PLM Implementation for Automobile Manufacturer

Name: Mr. Sachin Suryakant More

Project Guide: Dr. U. S. Bhapkar

Abstract:

The modern automotive industry is facing increasing pressure to innovate rapidly, maintain regulatory compliance, and efficiently manage complex product lifecycles. Traditional systems often suffer from data silos, poor traceability, and disconnected workflows, leading to inefficiencies in design, manufacturing, and collaboration. This project addresses these challenges by implementing a comprehensive Product Lifecycle Management (PLM) system using Dassault Systèmes' 3DEXPERIENCE platform within a mid-sized automobile manufacturing company.

The primary goal of the project is to assess, design, implement, and evaluate a centralized PLM solution that facilitates seamless integration across departments such as design, quality, manufacturing, and procurement. Through a phased rollout that includes requirement analysis, platform configuration (ENOVIA, CATIA, DELMIA), stakeholder training, and post-deployment performance assessment, the project showcases how digital transformation through PLM can lead to measurable operational improvements.

A case study on AutoNova Ltd. demonstrates real-world application, where KPIs such as design cycle time, issue resolution rate, BOM accuracy, and cross-departmental collaboration were significantly enhanced. The results indicate a 36% reduction in average design time, a 57% improvement in issue resolution, and better compliance through centralized data governance.

This report also explores the strategic importance of PLM as both a methodology and technological framework, underlining its role in driving continuous improvement, supporting concurrent and collaborative engineering, and enabling scalability for future expansion. The implementation of the 3DEXPERIENCE platform serves as a blueprint for similar organizations aiming to modernize their product development processes and become future-ready in the era of Industry 4.0.

Keywords:

Sr. No.	Keyword
1	Product Lifecycle Management (PLM)
2	3DEXPERIENCE Platform
3	Dassault Systèmes
4	ENOVIA
5	CATIA
6	DELMIA
7	Automotive Digitalization
8	Engineering Change Management

9	Concurrent Engineering
10	Collaborative Product Development
11	Product Data Management (PDM)
12	Workflow Automation
13	Bill of Materials (BOM)
14	Configuration Management
15	Digital Twin
16	Cloud-Based PLM
17	Cross-Functional Integration
18	Change Control Process
19	Enterprise System Integration
20	KPI-Driven Evaluation
21	Role-Based Access Control (RBAC)
22	Supply Chain Collaboration
23	Digital Transformation Strategy
24	Compliance and Traceability
25	Continuous Improvement (Kaizen)
26	Smart Manufacturing
27	Industry 4.0

1. Introduction:

1.1. Background:

The global automotive industry is evolving rapidly, driven by the convergence of new technologies, shifting market demands, and increasing regulatory pressures. Modern consumers expect vehicles with advanced features, efficient performance, and environmental responsibility. To meet these demands, automotive manufacturers must continuously innovate and adapt. This requires a robust and collaborative environment for product development, where information flows seamlessly across departments and stakeholders.

1.2. Role of PLM in Automotive Industry:

Product Lifecycle Management (PLM) provides a strategic framework that enables manufacturers to manage the entire lifecycle of a product—from initial concept through design, manufacturing, service, and disposal. In the automotive sector, PLM facilitates better control over product data, accelerates innovation, reduces time-to-market, and ensures compliance with regulatory standards. With the increasing complexity of vehicle design and production, PLM has become a critical tool for sustaining competitiveness.
In today's rapidly evolving automotive industry, managing the complexity of vehicle development—from concept through design, manufacturing, service, and disposal—demands an integrated and intelligent approach to product data and lifecycle management. Product Lifecycle Management (PLM) systems have emerged as critical enablers in this context, serving as centralized platforms that unify data, processes, and

people across the entire value chain. PLM empowers automobile manufacturers to reduce time-to-market, enhance product quality, support regulatory compliance, and facilitate innovation in the face of growing market demands for electric vehicles (EVs), autonomous driving, and smart mobility solutions.

However, implementing a PLM system in the automotive sector is not without significant challenges. Automotive manufacturing is characterized by complex product structures, large-scale production, global supply chains, strict safety and compliance standards, and the constant need for innovation. These factors create a demanding environment for PLM deployment, where technical, organizational, and strategic hurdles must be overcome to achieve full value from the system.

Integration with existing enterprise systems such as Enterprise Resource Planning (ERP), Computer-Aided Design (CAD), Manufacturing Execution Systems (MES), and Supply Chain Management (SCM) tools often proves difficult due to compatibility issues and data silos. Migrating legacy data, ensuring user adoption, managing change across global teams, and securing sensitive intellectual property further add to the intricacy of implementation. Additionally, automotive companies often require heavy customization of PLM tools to match their unique processes—such as variant configuration, Bill of Materials (BOM) management, and regulatory compliance workflows—resulting in increased costs and prolonged timelines.

Despite the promise of PLM in streamlining product development and fostering innovation, its practical implementation is frequently limited by high investment requirements, scalability issues, and resistance to change. Many manufacturers also struggle with vendor lock-in, limited support for agile and iterative development methodologies, and insufficient industry-specific capabilities in off-the-shelf PLM systems.

This paper aims to explore the various challenges and limitations faced by automobile manufacturers in implementing PLM systems, highlighting both technical and organizational barriers. By understanding these issues in depth, organizations can be better prepared to devise effective strategies that ensure successful deployment and long-term sustainability of PLM initiatives within the automotive sector.

PLM is a holistic approach for innovation, developing and introducing new products and product information management from an idea to the end of life. PLM -systems enable technology to integrate people, data, processes and business systems. PLM systems provide the backbone of product information both for companies and their extended enterprise. ("What Is PLM | PLM Technology Guide" n.d.).

A big amount of data is created during a product's lifecycle. Many people need to access the data. The data needs to be available to anyone needing it. An unauthorized access should be prevented. The environment can be complex if it is logical throughout. If there is a feeling that the environment can be controlled, it enables making improvements to it. (Stark 2005, 51–52).

PLM should be the responsibility of the CEO. All tasks can be delegated further, but the CEO is the only person who is in charge of products during the whole lifecycle. Different departments are in charge of a product only for certain lifecycle phases. (Stark 2005, 7–8).

Information Technology Infrastructure Library (ITIL) deals with similar problems at software development. It has an approach through the configuration management. The configuration management includes managing separate incidents, changes, releases, capacity, service level, availability and service continuity management. (Klosterboer 2008). As one can see, there are many overlapping themes only with different names and details because of different environments between traditional product and software development.

1.3. Why 3DEXPERIENCE?

Dassault Systèmes' 3DEXPERIENCE platform stands out as a comprehensive PLM solution. It offers integrated tools for product design (CATIA), manufacturing simulation (DELMIA), and collaborative data management (ENOVIA). The platform enables digital continuity, wherein all users work on a unified data model, ensuring real-time updates, traceability, and improved collaboration. It aligns with the needs of modern automotive enterprises by providing a flexible, scalable, and user-centric environment.
3DEXPERIENCE PLM enables a company for example to

- harness the opportunities of Globalization,
- outsource the product development,
- have a collaborative product development and support,
- have a multi-cultural and multi-lingual work environment,
- re-engineer existing processes,
- increase the shareholder value,
- mass-customizing consumer products,
- improve communication,
- improve the supply chain,
- acquire new information systems,
- have a clear strategy with computer systems,
- harness possibilities brought by the Internet,
- focus on the product lifecycle,
- easily trace products and batches etc.,
- audit the product development and improve performance,
- have less complex computer systems,
- handle large volumes of data,

- manage knowledge,
- store silent knowledge from retiring workers,
- have multiple versions of the same basic processes,

1.4. Project Motivation

This project is motivated by the need to optimize product development processes at a mid-sized automobile manufacturing company. The existing setup lacked integration among departments, leading to information silos, design inefficiencies, and poor traceability of changes. By implementing 3DEXPERIENCE, the project aims to overcome these challenges and demonstrate measurable improvements in performance metrics such as design cycle time, error rate, and user satisfaction.

A lot of time is wasted on searching information within organizations. Information might be outdated, which causes problems. Or then there are multiple different locations where the information could be located. The worst case is that there are both paper and digital information available and it is not clear where the information one is after can be found. Designs might be accidentally duplicated because earlier designs could not be found when needed, which causesd a lot of duplicate work and wasted time. Modern systems generate more and more data and the situation easily gets worse day by day. Knowledge Management can be implemented, but as long as the product data is not under control, it will not help. (Stark 2005, 79).

An uncontrolled data entry can cause problems. A mistyped attribute or a misnamed file usually means that information cannot be found. Having different data systems causes problems every time one needs to move information from one system to another. It neither is a manual operation or an automatic process. Manual operations have a risk of human errors. (Stark 2005, 80). The automatic process costs money and it is hard to adjust if changes are needed.
One big problem is that the data is out of phase between different systems. CAD has a valid Bill of Materials (BOM), but the Enterprise Resource Management (ERP) system does not. ERP users do not know that they have incorrect data, and problems can occur, and money is wasted. Project and resource management and production planning becomes hard or impossible because information is not linked to correct up to date versions for example. (Stark 2005, 80).

Multiple sources of the same information can be maintained between different systems. In the worst case nobody has got an idea about what is the master copy. Changes probably do not go through all systems and some stay out of date. If the production has wrong information, wrong parts will be produced for example.

Working with subcontractors makes things even worse than with the in-house resources. (Stark 2005, 80).

Uncoordinated engineering changes leave a possibility for unnecessary changes. Design cycles grow long, wrong versions of design data cause problems at multiple fronts. The actual working time required for the change might be a few hours but getting changes done might take days. Change control systems might be bureaucratic, complex and slow. This causes the change process to appear inefficient and people try to avoid it, which causes undocumented changes, and documentation falls out of sync with actual products. (Stark 2005, 80–81)

Missing suitable formal communications cause misconceptions and confusion. Informal communication chains are used instead, and confusion about information validity occurs. Obtaining simple information can take days. The control of configurations might break down. Nobody knows why differences between as built and as designed BOMs appear. (Stark 2005, 81–82)

All issues above are somehow related to product data and/or product workflow. Product data is all data related to product and processes for manufacturing the product. Product workflow is workflow of the activities that produce or use product data. Product data comes in multiple different forms. Some of it is generated in- house and some elsewhere. Product workflow runs across the product's lifecycle and includes for example welding instructions for a specific part. In theory, product workflow starts with initial product specification and ends with retirement and recycling of a product. But product workflow is rarely linear. Some activities run in series and some parallel. (Stark 2005, 82–83).

1.5. Basic principles for PLM

The fundamental goal of PLM is to **create a single source of truth for all product-related data** and to facilitate efficient collaboration across departments and global teams.

The basic principles for PLM strategy according to Stark (2005, 179) are:

• Focus on the product,

•involve the customer, listen product feedback,

• remember the planet and mankind,

• simple slim-line organization,

• highly skilled people,

• use of modern technology,

• coherent PLM vision, strategy and plan,

• continually increase sales and quality,

• reduce time cycles and costs,

• watch the surroundings,

• maintain security.

Product Lifecycle Management (PLM) is a strategic business approach that integrates people, processes, business systems, and information to manage the complete lifecycle of a product from its initial concept through design, manufacturing, service, and disposal. It enables companies to innovate, collaborate, and respond more effectively to market changes while ensuring product quality, cost-effectiveness, and regulatory compliance.

The following are the **core principles** that form the foundation of a robust PLM system:

1. Centralized Data Management

At the heart of PLM lies the principle of centralized and structured data management. PLM systems provide a unified repository to store, manage, and retrieve product data, including CAD files, bills of materials (BOMs), specifications, test results, manufacturing plans, and service documentation. This eliminates data silos, reduces redundancy, and ensures that all stakeholders are working with up-to-date and consistent information.

Key Benefits:

Improved data integrity and traceability

Easier access to historical records and revisions

Reduced risk of errors and miscommunication

2. Lifecycle Perspective

PLM emphasizes managing the **entire product lifecycle**, not just the design or manufacturing phase. This includes ideation, concept development, prototyping, engineering, manufacturing, marketing, service, maintenance, and end-of-life disposal or recycling. By taking a holistic approach, organizations can better plan for sustainability, cost control, and long-term product performance.

Lifecycle phases include:

Concept and Planning

Design and Development

Validation and Testing

Manufacturing and Production

Service and Maintenance

Retirement or Disposal

3. Collaboration and Communication

One of the most powerful principles of PLM is enabling cross-functional and cross-organizational collaboration. A PLM platform provides the tools necessary for multiple stakeholders (engineers, designers, suppliers, marketing teams, and customers) to collaborate in real-time, regardless of geographic location.

This fosters:

Faster decision-making

Shortened development cycles

Improved coordination between internal teams and external partners

4. Change and Configuration Management

Managing changes to product designs, parts, documents, or processes is critical to product quality and compliance. PLM systems offer structured workflows for **engineering change orders (ECOs)** and **configuration management**, ensuring that modifications are reviewed, approved, and documented properly.

Principles include:

Version control and audit trails

Configuration baselines

Formal approval workflows for changes

5. Process Integration and Automation

PLM supports the automation of business processes by integrating with enterprise systems such as Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM), and Manufacturing Execution Systems (MES). This integration helps ensure that design, production, and business functions are aligned and synchronized.

Automation capabilities include:

Workflow engines for approvals and notifications

Rule-based validations

Automated document generation and task assignment

6. Standardization and Compliance

PLM enables companies to enforce engineering standards, templates, and design rules across all projects and teams. This helps ensure **regulatory compliance** and industry standards (such as ISO, FDA, or automotive-specific standards like APQP and PPAP).

Benefits:

Reduced risk of non-compliance

Consistent product quality

Easier auditing and certification

7. Innovation and Reuse

PLM promotes innovation by providing tools to capture and reuse design knowledge, best practices, and intellectual property. By accessing historical data and previous product versions, teams can avoid reinventing the wheel, reduce development time, and introduce new products faster.

Example practices:

Use of modular designs

Knowledge-based engineering (KBE)

Digital twins and simulation data reuse

8. Customer and Market Focus

Modern PLM systems are increasingly customer-centric, ensuring that products are designed with end-user needs and market trends in mind. By integrating feedback loops from sales, service, and marketing, PLM allows companies to create more relevant and competitive products.

9. Sustainability and End-of-Life Planning

With growing emphasis on environmental impact, PLM helps companies plan for **eco-friendly materials**, **recycling**, **remanufacturing**, and **regulatory sustainability** standards like RoHS, REACH, and WEEE. Managing product data across the entire lifecycle enables better end-of-life decision-making.

10. Scalability and Flexibility

A successful PLM system should be scalable and adaptable to accommodate product line expansions, mergers, geographic growth, and changing market dynamics. This includes supporting different product variants, configurations, and multi-site operations while remaining flexible to new workflows and technologies.

The strategy is created in five steps. First the information is collected. Based on the information, possible strategies are identified. The best strategy is picked, and it is communicated. Finally, the strategy is implemented. The vision describes the company future, so the information collected should address the current situation both within the company and around the company. Strategy identification should always have multiple possible strategies because it will increase the probability of finding the best strategy. Strategy elements should be described in detail. List of strategies are analysed and compared with a set of questions or for example with the SWOT -analysis and the best one is picked. The selected strategy should be communicated to everyone who will either be affected or involved. People need to be fully aware of it and they must be able to understand and implement it. (Stark 2005, 195–215).

Bringing change requires time. And PLM brings a lot of changes. All the changes must be effective through the whole organization. The changes PLM brings are not concrete compared to purchasing a PDM system or new machinery that has different tooling compared to old ones. “reduce time-to-market by 35%” is not easy to grasp on. But still there needs to be full a understanding about how the change is required. (Stark 2005, 217–220). One of the most important components of PLM are Product Data Management (PDM) systems. They manage both the product data and product workflow. PDM is a multi-user and multi-organization environment. Without a PDM system there are only small odds to have a successful PLM implementation. (Stark 2005, 233–243). The financial justification for PDM comes from a more efficient workflow that reduces overheads and makes it possible to get products faster to markets (Stark 2005, 310–12).

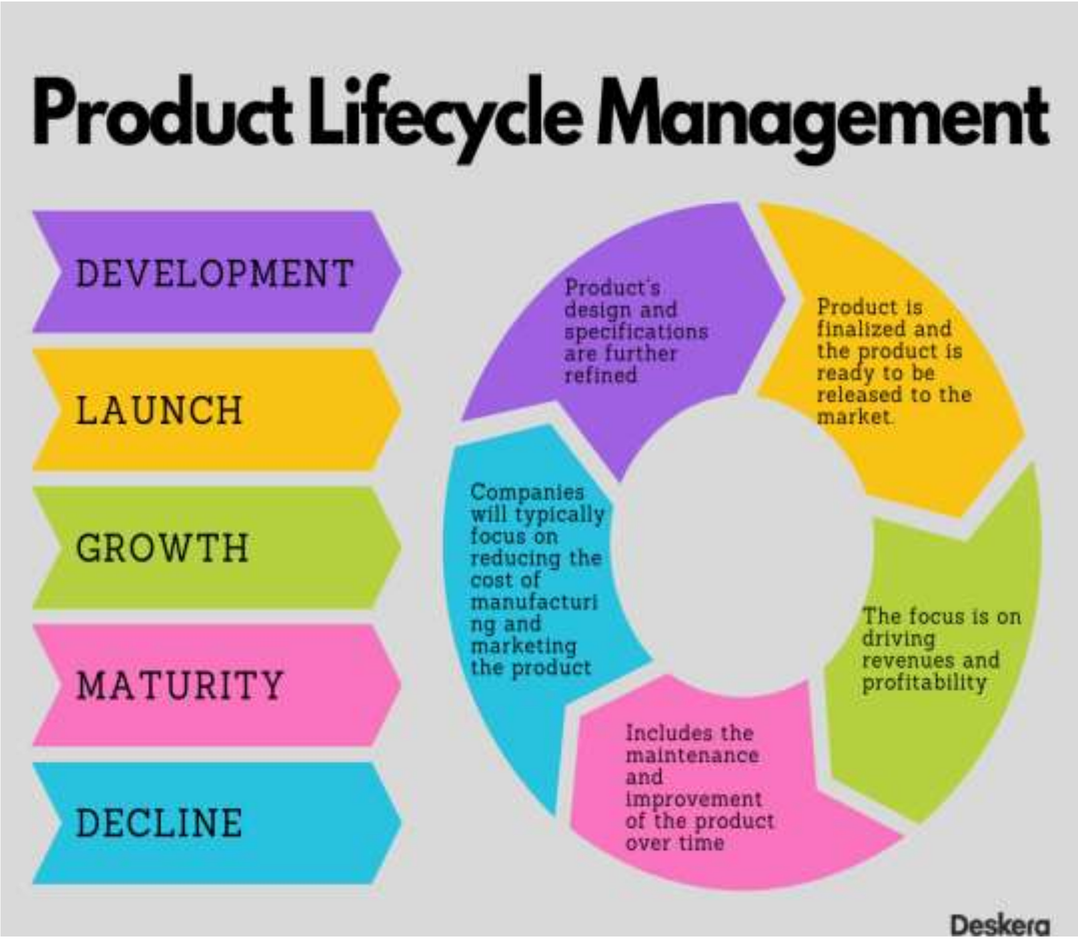

Figure 1.1: Basic Principles of PLM

1.6. Product Data Components

Product data is not maintained by itself. Anything that is not properly maintained will slide into a chaos eventually. (Stark 2005, 86). The product data components are explained in the table below .

Component	Explanation
Definition	Product data describes all data related to a product and processes that are used to define, produce and support it.

Scope	Wide range of different information is included in product data. All different types are used and managed differently. Different types can be for example: • specifications, • schedules, • project plans, • geometry, • formulae, • calculations, • computer programs, • photos, • manuals, • drawings, • sketches, • video data, • comments.
Media	Product data is stored on different media. • Traditional media ○ Paper ○ Aperture cards ○ Mylar film • Electronic media ○ Microfilm ○ Magnetic tape ○ Different storage devices ○ Different storage techniques ○ Different electric media Data management always depends on media used and its special requirements.
Type and format	Product data has many different types, for example:
Status	There can be multiple phases product data can be in. In-process, in-review, released, as designed, as built, as installed, as maintained etc. The more mature the data is, the less frequently it is modified. There are different rulesets depending on which status the data is in.
Change	The most product data undergo a lot of changes during the product's lifecycle. Change management adds complexity to the product data management process. There are multiple operations in storing changes.
Sources	Data is created in multiple locations. The source where data is from should be managed.
Users	There are multiple different functions, and each function can have multiple different users that require access to product data. Unauthorized personnel should

	not be able to access product data, so managing the access rights is not a simple task.
Uses	People will create, modify, delete and refer on data based on tasks they are working on. The background and computer skills can vary a lot between different persons doing similar things.
Locations	Product data can reside in different locations. Either in single location (same building as production plant, server room nearby, on different continent, etc.) or as a distributed system. Or within a cloud service providers system.
Departmental organizations	Multiple departments need to have access to product data. There can also be functions across multiple departments that require certain access.

All product workflow activities create or use product data. A product workflow is closely linked into product data. The product workflow consists of activities and the data is transferred between the activities. If the transfer is not automated, searching and transferring information can take a big portion of time spent for the entire activity. The more people there are to create and use data, the harder it is to do a manual data transfer. When automation is added to transfers, the workflow should be improved first to enable an efficient information flow. If that is not done, one can end up with an inefficient automated information flow and workflow. (Stark 2005, 93–94).

One might falsely presume that the information flow goes only from the beginning of a new product into product retiring. Some of the definitions can though be reused and previous product data can be reviewed to be created even better. This kind of more flexible information flow makes the product data hard to manage. The product data must be kept in control. There can be legal requirements to be able to trace the origins of any product problems with detail. Computer based systems have a concept called master data that defines where the main data is that will be traced as a slave to another system. It is easy to have irreversible conflicts for example if there are no ways to merge both master and slave data changes fluidly. The quality of the product data must be high meaning that it must be reliable, available when needed and accurate. This can only be done through company culture encouraging good quality data and penalising poor quality. Error creation and propagation must be prevented. Data management should span both the existing data and the data that will be created in the future. The data should be secure against an accidental deletion of one's changes made. In addition, moving data between different places must be handled reliably. Any suspicions must be able to be answered with an credible answer that assures people having doubts. (Stark 2005, 94–96).

1.7. Problem Statement:

Automobile manufacturers deal with complex data, design files, and workflows that become increasingly unmanageable over time. Without a centralized system, information silos emerge, leading to inefficiencies and duplication of work. The implementation of a PLM system aims to address these issues comprehensively.

This dissertation outlines a structured approach for implementing 3DEXPERIENCE in such a context and demonstrates how it can streamline operations, enhance collaboration, and improve product innovation cycles.

1.8. Scope of Work

The scope includes the assessment of current workflows, gap analysis, configuration of the 3DEXPERIENCE platform, and evaluation through a pilot project. It also covers change management activities like user training and feedback collection.

1.9. Objectives

- To assess the current state of product development workflows.
- To configure and deploy the 3DEXPERIENCE platform tailored to automotive needs.
- To improve collaboration and reduce redundancy through centralized data management.
- To evaluate the effectiveness of the PLM solution using KPIs.

1.10. Structure of the Report

The report is structured into chapters that progressively build on the foundation laid in the introduction. Following this chapter, the literature review examines relevant PLM concepts and technologies. The methodology chapter details the research design and implementation strategy. Subsequent chapters present the system architecture, implementation process, case study, results, and finally, conclusions and recommendations.

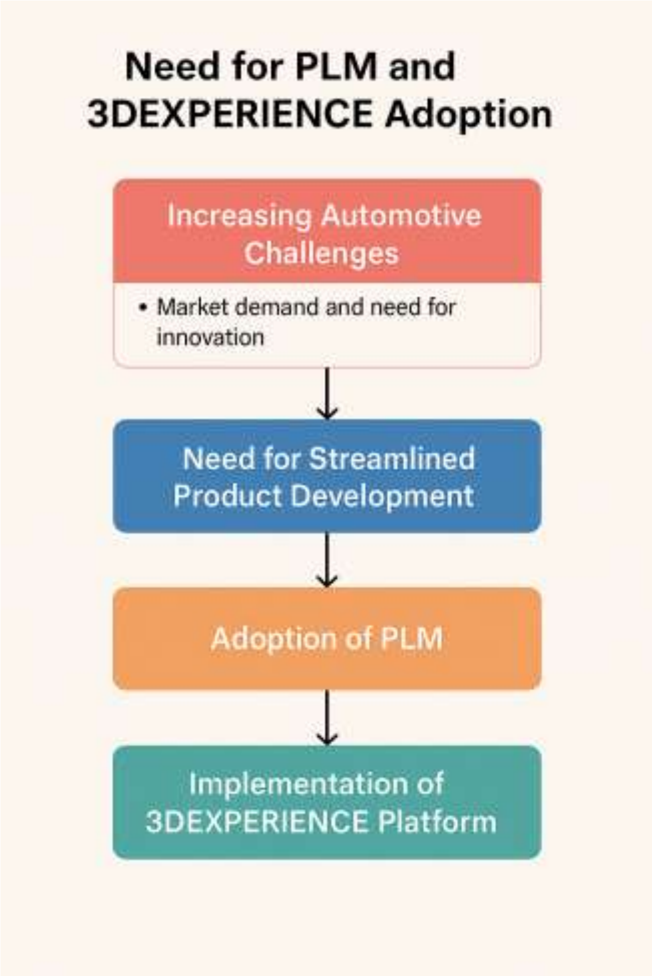

Figure 1.2: Flowchart - Need for PLM and 3DEXPERIENCE Adoption

Literature Review

1.11. Introduction to Product Lifecycle Management (PLM)

Product Lifecycle Management (PLM) has evolved into a foundational business strategy for manufacturers seeking to maintain competitiveness through innovation and efficiency. PLM is a systematic approach for managing the series of changes a product undergoes, from its conception through design and manufacture to service and disposal. This holistic approach integrates people, processes, business systems, and information across the product's life. In the automotive industry, where precision, regulation, and integrity.

PLM implementations in manufacturing companies are widely common throughout the world, especially in developed and industrialized countries. Even companies from other industries such as services, fashion, healthcare, among others, have started to implement PLM philosophy. This expansion has reached Small and Medium Size Enterprises (SME), forcing developers of these kinds of systems to generate light software versions in order to serve this large market. However, this kind of implementations requires formulating a clear strategy and a working methodology that will assure meeting the needed protocols and achieving success. In developing countries, such as Colombia, most of the enterprises are SME and this kind of implementations are not very common due to license costs, lack of a properly working methodology in engineering companies, low educational level of many of the company's members and a short term culture in the company's management. According to this and also because of the lack of literature (describing the implementation process strategy on the mentioned cases), a necessity of defining an implementation methodology has been detected to suit local needs.

The large amount of information which is created during product development, the increasing products complexity, and globalization have lead to developing Product Lifecycle management (PLM) strategies. PLM allows managing information and processes developed and conducted through the product lifecycle, connecting all the stakeholders regardless their geographic location. This strategy is supported by technological platforms which provide the means for performing the engineering processes in a collaborative way. However, the platform implementation depends on a properly strategy definition and execution. PLM strategies are widely used in the global context, nevertheless, in developing countries such as Colombia this kind of implementations are not common due to the up-front costs and the lack of knowledge and experience in the implementation process.

PLM strategies are widely implemented around the world, due to the benefits that PLM provides to the companies which implements it. Some benefits reported in the literature are automation and process acceleration (Sääksvuori and Immonen, 2008), avoiding documents duplication (Grieves, 2006), supporting decision making processes, reducing information search time, centralizing management information, facilitating simultaneous work throughout the product life cycle regardless of the location of the people involved, among others. These benefits increase the competitiveness of enterprises as in the case of aeronautic sector (Van Wijk et al., 2009), (Lee et al., 2008) and automotive industry (Trappey and Hsiao, 2008), (Tang and Qian, 2008). For these areas, an increase in competitiveness can be reflected not just in costs reduction, but also in the reduction in time to market (which strongly benefits any company in a global environment and enhances its innovation capacity). However, the implementation of these kinds of strategies implies high costs due to the price of the system's licenses, the long term of the strategy formulation and execution, the training process, among others. Due to this, some companies such as ARAS Corp have developed Open source systems which can be used without paying license cost and the developers of the commercial PLM systems have also started to provide lighter solutions focused on SMEs, in order to offer lower costs; nevertheless its prices are still high.

Even though there are some authors (Grieves, 2006), (Stark, 2005), (Sääksvuori and Immonen, 2008) who describe certain steps for the implementation of a PLM strategy, few of them such as Schuh et al (Schuh et al., 2008) provide an in depth explanation of the steps which should be conducted. This situation, together with the fact that not all the software sellers of these kinds of systems includes any kind of assessment for configuring, installing and using process making it even harder to obtain a low-cost implementation. This situation, along with the short term culture of local industry management, the lack of a proper working methodology in engineering companies and the low educational level of many of the company's members, hinders the implementation of PLM in the local engineering industry which is mostly composed by SMEs. In the long term, this could entail a loss of competitiveness of the local industry against international companies which provide similar products.

Based on all the assumptions previously exposed, defining a PLM implementation methodology focused on the local industry is vital in order to allow the use of this kind of strategies in developing countries such as Colombia, considering the economical limitations and cultural variations in working methods. This project proposes a methodology based in the use of low cost methods and tools and supported in the use of open source PLM systems.

1.12. What is PLM?

Major industrial sectors such as the automotive and aerospace, have stimulated the growth of new strategies and technological solutions through investment in market sectors related with business, such as: Mechanical Computer-Aided Design (MCAD), Comprehensive Collaborative Product Definition Management (CPDM), Digital Manufacturing, Simulation and Analysis, among others. The maturity level reached by technological advances achieved in these markets, has created the need in industries to associate the processes related to these developments in a synchronous way, through the product life cycle, promoting thus the emergence of new strategies such as PLM which aim to solve this need within a collaborative engineering framework. The different stages through which a product undergoes from its conception until its disposal are known as the Product Lifecycle.

According to Kusiak (Kusiak, 1993) the phases of the cycle are:

- Necessity
- Design and development
- Production
- Distribution
- Use
- Disposal

The most critical phases of product development are the first two, because all the subsequent phases should be considered to accomplish them and achieve an optimal product. For this reason, it is important to consider the concepts of Concurrent Engineering and Collaborative Engineering and differentiate them. Capuz (CAPUZ, 1999) has defined Concurrent Engineering (CE) as an organizational approach that seeks all actors who are working on a project to collaborate and work simultaneously throughout the product life cycle. This approach emphasizes the importance of product planning from the initial stages of development, considering New Product Development (NPD) and all aspects and restrictions related to the product in any stage, such as functional requirements, geometry, specifications, features, manufacturing processes and limitations, among others (Grieves, 2006).

PLM integrates both concepts, since its implementation as working methodology and strategy involves the application of Concurrent Engineering; and as a tool it facilitates the development of collaborative engineering, since it allows experts located in different places to "communicate" and share information through a common virtual environment. Some systems such as Product Data Management (PDM), Engineering Resource Management (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM), among others, have similarities with PLM concerning their role within organizations. However, they vary in approach, as specified by their definitions presented below: • Product Data Management (PDM), is an application to organize different CAD formats (Grieves, 2006), storing and allowing the access of all people to information related solely with the product within the organization. • Enterprise Resource Planning (ERP) are systems that automate activities such as manufacturing, human resources, finance and supply and which in turn support the decision making process within the company (Razmi et al., 2009). • Supply Chain Management (SCM) is a management information tool that integrates supply and logistics processes (Kovács and Paganelli, 2003), i.e., focusing on the supply operations. • Customer Relationship Management (CRM) is a strategy through which the company seeks to understand its customers and use the knowledge gained through them to improve the profitability of the company (Stringfellow et al., 2004). Analyzing in depth each of these definitions, it appears that all systems have in common the basic function of managing information. However, their difference lies in the type of information they manage and the number of processes and areas of the company who are concerned with that information. PLM has a great similarity with PDM systems, because both of them focus on information associated with product development. This is because PLM is an evolution of PDM systems, which also involves a work associated methodology and incorporates other areas of the company (not just engineering) that contribute or require information related to the product. Additionally, PLM includes within its operation, the information generated throughout the entire product life cycle. It is important to note that during each phase of the life cycle, the authors involved in the product can vary and therefore also vary the nature of the information generated for each of them. This situation is highly problematic because the information associated with the product is dispersed and the other authors involved will not be able to access it easily.

PLM is born of the need to properly manage all information associated with the product throughout its life cycle, properly integrating work methodologies such as Concurrent Engineering and enabling collaborative work, regardless of the geographic location of the actors, and involving not only the engineers who design the product, but also all company departments, suppliers, distributors, among others that are related to information associated with the product. Throughout this document, PLM will be analyzed in depth both as strategy and as technological tool. The definitions proposed by different authors in the area will be analyzed and a suitable definition will be proposed as a result of this analysis, also considering broadly the characteristics of PLM systems (technology tools) that currently exist.

1.13. PLM Systems Evolution

Previously, organizations oriented to product design were characterized by a division between all areas that in one way or another were involved in the life cycle. This division was generated from the limits imposed by the implemented enterprise architecture, which structured each area as an island, where each one represented a lifecycle stage, and in which internal processes in each of them were a black box for any other area of the organization. This approach is known as “Over the wall” (Anumba et al., 1997). The architecture provided a database for each area, where all the information resulting from their processes was stored and any other area could not have access to it. The interaction between them occurred only in a unilateral way (similar to a factory with mass production) where part of a process could not occur without the completion of the previous process (view Figure 1). This organizational structure caused that the companies which implemented it could not respond on time to market needs, thus becoming slow, expensive and uncompetitive organizations.

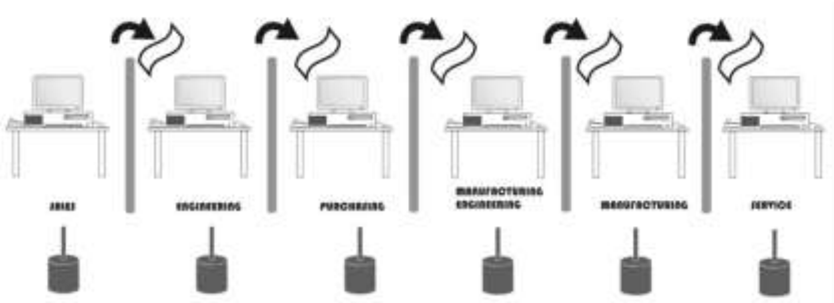

Figure 1.3: Serial process PLM Technology

The problems generated by this work methodology resulted on the development of Concurrent Engineering, which allowed more planning in product development. However, information management was still deficient. Problems such as duplication of documents, bad file regeneration, and misunderstandings in sending information, shipping of incomplete or incorrect information, missing information and availability of "garbage" information were very common during the development of engineering projects. This fact, together with an increase in product complexity, due to the increase in parts and components and the incorporation of complex systems, resulted in the birth of PDM, which has been implemented successfully in many organizations. However, its application area was exclusively for engineering departments within companies, thus excluding other departments, suppliers and distributors that interact with the engineering department to develop their functions, receiving information from them and generating information for them.

Figure 1.4: PLM Map

Therefore, it was necessary to create a system that allowed sharing information between all members of the organization and even with external actors working on a specific project. PLM was born as a solution that allows all members of the company, distributors and suppliers to interact and also integrates concurrent and collaborative work methodologies that enable better performance during product development. This system stores information in a common database that allows real time access for all project stakeholders, so it avoids problems due to inconsistent information. View Figure 2.2.

PLM brings benefits to companies that implement it for: • Standardization, automation and process acceleration (Sääksvuori and Immonen, 2008). • Considering from NPD all requirements, specifications and restrictions that will affect the product's design. • Centralizing management of information and avoiding duplication of documents (Grieves, 2006). • Connecting users scattered in different locations. • Efficient re-use of information and reduced information search time. • Support to the decision-making process. These benefits are reflected in the organizations in significant reductions of time, during the NPD of the product, as this is evidenced by the results obtained in industries such as aeronautics (Lee et al., 2008). These reductions have a direct impact on the costs associated with the product development, because in this field reductions are also achieved. Over time, different companies have been working on solutions that support the PLM concept, thus achieving: definition of product data standards and metadata, development of robust platforms for data exchange from increase in processing capacity, better broadband and storage capacity and use of Service Oriented Architecture (Srinivasan, 2008), thus facilitating access to all stakeholders and allowing further evolution of PLM systems. However, because of its short history, PLM technologies have not reached yet a sufficient level of maturity like CAD or ERP systems have (Stark, 2005). Even so, the global investment in PLM platforms for 2009 was about $ 14.03 billion dollars (CIMdata, 2010), which not only was made by areas of design and product development, but also for industrial areas for which these technologies were not originally designed for but can nonetheless benefit from the advantages they offer.

1.14. PLM Definition

Considering the analysis carried out on different definitions, and knowing the functionality of PLM systems, it is important to emphasize the use of words such as:

- Strategy
- Administration and / or management
- Product Lifecycle
- Intellectual Capital
- Processes
- People Resources
- Extended Enterprise

The words "Strategy", "Management" and "Lifecycle" were selected because of their frequent use during the definitions analyzed. "Intellectual Capital", for its part, will be used because it globally encompasses the knowledge associated with each lifecycle stage, without limiting it to the concept of "information"; "people", "processes" and "resources" are also considered, because they generate directly or indirectly the associated intellectual capital; and "Extended Enterprise" because the concept of PLM considers within its operation all stakeholders involved in product development, regardless if they are internal or external to the organization, including, for example, both clients and suppliers. The word strategy is defined as the way to achieve objectives by managing resources and the creation of rules governing the use of them (Stark, 2005). That implies planning processes prior to development of any activity and the existence of a specific goal, which will be achieved through the implementation of it. Due to this, the integration of a properly working methodology and the use of PLM systems, form a business strategy that must be supported by a proper planning process and an organizational culture that ensures its implementation. Thus, and trying to bring together the main concepts, in this project is proposed the following definition:

Definition 2-1. "Product Lifecycle Management (PLM): PLM is a strategy developed to manage the product life cycle, through the management of intellectual capital that is generated around it, in the extended enterprise, by integrating people, processes and resources supported by an organizational culture that can be supported on a technological platform". With this definition it was sought to express the concept of PLM in a versatile way, considering the definitions proposed by other authors and including terms that the authors of this thesis consider important, in a way that they suit to a marked tendency of increasing functionalities, and emphasizing that it manages knowledge rather than just information generated during product development.

1.15. Systems engineering is the interdisciplinary approach that governs the creation and realization of complex systems. It involves defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation. PLM and systems engineering intersect in their mutual goal of reducing complexity and enhancing collaboration. The application of systems engineering in PLM ensures traceability of decisions and requirements .

1.16. PLM Considered as a Strategy

To achieve all the benefits offered by an appropriate implementation of PLM, it is necessary to consider it as a strategy that encompasses all three levels: strategic, tactical and operational (Stark, 2005). The strategic level includes a long-term plan, and involves the entire organization, the tactical level is a medium-term plan and focuses on improving the performance of a specific area and the operational level has a short term range and focuses on individual activities. To realize a strategy for developing products based on PLM, it is necessary to consider, from the moment that it will be defined, the guidelines established by the company's corporative strategy, to ensure that it is consistent with it. Many authors propose certain steps for the development of a PLM strategy (Stark, 2005), (Grieves, 2006), (Sääksvuori and Immonen, 2008), due to the impact that an appropriate definition can generate within the company. However, it is not possible to speak of a standard strategy that can be successfully implemented in all organizations indifferently, since its approach varies depending on the needs, requirements and business model that the company handles as well as its corporate strategy and area of action. Within the product strategy generated, product lifecycle management, due to its definition, and supported by software systems available on the market, offers benefits associated with a work methodology based on Concurrent Engineering, which establishes guidelines related to the design and development process which can predict, from the early stages of NPD, all requirements and limitations, including multidisciplinary working groups and the appropriate distribution of tasks and activities among the actors involved in the process. All this must be supported by an organizational culture that generates awareness, among all members of the organization, of the importance of the implementation. This is to ensure that all people involved will act according to established guidelines, and make proper use of the software tool. For this purpose it is necessary that the strategy to be implemented in each company is built on consensus among the members of the organization, considering their views and opinions. In order to define this strategy it is important to apply Business Process Management (BPM). BPM allows finding the “Most efficient way to bring all resources together in an end-to-end cross departmental process that add value to the customer” (Davis and Brabänder, 2007). It entails analyzing the existing processes of the company (also known as “AS-IS”) aiming to define the improved new processes (“TO-BE”). “AS-IS” and “TO-BE” concepts are widely used in the “Re engineering” field.

1.17. PLM Considered as a tool

PLM tools are information technologies developed to support and assist the PLM strategy. Its main function is to put the associated information on the hands of everyone involved in the design process, allowing to re-use it. Additionally, this type of system provides tools to coordinate and support the decision-making processes, which facilitate and expedite the product design process. Some authors have classified PLM systems as an information management tool (Mejía et al., 2008), because it manages the information that is documented throughout the product lifecycle (CAD / CAM / CAE files, blueprints, assembly and process tables, among others) in a central database to which all stakeholders have access to.

FUNCTIONALS		KNOWLEDGE AND INFORMATION	COORDINATION	COMUNICATION
INFORMATION	MODELS			
-QFD -FMEA -IDEF-0	-CAD -CAM -CAE -ECAD	-Databases -ECM -Repositories -PDM -PLM	-Project Management -Workflow -Groupware -e-management -e-project	-Videoconference -Skype -Forums -Chat -E-mail -CSW

This would imply that PLM can be considered as a coding strategy (Hansen et al., 2005), i.e. a tool that focuses on re-use of information within the company. Coding tools are highly useful because they increase efficiency by allowing the availability of information, generated not only during an ongoing project, but also during previous projects for its reuse. Current PLM solutions are oriented to transmission and storage of explicit knowledge, which only covers a small percentage of total knowledge; the "top of the Iceberg" (Haldin Herrgard, 2000). However, this classification severely limits the scope of PLM solutions, and to categorize it solely as an administrative tool of information would leave out functional tools that are integrated into the platform, such as coordination, which together allow operation of the system. Because of this, a model in which PLM is composed of a set of coordination and functional tools (based on information and models) that complement its main function of managing information in a centralized database is proposed (view Figure 3). In this way, information that is generated throughout the product lifecycle is managed and stored by PLM, and while using complementary tools, all stakeholders have full access. Throughout this approach, all the tools that conform PLM are included and this makes PLM different from other technology solutions such as PDM systems.

Most of the current PLM commercial systems on the market, manage product development from a modular approach. It entails the tool can be configured by each company based on their needs and requirements allowing configuration by modules and libraries. This feature allows PLM system to adapt to any strategy which could be defined in any company. These modules are usually distributed in three broad areas:

• Project management: is done through portfolio management; tools like Project management, management reports and deliverables and performance analysis processes.

• Management and quality control: consider the application of methodologies such as Failure Mode Effect Analysis (FMEA) for product development, analysis of toxic substances and management of libraries associated with rules and regulations.

• Management of engineering processes: It includes CAD file management and similar, its approval flows related, Request for proposal (RFP) / Request for Quotation (RFQ) / Request for information processes and sourcing and production process design.

1.18. Integration with Existing Systems

In the business world, there are other solutions similar to PLM which are responsible for the management of information throughout the different processes that take place in a company, but with a particular approach. Such is the case of ERP, SCM and CRM, to name a few.

Thus all systems can be used in parallel within an organization, since neither replaces the other, but instead, complements it, covering the totality of the processes that take place in the company. Because of this, and with the goal of getting a full interoperability, technologies have been developed based on markup language, such as XML to represent data and metadata, allowing them to be interpreted by all other systems; so information as Bill of Materials, assembly structure, or management of versions and change history are compatible among all of them (Srinivasan, 2008). Thus, PLM not only ensures a wide coverage within organizations because of their inherent functions, but also allows interoperability with similar systems, so that all business processes may be covered from the focus or emphasis associated with each of the implemented information technologies. This facilitates the automation processes in companies and adequate management of information allowing greater flexibility in its daily operation. After analyzing PLM as a system, it is important to consider the implementation requirements needed for commercial solutions currently available.

1.19. Analysis of PLM System and its requirements

As it has been exposed, PLM has undergone a major transformation since its conception as a necessity, to become a robust strategy, which, according to the size of projects and organizations who adopt them, is supported by a software tool.

Additionally, PLM systems should allow scalability, as well as facilitate interaction with the other systems that will also be implemented by the company. The technological development has currently allowed software vendors to develop PLM systems according to market requirements, achieving with them, the benefits expected by the industry. However, given the complexity of PLM software architectures, organizations must incur in high investments to acquire information technologies. Often, these technologies are offered by large companies because the investment is not limited to licenses (which are expensive), but also to the acquisition of technological infrastructure (e.g. servers, database engines and technical support), plus the costs related to the implementation process and the strategy assimilation (Change management). In order to serve all markets, PLM vendors offer versatile solutions to suit different company sizes through scalable products that support less complex architectures and therefore do not provide full functionality. This needs have been unattended at the point that some software companies have developed Open Source PLM solutions. These open solutions enabled SMEs to access the technology needed to support a strategy for managing product lifecycle.

Therefore, the implementation of PLM in organizations is a decision that requires consideration of different points, including requirements such as:

- Data Base Engine
- Operating systems (from the server and from the client)
- Architecture
- Technology
- Additional Software

Because of all of the above, four commercial PLM solutions where considered for analysis:

- "ENOVIA V6"™ from Dassault Systems4.
- "Windchill"™, from PTC5.
- "Teamcenter"™ from Siemens6
- "Aras Innovator"™ from Aras Corp7.

From these solutions, the first three represent the most commercial and recognized in the market due to their sturdiness and wide implementation. The fourth is a relatively recent Open Source solution, whose business model is based on the assessment and technical support service associated with the implementation of the platform. This system presents almost the same functionality as commercial systems; however, it has deficiencies in connection with CAD systems, which is supplied through the installation of commercial connectors, and compatibility with different technologies. It is important to clarify that all applications support Web access and the vast majority allow connectivity with other solutions, usually of the same parent company. The technological requirements of selected PLM systems are detailed in Table 41, to Table 44 of Appendix B. A summary of the system requirements analysis

Database Engine	Operating system Server side	Software requirements
The only PLM system which can operate with all database engines analyzed (IBM DB2, Oracle, MySQL and SQL server) is Enovia V6. PTC Windcill and Teamcenter can operate just with Oracle and SQL server; Aras Innovator only works with SQL server.	Enovia V6 can be used with AIX, HP-UX, Macintosh, Linux, Sun Solaris and Microsoft Windows. PTC Windchill also works in these systems except by Macintosh and Sun Solaris and Aras Innovator can only work with Microsoft Windows.	Teamcenter can work properly in all analyzed Web Browsers (Internet Explorer, Safari and Firefox); Enovia V6 and PTC Windchill only works on Internet Explorer and Firefox ; Aras Innovator only can be used in Internet Explorer.

1.20. Application areas

Some PLM solutions have added to their basic functions, modules designed to answer specific needs in development areas different to those that it traditionally attended. Thus, sectors such as fashion design, healthcare, packaging, and others have begun to be covered with their solutions by different software providers. There is documentation on the use and implementation of PLM in different industries such as: manufacturing of digital components (Chiang and Trappey, 2007), thermonuclear (Muhammad et al., 2009); fashion design, which has specific solutions such as Lectra Fashion PLM (CIMdata, 2009); packaging (CPF Consumer Package Foods), through modules such as Packaging and Artwork Management of Siemens, which also considers the administration of the brand within this module (CIMdata Inc, 2009c); food, through solutions such as PLM Vivo developed by the Kalypso company (Cimdata Inc, 2009b); chemical, construction, oil and mining, which are covered by solutions provided by different companies, including SAP (CiMdata Inc, 2010); and even in the medical and pharmaceutical industry (CIMdata Inc, 2009a). This situation shows the great reception PLM systems have had in several areas and helps to measure the growth and importance achieved in different industrial sectors. As well as there are a lot of modules and applications developed for this kind of systems, there is also literature that includes many scientific publications about PLM from different perspectives or models trying to resolve certain failures related to the management of the product lifecycle. That is the case of Srinivasan (Srinivasan, 2008) that mentions the factors that encouraged the development of an integration system based on open standards and service oriented architecture for PLM. On the other hand, Ni (Ni et al., 2008) has focused on developing a model of flexible product structure for product families in PLM. Sharma (Sharma, 2005) proposes a system that integrates product development, collaborative work and innovation throughout the PLM platform, in order to get the benefits of each of the items integrated. Xiao (Xiao et al., 2009) presents a system model that supports aspects of modeling and simulation of virtual products. Jun (Jun et al., 2007) proposes the integration of RFID to products, so that it can capture product information generated during after-sale phases. Kakehi (Kakehi et al., 2009) develops a curriculum designed for PLM education and Alemanni (Alemanni et al., 2008) proposes a series of indicators to measure the efficiency after the implementation of PLM in companies. All cases previously exposed allow estimating the importance of managing the product lifecycle and show the number of fields from which it can be addressed. During the last decade there has been intense research and development in the field of PLM, which enabled the existence of robust platforms. These platforms assist the strategy and, instead of becoming a constraint, offer an effective solution that is successful in the business market. According to this literature review, no documentation of the implementations of PLM systems made in Latin America could be found, including statistics about this that could enable determining its application level.

1.21. Kaizen and Continuous Improvement in PLM

The concept of Kaizen—or continuous improvement—plays a critical role in refining PLM processes. Originating in Japanese manufacturing, Kaizen emphasizes the importance of consistent, incremental improvement. Within the context of PLM, Kaizen can be applied to enhance design workflows, improve documentation accuracy, and reduce rework and waste. When embedded into a digital PLM system like 3DEXPERIENCE, Kaizen practices lead to agile and adaptive product development cycles.

1.22. Workflow Management and PLM

Workflow management systems within PLM platforms automate business processes and ensure that product-related information flows efficiently between stakeholders. These systems allow teams to track progress, assign responsibilities, and ensure adherence to deadlines and standards. A properly implemented workflow management strategy reduces bottlenecks, enhances accountability, and fosters a culture of operational excellence.

1.23. Role of 3DEXPERIENCE Platform in PLM

The 3DEXPERIENCE platform by Dassault Systèmes provides a robust, integrated environment for all PLM activities. It supports digital continuity by allowing engineers, designers, analysts, and project managers to work on a common data model. The platform's applications—ENOVIA, CATIA, DELMIA—cover every aspect of the product lifecycle, including requirements capture, conceptualization, modeling, simulation, planning, and change management. By leveraging cloud connectivity and role-based access, it ensures th...

1.24. Comparative Study of PLM Solutions

Feature	**3DEXPERIENCE**	**Siemens Teamcenter**	**PTC Windchill**
Data Management	Centralized & Real-time	Moderate	Decentralized
Integration	High (CAD, ERP, CRM)	Moderate	Moderate
Collaboration	Real-time, Unified Dashboard	Role-based	Department-specific
User Interface	Intuitive & Visual	Text-based	Form-based
Cloud Support	Yes	Partial	Yes

2. Research methodology:

2.1 Overview of Research Design

The research follows a design-based methodology tailored to understand, implement, and evaluate the PLM system in a real-world automotive manufacturing setup. A mixed-methods approach—incorporating both qualitative and quantitative techniques—has been employed to ensure comprehensive analysis and practical insights. The primary focus is on iterative development and validation through continuous feedback from stakeholders.

2.2 Qualitative and Quantitative Methods

- Qualitative Data: Gathered through interviews, workshops, and observations to Understand challenges and expectations.
- Quantitative Data: Performance metrics such as design cycle time, issue frequency, and data access latency were collected before and after implementation.

2.3 Sampling and Case Selection

A purposive sampling technique was used to identify a representative automobile manufacturer actively engaged in product development. The organization selected faced typical PLM challenges, making it a suitable case study. Stakeholders from design, manufacturing, and quality departments participated in the implementation process.

2.4 Research Phases

The methodology comprises the following five phases:

- **Assessment of Current Systems:** Evaluation of workflows, tool usage, and information flow.
- **Gap Analysis:** Identification of inefficiencies, redundancies, and disjointed systems.
- **PLM Platform Configuration:** Installation and customization of 3DEXPERIENCE modules (ENOVIA, DELMIA, CATIA).
- **User Training and Rollout:** Role-specific training sessions and pilot deployments.
- **Evaluation:** Collection and analysis of post-implementation data to measure effectiveness.

2.5 Tools and Technologies

Tool/Module	Functionality
ENOVIA	Centralized data management, issue tracking, BOM control
CATIA	3D CAD design, modeling, product structure design
DELMIA	Manufacturing simulation, planning, logistics coordination
Excel & Power BI	Data collection, dashboard visualization

Tool/Module	Functionality
Interview Tools	Structured and semi-structured data collection

2.6 Data Collection Instruments

- **Structured Interviews:** Conducted with department heads to gather detailed perspectives on PLM needs.
- **Observational Checklists:** Used to document workflow inefficiencies and manual intervention points.
- **Digital Logs:** Tracked system usage and interaction post-implementation.

2.7 Validity and Reliability

The research ensured reliability by triangulating data from multiple sources and maintaining consistency in evaluation methods. Validity was achieved through iterative verification with stakeholders and domain experts, refining methods and models as insights emerged.

2.8 Ethical Considerations

Participants provided informed consent for data sharing. Company data was anonymized to ensure confidentiality. Feedback loops were established to verify interpretation and intended outcomes. This methodology provides a structured and iterative roadmap for understanding the practical nuances of PLM system implementation, making it both rigorous and adaptable to dynamic industrial environments.

3. Results and Discussion:

3.1 Introduction

This chapter analyzes the quantitative and qualitative results obtained from the PLM implementation project at AutoNova Ltd. The discussion focuses on key performance indicators (KPIs), stakeholder feedback, observed process changes, and system impact.

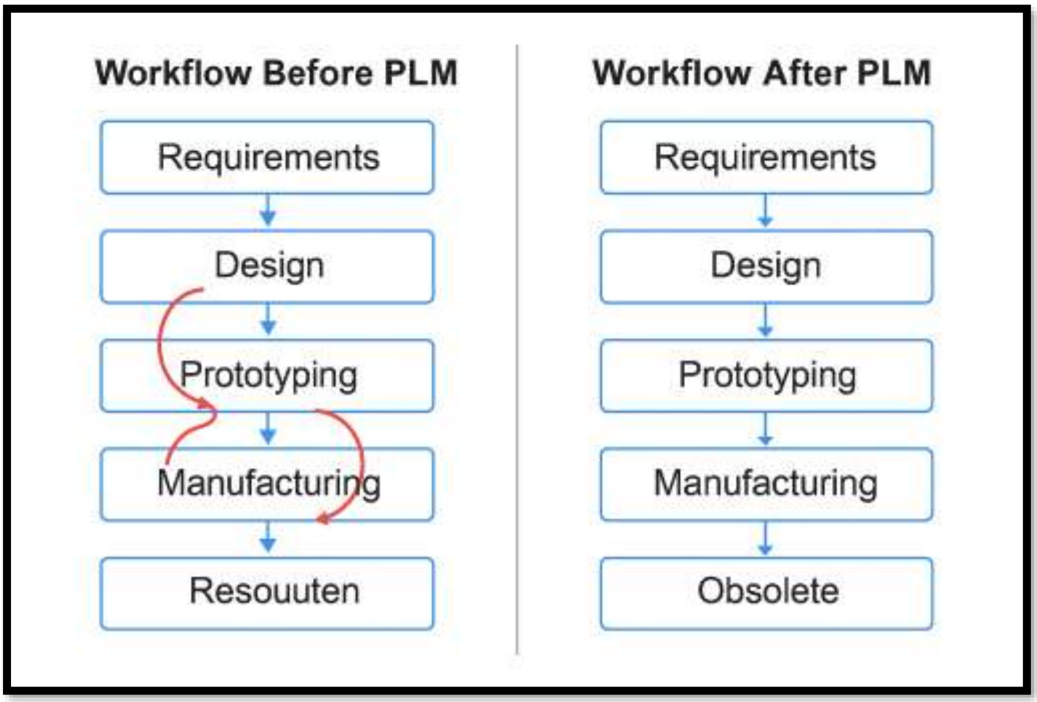

Figure 3.1: Workflow Comparison - Before vs After PLM

3.2 Key Performance Indicators (KPIs)

Metric	Before PLM	After PLM	Improvement
Avg. Design Cycle Time	22 days	14 days	36% faster
Issue Resolution Time	3.5 days	1.5 days	57% faster
Change Request Accuracy	72%	97%	25% increase
Task Completion on Time	65%	89%	24% increase
Cross-Team Communication Delay	High	Low	Improved

3.3 Data Traceability and Compliance

The centralized ENOVIA repository ensured that all documents, design versions, and approvals were traceable. The audit logs, revision control, and secure access helped meet compliance standards such as ISO 9001.

3.4 Process Efficiency Gains

Digital transformation enabled through 3DEXPERIENCE reduced manual errors, rework loops, and approval delays. Real-time collaboration and version control led to smoother workflows.

Process	Efficiency Gain
Design Approval	Reduced turnaround by 45%
BOM Validation	Real-time updates with 0% data loss
Supplier Collaboration	Increased visibility and alignment
Engineering Change Orders	2x faster cycle closure

Phase	Process Step	Before PLM	After PLM
Design	Model Access	Manual File Search	Centralized Repository
Design	Design Review	Email Feedback	Real-time Collaboration
Planning	BOM Tracking	Excel Sheets	ENOVIA Module
Production	Process Simulation	Trial Runs	Virtual Simulation via DELMIA
Testing	Defect Logging	Paper Reports	Automated Issue Tracker

3.5 User Experience & Satisfaction

Most users found the 3DEXPERIENCE interface intuitive and appreciated role-based access, dashboards, and centralized data access. The training programs and pilot testing played a major role in ease of adoption.

3.6 Visualization and Decision-Making

The use of project dashboards allowed for data-driven decisions. Task assignment, milestone tracking, and risk analysis were visualized through interactive KPIs and Gantt charts.

3.7 Stakeholder Reflections

- "Design changes are now traceable and transparent." — Senior Design Engineer
- "I can monitor BOM status from my mobile device." — Production Manager
- "Dashboards helped us track overdue tasks at a glance." — Project Head

3.8 Limitations of Implementation

- Initial resistance to new workflows slowed adoption.
- Integration with external ERP modules was partially manual.
- Some modules (e.g., DELMIA) were underutilized during the pilot.

3.9 Summary

The results from the AutoNova implementation demonstrate the potential of PLM to improve operational efficiency, traceability, and stakeholder satisfaction. While challenges remain, the observed metrics support continued rollout and refinement.

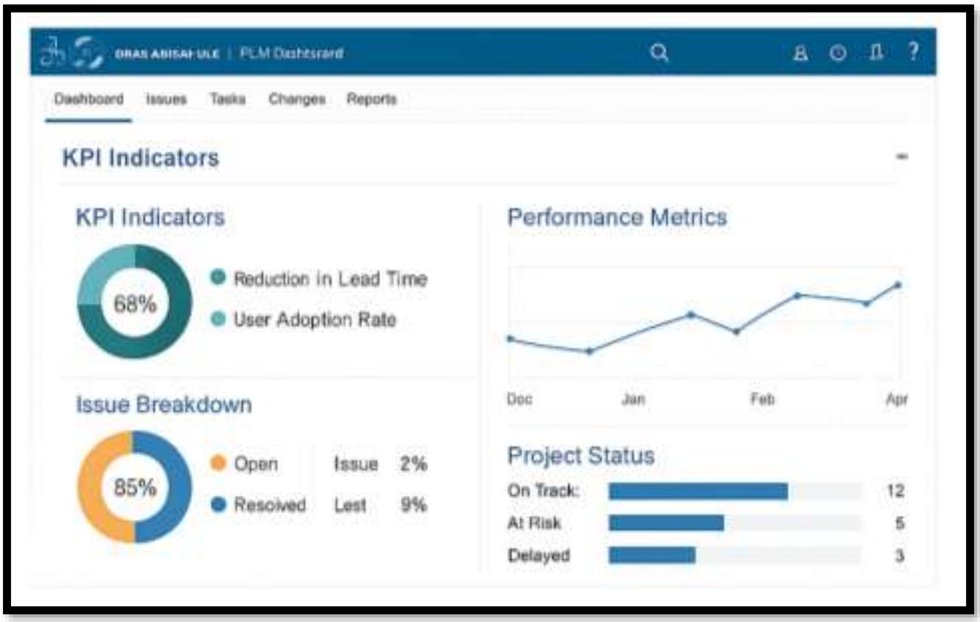

Figure 3.2: Real-Time KPI Dashboard in 3DEXPERIENCE

Figure 3.3: Comparative KPI Metrics Before and After PLM Implementation

4. Conclusion:

This chapter summarizes the findings of the dissertation and provides conclusion for project report.

The research demonstrates that the implementation of a Product Lifecycle Management system, specifically the 3DEXPERIENCE platform, can significantly enhance operational efficiency, data integrity, and interdisciplinary collaboration in automobile manufacturing.

Considering that local industry, particularly the Small and Medium Size Enterprises (SME) do not have their internal processes structured, it is important to make special emphasis in the formalizing and structuring of these processes during the definition and implementation of PLM strategies. No PLM software can be effective if the company processes do not work properly and the protocols and procedures are well assimilated by the company employees. The proposed PLM implementation methodology includes a proper diagnosis and re engineering process which contributes to structure the company processes. However it is required to measure the results and quality of the processes in a long term. In local industry one of the main problems for PLM implementations is the lack of information and historical measured data, which compels to conduct a proper diagnosis process and further comparisons after the strategy is implemented. Due to that, and based in the experience gained through the industrial case study, it is recommended to conduct a longer indicator measurement before the implementation in order to be able to highlight effective results after the implementation and enabling feedback. Considering that local managers are usually skeptical to make high investing which does not bring short term results, it is important to be able to show concrete results after first stages. It allows assuring that they will not stop the process before it is concluded. Consequently, the process of defining priorities and dividing the objectives for a short, medium and long term is very important, and it allows presenting short-term results that ensure the continuity of the implementation. However it is, necessary once again, to have enough data to make comparisons. Although the strategy definition is very important, most of the implementation success lies in the monitoring process. Considering that the proposed methodology is focused in SME, a closer surveillance can be easily conducted. However, in order to make the implementation process even easier and more effective, the members of the company which are part of the implementation team can be in charge of part of the process, contributing to reduce the implementation costs. It is important to assure that at least one member of the implementation team is available in the company during the implementation in order to solve the questions and suggestions of the company’s people involved in the implementation and to provide fast reactions to the contingences that arise during the process. In the industrial case study the weekly measurement of indicators was suitable for improving the performance of the maintenance members in the suggested methodologies. In these cases it is also useful to customize the PLM platform in order to automate the indicator measuring process, making easier the monitoring process.

Key takeaways:

- The structured implementation approach minimized disruption.
- Cross-functional teams benefited from better access to centralized data.
- Systems Engineering provided a holistic view of the lifecycle process.

References:

[1] M. Grieves, *Product Lifecycle Management: Driving the Next Generation of Lean Thinking*, McGraw-Hill, 2006.

[2] J. Stark, *Product Lifecycle Management: 21st Century Paradigm for Product Realisation*, Springer, 2005.

[3] A. Sääksvuori and A. Immonen, *Product Lifecycle Management*, Springer, 2008.

[4] T. Van Wijk, L. Fischer, and S. Rachuri, "PLM in the Aerospace Industry," *International Journal of Product Lifecycle Management*, vol. 3, no. 1, pp. 25–39, 2009.

[5] C.-H. Lee, C.-Y. Lin, and Y.-D. Yen, "Development of a PLM framework to support customer-oriented product design," *Computers in Industry*, vol. 59, no. 2–3, pp. 154–165, 2008.

[6] A. Trappey and D. Hsiao, "A Framework for Collaborative Product Development Using PLM and Knowledge Management," *International Journal of Computer Integrated Manufacturing*, vol. 21, no. 5, pp. 411–424, 2008.

[7] D. Tang and L. Qian, "PLM system implementation strategy in automotive industry," *Proceedings of the IEEE International Conference on Automation and Logistics*, Qingdao, China, pp. 2737–2741, Sept. 2008.

[8] R. Anumba, C. Egbu, and P. Carrillo, "Knowledge Management in Construction," *Blackwell Publishing*, 2005. (Referring to "Over the Wall" concept originally in 1997.)

[9] R. Razmi, M. Sangari, and R. Ghodsypour, "Developing a practical framework for ERP readiness assessment using fuzzy analytic network process," *Advances in Engineering Software*, vol. 40, no. 11, pp. 1168–1178, 2009.

[10] G. Kovács and F. Paganelli, "A planning and management infrastructure for large, complex, distributed projects—beyond ERP and SCM," *Computers in Industry*, vol. 51, no. 2, pp. 165–183, 2003.

[11] A. Stringfellow, S. Teasdale, and W. Nie, "CRM: Profiting from Understanding Customer Needs," *Business Horizons*, vol. 47, no. 5, pp. 45–52, 2004.

[12] N. Srinivasan, *Handbook of Product Lifecycle Management*, Springer, 2008.

[13] CIMdata, *Product Lifecycle Management (PLM) Market Analysis Report*, CIMdata Inc., 2010.

[14] C.-Y. Chiang and A. Trappey, "Development of a product data management system using an object-oriented database," *International Journal of Computer Integrated Manufacturing*, vol. 20, no. 1, pp. 17–30, 2007.

[15] M. Muhammad, B. Katalinic, and G. Kurdy, "PLM solution for nuclear industry," *Annals of DAAAM & Proceedings*, vol. 20, no. 1, pp. 1105–1106, 2009.

[16] CIMdata Inc., *Lectra Fashion PLM and Industry Overview*, 2009.

[17] CIMdata Inc., *PLM Market and Strategy Report: Consumer Packaged Goods*, 2009c.

[18] CIMdata Inc., *Kalypso Vivo PLM White Paper*, 2009b.

[19] CIMdata Inc., *PLM in the Medical and Pharmaceutical Industry*, 2009a.

[20] M. Ni, X. Zhang, and Y. Chen, "A flexible product structure model for product family modeling in PLM," *International Journal of Computer Integrated Manufacturing*, vol. 21, no. 6, pp. 558–570, 2008.

[21] R. Sharma, "An integrated PLM solution supporting product development and innovation," *Proceedings of the International Conference on PLM*, pp. 145–151, 2005.

[22] X. Xiao, H. Ding, and Z. Gao, "PLM-based system model for supporting virtual product development," *Computers in Industry*, vol. 60, no. 2, pp. 104–115, 2009.

[23] H. Jun, D. Kiritsis, and P. Xirouchakis, "Research issues on closed-loop PLM," *Computers in Industry*, vol. 58, no. 8–9, pp. 855–868, 2007.

[24] Y. Kakehi, M. Matsumoto, and M. Sakao, "Designing a Curriculum for PLM Education," *Proceedings of the International Conference on Engineering Design (ICED)*, 2009.

[25] M. Alemanni, A. Vezzetti, and S. Terzi, "Benchmarking PLM maturity: An innovative approach based on AHP," *Computers in Industry*, vol. 59, no. 2–3, pp. 210–219, 2008.

[26] R. Kusiak, *Concurrent Engineering: Automation, Tools, and Techniques*, Wiley, 1993.

[27] R. Capuz, *Concurrent Engineering and Product Development*, Valencia Polytechnic Press, 1999.

[28] N. Hansen, D. Møller, and S. Steenstrup, "PLM coding strategies for efficient reuse of information," *International Journal of Product Development*, vol. 2, no. 4, pp. 375–392, 2005.

[29] Y. Haldin-Herrgård, "Difficulties in Diffusion of Tacit Knowledge in Organizations," *Journal of Intellectual Capital*, vol. 1, no. 4, pp. 357–365, 2000.

[30] J. Davis and E. Brabänder, "Business Process Management: A Practitioner's Perspective," *Business Process Management Journal*, vol. 13, no. 5, pp. 672–688, 2007.

[31] M. Grieves and J. Vickers, "Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems," in Transdisciplinary Perspectives on Complex Systems, Springer, 2017, pp. 85–113.

[32] B. Stark, D. Fischer, and R. Stark, "Managing Variants in the Automotive Industry Using PLM Systems," Procedia CIRP, vol. 60, pp. 362–367, 2017.

[33] P. Dutta and R. Roy, "An Integrated Framework for Application of PLM in Manufacturing SMEs," International Journal of Production Research, vol. 58, no. 6, pp. 1752–1770, 2020.

[34] S. Terzi, A. Bouras, D. Dutta, M. Garetti, and D. Kiritsis, "Product Lifecycle Management – From Its History to Its New Role," International Journal of Product Lifecycle Management, vol. 4, no. 4, pp. 360–389, 2010.

[35] R. Garetti and M. Taisch, "Product Lifecycle Management for Sustainability," IFIP Advances in Information and Communication Technology, vol. 388, pp. 263–270, 2012.

[36] C. Gzara and A. Boukadi, "PLM Adoption: A Case Study of the Automotive Industry," in 2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), pp. 1675–1679.

[37] L. Rouibah and A. Al-Hassan, "E-collaboration and PLM Implementation: Drivers and Challenges," Computers in Industry, vol. 65, no. 4, pp. 646–657, 2014.

[38] J. Stark, Product Lifecycle Management: 21st Century Paradigm for Product Realisation, 3rd ed. Springer, 2015.

[39] A. Ball, R. Greenwell, and K. McMahon, "Managing Engineering Knowledge with PLM Systems," Journal of Intelligent Manufacturing, vol. 23, no. 6, pp. 2653–2666, 2012.

[40] D. Kiritsis, "Closed-Loop PLM for Intelligent Products in the Era of the Internet of Things," Computer-Aided Design, vol. 43, no. 5, pp. 479–501, 2011.

Nomenclature:

Term	Description
PLM	Product Lifecycle Management – Managing product data from concept to disposal.
PDM	Product Data Management – Subsystem of PLM for managing product-related data.
BOM	Bill of Materials – Structured list of components and assemblies.
CAD	Computer-Aided Design – Software used for creating 2D/3D models.
ERP	Enterprise Resource Planning – Software for business process management.
MES	Manufacturing Execution System – Controls and monitors production on the floor.
SCM	Supply Chain Management – Coordination of material, information, and finances.
CRM	Customer Relationship Management – Managing company interactions with customers.
3DEXPERIENCE	A platform by Dassault Systèmes offering integrated PLM tools.
ENOVIA	Module for data and lifecycle management within 3DEXPERIENCE.
CATIA	Module for 3D design and product modeling.
DELMIA	Module for manufacturing simulation and digital production planning.
AutoNova Ltd.	Case study company for PLM implementation.
KPI	Key Performance Indicator – Metrics used to evaluate success.
RBAC	Role-Based Access Control – Permissions based on user roles.
Digital Twin	A virtual model of a physical product used for real-time simulation and monitoring.
Change Request	Formal proposal for an alteration to a product or process.
Workflow	Sequence of processes through which a piece of work passes from initiation to completion.
Version Control	Tracking changes and revisions in digital files or datasets.