publishing of design and manufacturing data.
4. Simulation and debugging of the FPGA with the VHDL language, and ensuring that expected output signals are generated given a set of input signals.

Ansys

Ansys develops and markets engineering simulation software. Their software can be applied to product and semiconductor software, as well as create simulations to test durability of a product, its temperature distribution, electromagnetic properties, and fluid movements.

Ansys acquisitions include other engineering design companies involved in electronics design, fluid dynamics, and various physics analyses. Ansys SpaceClaim is actually a product of Ansys acquisition, SpaceClaim. SpaceClaim is a solid modeling CAD software. It runs on Microsoft Windows and targets the mechanical engineering niche. Its approach to solid modeling uses design concepts resulting from pulling, moving, filling, combining, and reusing 3D shapes.

There is also SpaceClaim Engineer for end-users. SpaceClaim software are also licensed for OEMs (Original Equipment Manufacturers) like Ansys, CatalCAD, Flow International Corporation, and Ignite Technology. Ignite markets a version of SpaceClaim used for jewelry design.

Four tools express SpaceClaims's 3D direct modeling technology through its user interface: pull, move, fill, and combine.

Pull is the most feature-heavy. It contains most tools found in traditional CAD systems, and relies on user selections and secondary tool guides to determine behavior. An example is the Pull tool on a face by default offsetting the face while on the edge, Pull rounds the edge.

Move repositions geometry and components, and is applied to make patterns (arrays). Fill on the other hand, will often remove geometry from one part by extending geometry to fill the surrounding area. This is mostly used to delete holes and rounds from a model. SpaceClaim Engineer has more specialized tools for model preparation.

Combine is responsible for boolean and splitting operations like merging and subtracting parts from each other.

Let's mention here that these functions were developed in the ACIS modeling kernel licensed to SpaceClaim by Dassault Systemes.

Aras

Aras is the American developer and publisher of product development software, Aras Innovator. Aras Innovator is used for product lifecycle management and various other applications.

Aras Innovator has been open-source software since 2007, and Aras Corp provides key software updates and technical support as subscription services.

The Innovator is based on the Microsoft .NET Framework and SQL Server and is dedicated to managing product lifecycle management business processes.

Other applications of Aras Innovator include lean product development, advanced product quality planning (APQP), collaborative product development, and new product introduction (NPI).

Arena Solutions

Numerous professionals and companies around the world trust Arena for their Cloud PLM, quality management systems (QMS), and requirements management.

Arena focuses on integrating distributed teams as they keep track of latest product design with unstructured information silos. Innovative products demand mechanical, software, and electrical teams cooperate with external partners throughout the product development process.

Arena PLM is cloud-based making it easy to deploy, configure, and use from any location, making it easy for everyone to observe new product development and introduction (NPD/NPI).

Regulated defense suppliers must comply with US export controls like ITAR and EAR. They can deploy Arena PLM on AWS GovCloud.

Cadence

Cadence Design Systems, Inc. is a multinational electronic design automation (EDA) software and engineering services company. The merger of SDA systems and ECAD, Inc. in 1988 formed the company. It makes software, hardware, and silicon structures for designing integrated circuits, systems on chips (S0C) and printed circuit boards.

Cadence acquired OrCAD Systems to bolster its position in the shrink-wrap PCD Design Tools market.

OrCAD is Cadence's software for electronic design engineers and electronic technicians. It can create electronic schematics, perform mixed-signal simulation and electronic prints for manufacturing printed circuit boards.

OrCAD is really a suite of products including a schematic editor – Capture, an analog/mixed-signal simulator – EE Pspice, and a PCB board layout solution – PCB Designer Professional.

Microvellum

Microvellum targets woodworkers who need to meet customer demands. It helps them build products on time and on budget, in the face of pricey labor and scarcity of skilled workers. Microvellum software streamlines the numerous processes related to wood product design, production, engineering, and production so projects can be built on time and with precision.

For 3D models, Microvellum offers the Solid Model Analyzer (SMA). This powerful tool makes it flexible to process 3D models from virtually any solid modeling application, such as Solid Works, AutoCAD, SketchUp Pro, and Inventor. For design teams that build unique products in a separate modeling application or receives models from outside designers, SMA allows seamless manufacture of these 3D models without any need to re-engineer them.

Mitre Software Corporation

Mitre Software focuses on speeding up the work of busy geotechnical engineers, and AcornPipe is preferred for isometric piping drawings. AcornPipe is cost-effective and user-friendly.

It is highly innovative software that allows users to click through a piping drawing, set up specifications, create weld maps, and allocate heat numbers and inspection information easily.

AcornPipe provides adequate support in all aspects of industrial piping design, fabrication, installation, estimation, inventory control and quality control.

Oracle

Oracle does not provide a native CAD application, but acquired Agile in 2007. Agile remains a leading PLM option for larger, enterprise manufacturers. Agile's PLM solutions underpins the product innovation and introduction process in many industry types – life sciences, consumer packaged goods, industrial manufacturing, and high-tech.

AutoVue Enterprise Visualization is a suite of Oracle products suited for delivering web-based capacity to access, view, annotate (digitally) and collaborate on technical and business documents, without the need to invest in specialized CAD tools.

With the right documents available to the right resources when needed, AutoVue can enhance decision making and tailor improvements in customer's engineering and document intensive workflows, like design reviews and approvals, asset management, maintenance operations, and more.

AutoVue is the industry leader for AutoCAD and hundreds more 2D CAD, 3D CAD, ECAD and office formats.

Trimble

Trimble develops many different business applications and entered the CAD market in 2011 with the acquisition of Tekla. Trimble's EC-CAD and MEP range of construction management software, services, and hardware improve workforce productivity.

Tekla is a software suite for analysis and design, detailing, and project communication.

Tekla Structural Designer is a software solution for building analysis and design. Structural engineers working on concrete and steel buildings use Structural Designer a great deal. Tekla Tedds automates repetitive structural and civil calculations, providing key calculations, sketches and notes.

We have realized an elimination of human errors on the data entry side. Now all human errors fall on engineering BOM mistakes. From manual to CADTALK automation is over 98% time savings. Extremely complicated BOM (>500 recursive line items) would take over 10 hours to manually enter and now that is done in 3-5 minutes CADTALK processing time and less than a minute of human interaction.

Sasha Johnson, Engineering Manager
Russ Bassett Corporation

Tekla BIMSight builds information model-based construction project collaboration. It is able to import models from BIM (Building Information Mananagement) applications with Industry Foundation Classes (IFC) format, DWG, and DGN. Users can also do spatial coordination (clash or conflict checking) to prevent design and constructability issues. By sharing models and notes, communication during construction project is made possible.

Tekla Structures is BIM software for steel and construction detailing, precast, and cast in-situ. It gives users the ability to create and manage 3D structural models in concrete or steel, guiding the process from concept to fabrication. The shop drawing creation process is automated. CNC-files are created, along with files to control precast concrete manufacturing, control reinforcement bending machines, import PLM systems, and so forth. Structures is available in various configurations and environments to suit various culture- and segment-specific needs.

TinkerCAD

TinkerCAD is also another top CAD software with several features which include a browser-based 3D design and modelling tool, Click-to-3D print, fast, (ability to complete models and designs in minutes) and an accessible user interface perfect for beginners.

TinkerCAD features a block-building concept that allows users to develop models from a set of basic shapes, and also has an online software that comes with a store of millions of shapes that a user can choose from.

It is well-suited for any skill level, as it has several functions that appeal to students, newbies, as well as experienced professionals. Its 3D printing solution and a direct connection with 3rd party printing services gives it an added benefit over other CAD software in the market.

TinkerCAD has definitely helped many designers to develop high quality products for consumers.

SketchUp

SketchUp is 3D design software that makes 3D modeling accessible to everyone. It is used for a wide range of drawing applications like architectural, landscape architecture, civil engineering, mechanical engineering, film and video game design, and interior design.

An amazing feature that makes SketchUp stand out from its order CAD software counterparts is its neat and well-organized interface. Users are not bogged down with too many buttons and complex functions that can be hard to understand especially by newbies using the CAD software. Rather, it offers a simple intuitive interface and several basic tools to help users create your 2D and 3D models.

Another benefit of SketchUp is the exchange repository feature integrated into its CAD software as well as a store where more than 2 million SketchUp models are available for download by the user.

The SketchUp pro version has several features of its own. Apart from its ability to create simple 3D designs from scratch, you are also able to either edit or export these designs. Its editing toolbox is large with the addition of more advanced tools to help you with your design like solid modeling.

Lastly, this is a great tool for making architectural designs due to its ability to help users generate technical plans, reports, and lists to complement the fanciful renderings common to CAD software. These generated technical plans are good for planning, executing and analyzing building projects

FreeCAD

Our list would be simply incomplete without FreeCAD which, deducing from its name is a completely free CAD software. Despite being free, its features are quite amazing and they include BIM, software with finite-element-method (FEM) support and parametric 3D modeling which is very suitable for designing realistic models of any size and modifying designs.

The parametric 3D CAD modeler erases the hassles with editing, since designers just need to go back to model history and change parameters to get a new model whenever they want to modify a document. FreeCAD Is easy to read and highly customizable.

It is open-source and as such it can read and write several open file formats namely SVG, DXF, IGES, DAE, STEP etc. FreeCAD also has a moderate toolbox with several advanced tools. However it might not be the best CAD software for your professional designs, but it can serve as an excellent training tool which is advisable to use before purchasing CAD software with paid licenses and subscriptions.

While FreeCAD's original purpose was mechanical product design but expands to a wider range of uses in engineering (architectural or electrical). Functionality can be extended using the equally open source Python programming language.

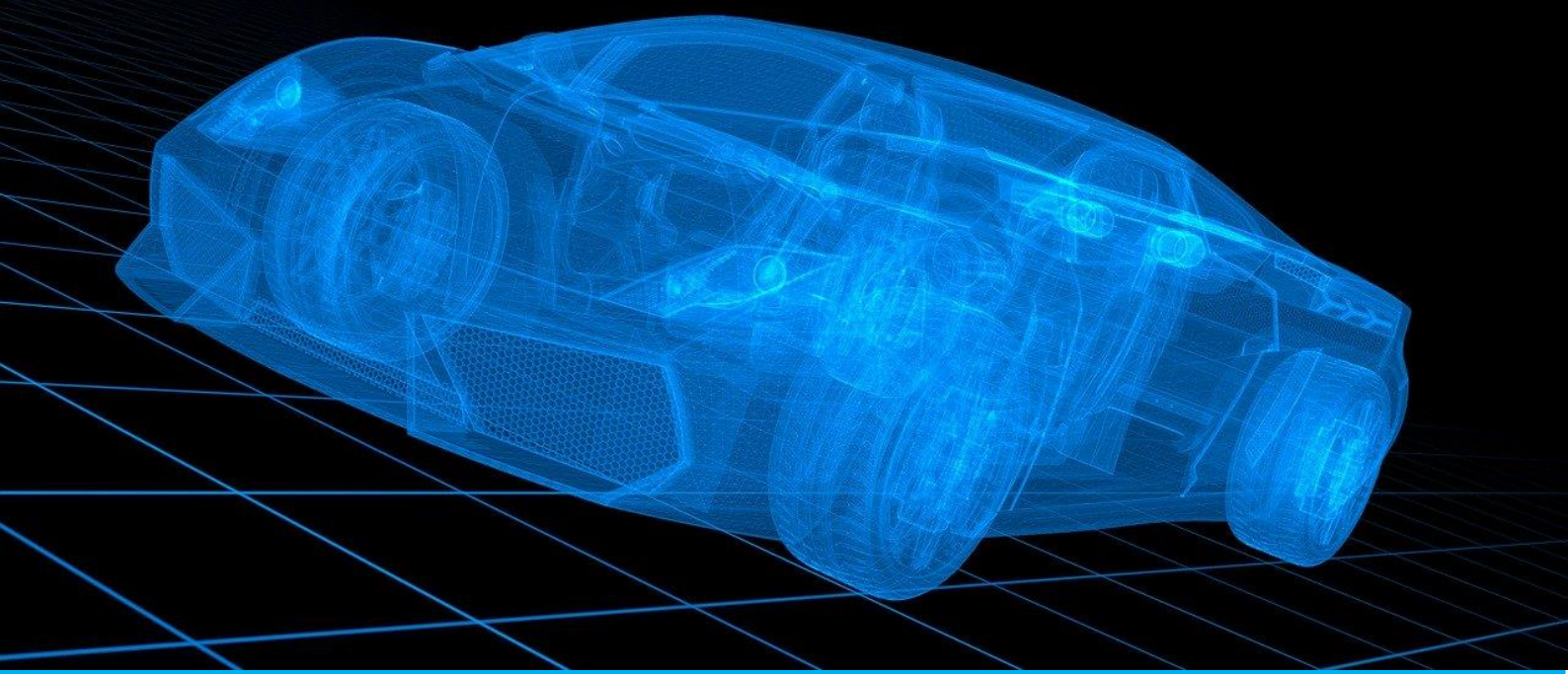
It supports various file formats: DXF, SVG, STEP, IGES, STL, StereoLithography, OBJ, SCAD, IV, IFC, and its own native file format.

TurboCAD

TurboCAD 2018 Deluxe is a basic and powerful 2D/3D CAD software tool recommended for individuals new to CAD software because of its easy to learn and use interface. It comes with several tools that can be used to draw, annotate, modify and create dimensions to facilitate the creation and development of high quality models in your product design process.

Its other features include: a highly customizable UI, XREF support, and mechanical tools highly preferred by product engineers like 2D/3D Boolean operations, revolve, extrude, sweeps, a conceptual selector and tools that can be used to light up and highlight 3D objects. TurboCAD users can share their designs with other 3rd party CAD software like SketchUp and AutoCAD.

It is notable that CAD runs on Apple Inc.'s Macintosh platform as well as Microsoft Windows. The Mac versions are built off a separate codebase. They are not directly comparable with the Windows versions. Both 2D and 3D tools are contained in TurboCAD Mac Pro, while the standard version is for 2D drafting only. A High Sierra-compatible version of TurboCAD v10 was released in February 2018 by IMSI Design.



How CAD, PDM, and PLM Fit Into Engineering Change Management

As described previously, many manufacturers utilize CAD with PDM and PLM applications which provide control over the engineering change and revision process. However, others often utilize the engineering change order (ECO) or engineering change notification (ECN) modules and features inside their ERP applications. There are advantages and disadvantages to both strategies.

Using PDM or PLM for engineering change management makes a lot of sense for many manufactureres. The applications offer very deep functionality around all aspects of the part design, documentations, supplier management, and even some aspects of labor operations. However, PLM applications that are not tightly integrated with the main ERP business system will likely miss some of the information utilized for production in the ERP. For example, without tight integration, how will a material planner working in ERP understand the impact of a newly approved revision in PLM that takes effect in the next 30 days? And how will the production schedule inside ERP be impacted when that engineering revision takes place? A revision can significantly impact production schedules as manufacturing processing times can be dramatically less (or more) and some operations can be completely eliminated. Further, an engineering revision could impact where the manufacturing operations occur – such as a different machine or work center or outsourced to a third party vendor for such things as heat treating, plating, coating, or painting. Lastly, engineering revisions most often impact manufacturing costing which is managed inside the ERP system. Swapping out one part for another may sound simple but the replacement item could cost a lot more or a lot less and it may come from a different vendor with longer or shorter lead times.

Manufacturers who manage the engineering change process inside their ERP systems face similar, albeit different, challenges. Many entry-level ERP systems offer very little engineering change order functionality and most do not integrate directly with CAD applications requiring significant manual data entry or export/import processes that are prone to human error. Most midmarket ERP applications have some level of engineering change order management but these are almost always very basic with limited controls compared to the power of PDM or PLM applications. Further, midmarket ERP vendors may offer some integration with the most popular CAD applications on the market (such as Solidworks or Autodesk Innovator) but it is very unlikely that they integrate to other CAD systems – especially niche applications from smaller, less known vendors. Managing engineering changes inside the ERP often solves problems with material planning, scheduling, and costing but it requires significant effort to keep these types of changes in sync with the original CAD models and bills of material inside the CAD application.

Most manufacturers simply live with the deficiencies in both of the aforementioned strategies neglecting to automate these critical processes. This can cause catastrophic disruption throughout the business including orders for the wrong items causing production delays with downstream impact on product quality, costly rescheduling of expensive machine and labor capacity, or worse – the loss of a high profile customer due to delays and inconsistent product quality.

It is highly recommended that IT management steps in and addresses the integration and automation process to close the gaps between the CAD, PDM, and PLM business applications and the ERP system of record. Many manufacturers develop their own one-off integrations. This is better than nothing but often these integrations offer minimal improvements to the process and they must be maintained for each new version of the CAD, PDM, PLM, and/or ERP business applications to ensure the continue to function properly. Second, they require resources for development, testing, training, and support by an IT department that is likely strapped and stretched too thin with more critical business and technology issues.

The good news is that there are now a few automation systems available to connect data between CAD, PDM, and PLM systems and ERP. One such product is CADTALK ERP. CADTALK leverages artificial intelligence to fully transform the engineering bill of material from manufacturing design engineering systems into fully-functional manufacturing bills of material, routings, and items inside the ERP system. The software also works bidirectionally ensuring that data flows seamlessly between both areas of the business. CADTALK also provides a design for manufacturing (DFM) module for use inside the CAD software so that manufacturing engineers can see data from the ERP system when they are designing or revising parts to ensure that they are using the right parts and have additional information available such as vendors, stocking locations, and other data that often impacts the product design. Another great benefit of products like CADTALK is that they offer additional capabilities such as updating manufacturing jobs or work orders directly from the CAD model in traditional engineer to order environments.

Optional modules are also available to connect the ERP system with nesting layout applications as well as configure price quote (CPQ) software where the configuration can generate a CAD model.

Without systems like CADTALK, IT is often tasked with the mundane task of exporting bills of material from CAD and importing that data into ERP. Or worse, IT is responsible for manually creating and updating bills of materials, routings, and items in the ERP system every time a new part is designed or revised. And this manual process can take a very long time and is prone to data entry and interpretation errors. Conversely, applications like CADTALK validate the data transformation resulting in about an 80% improvement in the engineering to manufacturing hand-off process shaving hours and days of work down to minutes.

Leading PLM Applications

There are millions of consumer and business products manufactured in today's world – from combs and brushes to fasteners and complex machines and all their intricate parts. The complexity of these products and ever-changing designs and components make it nearly impossible for manufacturers to manage their product portfolios and designs without automation and detailed processes for all product development phases.

Product Lifecycle Management software assists a product's complete lifecycle from its early design and development through to prototype design to high volume production. PLM connects people, data, designs, processes, and business systems providing a foundation to manage every facet of your engineering research and development projects.

The world of PLM software has changed dramatically over the past few decades with many great choices for manufacturing engineers to choose. Some of these are specialized for particular industries while others are applicable to many manufacturing disciplines. Below are 15 of the top PLM products available today that manufacturers may choose to manage their engineering and product lifecycles. Products are not listed in any particular order.

ARAS Innovator PLM

ARAS Innovator PLM software is available for purchase or as a free open-source download. With the latter option, paid support and technical services are available from ARAS. The product is one of the leading PLM applications on the market covering all facets of product lifecycle management including bills of material, engineering changes, documents, integration with most popular CAD applications, costing, quality and compliance, project management, product configuration, formulas and recipes, and more.

Arena PLM Solutions

Arena PLM is a popular choice for electrical, electronics, and medical device manufacturers. It is deployed via the internet and available in multiple configurations allowing to scale both in terms of cost and complexity for small to large manufacturers. Arena offers excellent collaboration tools for working with external contributors to the design process. One thing that makes Arena unique is that they do not do anything other than PLM where some of the larger CAD application vendors offer both CAD and PLM. Arena claims to be the first PLM application on the cloud and continue to lead in this category.

Autodesk Fusion Lifecycle

Autodesk is without a doubt one of the best known brands in the engineering field known primarily for their AutoCAD, Innovator, and other CAD applications. Autodesk Fusion Lifecycle (formerly Autodesk Fusion360 PLM) is the company's cloud-based PLM offering. The product is gaining momentum in the crowded PLM market space and offers compelling features to rival those of other competitors in the space.

Autodesk Vault

Autodesk Vault is one of the most popular PLM applications in the market. Autodesk Vault may be one of the more comprehensive PLM products available and it's design and lower cost make it a very popular option for a larger number of manufacturers. Further, various editions of the product allow it to scale from very small manufacturers to extremely large manufacturers with hundreds of engineering users. It offers everything most companies need including bill of materials, engineering change management, collaboration, CAD integration, project management, multi-site deployment, concurrent design, product configuration, and much more.

Dassault Enovia PLM

Powered by the 3DEXPERIENCE® platform, ENOVIA is a great PLM option for manufacturers and is quite popular among aerospace and defense product manufacturers. The product is quite comprehensive and utilized in some of the largest manufacturing environments in the world. Available as a cloud-based application, Dassault Enovia is a smart option for larger manufacturers with a comprehensive suite of modules and features to manage every aspect of their product lifecycle.

Dassault Enovia SmarTeam

ENOVIA SmarTeam is a product data management (PDM) application for engineering departments and small to medium sized companies. SmarTeam is designed for smaller manufacturers and manufacturers with less complex PLM requirements. Thus, it is a very popular option for a wide variety of manufacturers and is a very cost-effective choice for product management. While lacking some enterprise features, Dassault Enovia SmarTeam is still very powerful with appropriate features to manage most elements of the product design and revision process. SmarTeam customers with a need for more complex product lifecycle management (PLM), multi-discipline or multi-site collaboration, sustainable innovation, business applications leveraging PLM data, enterprise-wide quality management, integrated project management, requirements management or advanced change and configuration management should consider Dassault Enovia PLM instead.

Infor CloudSuite PLM

Infor offers multiple PLM products – one for discrete manufacturers, a specialized PLM for the fashion and apparel industry, Infor PLM Accelerate (powered by Aras Innovator) and Infor PLM Optiva for process manufacturers engaged in chemicals, food, beverages, and other recipe or formula-driven industries. While perhaps less know among PLM vendors, Infor's products have a storied history and loyal following across manufacturing segments with a robust set of features covering the full gamut of requirements from basic PDM to advanced PLM processes.

Arena Omnify Empower

Arena recently acquired Ominify to expand its reach beyond the high tech and medical device manufacturing community into other manufacturing industries. Omnify is a much broader PLM system utilized across many discrete manufacturing industries with some overlap with Arna in electronics and medical device but a significant installed base in aerospace and defense, telecommunications, and other markets. Omnify can be deployed on-premises or in the cloud and offers direct integration with your existing engineering (CAD/CAE) and business (ERP) systems. Omnify Empower PLM helps OEMs manage their product data from concept to obsolescence in a unified environment. It provides a single, secure location to manage the complete product record including: component data, bill of material, engineering change, document, project, quality/CAPA, and training records information. Built on the Microsoft .NET Framework, the Omnify solution is quick to implement, easy to use, and provides an open integration platform for direct interfaces to existing engineering and business environments. Omnify's seamless interface with SOLIDWORKS provides users with a location to store and manage released BOMs and associated files in addition to synchronizing SOLIDWORKS and Omnify revisions. Users can generate BOM reports from any SOLIDWORKS assembly and automatically upload BOMs, models, and final documentation to the Omnify Empower PLM system.

Oracle – Oracle PLM

Formerly Oracle Agile, Oracle PLM is a very popular product lifecycle improvement application that enables profitability and efficiently centralize data through faster launch of products. This PLM has features such as cost tracking, design management and requirement management. This product provides fully integrated solutions & is suitable for electronics and high-tech industries, pharmaceuticals, medical devices, food & beverage, consumer packaged goods and many more. It emphasizes process efficiency, cross functional collaboration in the extended enterprise, rapid innovation, rigorous quality control, risk mitigation and cost effectiveness. There is scope for improvement in user experience, customer service, dissemination of product knowledge with the help of webcasts, videos, elaborate product documentation etc.

ProductCenter PLM

ProductCenter PLM by Essig PLM is not a mainstream player in the PLM space. With that said, it is a great product for manufactures of aerospace and defense, automotive, energy, consumer, high technology, medical, industrial and other complex products bringing together the people to work collaboratively and centralized and improves the management of all the user's

product data. This PLM offers benefits on Streamlined engineering change processes, enhanced collaboration and improved control of SolidWorks® product data thereby significantly reducing design cycle times and cost. Enhanced control over production information critical for International Organization for Standardization (ISO) certification and International Traffic in Arms Regulations (ITAR) requirements. Improved data management and process automation that saves time and enables design re-use.

Propel PLM

Propel is one of the youngest PLM players. Founded in 2015, Propel is a native cloud PLM application with a surprising amount of functionality for such a young offering. With Propel, all employees, partners, and customers can collaborate on any most vital product information – helping boost innovation, product throughput and customer adoption. In just one dashboard it provides all information as needed such as project status, customer reported issues, potential sales and more. Propel keeps track of all the changes that happened with graphically redline any product attribute make it easy to monitor. Configure approval workflows the way enterprises want for ECOs, ECRs, CAPAs and more. Review and approve change orders by phone which makes it possible to review right on hand and reduce delays.

PTC Windchill

PTC Windchill is a smooth integration tool for product development and management for leading enterprises. Its highly configurable roles are included transfer, distribution, visualization and publishing of the product data. This comprehensive out of the box PLM software is being used for all sizes companies specially for its open architecture system which enables easy integration with other enterprise systems, helping to quickly see value from your PLM software. It's ability to expand access the data to stockholder who doesn't use PLM made it easier for communicating in business. Thus it provides a single platform with a wide breadth of applications and key functionality, like managing Bill of Materials (BOM), tracking changes and configurations, managing requirements and quality, and viewing product designs in AR.

SAP PLM

SAP PLM is a system which helps companies to plan, design, build and administer production with greater vision and more control. It allows efficiently tracking, controlling and managing all information related to products over the complete lifecycle. The software makes environment and health and safety a key component of the development process. It helps organizations identify and assess regulatory risks, integrate compliance controls in the supply chain, manufacturing processes, quality management and also ensure compliance in sales, service and distribution. Core components of SAP PLM include integrated product development, innovation management and product compliance. It also includes analytics tools and business intelligence for better collaboration, while it also allows proactively identifying new strategic opportunities.

Siemens Teamcenter

Teamcenter introduced by Siemens as a Product lifecycle management software that unites product knowledge with process innovation. It is mostly popular as a great tool for reviewing 3D CAD models. it is a user-friendly software; so, one can easily become an average level user even after no/limited training. There are several tools to manage the data: such as you can rotate, transform, get section cut, make measurement etc. Models can be exported as a single or assembly data and saved as a different 3D format as well. Navigating in the workspace is quite easy. You can use web based Teamcenter client through your browser and then visualize the downloaded data. A platform that fosters collaboration and accelerates innovation. Teamcenter helps to manage requirements in workflows or record suppliers leverage system-based design, streamline manufacturing and more. Smart design is essential for today's smart product. Teamcenter promotes system driven development that promotes integration between mechanical, electrical, software and electronics design.

Manufacturing Engineering Software Selection Tips

With so many options on the market today, it can be extremely difficult for IT management to understand the pros and cons of each vendor, each application, and how those systems will connect and interact with existing systems and business processes. There is a wealth of information available online for these systems and vendors are more than happy to help you understand the functionality their software provides. However, most CAD, PDM, and PLM vendors know little (if anything) about ERP software and may not provide you with the right information you need to understand the impact those systems will have on your IT

department or current business processes. Likewise, very few ERP providers understand CAD, PDM, or PLM and will be of little help in your evaluation.

There are some specialized and independent PLM consulting firms available that can provide some assistance. Make sure that you choose an evaluation partner that clearly understands both sides of the business – PLM and ERP and call on references to discuss how their past integration projects turned out.

You may also consider working with a company like CADTALK which specializes in integration of CAD, PDM, and PLM with ERP. These highly specialized organizations are truly unique as they must have very deep knowledge of these systems in order for their software to function as designed. CADTALK offers software evaluation and consulting services to help you select the right CAD, PDM, or PLM application taking into account not only your manufacturing engineering design requirements but also how those applications will connect to your ERP applications.

One other tip – talk to your manufacturing engineers – the men and women who use the software every day. Understand what they need, what they cannot live without, and what features or processes cause them (and your business) the most issues today. Document these in a detailed request for information (RFI) or request for proposal (RFP) document and provide that to all involved parties – the CAD, PDM, PLM providers or prospective providers as well as your current or planned ERP vendor or reseller. When in doubt, stop and get all parties together for a call and make sure everyone has a clear understanding of the requirements and their role in the process as well as the implementation.

If you are relatively new to manufacturing engineering you may want to attend industry trade shows or vendor conferences with your engineering team members to gain a deeper understanding of the options available on the market. You can also utilize RFP and RFI services such as Technology Evaluation Centers which monitor and manage functional information for both PLM and ERP products.

Summary and Recommendations

An IT manager's job is never done. There is always an application that needs to be upgraded, systems that need replaced, backups and security issues, user support, and training. IT is tasked with keeping the entire organization running at optimal performance – from up-time to server speed and connected business processes, and data management. IT managers are technology wizards, they are not manufacturing engineers and while they are tasked with the selection, implementation, and management of CAD, PDM, and PLM applications, they simply do not understand how these specialized systems integrate seamlessly with other critical business applications like ERP.

The good news is that there are plenty of resources available to help IT to manage the selection process and specialized PLM experts and integration applications available to connect data between their systems so IT can focus on more strategic and critical tasks rather than copying or importing bills of material from one system to another.

The key is for IT to make it a priority to thoroughly investigate the manufacturing to production hand-off business process and to select the right technologies to streamline and automate this process to improve efficiencies, reduce profits, and minimize risk.

WAC SOLUTION PARTNERS

Learn how CADTALK can work for your business by visiting us online at **wacacumatica.com** or by calling **866-901-9955.**

About CADTALK

CADTALK Software leverages powerful artificial intelligence to transform engineering CAD, PDM, and PLM bills of material into manufacturing bills of material, routings, and items in popular ERP applications streamlining the engineering to manufacturing hand-off by 80%. Additional modules and products are available to automate and transform data between ERP, engineering, configure price quote (CPQ), nesting, and other connected business applications. CADTALK offers consulting services to help IT managers evaluate, implement, and integrate business applications and processes. Contact us today for a free consultation, personalized demonstration or trial.

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