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# Tech-Clarity Insight:

# The Evolving Roles of ERP and PLM

***Integrating the Roles of Execution and Innovation***

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## Executive Overview

ERP and PLM are two of the most significant components in the enterprise systems ecosystem for manufacturers. Tech-Clarity research report "*The Complementary Roles of ERP and PLM*" indicates that ERP and PLM play important, distinct, and complementary roles in helping companies achieve product profitability. PLM plays the primary role in product innovation, product development, and engineering while ERP plays the primary role in planning and managing business execution. Of course ERP also plays other important non-product-related roles in accounting, corporate governance, and human asset management. As companies have matured the use of these systems, integrating the two solutions and ensuring they work in harmony has increased in importance.

Until recently, however, research has shown that most companies have limited integration between these systems. As PLM has matured and companies have used it for longer periods of time, the view towards integrating ERP and PLM has also matured. The role each system plays has remained the same – PLM for managing innovation and ERP for managing business execution – but the integration between them has evolved significantly. This is the result of the continued extension of PLM beyond the engineering department and into the enterprise, including the incorporation of more advanced product-related processes in domains such as product compliance, direct materials sourcing, design for cost, and quality planning. Each of these processes has a corollary in both ERP and PLM, with PLM typically taking the lead in designing the approach and ERP taking the lead in putting the strategy into operation and reporting actual results.

***The role each system plays has remained the same – PLM for managing innovation and ERP for planning and managing execution – but the integration between them has evolved significantly.***

Although this two-system ecosystem is a good generalization for the purposes of this paper, it's important to recognize that real-time execution of these processes is frequently found in more detail-oriented, real-time systems such as Manufacturing Executions Systems (MES), Quality Management Systems (QMS), Supply Chain Management Systems (SCM) and Asset Lifecycle Management (ALM, also known as MRO systems).

The report concludes that manufacturers can take an evolutionary approach to achieve an integrated ecosystem of solutions that spans product innovation, product development, engineering, manufacturing, and support. Regardless of where a company starts with ERP or PLM, their evolution can include the maturation and greater use of each of these systems in parallel with greater integration of the systems to close the loop between innovation and execution cycles. The clear result is that each solution provides value in a unique way to the manufacturing community, and that the combination of the two offers even greater value.

## Defining the Roles of ERP and PLM

Tech-Clarity has researched the roles of ERP and PLM in manufacturing before. The first report, "*The Complementary Roles of ERP and PLM - Leveraging Enterprise Applications to Maximize Product Profitability*" explored the roles of each of the systems. A follow-up study by Aberdeen Group, "*Enabling Product Innovation: The Roles of ERP and PLM in the Product Lifecycle*" confirmed many of the findings with a benchmark survey. The key finding of these reports was that ERP and PLM provide fundamentally different value based on the strategic focus of each. Although the lines between the systems sometimes appear blurry, there are distinct characteristics and requirements for each, and each has their own strengths.

Since these reports were published, manufacturers have made a lot of progress implementing and using PLM. During this time, the use of PLM has matured considerably, expanding to cover more product-related processes, product information, people, and lifecycle segments. This report updates these perspectives, although the relative roles of ERP and PLM have not changed significantly. Each of these systems has certain "themes" and "focuses" that they are strong in. The power of ERP includes managing orders and centralizing control and accounting. As an example, Cameron manufactures flow equipment products for the oil and gas and process industries. Greg Obets, the Manager Engineering Systems at Cameron describes the role of ERP in his company. "*ERP is largely where the finances are, it's what runs the company, everything about the business is kept there.*" The power of PLM, on the other hand, includes themes of managing product knowledge, enhancing speed to market, and collaboration.

***ERP is fantastic at executing transactions, but the design and collaborative space are not strengths.***
*Tano Maenza, Director of Business Solutions, Emerson*

Both ERP and PLM play a very important, but distinct role in driving product profitability. They were designed for different business processes, and have evolved to better support the needs of those processes. Tano Maenza, the Director of Business Solutions for diversified global manufacturer Emerson, explains that each system has strengths and weaknesses. "*ERP is fantastic at executing transactions, but the design and collaborative space are not strengths,*" Mr. Maenza explained. Cameron's Greg Obets discusses how these strengths impact where they use each system. "*We use our ERP company's PLM for document control, but we are moving away from that. Revisioning and document control are in ERP, but it is all manual and we rekey a lot of stuff. It also won't manage CAD files. We are moving document control into PLM and then pushing into ERP for non-engineers.*"

The following table (Figure 1) helps underscore the differences in ERP and PLM. The table was originally published by Tech-Clarity in 2004, and has been updated to reflect the maturation of both the roles of PLM and the relationship with ERP:

| ERP | PLM |
|---|---|
| Execution Focused | Innovation Focused |
| Repeated Transactions | Creating, Designing, Iterating and Revising |
| Steady State | Manages and Promotes Change |
| Inventory / Order Lifecycles | Product Lifecycles |
| Controlled, Well-Defined Business Processes | Disciplined, but Flexible Design Processes |
| Simple BOM Hierarchy | Complex Design Relationships, Systems View (Mechanical, Electrical, and Software) |
| BOM to Procured Part / Assembly Level | Full Product Structure to Component or Raw Material Level |
| Released Versions | Product Iterations, Revisions and Decision History |
| Central Theme of Control | Central Themes of Speed and Managed Creativity |
| Order / Supply / Demand Focused | Design / Requirements / Configuration / Project / Program Focused |
| Rigid Data Model | Flexible Data Structure |
| Structured Data | Documents, Structured and Unstructured Information, Metadata |
| Hierarchical Data Relationships | Dynamically Related, Networked Data Relationships |
| Data Mining | Knowledge Search and Retrieval, Geometric Search |
| Text-based with some static 2D and 3D Images | Visual, 3D Models, Simulation, Animation |

**Figure 1: Comparing the Characteristics of ERP and PLM**

ERP and PLM serve very different needs, and have different requirements. For example, ERP requires a bill of material (BOM) at a level required to plan and account for production. Therefore, a purchased assembly may have all of its parts designed and documented in PLM, but be summarized into ERP simply as a purchased part. This is particularly true for electronic parts, where an electrical design that includes all of the individual mechanical and physical components is likely to be incorporated into ERP as a purchased board. This information is a level of detail acceptable for materials planning, but falls short when detail is required for activities like compliance analysis, costing, quality, or parts reuse.

***ERP requires a BOM at a level required to plan and account for production… a level of detail acceptable for materials planning, but falls short when detail is required for activities like compliance analysis, costing, quality, or parts reuse.***

"*If you just want to manage a BOM, ERP is OK. But integrating CAD, document management, viewing and markup, collaboration and workflow configuration is very helpful, not to mention engineering BOM to manufacturing BOM planning, visualization, and process simulation – ERP is just not there,*" Emerson's Tano Maenza explains. The level of detail required in ERP is simply different. This is even more so for mechatronics parts where companies are modeling the entire mechanical, electrical, and software system together.

## Where does PLM Stop, and ERP Begin?

With clearly different roles for ERP and PLM, the question then becomes which solution to use for which needs. When asked, most manufacturers see a clear handoff point between PLM and ERP. This was further supported by the survey research conducted by Aberdeen Group. This handoff point is typically "release to manufacturing," although some companies have matured from there a bit in their integration. For example, companies have extended the use of PLM beyond release to manufacturing to manage as-built and as-maintained configurations. Others have extended the integration to earlier phases in product development. "*In our new product development (NPD) process, we expose the product to our ERP system after our preliminary design phase-gate to support forecasting and pricing,*" explains Emerson's Tano Maenza. "*Then, after detailed design we have our formal release.*"

***Most manufacturers see a clear handoff point between PLM and ERP … typically "release to manufacturing."***

One way to think of the roles of ERP and PLM is that PLM determines what the product should be, and ERP helps manage the business of turning that vision into real products.

Again, it's important to recognize that the detailed execution is often found in solutions such as MES, SCM, or ALM/MRO. PLM has also evolved to other aspects of the product, such as regulatory or customer compliance, quality and safety, manufacturing planning, and costing. But what remains consistent is that PLM focuses on defining the intent of the product – both technically and commercially. ERP then helps plan production resources at a high level, accounts for material usage, plans inventory, manages orders, and accounts for the physical delivery of the product. In essence, PLM is the innovation cycle and ERP is the backbone for the execution cycle (Figure 2), with ERP serving as the backbone for execution, and with execution details integrated in from more detail-oriented, real-time systems or manual processes. This graphic was originally published by Tech-Clarity in 2004, and has been updated to reflect the maturation of both the roles of PLM and the relationship to ERP.

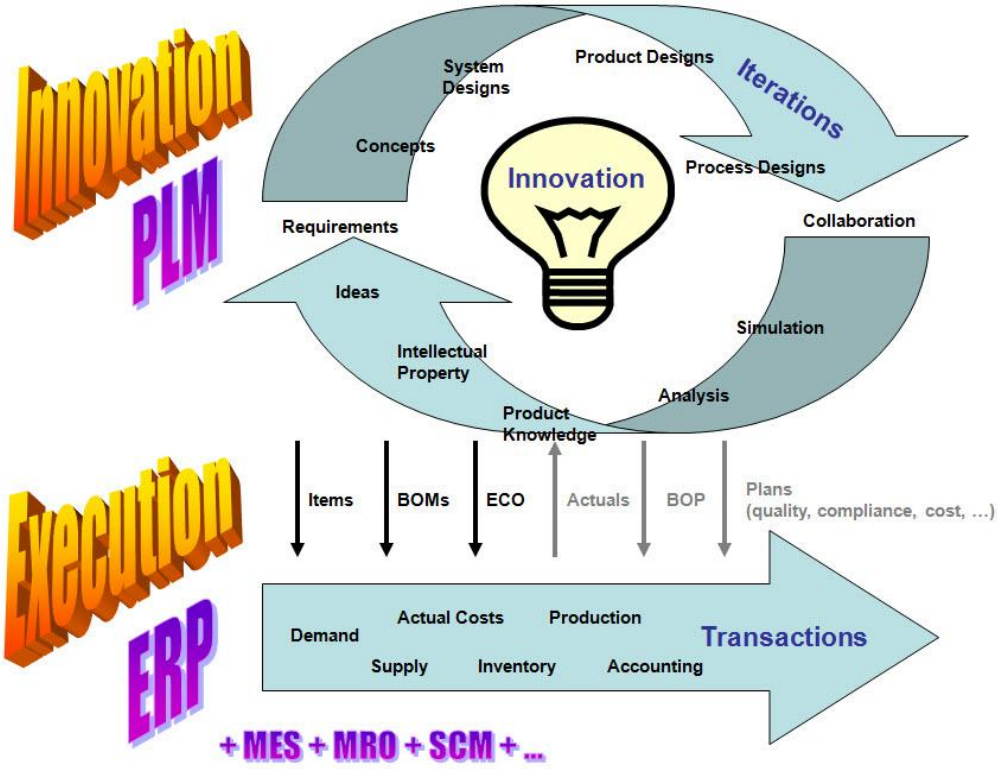


**Figure 2: Manufacturing Systems Ecosystem**

The innovation cycle is characterized by rapid iteration and revisions, while the execution cycle is- characterized by a more linear, repeatable processes. Much of the information in the innovation cycle, including work-in-progress designs and plans, are not formally captured and shared without PLM. This information does not have a home in ERP, and is typically found in unmanaged documents and spreadsheets.

"*A lot of data never makes it to ERP, and historically we would lose it,*" says Cameron's Greg Obets, "*All of that data is what we were so concerned about, we lost it way too often. But PLM was born for work-in-process designs and products.*" Design iterations and other product development information are considered clutter in an execution-oriented system such as ERP, but this intellectual property (IP) stored in PLM represents a valuable corporate asset.

The graphic also includes more advanced integration concepts, including bi-directional integration of information and more advanced integration from ERP to PLM to reflect the evolving, maturing roles of ERP and PLM. These more advanced integration concepts are a direct result of expanding PLM to encompass more product-related processes. The following table reflects the roles that ERP and PLM in these advanced integration domains including quality, costing, compliance, manufacturing, maintenance, and direct material sourcing.

| **ERP** | **PLM** |
|---|---|
| Quality Specifications, Quality Data, Inspection Plans | Quality Plans, FMEA, Risk Management, Predictive Quality |
| Account for Cost Performance / Variances, Enterprise-wide Cost Analytics | Optimize As-Designed Cost |
| Compliance Certification | Compliance Validation, Supplier Collaboration, Bill of Substance, etc. |
| Routing at Operation, Workcenter Level for Planning | Bill of Process, Work Instructions |
| Maintenance Transactions, Contractual Agreements, Materials | Maintenance Plans, Procedures, Resource Requirements, As Maintained |
| Managing Manufacturing Operations | Optimizing Production Model, Manufacturing Engineering, Simulation |
| Purchasing Transactions, Orders, History | Direct Material Sourcing, Supplier Selection |
| | |

**Figure 3: Advanced Roles of ERP and PLM**

## Roles: The Technical Perspective

So far the discussion has been primarily about the functional roles that ERP and PLM play and the resulting functional differences. It is important to understand that these differences in purpose have also driven the way that the respective systems architectures have evolved. The following are some considerations when determining the differences in technical requirements between PLM and ERP. As mentioned earlier, much of the data in PLM is clutter to ERP, including revisions that have not been released to production. These unreleased products and revisions carry valuable product knowledge, but are baggage – and potential for mistaken usage – in an execution management system like ERP.

Mathias Mond is the CEO of a systems integrator with special focus on ERP-PLM integration, whose company is partnered with leading PLM and ERP companies. Mr. Mond provides his perspective on product data size as technology driver. "*You have to consider the amount of data that needs to be handled in product development, where much of the data has nothing to do with the operation of the company. Most of it is only relevant to engineering, for example, to go back to a dead end to understand why a decision was taken. That information doesn't have a place in ERP and there it would be hard to get any value out of it, but it is very valuable in PLM.*"

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Design iterations are a key consideration to the amount of data in PLM. Another important aspect is that each revision in PLM may include all of the related analysis, design, graphics, documentation, and other information that is not required for execution until that revision is released (if it is released at all). For this reason, and the large file sizes generated by modern CAD systems, PLM manages potentially gigabytes of information for a single product or program. This drives very different requirements for storage and data search, and frequently leads to the need for data to be segmented and synchronized between engineering sites. ERP is simply not architected for this (nor should it be).

## Integrating Innovation to Execution

Now that we have discussed the reasons that companies require complementary systems in ERP and PLM, let's turn to integrating the two solutions. Integrating PLM and ERP, previously seen as a "nice to have" or "later phase" project, is now being addressed sooner in the implementation lifecycle. This is likely due to the maturation of PLM use to

include users and functionality outside of the Engineering department. Now that PLM is addressing the business of innovation and product development, the opportunities to streamline processes through integration have become greater. "*Our goal is to have a single source of truth for our product information,*" explains Emerson's Tano Maenza, "*The bridge between ERP and PLM is a key enabler.*" Cameron's Obets also points out the value of a single place to look for product data, "*The attributes that you need are all on one form, one place for all of the information.*"

***We needed to remove rekeying and reconstructing information … it was not a good practice.***
*Greg Obets, Manager Engineering Systems, Cameron*

The primary driver for integrating ERP and PLM in most companies is productivity. Integrating the solutions reduces redundant work and streamlines processes. "*We are asked to help integrate ERP and PLM for efficiency, speed, and to eliminate quality problems because data was incorrectly represented,"* explained systems integrator Mathias Mond, "*The need to integrate both sides is no longer questioned, it is an absolute natural step to integrate.*" Cameron's Obets further explains, "*We needed to remove rekeying and reconstructing information, we captured the BOM in spreadsheets and then keyed it into ERP, and then it would be different and incomplete. We would add things or leave things out, it was not a good practice. Now, when we create an assembly in CAD, we already have the parts and the BOM is automatically transferred into PLM. Now, we use that to push to ERP.*"

The basics of integration between ERP and PLM are to support release to production and engineering change. This is where most companies start. To support these processes, the integration typically involves transferring items and BOMs to ERP such as Cameron described. Some manufacturers have also started incorporating product graphics in the release to ERP including 2D thumbnails and even 3D viewable files. These are the basics of ERP-PLM integration. But companies are not stopping there. In fact, many manufacturers are adopting a phased approach to integration as their use of PLM matures. Tano Maenza describes the integration model for Emerson divisions. "*We have different integration models for our different businesses, we call them the crawl, walk, run, and fly models.*" Emerson's model offers different levels of maturity based on the business unit's readiness for an integrated solution, as follows:

- ***Crawl*** *– little integration*
- ***Walk*** *– integration between the engineering BOM and ERP, with the manufacturing BOM developing in ERP*
- ***Run*** *–both the engineering BOM and the manufacturing BOM are in PLM, providing advantages for change control, planning, and allocation from one to*

*the other. In this more collaborative model, process engineers work in the PLM environment*

- ***Fly*** *–this model adds manufacturing process simulations in the PLM model*

Emerson has adopted different models in recognition of the different levels of ERP and PLM maturity each of their divisions exhibit, and offers them the ability to mature their integration along an improvement path. This model could be applied to other companies as well, providing a roadmap to allow manufacturers to achieve more value from their integrated solutions as they are ready. Frequently, companies adopt a basic integration, then move to a bi-directional model where ERP updates PLM as well, and then they may move to a more advanced integration.

## Evolution: Bi-Directional Integration

The typical flow of information in early integration is from PLM to ERP. One evolution that the research uncovered is the incorporation of ERP data into PLM. As engineers are expected to take into account more aspects of the product in the early phases of the lifecycle, they require more information from the execution management and transactional data in ERP. "*We started bringing engineering change numbers and a few attributes back from ERP,*" describes Cameron's Obets, "*Then in phase two, engineers wanted to see stock information, what's on order, costs, and how much will be scrapped in PLM too, all of that is in ERP.*" This is a typical approach, as engineers can make better decisions when they can access costs and usage for existing purchased parts and other transactional information that is already in ERP.

***Our costs and inventory are mapped back so they are visible in PLM, but they are owned by ERP.***
*Tano Maenza, Director of Business Solutions, Emerson*

"*The trend is towards bidirectional integration – PLM to ERP, but also ERP to PLM – as engineering is now much more interested in access to pricing and vendor information which is in the ERP system,*" comments Mathias Mond, "*We don't transfer the information, we just make it visible in the PLM user interface. Technically, bi-direction integration may be accomplished by simply making ERP data visible in PLM and vice-versa, reducing the opportunity for redundant or conflicting data.*" Tano Maenza explains how this works at Emerson, "*Our costs and inventory are mapped back so they are visible in PLM, but they are owned by ERP.*"

## Further Evolution: Advanced Integration

Beyond the basics, many companies have moved to a more mature integration between the two primary systems that run their manufacturing businesses. As PLM usage matures,

companies are tackling more processes and moving further into the product lifecycle. This maturation includes a broader view of the product, and typically includes a much more thorough and integrated approach to ensuring products are designed for product lifecycle profitability. In addition to designing products for quality and performance, engineers today are being asked to:

- Design for cost
- Design for sourcing
- Design for manufacture and assembly
- Design for compliance
- Design anywhere, build anywhere

***Companies are trying to design and validate the full product digitally early in the product lifecycle, including manufacturing procedures, cost, compliance, serviceability, and sometimes even disassembly and disposal. In order to accomplish this, engineers need access to more information.***

Companies are trying to design and validate the full product digitally early in the product lifecycle, including manufacturing procedures, cost, compliance, serviceability, and sometimes even disassembly and disposal. With more manufacturers taking a larger stake in the full lifecycle of the product, such as offering performance-based contracts that include maintaining the product, it is increasingly important for manufacturers to get products right the first time. In order to accomplish this, engineers need access to more information. They also need to communicate their designs back to the execution personnel in a way that ensures that these plans are executed as intended.

Perhaps one of the biggest processes that has matured is the development of manufacturing plans in the PLM environment. As Emerson's Tano Maenza explains, "*Our most collaborative approach is to develop the manufacturing BOM in PLM.*" Even further advanced is to fully model the manufacturing of the product, including lines, tooling, and factory automation. Digital manufacturing results in a bill of process (BOP) that can be pushed to ERP along with the BOM. This is then typically translated into a manufacturing routing. Of course the full BOP is more detail than ERP is interested in (or can handle), because it provides enough information to manufacture the product. In a similar way to the differences between an engineering BOM and an ERP style BOM, the information that is required for execution is typically at a higher level of detail. For example, ERP is not likely to have manufacturing instructions, and typically is not focused on individual operations within a workstation or workcell. The level of routing data that ERP is interested in – and was designed to handle, similar to the BOM – is what is required to plan and account for business operations related to producing the product and any related commercial business transactions. Although valuable in ERP at a higher

level, a more logical integration for the BOP is to drive the BOP detail directly into a MES system.

***Ideally, ERP-PLM integration becomes a closed loop, where actual results are fed back from ERP into PLM so designers can learn from real-world experience to improve designs.***

More advanced integration supports the more mature roles of ERP and PLM as seen in Figure 3. This allows a more interactive flow of information between product developers and engineers that are defining what the product should be, and the people that are managing the execution that brings that product to life. Ideally, ERP-PLM integration becomes a closed loop, where actual results are fed back from ERP into PLM so designers can learn from real-world experience to improve designs.

## Integration: The Technical Perspective

ERP and PLM integration has also matured from a technical perspective. More configurable solutions, more open data models, and published application programming interfaces (APIs) have eased traditional integration challenges. The adoption of web services and service-oriented architectures (SOA) has also made integration easier, and opened up the opportunity to create "composite applications" that incorporate the specific data and capabilities of ERP and PLM that a user might need for a specific function or business process. This has helped to reduce the need for users to either use two systems, or settle for more limited capabilities from a single-vendor solution. Cameron's Greg Obets describes the blending of their ERP and best of breed PLM system. "*We are graying the role of our ERP tool, because people in manufacturing will not know that the data is really from PLM. We don't want them to care that it's from somewhere different so we didn't have to mess with their processes.*" Tano Maenza describes the integration environment at Emerson. "*We built a hub and spoke model based on standards, and now we are just swapping out web services. It is more costly and sophisticated, but we felt it was the best investment because it can be used more broadly and isolate different applications.*"

***On a process level, it is the same effort to integrate a best-of-breed PLM to ERP as it is to integrate the ERP company's PLM to their own ERP solution.***
*Mathias Mond, CEO, Systems Integrator / ERP and PLM Partner*

While integration is still a time-consuming effort, SOA and other integration advances have opened up integration options that make single-vendor solutions less necessary than in the past. "*It's easier to integrate these days, a lot was out of the box and worked like a charm,*" explained Cameron's Obets, "*It really didn't cost much to integrate, it wasn't an*

*expensive venture. It was in a previous life, software has come along so there is a lot more configuration than customization.*" As Mathias Mond explains from his experience as a partner of both ERP and PLM companies, "*The integration and interface effort does not go away because data is in one system, you still need to define processes to move data from ERP to PLM. On a process level, it is the same effort to integrate a best-of-breed PLM to ERP as it is to integrate the ERP company's PLM to their own ERP solution.*" Integration of ERP and PLM are different by company and industry. While a pre-integrated or single-vendor solution can help by providing systems integration, even integrating solutions from a single vendor requires tailoring and customization.

## Conclusion

ERP and PLM have clear, distinct roles. ERP supports the business of planning and managing the execution cycle and PLM owns the innovation cycle including product development and engineering. As those roles have matured, they still remain focused on the intent and strategy for the product (PLM) and managing the business that produces the product (ERP). The evolving and maturing use of PLM has also led to more mature integration of ERP with PLM, although most companies start with a more simple integration to support "release to manufacturing." Even this basic integration helps to improve productivity, and helps make realizing profitability from innovation faster and more efficient. "*This truly was an investment to save money, we did it as a six sigma black belt project,*" explained Cameron's Greg Obets, "*I came from another large, engineering-centric company where we integrated PLM to ERP, and it saved us tons of money there too.*"

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*Greg Obets, Manager Engineering Systems, Cameron*

Integration strategies continue to mature, as Mathias Mond explains. "*Integrations are becoming broader and more bi-directional. Where in the past it was more just about transferring BOMs, now demands are much broader.*" Manufacturers today can start with a simple integration, and then grow to a more mature integration over time. Integrating ERP and PLM can be accomplished in phases, as the use of PLM matures. "*Start with a basic, lower risk solution and then you can mature to walk and fly*," advises Emerson's Tano Maenza, "*Always engage on process maturity first - focusing on your situation and what will work best - and then drive to move up maturity to improve efficiency, reduce engineering changes, and make better engineering decisions up front.*"

The most promising news is that ERP-PLM integration has not only matured functionally, it has become easier. This is important because even a single vendor

solution does not necessarily mean an integrated solution. More configurable applications and integration have helped, and web services and SOA integration technologies promise to continue to make it easier to leverage multiple systems to provide users with the functionality they need without the need to learn two systems or switch back and forth between them. Integrating solutions has increased in value as PLM and ERP mature, and has simultaneously become much less technically challenging than before, allowing companies to achieve a better, faster ROI from their ERP-PLM integration efforts.

## Recommendations

- Define distinct, complementary roles for ERP and PLM, potentially using the ISA95 standard which defines "standard" integration between the systems.
- Take advantage of easier ERP-PLM integration techniques, including configurability, SOA, and composite applications.
- Blur the lines between ERP and PLM for users, by providing bi-directional integration to give users the information they need when they need it, regardless of which system owns it.
- Evaluate (or re-evaluate) tradeoffs between best of breed PLM and ERP-provided PLM. Reduced integration cost and effort may have changed the trade-offs between integration and workarounds that hamper internal productivity and collaboration with customers and partners.
- Look for opportunities to apply advanced integration between ERP and PLM as ERP and PLM usage mature.
- Beyond ERP and PLM, look for opportunities to integrate execution-oriented applications such as MES, SCM, and MRO to ERP and PLM for a more integrated product innovation and execution environment.

## About the Author

Jim Brown is the President and founder of Tech-Clarity, an independent research and consulting firm that specializes in exposing the true business value of software technology and services. Jim has over 20 years of experience in application software for the manufacturing industries, with a broad background including roles in industry, management consulting, the software industry and research spanning enterprise applications such as PLM, ERP, SCM and others.

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