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Transforming Product Development with a Platform-Based Approach to Product Lifecycle Management

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Abstract

The advent of EVs, ride sharing, global events such as the pandemic, chip shortage, and increasing dependency on suppliers are just some factors reshaping the automotive business. Consumer sentiment moving from product to experience resulted in more variants being launched at a record pace. Consequently, product development processes need to be more agile and yet more rigorous while bringing about cohesion and alignment across cross-functional teams to launch vehicles on time, on quality, and in budget.

Automotive companies have been using Product Lifecycle Management (PLM) solutions for years to manage CAD, change, and BOMs. With changing business scenarios and increasing complexity of products, the sphere of influence of PLM solutions has expanded significantly over the last decade to manage all aspects of product development.

Traditionally PLM software focused on integrating with different authoring tools and managing data in a central repository. The PLM solution had multiple such repositories to manage different types of data—CAD, manufacturing, simulation, requirements, engineering changes, and the like. This resulted in additional overhead of synchronizing and replicating this information across these repositories. This approach is not scalable to meet the dynamic needs of product development today. With a significant increase in the scope of PLM, a platform-centric approach that aims to eliminate rather than integrate silos is essential to the successful adoption of PLM software. The answer is next-generation PLM software such as DASSAULT SYSTÈMES ENOVIA PLM on the **3D**EXPERIENCE platform that takes a platform-centric approach to managing data, people, and processes. ENOVIA PLM differentiates by being data-driven, eliminates silos, and models business processes that connect the dots throughout the product development process. Dongfeng Automobile Corporation realized 30% efficiency in the design process and 70% decrease in design problems when designing a van with design software and ENOVIA PLM on the **3D**EXPERIENCE platform [1].

Keywords

Product lifecycle management, New product development, Platform-based approach, Eliminate silos, Data-driven and model-based, Virtual Twin Experiences, Software as a service (SaaS), Openness, Artificial intelligence

Introduction

Industries that are predominantly "engineer to order" (ETO) such as airplane manufacturers where no two products are the same have always been focused on personalized experiences. Industries such as car manufacturers that are not ETO had to introduce a plethora of features and options to address the personalized experience demanded by customers. The parameters for buying a car even as recent as 15 years ago were based on gas mileage, reliability, price, and some individual preferences of size, shape, and color. As cars have evolved over the past decade with the introduction of technology and several features and options, the car-buying decision is more personalized than ever before. It is no longer just about color. Customers want to pick and choose from several technology options—wireless connection to mobile phones, 360-degree cameras, live traffic information, to name a few. Even safety and comfort features such as blind spot monitors, lane keeping assist, parking assist, heated and ventilated seats beyond just the first row have significantly influenced the customer's car-buying decision.

The number of automotive companies and related startups is increasing at a rapid pace globally, resulting in stiff competition for market share. There is a significant uptick in the sales of EVs. Nearly one in five cars sold in 2023 was electric, with almost 14 million new electric cars registered in 2023 [2]. With so many options for consumers, speed to market for vehicle launch can be a make-or-break factor for a company.

Automotive companies typically have globally dispersed teams who need to work hand in glove with one another to reduce errors, rework, and eliminate non-value-added activities that can decrease the velocity of product development. Fostering collaboration among these teams throughout the product development process—"anytime, anywhere" is mission-critical to creating a successful product and in turn a sustainable and profitable organization. This is the primary goal of a PLM solution.

While this might sound simple, successful PLM adoption is quite the opposite due to working with a plethora of authoring tools, not just in the CAD world but those used by teams throughout the product development process. This is further complicated when teams have their own unique processes that might work well for a single team but perhaps not so well while collaborating with other teams working on the same product definition. Successful adoption of a PLM solution is first about managing organizational change and then about the underlying technology.

It is vital for PLM solution providers to lead with the desired customer experience and then align the technology to deliver that experience best in class, instead of the other way round. The product development processes and related user experience vary depending on the business needs of the automotive company. For example, a recent automotive startup, seasoned OEM, and tier-1 automotive supplier will all have different business models and ways of working, and while there are some similarities in the overarching product development process, it is never a "one-size-fits-all" solution. Furthermore, different companies are at varying levels of maturity in adopting PLM. Some might be ready for a large organization-wide PLM transformational project that is implemented in a large timespan of 2–3 years, but most follow the crawl, walk, and run approach to adopting PLM in increments across teams and processes.

PLM solutions that take an approach of integrating different siloed systems provide a short-term value of not changing the way of working for product development teams. While it might be enticing to adopt such an approach, integrating different siloed applications, transferring and translating data with the IT overhead of having to do this accurately and in real time every time, is not sustainable. It is not a question of if, but when the glue to integrate these siloed applications can no longer work with the technology of a siloed system. PLM solutions with such an approach to integrating siloed systems often struggle to meet the dynamic needs of product development processes today. With a platform-based approach to PLM, automotive companies are embarking on a cohesive product development ecosystem from the get-go. This allows them to crawl, walk, and eventually run in their PLM adoption journey. A fundamental characteristic of a platform-based approach is working off a single database as opposed to multiple databases for each application involved in the product development process, which are loosely coupled to exchange information. This allows for modeling business processes to connect the dots across teams during the product development process. The platform-based PLM solution should look to manage data from different authoring applications by allowing them to directly **connect** to the PLM solution so that the data can be captured and then **revealed** for downstream consumption and ultimately **released** through governance. Along this process of connect, reveal, and release the PLM solution should provide real-time data-driven dashboards so that decision makers can see the most up-to-date product status allowing them to make informed decisions quickly. This is possible using a PLM solution with a platform-based approach where all applications work off a single database, have a unified data model, take a model-based approach not just for product data but all intellectual property (IP) on the platform and can execute business processes to connect the dots all the while providing a consistent user experience anytime, anywhere rather than a PLM solution that is a collection of loosely integrated disparate applications. XOS, a Los Angeles-based electric truck company, shortened their product development time by consolidating a lot of their product development processes with ENOVIA on the **3D**EXPERIENCE platform. Prior to using the **3D**EXPERIENCE platform they had separate systems for CAD, PLM, and ERP, and due to working in silos they risked making mistakes and experienced carryover issues. These issues were eliminated by using ENOVIA on the **3D**EXPERIENCE platform [3].

Literature Review

Oleg Shilovitsky, in the article "**Building a digital footprint through data transformation,**" discussed how even today a significant number of product development processes are centered around working with files with information stored on shared drives. This might have met the business needs decades ago, but is no longer viable to meet the product development needs of today. He speaks about how reliance on documents is inefficient with integration challenges resulting in silos of information that limit collaboration. He emphasizes the importance of taking new approaches to data management and system design to overcome the challenges of working with files in silos. He says that implementing such an approach requires strategic, technological, operational, and cultural changes in the organization [4].

Sharma, Angira et al., in the paper "**Digital twins: State of the art theory and practice, challenges, and open research questions**," provided a better understanding of digital twins, its practice, and related technologies. The primary value of the digital twin is to reduce the cost and time of physical prototyping. The paper provides details on how a digital twin is different from existing technologies. It further details the components of a digital twin, challenges of implementing a digital twin due to a lack of a universal definition of a digital twin, the need for synchronization of data across systems, and real-time information flow. The paper refers to case studies of digital twins in the real world and concludes on the value of a digital twin but yet the challenge of being able to quantify the performance of a digital twin [5].

Abbas, Zafer, and Chikwarti, Dileep Kumar, in the paper "**Cloud Migration Strategies: Moving Applications and Workloads to the Cloud**," discussed the different strategies to move from on-premise to the cloud with benefits and limitations of each strategy. The different cloud migration strategies discussed are lift and shift migration, re-platforming migration, and application rewrite migration, which is centered around software as a service (SaaS). While each of these strategies has benefits and limitations, it is crucial that a company chooses the right strategy that supports their business needs to get the desired value of migrating to the cloud [6].

Wang, Lei et al., in the paper "**Artificial intelligence in product lifecycle management**," presented the concept, history, and application of AI in PLM. The AI framework in PLM is divided into AI for product design, product manufacturing, and product service. This paper covers the use of AI in PLM topics such as conceptual design, detailed design, BOM generation, supplier selection, manufacturing execution systems, product status monitoring, and failure prediction. It further describes the benefits and challenges of embedding AI in PLM [7].

Lionel Grealou, in the article, "**The promises and pitfalls of modernizing PLM**," highlighted how upgrading a legacy PLM solution is not a small project. He highlighted that this type of project needs to navigate organizational change involving people besides a technology upgrade. He says that despite these challenges, the benefits from a well-executed PLM project far outweigh the risks associated with it [8].

Managing Organizational Silos

Products these days are all about experiences. A not-so-great experience can kill a product that could be technically superior to competitive products offering more features. Product development teams such as product management, program management, design, engineering, manufacturing, sourcing, supplier development, quality, sustainability, and the like all need to work hand in glove with one another to innovate and deliver sublime experiences. Each team has its own set of experts who need to collaborate in real time with experts on other teams located in different parts of the world. Quite often, these teams are not able to work collaboratively with other product development teams due to several factors such as using different IT systems and repositories, specific processes that are in the context of only one team, lack of visibility into common timelines, KPIs, workload, and the like. This adversely affects product development efficiency.

PLM solutions should look to eliminate these product development inefficiencies coming about due to teams working in silos. There are two very different ways of approaching this problem—integrate or eliminate silos. A PLM solution that is made of loosely integrated disparate systems will never be able to eliminate organizational silos. At best, the PLM solution will be able to loosely integrate teams and exchange data. Depending on how good the integrations are between the disparate solutions, the lesser the visibility into the underlying differences between the systems used by these teams. This does not really address the underlying problem and, at best only masks the problem with limited efficiency gains. The idea is sold as—"*no major change in the way you are currently working*," words that appear reassuring to end users but are in fact detrimental to fostering collaboration across the organization. Integrating silos does not foster a cohesive collaborative product development process rather encourages teams to think more about their micro processes and not at the bigger picture to innovate together throughout the product development process and increase the speed of launching products in a market. Furthermore, the integration approach does not allow for a cloud SaaS adoption due to the number of loosely integrated applications.

On the other hand, a PLM solution with a platform-based approach looks to eliminate organizational silos by changing the way of working for product development teams. These teams are now working on a single system where the output of one team is readily consumable as input by another team. Since the PLM solution is working off a single database with a unified data model, delays and errors in the transfer and translation of data are eliminated. All teams can see the most up-to-date status of the product data, project status, and all related IP. What is even better is that each team can view and update the data in context, i.e., they can visualize and view the data in a way that makes sense to that team, all while working off a single system. While this approach changes the way of working and might appear daunting in the beginning the benefits of eliminating organizational silos far outweigh any gains with the integration approach that allows users to continue working in a way that they are used to. The reality is that PLM solutions that look to integrate silos with smart frontend software while masking the underlying complexity are not scalable—it is not a question of *if* but *when* the glue used for the integrations cannot integrate with a technology and/or processes being used by a product development team. If a PLM solution does not change the way a company is working then why use it at all?

A PLM solution with a platform-based approach fosters innovation, eliminates the need to transfer and translate data, thereby reducing costly errors and increasing product development velocity. It introduces a sustainable change in the way of working with best-in-class technology that fosters cloud SaaS adoption and, in turn overall cost of ownership of the PLM solution. In a survey conducted among 187 IT, product development and manufacturing professionals, those using a platform for product development, 99% validate the advantages of a platform-based approach over using the best technical solutions that require working in silos. The advantages include improved product quality, efficiency, business scalability, lower product cost, and better business agility [9]. UK-based automaker Jaguar Land Rover inherited a wide set of auto industry software from its previous owners. Rather than continue with a collection of siloed software, Jaguar Land Rover embarked on an enterprise-wide transformation to replace these systems with a single collaborative new product development platform. The project labeled “i-PLM” yielded up to 40% time savings in certain functions of product development [10].

FIGURE 1 PLM solution made up of loosely integrated disparate solutions still working in silos.

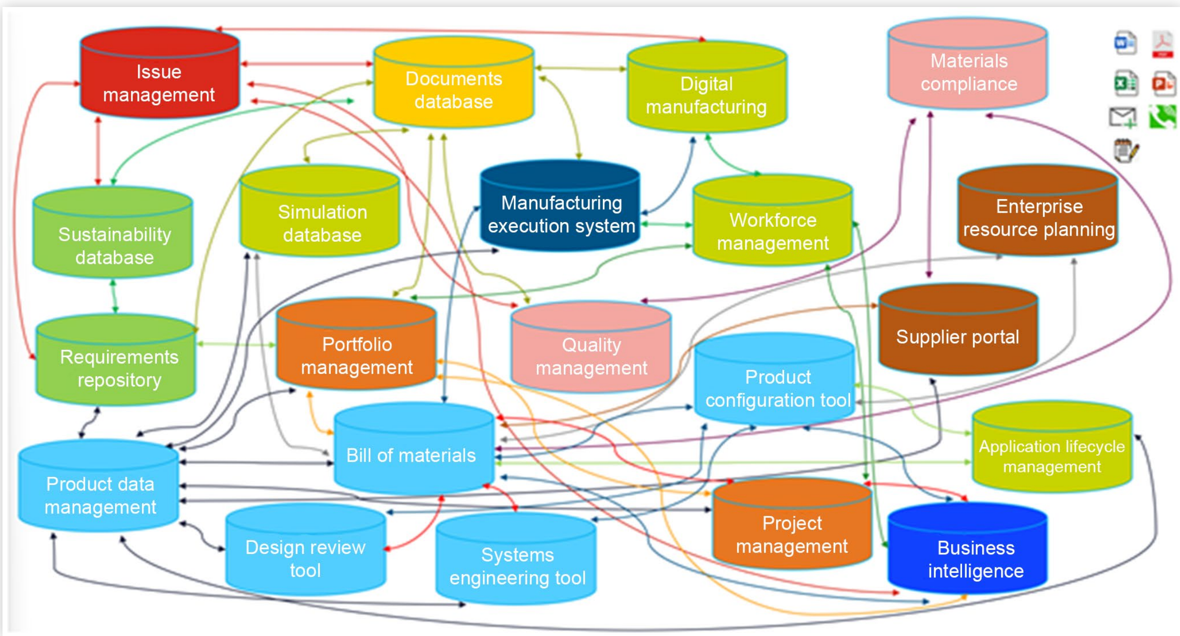

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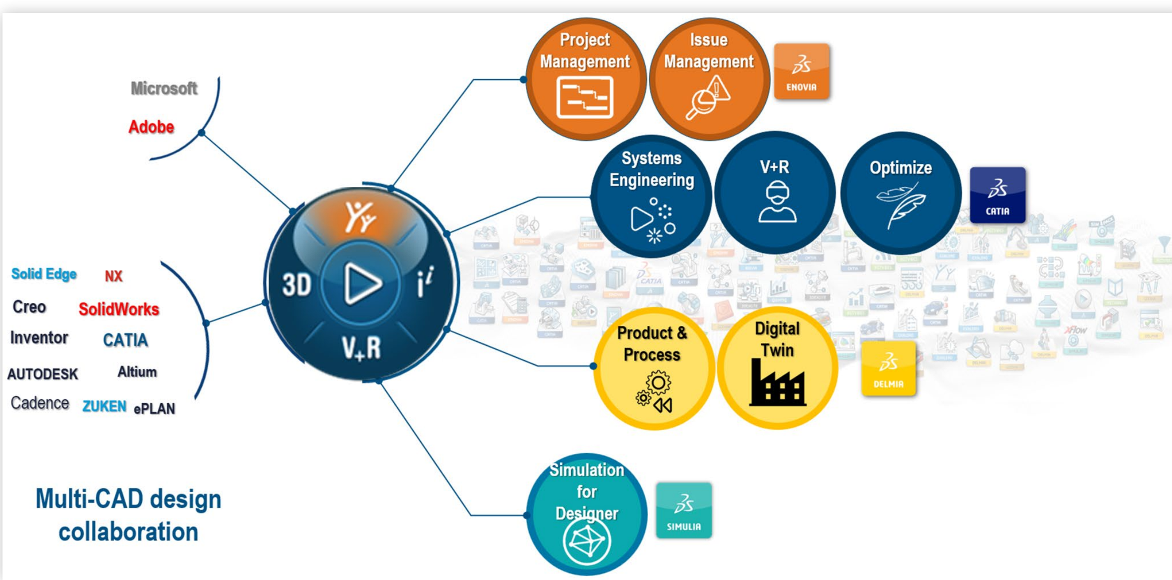
FIGURE 2 The **3D**EXPERIENCE platform eliminating silos. (Courtesy Dassault Systèmes.)



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Data-Driven and Model-Based

A lot of product-related information resides in files even today. While working with files might be unavoidable, PLM solutions should look to extract the information from these files and digitize it in a database. The reason to do this is that working with files is inherently inefficient and error-prone when the information in the files is to be shared and updated by different teams. Consider an automotive company launching a new vehicle in a market with multiple configurations. If all of this information were to be managed in files in folders as opposed to digitally managing the configuration information in a database with objects and relationships then the product manager would need to manage several hundreds or thousands of files across configurations, track the latest version, and ensure that all teams were working on the latest released version of the file. Even if the files were vaulted in a traditional PLM solution, the information in the files and related visualization of the product configuration would require the files to be downloaded and viewed offline. In the event of a change, the updated file would need to be copied over and replaced across multiple configurations, which is very inefficient compared to updating it once and having it reflected automatically across configurations instantly.

On the other hand, if the authoring applications could connect to the PLM solution on a platform that not only vaulted the files under revision control but extracted the information from the file into a database with attributes, relationships, and objects, then the information is no longer just electronic, it is digital. Once it is digital, then the information can be shared readily across teams who need to view it real time and need to be notified of changes. This provides a foolproof mechanism where the PLM solution automatically ensures that the most up-to-date information is shared with the right users in a controlled environment without relying on the discipline of an end user to download and view the right version of the right file. This goes a long way in preventing a slip between the lip and the cup throughout the product development process.

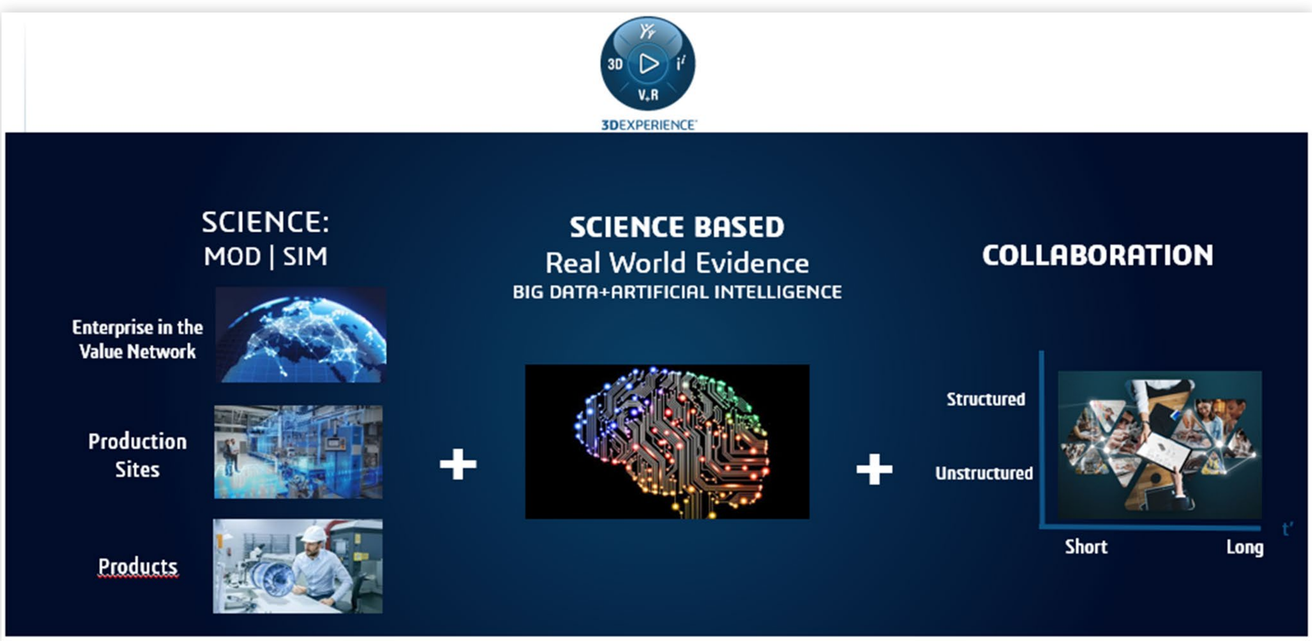
Information extracted from the files can be viewed and consumed by other teams downstream in the product development process. The PLM solution not only allows for product development teams to visualize the product data without the need for authoring tools, the information extracted into attributes can be used to trigger other processes such as simulation, sourcing, manufacturing process plans, and the like by users in teams who may not be designers themselves. This way teams can vary parameters and determine the real-world behavior of the product. They can do this easily without rework each time the product data changes because all teams are working off a single version of the truth that is not file-based rather is data-driven and model-based.

Traditional PLM solutions, especially those that integrate disparate systems, manage separate BOMs for CAD, engineering, manufacturing, and other disciplines that cause a lot of overhead related to synchronizations between these different views of the BOM. The synchronization, especially between the CAD and engineering bill of materials (EBOM) results in performance issues and errors depending on the size, complexity, and reuse of parts across BOMs. ENOVIA PLM takes a different approach and eliminates this overhead of synchronization between the CAD BOM and EBOM by providing a unified product structure (UPS) model that is a single product structure made up of engineering items (EI) that not only manage the associated 3D designs but also the engineering definition in the same product structure [11]. This eliminates the inefficiencies of synchronizing the BOMs and increases the design velocity. The product structure is then used to generate a structure for manufacturing made up of manufacturing items (MI) with related business logic to identify fully consumed and partially consumed items between the engineering and manufacturing definitions of the product structure.

ENOVIA PLM further reduces the product development time by facilitating early involvement of suppliers in the product development process. The influence of suppliers has increased significantly to where suppliers are no longer just supplying parts, rather some tier 1 suppliers are supplying entire systems that go into vehicles. These suppliers are the best in the world at what they do. Supplier innovation results in an innovative product for the automaker as well. Hence it is critical to involve the supplier early on in the product development process when the designs are not frozen and the cost and impact of changing a design is not as much as doing it further in the product development process when cross-functional teams are working off the frozen designs. ENOVIA PLM allows for onboarding suppliers, defining APQP/PPAP plans, sharing design data, linking supplier components into the UPS as part of the design process. The focus is more on linking the supplier to the design and engineering side of the product development process and not necessarily the transactional nature of interacting with a supplier that is done in an ERP system. Using ENOVIA PLM on the **3D**EXPERIENCE platform, suppliers can not only connect to the platform to collaborate and share data, work on issue resolution, projects, and the like but they can even connect with CAD directly to the automaker's environment and design in 3D, with the automaker being in full control of the supplier's access rights and visibility. Using ENOVIA on the **3D**EXPERIENCE platform, the strategic sourcing team can send out request for quotes (RFQs) to suppliers much early in the product development process, suppliers can respond to the RFQs with multiple rounds before the RFQ is awarded to the supplier. All of these capabilities with ENOVIA on the **3D**EXPERIENCE platform are working off a unified data model. The same data model is used for defining manufacturing process flows, work instructions, and the like using DELMIA on the **3D**EXPERIENCE platform and also for simulation using SIMULIA on the **3D**EXPERIENCE platform. Cross-functional teams are each able to work off the same data model and deliver results quickly as there are no inefficiencies related to data replication, migration, translation, and related errors, as none of these actions are needed for cross-functional collaboration on the **3D**EXPERIENCE platform.

The approach of being data-driven compared to file-based is relevant beyond the realm of product data. Take the case of a program manager managing a new product development project. If the program manager were to execute and track the status of the project by emailing the project schedule to team members, then the entire process of following up on the status with each team member only to make updates again and re-share a new schedule is not only inefficient but is also inherently error-prone. It relies on the project leader emailing and updating schedules frequently and project team members having the discipline to download and view the latest project schedule, regardless of where they might be located. Even compiling a project status report would involve a lot of non-value-added activities. Approximately 30% of a project team's time is spent on non-value-added activities [12]. If this process was to be replaced with ingesting the project schedule to create a centralized digital live schedule on a platform-based PLM solution that allowed product data to be directly managed as deliverables on a project, then the project leader and project team would spend more time on completing the deliverables and mitigating project risks compared to reporting on status. Furthermore, the project team is also aware of the status of the deliverables and can visualize product data in the context of a project without the need for a design tool and understand product data maturity, issues, and other factors affecting the completion of a deliverable. With this data-driven approach, the project leader can also model what-if scenarios of changing the project schedule to accommodate changing requirements and other factors affecting the launch of the product. This way, being model-based allows the entire organization and not just teams working with product data, to be able to model and steer their processes for the timely launch of a product with a great experience. Neta Auto, a Chinese EV manufacturer, uses ENOVIA, CATIA, DELMIA, and SIMULIA apps on the **3D**EXPERIENCE platform to reduce product development time and save costs. The data-driven model–based approach of the **3D**EXPERIENCE platform allows for all apps to work off the same data model, ensure real-time up-to-date data flows across disciplines and take advantage of a unified modeling and simulation (MODSIM) approach to realize 20% fewer issues at prototyping and savings of almost 1.3 million Euro in R&D costs [13].

FIGURE 3 **3D**EXPERIENCE platform's unique value. (Courtesy Dassault Systèmes.)



Virtual Twin

Digital Twins and Virtual Twins are terms used commonly and quite often interchangeably in the PLM world. However, a virtual twin goes far beyond a digital twin. A "digital twin" is a 3D representation of a physical product visualized in a lightweight format on a web browser or mobile application without the need for design data to be downloaded and opened in CAD software. It provides related product information such as maturity and attributes of the data, analysis such as clash analysis and so forth and allows for viewing current and past state of the data.

A digital twin can be built even by integrating and duplicating data across disparate systems and working with files (Figure 4). As long as there is digital continuity between these different systems, a digital twin can be delivered. However, the digital twin is static, and changes to the underlying data need to be reconciled and updated across systems. This allows only for a digital representation to analyze the current and past states without real-time updates.

A virtual twin is a scientific 3D representation of a physical product built off data in a single database and a common data model, allowing not only understanding the history and current status of a product but also predicting future behavior in the real world (Figure 5). Since different product development teams are all working off the same system, changes made by one team are instantly available for consumption by another team, making the virtual twin dynamic in nature with real-time updates. Furthermore, with model-based processes where information is extracted from files and digitized, the virtual twin allows for intelligent virtualization of the physical product by not only understanding current and past states but also being able to predict future behavior and simulate real-world experiences of the physical product. All of this is done without the need to integrate and duplicate data across different systems. Being able to support what-if scenarios in a model-based platform is what differentiates a virtual twin experience from a digital twin [14]. German Engineering Services Provider csi entwicklungstechnik carries out life cycle assessment (LCA) studies on the virtual twin of the product to understand all the environmental aspects of a design from raw material extraction to disposal at the end of life. This is possible by combining science for modeling and simulation, real-world evidence, and enterprise collaboration, resulting in an experience far beyond just a 3D visualization of the product [15].

FIGURE 4 Digital twin—static 3D representation of a product incapable of reflecting real-time updates. (Courtesy Dassault Systèmes.)

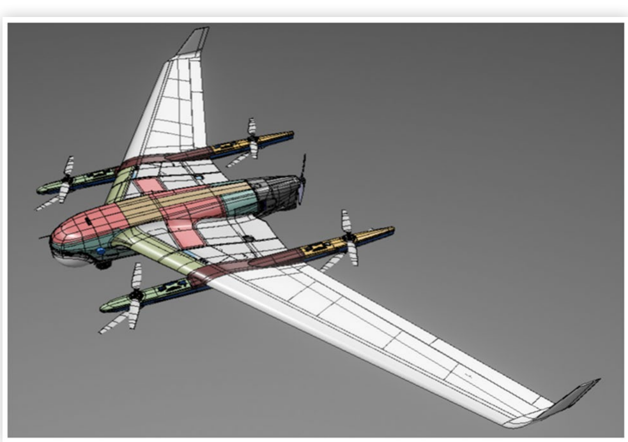
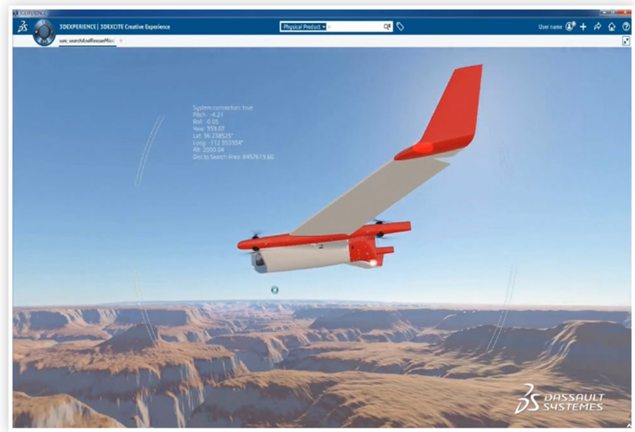


FIGURE 5 Virtual twin on the **3D**EXPERIENCE platform—scientific 3D representation of a product with real-time updates to understand the current and past status and predict future behavior of the product in the real world. (Courtesy Dassault Systèmes.)



Openness

With the myriad of authoring tools and enterprise solutions that are in play during product development, a platform-based approach to PLM cannot foster organizational collaboration if it is not inherently open to exchanging and digesting information from other IT systems. When we talk about openness, the context usually considered is integrating with other IT systems. However, there are different aspects to openness:

- Authoring Tool Openness
- Data Exchange Openness
- Enterprise System Openness
- Server Openness

Let us look at each aspect.

Authoring Tool Openness: The CAD world has a plethora of design solutions. A platform-based PLM solution needs to manage product data sustainably by allowing these different design solutions to connect to the PLM solution so that the CAD files are not only vaulted and under revision control, but the information in the design files is extracted for downstream consumption. This allows companies to preserve their investment in CAD and still take advantage of a platform-based approach to PLM throughout the product development process. This allows designers to connect to the platform for the data to be ingested so that it is revealed for downstream consumption and ultimately released through a governance process. Doing all of this with a single-platform–based PLM solution is much more efficient than a collection of loosely integrated systems because with the latter, data needs to be replicated and quite often is done only when released or intermittently at predefined intervals to manage change, thus slowing down product development velocity.

Data Exchange Openness: Data exchange is a hot topic among PLM solutions. With so many different authoring tools used by OEMs and suppliers it is make or break if PLM solutions are unable to exchange and ingest product data across formats and release levels of authoring tools. Suppliers are also hard pressed to adhere to one format as they work with several OEMs, each of whom might have different authoring tools. In this landscape of diverse authoring tools and formats, it becomes even harder to exchange, ingest, and replicate product data across a collection of loosely integrated systems making up a PLM solution. In the case of a PLM solution made up of loosely integrated systems, product data needs to be replicated and ingested across multiple systems each time there is a change to the data, making it highly inefficient and error-prone. On the other hand, with a platform-based approach to PLM, the data is exchanged and ingested once, and all applications and processes throughout the product development process are working off the same data, making it easier to manage change.

Enterprise System Openness: One of the dangers to guard against with a platform-based approach to PLM is the tendency to build everything on the PLM solution, even though it might not necessarily be a product development process. The need to manage resources during the product development process is essential in a PLM solution. However, the PLM solution is not necessarily the best place for HR to hire and onboard resources in the organization. The PLM solution needs to be able to connect to active directory for single sign on and be able to view the organization structure, which in turn is translated into an access rights vector for data within the PLM solution.

It is mission-critical for the PLM solution to be able to connect to an ERP system, digital manufacturing solutions, specialized solutions that are players in specific industries such as aerospace and defense, construction, and the like. With a platform-based approach to PLM, there needs to be OOTB connectors and frameworks to these systems that are scalable to account for data model changes and increments to functional capability so that the framework and approach to information exchange is not broken with an update to either the PLM solution or the authoring tool or the enterprise system. Connecting to the enterprise systems is much easier with a platform-based approach to PLM than the overhead that comes with multiple integrations needed with loosely connected, disparate systems that make up a PLM solution.

In the former case, with only one integration framework data is exchanged with enterprise systems, but with the latter, multiple integration frameworks are needed, with a much more complicated process for scenarios where the data has to be exchanged back and forth with the external enterprise IT system.

Server Openness: Quite often PLM solutions need to be configured and customized to meet product development business needs and processes. This requires server-side code customization, data model changes, application behavior modifications, custom user interface, and the like. PLM solutions need to allow for these types of changes to the data model, application behavior, and user experience. It involves providing public APIs that allow for these types of changes, a framework for data model changes, and configurable UI components to elevate the user experience. Being able to do all of this in a platform-based PLM solution is much simpler than having to do this across multiple loosely connected systems to deliver a consistent user experience and business process across systems.

Cloud Strategy

The trend of companies moving their IT solutions to the cloud is ever-increasing. PLM solutions are no exception. More and more companies, especially startups and EV manufacturers, are looking to execute their product development processes on the cloud from the get-go. The cloud has also been an enabler for small shops with basic PLM needs such as product data vaulting, to be able to move to the latest version of PLM with added benefits and take a leap of faith from a legacy, unsupported version of the PLM software that they might have been using for several years.

The automotive business is no longer concentrated on traditionally mature markets of North America and Europe. The top 5 largest markets for new vehicles in 2023 were China, the United States, India, Japan, and Germany [16]. These markets were followed by Brazil, the United Kingdom, France, Italy, Canada, and South Korea, making up the top 10 markets for new vehicles in 2023 [16]. Automotive companies today have a global presence with localized design, manufacturing, and supply chains to launch vehicles across all these markets. With a cloud-based PLM executing the product development process, global teams across locations are able to collaborate and work well with each other on the same product definition, standardize on common components, facilitating reuse, and able to source components more efficiently by combining volumes and identifying second-source suppliers more easily. Harbinger is an example of an automotive company making medium-duty EV trucks. They started with the cloud from the get-go to take advantage of collaborating across teams with access to the most up-to-date data anytime, anywhere, and on any device [17].

PLM software companies are looking to expand their cloud portfolio rapidly with each new release of the software. An example of this is DASSAULT SYSTÈMES whose portfolio of products is broader on cloud than on-premises. Developing a broad cloud portfolio is not easy if the PLM software has not adopted a platform-based approach to development. Consider a PLM solution that is made up of loosely connected systems. In order to be on the cloud, all of these systems would need to be on the cloud individually, and this is easier said than done. On the other hand, a PLM solution with a platform-based approach, with all applications working off a single database connected with business processes, can be easily adopted on the cloud. The infrastructure is much simpler to manage, and in fact, it is only a platform-based approach that allows for adoption of SaaS in a multi-tenant setup, which is the fundamental value of moving to the cloud to reduce total cost of ownership.

A PLM solution made up of loosely connected systems with a slick frontend glue that masks the underlying complexity can never truly take advantage of SaaS due to the challenges of integrating these diverse systems, some of which may just not be cloud compatible. The only option for such PLM vendors is to move with a "**Lift and Shift**" [18] strategy where the promise of cloud is partially delivered by moving all these diverse systems to a datacenter managed by the PLM vendor, and each customer has their own dedicated tenant. This implies that the customer is not on the cloud with a SaaS multi-tenant model but in fact their existing on-premise setup has been replicated at the PLM vendor's datacenter and is now managed by the PLM vendor's team, providing an illusion of being on the cloud. The reality is that the cost savings of moving to the cloud are not realized, and this is masked by the PLM vendor promoting "*customization on cloud,*" which sounds good to a customer. In addition, upgrades are needed for each dedicated setup per customer and this is not scalable by one team managing all these different customer environments.

The notion that a SaaS model provides limited customization is true but the benefits of following an OOTB best practice process on a SaaS setup, such as sharing infrastructure cost with other customers, elasticity of computing resources, security of data, 24×7 availability anytime, anywhere with automated updates of software that guarantees being on the latest release far outweigh any limitations in customization [19]. Furthermore, PLM solutions that are platform-based are introducing new configurations and frameworks for increasing the capability to specialize and control application behavior. With this trend of increasing cloud adoption, PLM solutions with a platform-based approach have a significant advantage in delivering the value and promise of a multi-tenant SaaS cloud over a PLM solution made up of loosely connected systems.

AI in PLM

The advent of ChatGPT made AI mainstream in IT applications worldwide. Almost all enterprise IT system vendors including PLM vendors are being asked about AI capabilities in their software. In product development, the most important aspect is the dataset. This is more important than the AI engine and machine learning (ML) algorithms. The reality is that the value from AI is only as good as the dataset [20]. Hence PLM vendors need to invest heavily in ingesting and extracting information from the large volumes of data generated across authoring tools, enterprise applications, and business processes during product development.

The quality of the dataset is not great when working with a PLM solution that is a collection of loosely integrated systems. Elements of the dataset are often replicated due to exchanging information across different systems. There is information loss in the translation of the data. Moreover, since the systems are loosely integrated, the information is often not viewed and understood in the right context. With a platform-based PLM solution, data is not replicated. It is managed in a single database, and the business processes that manage the data across different product development applications not only stitch a digital thread, but also allow that information to be viewed and understood in the context of the virtual twin. This, coupled with the best practices of users, for instance, classifying all data so it can be sliced and diced as needed, is the recipe for a great dataset. By layering an AI engine and ML algorithms on top of this for target business cases, a platform-based PLM solution can provide exceptional value to increase product development velocity, thus making the company profitable and sustainable.

With a platform-based PLM solution, virtual assistants can leverage the learnings of the AI model from both structured and unstructured collaboration and provide key insights during the product development process. The insights can be limited in scope, e.g., a vertical AI offering within the context of a single app, or it could be a horizontal AI offering that connects the dots across all apps. A horizontal AI offering provides insights to cross-functional teams who might be working on the same data but executing different processes with different outcomes at the same time. For example, a change in a requirement could delay a project task that in turn could result in a milestone being extended, resulting in additional product cost impacting product configurations. The AI model itself could be self-learning, meaning that the more data added to the PLM solution, the better the insights. However, this will require appropriate hardware and computing resources.

Examples of a few common product development use cases that could be transformed with the use of AI include:

- **Requirements Management—**using natural language processing (NLP) to process requirements documents and automatically build a requirements specification indicating components in the PLM database that already address the requirements

- **BOM Management—**automatically generating BOMs based on the features and options tied to product configurations by including reusable systems and components; automatically syncing the different views of the BOM across disciplines—engineering, manufacturing, sourcing, and service BOMs
- **Strategic Sourcing—**automatically identifying the best supplier for RFQs based on supplier quality, competency, price, and determining the net cost of working with a supplier; identifying opportunities to reduce sourcing cost and anticipating supplier risk
- **Design Options—**providing insights to designers to make the best design choices in the design environment connected to the PLM solution, e.g., the choice of material may reduce the overall weight of the component but it could result in engineering changes down the line as this material has seen a lot of product failures in the real world
- **Design Analysis—**automated clash analysis and design reviews to speed up the process of freezing designs
- **Project Management—**using AI assistants to automatically generate a new product development project by asking a project leader questions to understand the scope of the project; automated resource optimization across projects; anticipating project risks and delays based on current progress of project tasks
- **Change Management—**automated impact analysis to identify ways in which multiple changes can be combined under a single change umbrella to speed up the process of effecting the change without impacting downstream manufacturing processes
- **Sustainability—**automatically crawling the internet to identify newer sustainability trends, components, and making recommendations to improve the sustainability of the product
- **Quality and Compliance—**automatically tracking changes to materials compliance regulations across the globe and providing insights to stay in sync with changing regulations; learning from past issues and making recommendations for resolving ongoing product issues
- **Product Data Management—**automatically connecting to supplier websites and identifying manufacturer equivalent items (MEIs) that can be used as alternates and substitutes for EI and kickstarting a qualification process
- **Workflow Management—**automatically orchestrating cross-functional team workflows; learning from past workflows and optimizing workflow templates so that they are more efficient
- **Data Management—**automated tagging of data and application of security policies to facilitate reuse and prevent unauthorized access
- **Collaboration—**automated updates of Kanban boards and project backlogs based on updates to the status of requirements, issues, and deliverables
- **Training and onboarding new users—**virtual assistants to guide new users on the use of the PLM solution and provide best practices to speed up the learning curve

There could be industry-specific use cases such as planning and executing predictive maintenance for airplanes in aerospace and defense, maintenance of power plants in the energy sector, and tracking raw material cost to make purchasing recommendations for cost savings in batch production industries such as transportation and mobility and industrial equipment to name a few.

The adoption of AI in a platform-based PLM solution to deliver exceptional outcomes is dependent on a partnership between the PLM solution provider and the customer. PLM solution providers need to use the customer dataset, keeping in mind the IP rights of the customer. The customer, in turn, is also able to tap into the best practices learnt by the PLM solution provider from past implementations that are also used for learning by the AI model. Once this partnership with the customer has been established and a framework for securely leveraging the customer dataset is in place, the application of AI could even result in the establishment of an outcome-based revenue stream for the PLM solution provider.

Potential Implementation Challenges

Large-scale PLM transformation projects have their fair share of implementation challenges. This being said, implementation and adoption challenges are part of any major IT project across domains, PLM included. Some of the main challenges while implementing and adopting a platform-based enterprise PLM solution are:

- **Managing organizational change—**The end users of a PLM solution are used to doing things a certain way and may be resistant to a change in their way of working. This can be overcome by working with a group of subject matter experts (SMEs), understanding the concerns, and translating them into opportunities to create more value for the end users. The goal is to focus on the desired outcome vs. trying to replicate the same process in the PLM solution.
- **Data Migration—**Most PLM implementation projects involve some form of data migration related to product data. Incorrectly estimating the scope

and complexity of the data migration activity can lead to cost and time delays for both the customer and the implementation partner. The data migration most often needs to be proved out with a pilot project.

- **Enterprise Integrations—**Even with a platform-based PLM solution, integrations to other enterprise systems cannot be avoided, e.g., ERP. These integrations are typically built with OOTB API calls and services, but nevertheless end up being customized to suit the customer's business and can involve complex use cases.
- **Implementation Scope—**Large-scale PLM implementations involve modeling processes of several teams involved in the product development process, who may be spread across the globe. While it might be tempting to deliver a grand end-to-end solution, this can quickly become a project that is not scalable. Quite often, customers do not prioritize their immediate business needs and define a minimum viable product (MVP) or a pilot program to launch the adoption of the PLM solution that is first launched to a subset of users and then iteratively enhanced to include more processes and users. In the absence of such an approach, it is challenging to develop, test, and deliver a large-scale end-to-end PLM solution that can improve the entire product development process.
- **IT Infrastructure—**Large-scale PLM implementations especially in organizations with globally dispersed teams require robust scalable infrastructure to ensure smooth adoption of the PLM software. The challenges related to maintaining the IT infrastructure, upgrading the PLM software, and so on can be mitigated by adopting a platform-based PLM solution on the cloud in a SaaS multi-tenant setup. This not only reduces the IT overhead but ensures a high degree of availability of the latest version of the software.

Summary

Companies making products especially automotive companies need to innovate and elevate their product experience. Without innovation and exceptional product experience, they stand to lose customer loyalty and run the risk of becoming extinct. Hence, the need for an innovation platform—a PLM solution that is platform-based to eliminate non-value-added activities, minimize rework and errors, and foster organizational alignment and collaboration throughout the product development process and beyond. A system that works off a single database with a common data model and overarching business processes across product development applications in the context of the virtual twin, all while leveraging the benefits of a multi-tenant SaaS cloud, is the need of the hour.

In order to transform their product development processes and launch products faster, companies need to rethink their PLM strategy. Specifically, they need to consider the items below:

- Take an approach to eliminating vs. integrating silos
- Reduce working with files and take a data-driven approach to execute product development processes
- Adopt a cloud-first strategy to take advantage of low total cost of ownership (TCO), staying up-to-date on the latest version of software, and providing anytime, anywhere access
- Look at adopting a virtual twin, not just of the product but of the enterprise. Model what-if scenarios of projects, sourcing strategies, cost engineering, quality, LCA, and materials compliance, besides the standard product clash analysis and simulation
- Adopt a platform-based PLM solution and process that involves suppliers early on when the designs are not yet frozen, so that they can take advantage of supplier innovation
- Embed suppliers in the product development process rather than just working with suppliers in a transactional mode
- Adopt a platform-based PLM solution that allows them to preserve their investment in CAD and still take advantage of being model-based and data-driven, allowing for downstream consumption of data
- Ensure product and project data are managed in one PLM solution working off a single database and connected with a business process to prevent manual reconciliation of product and project status and eliminate costly errors
- Adopt a platform-based PLM solution where collaboration across cross-functional teams is inbuilt and doesn't require additional software and/or customization
- Plan out the PLM transformation journey by:
  - Defining an MVP, a list of SMEs
  - Focus on the outcome desired and then define the best-in-class process and technology to deliver that outcome
  - Adopt an agile iterative approach to deliver and build on the scope of the MVP, thereby incrementally increasing the user adoption

Companies that consider the above points and adopt a platform-based PLM solution for their product development processes from the get-go are investing in the long-term sustainability and profitability of the business. Even with such a system, the ability to manage change, collaborate anytime, anywhere with a focus on the bigger picture rather than microprocesses with picks and clicks needs to be in the DNA of product development teams. Teams that operate like this on a platform-based PLM solution are bound to launch superior product experiences faster than their competitors and become extremely successful. One such example is BMW Group. BMW Group has recently embarked on a transformation project to leverage the **3D**EXPERIENCE platform as its future engineering platform for more than 17,000 employees. The project involves migrating data from existing IT applications onto the **3D**EXPERIENCE platform and working on a virtual twin of a vehicle and its variants with real-time data in an effort to reduce the cycle time from engineering to manufacturing. The engineering platform will extend to other disciplines such as modeling and simulation [21].

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Abbreviations

3D - Three Dimensional
AI - Artificial Intelligence
API - Application Programming Interface
APQP - Advanced Part Quality Plan
BOM - Bill of Materials
CAD - Computer-Aided Design
DNA - Deoxyribonucleic Acid
EBOM - Engineering Bill of Materials
EI - Engineering Item
ERP - Enterprise Resource Planning
ETO - Engineer to Order
EV - Electric Vehicle
HR - Human Resources
IP - Intellectual Property
IT - Information Technology
KPI - Key Performance Indicator
LCA - Life Cycle Assessment
MEI - Manufacturer Equivalent Item
MI - Manufacturing Item
ML - Machine Learning
MODSIM - Modeling and Simulation
MVP - Minimum Viable Product
OEM - Original Equipment Manufacturer
OOTB - Out of the Box
PLM - Product Lifecycle Management
PPAP - Production Part Approval Process
RFQ - Request for Quote
SaaS - Software as a Service
SME - Subject Matter Expert
TCO - Total Cost of Ownership
UI - User Interface
UK - United Kingdom
UPS - Unified Product Structure

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