PLM and ERP Integration: Business Efficiency and Value

A CIMdata Report

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1. Introduction

The integration of Product Lifecycle Management (PLM) and Enterprise Resource Planning (ERP) significantly improves the productivity and effectiveness of users and organizations working with product and plant related information. These two enterprise domains encompass many of the critical functions required to develop, test, manufacture, deliver, use, and support a product throughout its life, and integration of PLM and ERP can deliver significant benefits for companies of all sizes.

The purpose of this paper is to discuss the business motivations for integrating PLM and ERP, factors that should be considered, and various approaches and methods that can be used to perform the integration.

Initial PLM and ERP integrations occurred in larger companies because they had the resources needed to support such projects. But all companies, regardless of size, face similar problems and have the same needs for integrating PLM and ERP. Most companies, particularly small to medium enterprises (SMEs) within the supply chains, are working to add more value to their products and services and not just provide commodity components. Other companies that compete on pricing need the efficiencies that PLM and ERP integration delivers. ERP and PLM solutions address different business needs and processes.

PLM manages the innovation process – enabling companies to quickly create right-to-market products and to leverage part re-use. It focuses on the digital, context-oriented intellectual property (information), functions and business processes – the assets associated with product and plant definition. It manages the definition lifecycle and the relationships between product–related information and processes.

For example, PLM links product requirements to the functional definition of a product, the geometry of the product, and the service procedures used to maintain the product. PLM applications have been designed and optimized to maintain digital information in context.

ERP ensures that a quality product is produced according to customer demand in a timely, cost-controlled manner. It is focused on the physical, transaction-oriented business processes and deliverable assets, and addresses production planning and scheduling, inventory management, cost, and other physical aspects of product production. It has been optimized to manage transactions and large volumes of historical transaction data.

The following figure illustrates the primary functional domains of PLM and ERP/ERM. In this figure, ERM or Enterprise Resource Management, encompasses ERP as well as some other enterprise functions, but ERP is the foundation for ERM. It is important to note that there can be significant overlap areas between ERP/ERM and PLM and each is continuing to expand and deliver support for more business processes and functions.
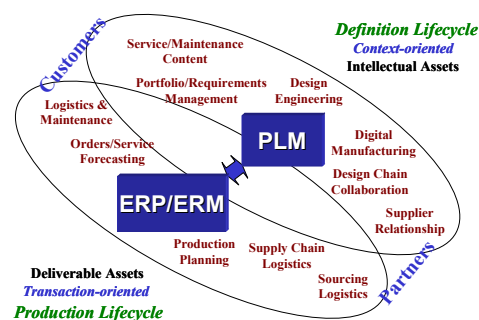

Figure 1. Primary Enterprise Domains

As PLM has delivered more complete solutions for design and engineering users within an enterprise, the management "ownership" of product related information is changing. For example, ownership of product structure and bills of material (BOMs) is shifting from manufacturing to engineering. However, BOM information must still be supported and accessible from within ERP applications. This

increases the importance of integrating PLM and ERP to ensure consistency of BOM, product change, and other related information used throughout the enterprise.

Large enterprises may integrate PLM and ERP to work downward along their supply value chain. These companies want to enable their suppliers to exchange design, change, and other information directly with their PLM and ERP environments.

SMEs typically integrate PLM and ERP to better enable them to more quickly and accurately respond to requests from their partners for quotes, designs, and physical components that will be integrated into end products. As integration technologies and vendor provided solutions have improved, SMEs can now integrate PLM with ERP in a similar manner as large enterprises – achieving many of the same efficiencies and benefits.

2. Benefits of Integrating PLM and ERP

There are many benefits associated with the integration of PLM and ERP. These benefits accrue in several areas including:

- Ensuring consistency and use of product/plant related information by personnel in organizations throughout the enterprise
- Reducing the time to bring new and better products to market at a lower cost while improving quality
- Creating and using common product-related terminology and processes throughout the business

CIMdata research of PLM and ERP integration benefits showed the following:

75% reduction in the time, cost, and errors associated with re-keying data entry from one system to the other.

75% reduction in BOM error cost as BOMs are created once and then managed consistently in both PLM and ERP.

15% reduction in inventory costs as the result of designers and engineers knowing what parts are already on hand and incorporating them into new versions or products – improved part reuse.

8% reduction in scrap of materials that cannot be used in production and which were either already in inventory or ordered before procurement was aware of pending changes.

Foremost is the need to ensure that consistent product and plant definition information is available to all users, regardless of their organization or work tasks. When individuals, and indeed, different organizations and business systems, use incompatible and inconsistent information, errors are introduced into the products being designed and manufactured. Several studies have documented that the cost for correcting errors that emerge in later phases of a product's lifecycle can be orders of magnitude higher than the cost for correcting errors identified during the early phases.

Reducing cost – cost of design, cost of manufacturing – are significant benefits that can accrue from integration of PLM and ERP. Engineers can have access to component cost information and inventory levels. This knowledge can be used to design products that use the lowest-cost, approved parts and components, and to also use parts in inventory if they meet the design requirements so that they do not have to be declared surplus or returned to the supplier. Also, the ability to alert personnel and organizations "downstream" of possible problems and pending changes and then to quickly propagate those changes is critical to reducing or eliminating errors, rework, and scrap.

Shortening time – time to design, time to first production, time to volume production, time to incorporate a change, time to market – is a major benefit of integrating PLM and ERP. Integration can provide early availability of design and change information to downstream users, i.e., manufacturing engineering or service and maintenance personnel who review designs and provide feedback and to "work ahead" to prepare the production facilities and processes that will be needed to manufacture the products. This can significantly reduce the time needed to get a product into production once its design is completed and approved.

Another time-related benefit is to ensure that changes to a product's design and configuration, including options and variants, are quickly and accurately passed to ERP for planning and scheduling, thus enabling production to meet expected customer requests. Such information may also be passed to sales and marketing so that they know what products to sell and what configurations are valid for customers to order.

Improving the quality of a product and its associated manufacturing processes is another major benefit of integrating PLM and ERP. For example, to ensure an engineer uses the best parts, or procurement acquires parts from suppliers that deliver the highest quality.

Downstream users who frequently use ERP application modules, need to have their input and feedback passed upstream to ensure that all aspects of a product and its use are considered and that quality is designed in from the beginning.

Exposing product information to users and partners throughout the development lifecycle enables users to have a more complete "picture" of both the product information and their role as part of the product lifecycle. Such information resides in more than one location and system, e.g., design data in PLM and cost/inventory information in ERP.

Having a bi-directional flow of information between PLM and ERP enables every user to understand all aspects of a product's design and manufacture earlier in its lifecycle and to provide input to ensure the final product meets or exceeds customer expectations.

PLM and ERP integration provides companies the opportunity and motivation to address and resolve many issues that may have been impacting their ability to operate more effectively. Establishing common business processes, defining clear rules for data ownership, establishing where the "master" information is located, and using common terminology will significantly reduce misunderstandings related to product information and processes among individuals and organizations and the errors that such misunderstanding and confusion introduce.

Automating and managing the processes used to design and manufacture a product across both PLM and ERP ensures that users know what they need to do, when they need to do it, and are provided the correct, up-to-date information needed to perform their tasks.

3. Implementation Considerations

There are several factors to consider when integrating PLM and ERP. These factors cover many different areas including corporate cultures and organizational structures, business practices, and technology.

A key decision is defining the level of integration needed for the company. Integration between PLM and ERP can vary in complexity from a simple one-way transfer of BOM information from engineering to manufacturing, to an immersive bi-directional environment in which users access information in both domains from within the user interface of their primary applications.

Every company does not need the same level of integration. Large companies tend to want, and need, a very comprehensive integration between PLM and ERP. SMEs generally have more narrowly defined requirements that can be met with a more basic integration.

One difference between the two is that larger enterprises may have more types of information that they will be exchanging, e.g., digital manufacturing. Making decisions about how best to integrate PLM and ERP must take into account each company's particular business and operational models.

Organization and Cultural Factors

Traditionally, users of PLM and ERP have been in different "camps" within a company, each with different objectives, methods of working, and cultures. There are also differing overlaps of functionality and processes based on PLM and ERP philosophies, histories, and cultures within each company. Integrating PLM and ERP forces a company to address these differences in order to create a solution that all groups will adopt and use.

Determining which domain will "own" and control information and processes is an issue that will need to be resolved. Historically, product structure control and change was owned and managed in manufacturing – partly because there had been no engineering systems to do that, but also because manufacturing was the major cost center and "owned" more budget and control.

Product related processes resided in both engineering and manufacturing and these organizations have historically had different views and priorities about those processes, e.g., how change should be managed. However, with the evolution of PLM, that has changed.

Companies are assigning responsibility for product structure and change management to engineering who "owns" the design and ensures that it meets all functional and regulatory requirements. Manufacturing is responsible for efficient production of that design. This change has moved the "master," or source of truth for product structure and change management from manufacturing to engineering and affects which information needs to be shared or passed between PLM and ERP.

As with change management, companies must determine which processes and information will be owned and managed by PLM applications and which will be owned or mastered within the ERP environment. Such decisions need to reflect the company's organization and culture but also support the company's vision for its future.

As with all enterprise initiatives, executive sponsorship is critical to success. Those executives who "feel the pain" and those who own the problems (and these may not be the same individuals) need to be educated as to the need, the solution, and the benefits of integrating PLM and ERP. Further, they need to be proactive proponents of that integration, providing guidance, support, and resources for the project.

In larger enterprises, it may be more difficult to identify the executive(s) that need to be involved and then to get their time and commitment to the project. Most SMEs have smaller executive teams, each of which has a broader management view and responsibility of the overall business than their counterparts in large enterprises. Therefore, it is often easier to identify appropriate sponsors in SMEs.

Business Practice Factors

A company's business practices will impact how to best implement PLM and ERP. Companies that have distributed organizations and autonomous operations will have a different set of business processes and practices than one with centralized management. For example, they may need to have separate and distinct integrations within different divisions versus having a common integration used by all groups.

Integration between PLM and ERP is as much about integrating processes, e.g., change management, as it is about transferring data from one application to another. Integration of PLM and ERP requires addressing the transfer of information and management control of business processes that span multiple organizations. Information may need to flow across PLM and ERP boundaries several times though the course of the process. Effective integrations must address how a business will work, as well as what data will flow where. Process automation should be embedded within the integration whenever possible since that automation will significantly reduce non-value-added work.

Many product related processes will span both PLM and ERP. For example, in evaluating a proposed change, PLM users may assess the impact of a design change on the functionality or performance of a product, while ERP users would assess the impact on manufacturing such as inventory, parts, material scrap, or lead times for delivery of new components.

While several processes and business functions can be supported in either PLM or ERP, there may be significant differences in how a similar function in the different systems will support the business.

Understanding how a specific business operates is a key step to successful integration of PLM and ERP.

Technology Factors

Some enterprises make technology and architecture decisions and investments over time, and create an infrastructure within which both PLM and ERP must operate. These decisions, e.g., corporate solutions, development suites, network architecture, etc., will influence how PLM and ERP will be integrated as each company needs to leverage earlier decisions whenever possible to reduce the complexity of their overall environment.

There are many technology factors to be considers, including:

- The type of information to be integrated
- The processes to be supported
- The type and complexity of integration required
- The tools and methods to be used to create and maintain the integration

Product structure and BOM exchange are normally the first integration undertaken. The second is more complete change information. Other potential integration points between PLM and ERP include (but are not limited to) supplier details, inventory and stocking information, cost data, manufacturing processes and routings, Approved Vendor Lists (AVL), part and component classification data, and item master data.

Additional process information may also be exchanged, e.g., what is the state of a design? As part of these decisions, defining what information should be exchanged versus what information needs to be accessible must be determined. This will also determine what process steps will be managed in which systems.

Defining the scope of integration also means determining the level and direction of data flow between PLM and ERP. For some information, a one direction exchange may be all that is needed, e.g., moving cost information from ERP to PLM. In other instances, a bi-directional exchange may be required, e.g., change requests and notices. Bi-directional exchange is more complex than one-way transfers and should be used where it provides the most value for the business but offers opportunities for more functionality and associated benefits.

An example of a one-way flow might be cost information that is created and maintained within the ERP domain. A design engineer needs to know the cost

of possible components that could be incorporated into a product. Since the designer will not be modifying the cost of a purchased component, simply passing that information upstream to the PLM environment may be sufficient.

Change requests and actions that can occur in both areas may be better maintained via a bi-directional integration as a user of both PLM and ERP need to be aware of the current state of the design and/or product.

Information exchanged between the two domains must be synchronized. If common information is allowed to diverge, then that information becomes invalid and re-introduces the problems that the integration is intended to address. More frequent updates keep the information more up-to-date, but increase the loads on networks and servers.

For all integrations, information needs to be consistent between both PLM and ERP. This includes maintaining information integrity, information states, information replication, defined attributes, and meta-data and consistent use of standards.

Not all information must be exchanged between PLM and ERP. In some instances, providing access to the information that resides in the other domain may be sufficient. This can be provided by incorporating access to PLM and/or ERP managed information within the user interfaces of the primary user applications such as CAD, PLM, and ERP, or via browser-based portals.

Another issue is that every company tends to implement ERP differently, even within multiple instances in the same distributed enterprise. This can be true even if each organization within an enterprise uses the same ERP supplier. This makes it difficult for PLM vendors to create generic off-the-shelf PLM and ERP integration solutions that meet every company's needs.

Using a generic implementation as a starting point can significantly reduce the overall cost and time to create the required solution for a specific company. Large enterprises often extensively extend an off-the-shelf integration while an SME may be able to effectively utilize such integrations with little or no modification.

Typically, ERP systems have been implemented before PLM solutions have been introduced within an enterprise and are often legacy systems. Integration of PLM and ERP must accommodate what has already been established, but may require changing some of the legacy environment (e.g., process and data ownership).

All businesses evolve over time; thus any integration should be designed to be flexible and cost effective to maintain, so that it can evolve to meet changing business requirements. The PLM and ERP integration will need to address the expected, like application upgrades, as well as challenges brought on by growth, acquisitions, mergers, new suppliers, and other unforeseen business changes.

4. Approaches to Development

There are multiple approaches that a company can take to accomplish integration between PLM and ERP. Each approach will provide differing levels and complexity of integration, functionality, scope, and cost of implementation and support. Companies need to assess the issues described previously and select the best approach based on their specific needs, future plans, current infrastructure, and estimated cost.

There are three primary methods used for PLM and ERP integrations, and each has advantages and disadvantages, strengths and weaknesses – increasing capabilities deliver higher benefits but generally at a higher cost.

- *Encapsulation* is a relatively simple solution (implementation can be done within *person days*) and is easier to implement than either interface or integration.
- *Interface* is more difficult to implement (implementation can be done within *person weeks*).
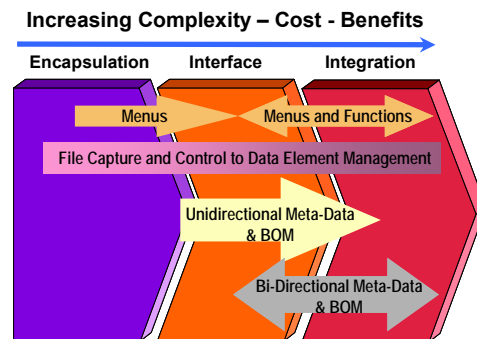- *Integration* is the most difficult to implement (implementation may require *person months to person years*).

Figure 2. Methods for Integration

To encapsulate means to enclose or surround. In the context of PLM and ERP integration, an example would be of putting a wrapper around a set of CAD files (create a data package) and transferring them to the ERP system where they would be stored. Persons using the ERP system could search for and locate the package of data but would have to transfer it to another

application for use. The ERP system would not recognize the contents of the data package or be able to use the information within. Encapsulation is sufficient for applications that can create all data as files, but encapsulation can't manage data inside the files. In an encapsulation approach, application files are recognized and applications can be launched but there is limited functionality.

When using an interface approach, PLM and ERP can exchange files and some meta-data automatically (without user intervention). PLM functions are provided via ERP menus, and PLM information such as product structures, are passed one-way to ERP. Meta data is transferred from one domain to the other (uni-directionally) and some knowledge of data structures of both PLM and ERP is required to establish the interface. Typically product structure/BOM information is transferred from PLM to ERP and is available for use within the ERP domain and applications.

Developing more compete integrations enables a full, automatic exchange of all types of product data and meta-data between the two domains. Application-specific data (such as product structures) are two-way associative and are normally managed within PLM. Most PLM functions are available from within ERP and appropriate ERP functions are available within PLM. In this scenario, users work in a consistent environment, accessing needed information and processes from within their primary application user interface regardless of whether the information resides under PLM or ERP control.

Integration implementers need to have a deep knowledge of the PLM and ERP data structures. It requires user interface work in both domains. Cooperation of the PLM and ERP solution suppliers is a critical success factor.

Regardless of which method and starting point is chosen, there are multiple approaches for implementing these methods. Different approaches for integration include:

- Information portals
- Point-to-point integration
- Enterprise Application Integration (EAI) tool sets
- Supplier-provided out-of-the-box integration
- Custom implementations

An information portal approach provides some of the value of integration, but at lower cost and more quickly. A web browser is used to present information from multiple enterprise systems and repositories - for example, stock or cost information from ERP, or viewing of engineering drawings from PLM. The portal approach provides limited or no data control integrity (systems integration), or integration of processes. However, it is a potentially cost-effective starting point for integration.

Point-to-point is based on an application-to-application-specific interface built using application programmatic interfaces (APIs) and custom code. Such integrations can be acquired from a vendor or custom developed. Point-to-point integrations can provide a very rich, uniquely tailored solution, although at a higher cost when compared to some other approaches.

Further, if multiple PLM solutions have been implemented within the enterprise, then multiple point-to-point integrations may be required, e.g., multiple PDM solutions to one or more ERP applications, multiple PLM applications to one another, and PLM applications to other business systems. This can significantly increase the complexity and cost of implementation and support when compared to other implementation options such as using EAI which provides a common interchange method and tools.
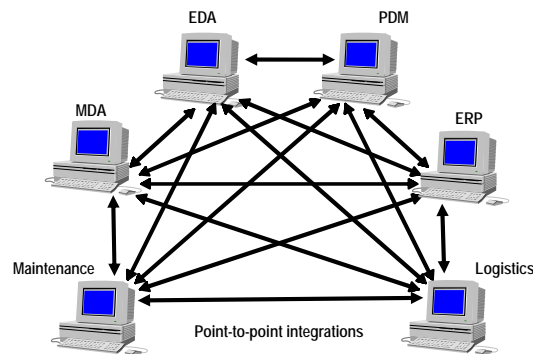

Figure 3. Point-to-Point Integration Model

To simplify the overall cost of development and support of multiple integrations, EAI is used by many suppliers and companies to create and maintain their PLM and ERP integrations. EAI integrations can be obtained from the vendors or can be custom developed. EAI tools are designed to integrate applications, processes, and data on an enterprise level and incorporate data and business rules within the integration. Importantly, EAI significantly reduces the requirement for custom software integration development and maintenance. It is designed to be non-invasive and doesn't require modification of the application systems being integrated.
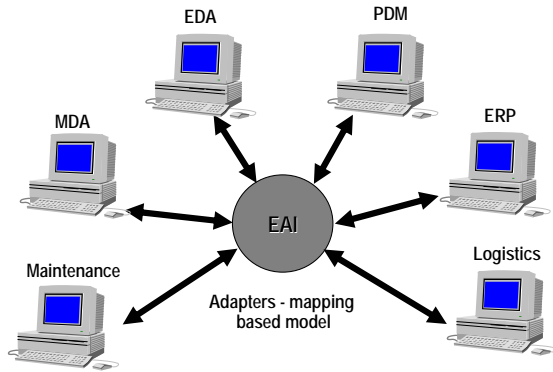
Figure 4. EAI Integration Model

In the example shown in Figures 3 and 4, the number of integration points was reduced from 15 to 6 using EAI. Reducing the number and complexity of integrations can dramatically reduce the cost and resources needed to support those integrations. There are several EAI solution providers including: BEA Systems, TIBCO, webMethods, WebSphere, and others. Many PLM solution suppliers use EAI technology as the mechanism by which they deliver integration to other applications, particularly ERP. Examples include IBM and Dassault Systèmes using IBM's WebSphere and PTC using TIBCO.

As with PLM, EAI was originally adopted by larger enterprises as early versions of these products were costly and complex to implement. Over the last several years, EAI solution providers have developed improved technology enabling them to reduce the price of the tools, and to create pre-configured packages that include integrations with popular business applications. These new versions are easily adopted by SMEs and provide capabilities that were previously cost effective only for major enterprises.

Almost all PLM solution suppliers provide one or more supported generic integrations to ERP systems, with SAP the most common. Each of these solutions provides differing levels of integration and may need to be tailored to meet the needs of an individual company or division within an enterprise. As each implementation of ERP tends to be highly customized to meet a company's specific needs, it is impossible for the PLM suppliers to develop generic integrations that meet all possible variations.

PLM vendors also have to update and maintain these integrations as each ERP vendor releases a new version of their product suite. While the PLM vendor may maintain multiple versions of their supported ERP integrations, there will be some delay from the time the ERP vendor releases their product until the PLM

vendor supports it. A mitigating factor is that most companies do not upgrade to a new version of ERP immediately and that gives the PLM vendors time to catch up.

Vendor-developed integrations provide a solid foundation from which the final solution can be built. In some cases, only additional tailoring (an administrative effort) is required; for others some minimal level of customization is needed; but in some cases, significant customization may be required. Some factors to consider when evaluating vendor supplier PLM to ERP integrations are: API functionality, completeness and documentation, flexibility of the integration, coverage of product functions and commands, access to application's data structures, availability of knowledgeable support personnel, and APIs that may change with PLM or ERP product suite upgrades.

Custom implementations can be developed using combinations of APIs, EAI technology, and programming. Custom implementations are uniquely tailored to meet a company's specific requirements, but custom integrations are only as good as the requirements gathering and definition used as the basis for its design. Further, custom implementations can require long development times and are usually the most costly method to achieve PLM and ERP integration (both in initial and on-going maintenance costs).

Unless a company has the internal expertise and resources to develop the custom integration, they will have to contract such development to systems integrators, vendor services groups, or other third parties. When third parties develop custom solutions, there is a risk of long term support if knowledge of the development activities and code are not transferred during implementation. Also, the PLM and ERP solution suppliers are not responsible for ensuring that future upgrades of their product suites will be compatible with a custom integration. However, even with the issues described above, custom implementations may be the most effective approach for some companies.

It is important to note that each solution provider will pitch their approach as the "best" but companies that plan to integrate PLM and ERP need to understand what alternatives exist and should fairly compare how each would address the company's unique business needs. Large companies may be more likely to do custom implementations either point-to-point or EAI-based. SMEs will look to the vendors to provide the

solution and are more likely to work with the out-of-the-box capabilities of those solutions or pre-configured EAI solutions rather than undertake expensive custom implementations. EAI-based solutions, generic or tailored, can deliver an overall lower cost of ownership than other approaches. Further, using EAI technology also provides for other enterprise business application and functional integration all based on a common technology foundation and suite of tools.

5. Summary

The information and process integration of PLM and ERP enhances the productivity of users in areas to deliver an overall benefit that is greater than the sum of the individual contributions. However, to achieve these benefits, information must flow between these domains and defining the scope of integration can be a complex task. Factors that must be addressed include: data and process ownership, defining the master source of information, the level of integration required, and how processes will be managed that span the two domains.

While solution suppliers have been developing better and more comprehensive off-the-shelf integrations between PLM and ERP, each company has different ways of doing business. Historically, most PLM and ERP integrations required a significant amount of custom services even when starting with a supplied off-the-shelf solution. However, as the scope of supplied integrations (API or EAI based) has improved, much less customization is being required – more so for SMEs than for larger enterprises. But even with improved starting capability, it is important that a needs analysis be performed to determine what a specific company really requires. This needs analysis is then the basis for performing a gap analysis against alternative solutions to determine which offers the most cost effective approach for that company.

In making a determination of how best to integrate PLM and ERP with your company, set priorities on what is needed, not on what is desired. Evaluate the total cost of ownership, including development, initial deployment, and on-going maintenance. Costs will vary based on the scope of the integration and the method chosen for implementation. PLM and ERP integration is more than just data integration. It should encompass a wide range of product related information, processes, organizations, and people – it is not just technology integration.

Integrating PLM and ERP may appear to be a daunting task. However, there are many off-the-shelf solutions that provide significant capabilities, and for some companies all that is needed. The benefits of integrating PLM and ERP impact many areas of a business, not just engineering, and help companies of all sizes be more competitive in today's global competitive markets. PLM and ERP integration is not just for large enterprises. The improvements in integrations technology, i.e., EAI, and off-the-shelf solutions have made these integrations cost effective for small- to medium-sized enterprises around the world.

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 PLM. CIMdata works with both industrial organizations and suppliers of technologies and services seeking competitive advantage in the global economy by providing world-class knowledge, expertise, and best-practice methods on PLM solutions.

CIMdata helps industrial organizations establish effective PLM strategies, identify requirements, and select PLM technologies, optimize their operational structure and processes to implement solutions, and deploy 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 international conferences in North America, Europe, and the Pacific region.

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