Use of Product Lifecycle Management in Preparation for Simulation of Logistic Processes

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Abstract. This article deals with the use of Product Lifecycle Management (PLM) in the preparation of logistics process simulation. PLM is a comprehensive information system that provides management and tracking of the product lifecycle from the conceptual phase to disposal. Logistics process simulation is a tool that allows to analyze and optimize the course of logistics operations without the risk of real interventions. In this abstract, we present an example of the use of PLM in the preparation of a simulation of logistics processes in a manufacturing environment. We demonstrate how PLM allows us to model different logistics scenarios, optimize inventory, minimize time and financial costs, and increase overall supply chain efficiency. The combination of PLM and logistics process simulation opens the way to improving supply chain management and increasing business competitiveness through more accurate and efficient logistics solutions. This abstract discusses the benefits and potential of this combination and suggests further avenues for research and implementation in practice.

The paper highlights the synergy between PLM and simulation technologies, illustrating how PLM acts as a bridge between disparate data sources, ensuring a unified and accurate representation of the product and its associated logistics processes. With this integration, organizations can create realistic simulations that reflect the complexity of their supply chains, enabling them to identify potential bottlenecks, optimize resource allocation, and increase overall operational resilience.

Keywords: PLM · simulation · warehouse

1 Introduction

In the ever-evolving landscape of global supply chains, the imperative to enhance efficiency and resilience in logistics processes has become paramount. This research paper delves into the strategic utilization of Product Lifecycle Management (PLM) during the preparatory phase of logistics simulation. By bridging the chasm between product design

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and supply chain management, our investigation aims to unearth the transformative potential of PLM in optimizing logistics operations.

Effective management of logistics processes is a critical pursuit for organizations navigating the dynamic terrain of modern supply chains. The quest for heightened efficiency, cost reduction, and risk mitigation underscores the significance of logistics process management. Our study delves into the strategic integration of PLM tools within the process simulation design phase, seeking a holistic understanding and optimization of logistics operations. Traditionally associated with product design and development, PLM now extends its reach to the broader realm of supply chain management. We explore the application of PLM methodologies in the context of logistics simulation, emphasizing data consolidation, standardization, and collaborative practices across the supply chain.

Furthermore, our research investigates the impact of simulation-driven PLM on decision-making processes within logistics. By harnessing PLM's capacity to provide a comprehensive view of product information, organizations can make informed choices regarding inventory management, demand forecasting, and order fulfillment. The outcome is a more agile and responsive supply chain, adept at adapting to shifting market dynamics and unforeseen disruptions.

In the industrial environment, the convergence of PLM and logistics simulation promises to revolutionise supply chain practices. Our inquiry seeks to unravel the intricate interplay between these domains, shedding light on novel strategies that enhance operational efficiency and resilience. As we delve deeper, we anticipate uncovering insights that propel logistics management into a new era of effectiveness and adaptability.

Recent advancements in digital technologies, such as data warehousing and SAP systems, have revolutionized the way shop floors, warehouses, and logistics organizations operate, moving away from static, paper-based processes [1, 2]. However, the dynamic nature of modern supply chains demands a more agile approach to decision-making, particularly regarding ongoing and future logistics operations. This is where the transformative power of PLM-driven simulation comes into play.

Digital transformation serves as a key driver of Industry 4.0, fostering the development of digitalized, networked, and intelligent supply chains and logistics systems [3]. By integrating PLM with simulation technologies, organizations can leverage a holistic view of product information, enabling informed decisions on inventory management, demand forecasting, and order fulfillment. This ultimately leads to a more agile and responsive supply chain, capable of adapting to ever-changing market demands and unforeseen disruptions.

The use of PLM as an integrated information system also allows you to manage and track all stages of the product life cycle - from the initial conceptualisation phase to the disposal phase. The ability to effectively integrate data and processes from different functional areas of the enterprise makes it an ideal tool for modelling and analysing logistics processes.

Simulation of logistics processes is important tool that allows companies to analyse and optimise their logistics operations. It helps to identify bottle-necks in the supply chain and predict their impact on overall performance and costs. In this way, it provides businesses with the opportunity to experiment with different scenarios and decisions without the risk of real interventions [4].

In this paper, we will explore the advantages and benefits of using PLM in the preparation of logistics process simulation. We identify the main areas where PLM can provide value in logistics management and how it can improve the overall efficiency of the supply chain. We will then discuss examples of specific applications and case studies that illustrate the successes and benefits associated with this combination of technologies. Finally, we will focus on opportuni-ties for further research and development in this area and the potential challenges that need to be overcome in implementing these solutions in practice.

2 Methodology

To establish a solid foundation for this research, an extensive review of the existing literature about Product Lifecycle Management (PLM) and logistics simulation was conducted. Key concepts such as the strategic integration of PLM in logistics, resilience, and sustainability in global supply chains were explored. Drawing from recent advancements in PLM technologies and their applications in logistics, the theoretical framework was formulated. This framework serves as the guiding structure for understanding the transformative potential of PLM in optimizing logistics processes.

Modelling logistics processes in PLM has several key advantages, namely modelling individual processes and real-time monitoring with feedback [5].

Process Modeling

PLM facilitates the definition and documentation of logistic processes. This includes the flow of materials, transportation routes, warehouse operations, and other key elements of the supply chain. This detailed modeling process forms the basis for subsequent simulation activities [6].

Real-Time Monitoring and Feedback

PLM systems, when integrated with real-time data sources, enable continuous monitoring of logistic processes. This facilitates ongoing feedback loops and supports a culture of continuous improvement. Organizations can adjust their logistic strategies in response to changing conditions, emerging trends, or new data.

The simulation of logistic processes within a PLM framework offers a comprehensive and data-driven approach to supply chain optimization [7]. This integrated strategy, combining product lifecycle considerations with logistical simulations, empowers organizations to navigate the complexities of modern supply chains with greater efficiency, resilience, and adaptability.

The model in Fig. 1 outlines a four-stage, data-driven methodology for optimizing logistics processes. The initial stage involves a comprehensive diagnostic assessment of existing operations, employing tools like process mapping and performance metric analysis to identify areas for improvement. Subsequently, predictive modeling and simulation techniques are leveraged to evaluate various potential solutions and their impact on key performance indicators (KPIs) [8]. Based on the simulated outcomes, an optimized process flow optimization algorithm generates a tailored process list. Finally, the implementation and post-deployment monitoring phase involves meticulously rolling out the optimized processes while continuously collecting data to measure the actual performance changes and ensure alignment with initial goals. By adopting this systematic and data-driven approach, organizations can achieve statistically significant improvements in their logistics efficiency and effectiveness.

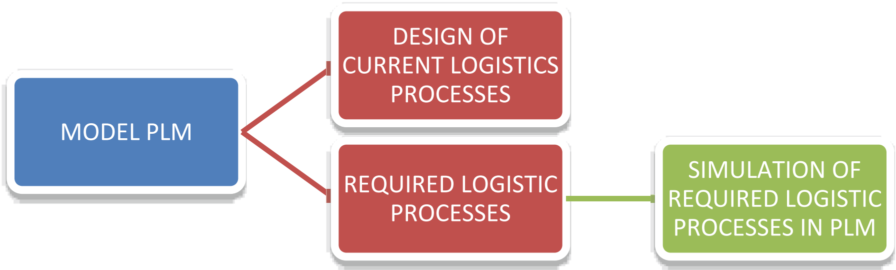

Fig. 1. Model PLM which shows diagram of current and required logistic processes.

Designing a representation of the current logistics process involves stages and steps involved in the movement of goods from the manufacturer to the end customer. The stages involve using PLM capabilities to define and document logistics processes in complex cases. This involves modelling the flow of materials, transport routes, warehouse operations, and other important elements in the supply chain. The accuracy achieved at this stage of modelling provides a solid foundation for further modelling activities [9].

As shown in Fig. 2a, in the first phase it is necessary to prepare a graphic design of the current logistics processes in the direction of the selected warehouse. The simpler these processes are outlined, the easier it will be to update them afterwards.

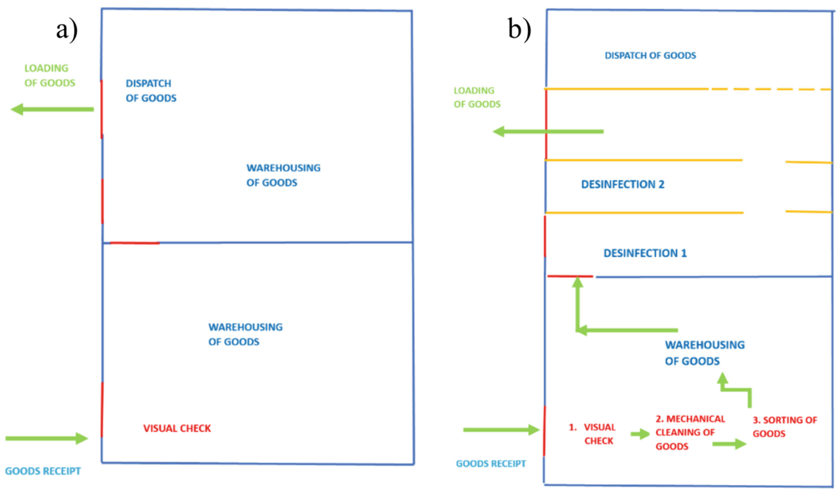

Fig. 2. Initial design of logistics processes (a) and advanced design of logistics projects (b).

In the next phase, as shown in Fig. 2b, the required logistics processes are proposed for updating the warehouse layout following longer-term studies, management meetings, investment plans or reorganisation schemes.

3 Improved PLM Design Using Technomatix Plant Simulation

To optimize Product Lifecycle Management processes, companies often resort to using simulation tools such as Technomatix Plant Simulation to improve the management of their logistics operations. Technomatix Plant Simulation is known for its ability to model and simulate various aspects of production, from planning to manufacturing, allowing businesses to identify potential problems and design more efficient solutions.

Technomatix Plant Simulation, a software solution offered by Siemens Digital Industries Software, is an advanced tool in the field of product lifecycle management design. The software enables the modelling, visualisation and analysis of complex production systems. Using simulation algorithms and user-friendly interfaces, Technomatix Plant Simulation provides a platform for optimising production processes, increasing resource efficiency, and reducing time to market. This chapter discusses the many opportunities that come with integrating Technomatix Plant Simulation into your PLM design framework [10, 11].

In the context of PLM, Technomatix provides businesses with the means to better integrate and visualize their logistics processes. By allowing different scenarios to be simulated and tested in a virtual environment, businesses can anticipate and prevent potential problems before they arise in the real world. For example, in supply chain planning, businesses can use Technomatix to simulate delivery, warehousing and distribution, minimizing the time and financial costs associated with inefficient processes. It provides the means to better predict, plan and manage their processes, leading to improved overall performance and competitiveness [12].

One of the key benefits of using Technomatix Plant Simulation is ability to offer advanced visualisation and analysis capabilities. Through intuitive 3D modelling interfaces, engineers can create virtual representations of production systems, including production lines, workstations, and material flow paths. This visual representation allows for in-depth analysis of system behaviour, identifying bottlenecks and optimising workflow efficiency [13].

Figure 3 shows a simplified simulation model for transporting goods between warehouses. The route is divided into several stages, according to the type of journey, according to the type of charges and other variables.

Another significant feature is the seamless integration with PLM systems. By linking simulation models directly to the design and product development life cycle, engineers can perform virtual verification of production processes in the early stages of design. This integration ensures synchronisation between design specifications and production realities, thereby minimising costly rework and accelerating time to market. Recent research has demonstrated the effectiveness of integrating simulation tools such as Technomatix Plant Simulation with PLM systems to streamline product development workflows and optimise manufacturing strategies [14].

TPS offers powerful optimisation algorithms that allow engineers to fine-tune manufacturing processes to achieve maximum efficiency and productivity [15]. Through

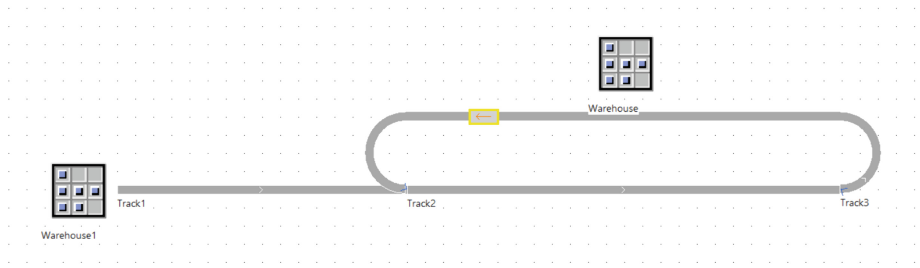

Fig. 3. Simulation of tracking the movement of goods between warehouses.

iterative simulation experiments, engineers can explore different scenarios, evaluate alternative production strategies, and determine optimal configurations. This capability enables organisations to reduce production costs, improve resource utilisation, and improve overall performance.

Extensive use of the software contributes to a culture of continuous improvement in manufacturing organisations. By providing a platform for continuous performance monitoring and analysis, engineers can identify opportunities for process improvement and innovation [16]. This iterative approach to simulation-driven design facilitates a dynamic feedback loop where insights gained from virtual experiments inform improvements to real-world processes.

Despite its many benefits, using Technomatix Plant Simulation in PLM design is not without its limitations. One of the most significant limitations is the difficulty of accurately modelling real production systems. While TPS offers advanced modelling capabilities, capturing all the nuances and subtleties of complex manufacturing environments can be challenging [17]. In addition, the accuracy of the simulation results is highly dependent on the quality and completeness of the input data and assumptions. Inaccuracies or oversimplification of modelling parameters can lead to discrepancies between modelled results and actual production performance. In addition, the computational resources required to perform detailed modelling of large-scale manufacturing systems can be significant, potentially limiting the scalability of simulation-based PLM design approaches. Addressing these limitations requires ongoing research and development aimed at improving modelling accuracy, data integration and computational efficiency within PLM development [18].

4 Simulation Model of PLM

The setup of the simulation model must be based on actual data, which must be collected to assess the current logistics simulation environment and identify problems in data integration and accuracy. Subsequently, the capabilities of PLM tools in consolidating, standardizing, and managing product data for simulation purposes need to be explored.

A simulation model can be used for several purposes, including predicting the time and costs associated with product development, optimising processes, identifying potential risks and inefficiencies, and planning resources and capacity.

The next steps assess the impact of PLM-driven simulation on decision-making processes within logistics, and overall examine how PLM integration enhances the adaptability and resilience of logistics processes.

The Fig. 4 shows a simulated situation of tracking the movement of goods a warehouse to another warehouse, the route is divided into several stages, according to the type of journey, according to the type of charges and other variables.

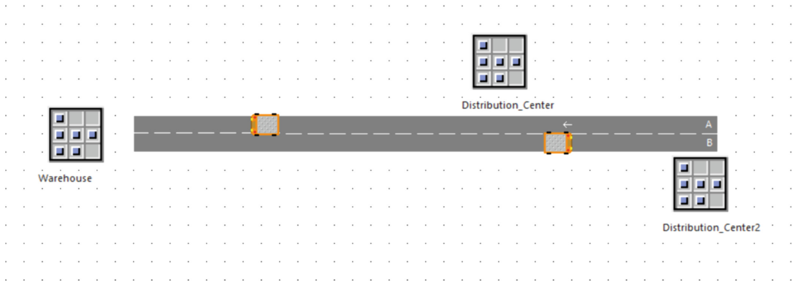

Fig. 4. Simulated situation the movement of goods between distribution centers.

Within the logistics processes, it is necessary to set up a simulation of the logistics processes at the level of the distribution centers, including the warehouse, in the software (Fig. 5).

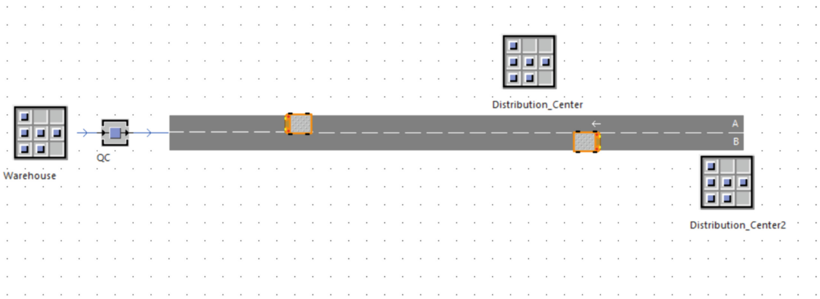

Fig. 5. Simulation updated about quality check control.

It is important to prevent complaints when transporting goods between the warehouse and the distribution centers, so a quality check has been added before the goods leave our warehouse (Fig. 6).

When receiving goods, it is important to set up several checkpoints. There are three important phases when taking delivery of goods:

1. Visual inspection - visually check how the goods are packed, whether the packaging material is not broken or damaged, if there are any shortcomings, the goods will not be accepted at all into the warehouse.

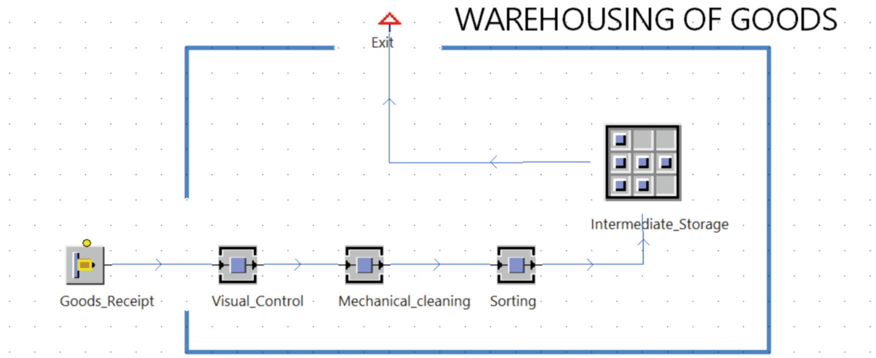

Fig. 6. Warehouse receiving processes.

2. Mechanical cleaning - in case of fine contamination, e.g. dust or other particles, the goods will be mechanically cleaned to prevent contamination of our warehouse and it is also a preliminary preparation before the disinfection process.
3. Sorting of goods - according to the type of goods, type of assortment and packaging, the goods are sorted for more efficient storage and preparation for the disinfection process.

After passing these checkpoints, the initial storage of the goods takes place, from where they are gradually transferred to the disinfection zones of our warehouse (Fig. 7a).

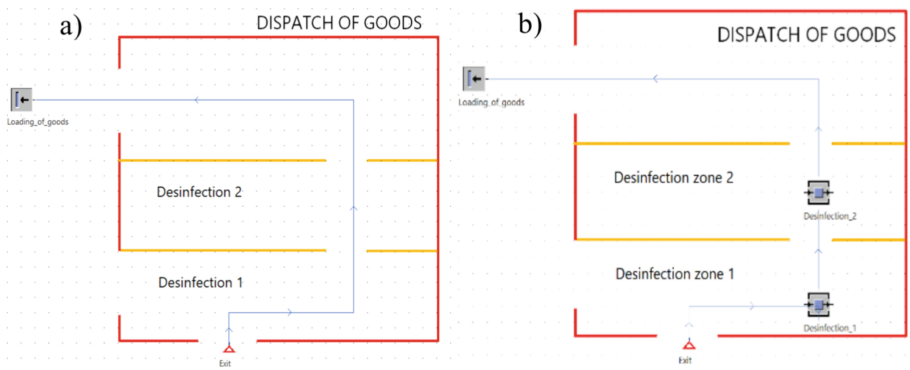

Fig. 7. Warehouse dispatch of goods area without (a) and with the setting up of disinfection stations (b).

The whole part of the goods dispatch has been partitioned to create zones in which the disinfection processes take place and in the last part there is space for short-term storage before the goods are loaded or the goods are loaded directly into the logistics process (Fig. 7b).

The warehouse part of the goods dispatch is made up of two zones. The first is a zone for disinfection of goods, for example with dry mist. The second zone is a zone for disinfection of goods, for example by spraying disinfectant.

Depending on the classification of the goods in the first part of the warehouse, the goods pass through either both, only the first, or only the second part of the disinfection zone. The goods are then ready to be loaded directly for transfer, but-or they can be stored for a short time near the dispatch gate (Fig. 8).

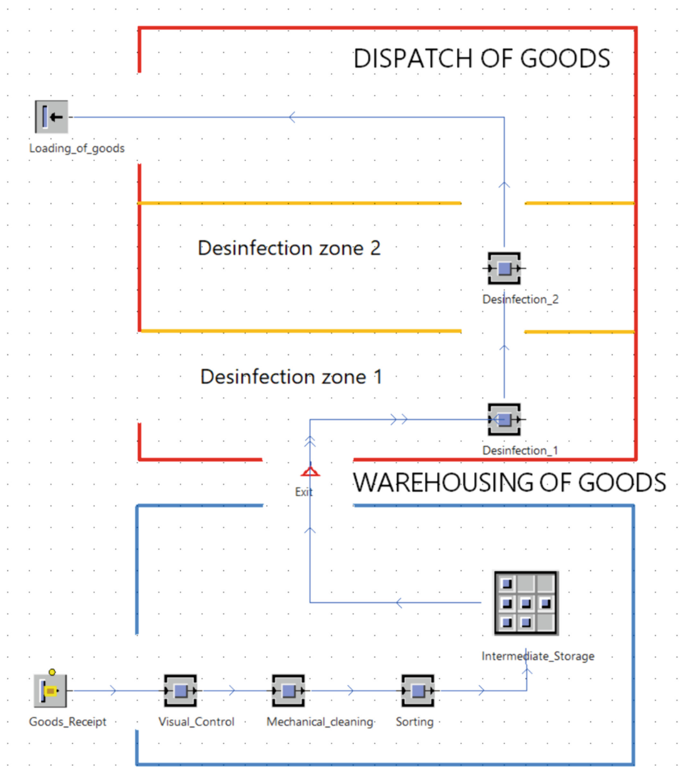

Fig. 8. Warehouse with all applicated checking points and disinfection zones.

The PLM program also simulates the overall logistics of the goods after setting up all the glassworks and distribution centers. Which has a great impact on the consistent planning of processes, cars, drivers, and the transfer of goods. It is possible to add additional stops, such as gas stations or car parks.

In Fig. 9 we can see the 2D layout of the warehouse with the applied checkpoints in the goods receiving zone, transitioning to the dispatching part of the warehouse. The disinfection zones with disinfection processes are clearly marked, these areas have a variable partitioning of the steins, allowing them to be expanded or contracted according to the types of goods and a smoother dispatch process to the actual process of loading the goods for the next transfer.

In practice, a PLM simulation model can help companies in the decision-making process regarding investments in new products, production technologies or logistics strategies. It also allows businesses to experiment with different scenarios and decisions

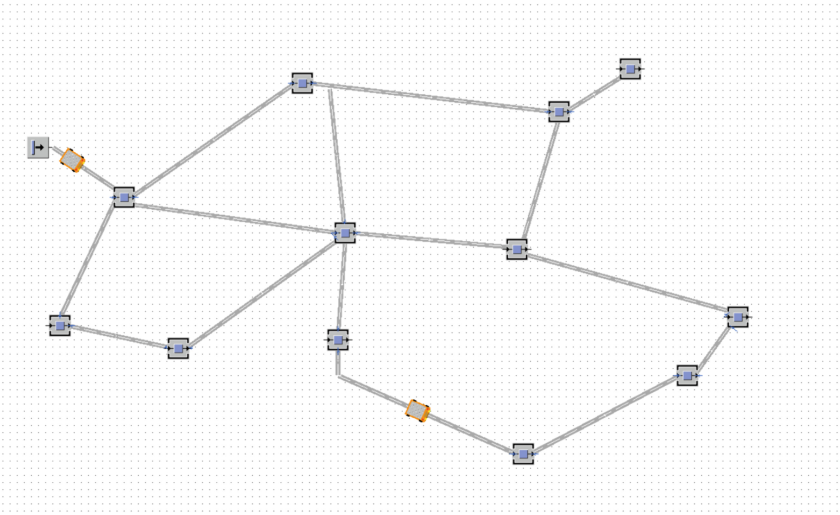

Fig. 9. Simulation of logistics routes of goods.

without the risk of real-world interventions and gives them the space to test new ideas and innovations.

5 Conclusion

The convergence of Product Lifecycle Management (PLM) with simulation for logistic processes signifies a revolutionary advancement in supply chain optimization. PLM's systematic approach transcends conventional logistics by establishing a multifaceted framework that seamlessly integrates product design, manufacturing, and sustainability considerations into simulations. This holistic perspective fosters a collaborative environment, adaptability to evolving circumstances, proactive risk mitigation, performance optimization, and a commitment to sustainability – all essential for navigating the intricate complexities of the contemporary business landscape.

PLM-based simulations empower organizations to move beyond a singular focus on efficiency. By incorporating product design and manufacturing data, simulations can assess the logistical implications of product decisions early in the development cycle. This enables proactive adjustments to product features, materials, or packaging that can optimize logistics from the outset. Furthermore, integrating sustainability considerations ensures environmentally responsible practices are embedded within the supply chain. For example, simulations can identify opportunities to reduce packaging materials, optimize transportation routes for fuel efficiency, or leverage reusable components. This holistic approach fosters a more responsible and sustainable supply chain, aligning business practices with environmental goals.

The incorporation of risk analysis within the PLM framework elevates logistic simulations to a new level. By proactively identifying potential disruptions – such as material shortages, geopolitical instability, or natural disasters – organizations can assess their impact and develop mitigation strategies. This proactive approach strengthens the resilience of logistic processes, enabling organizations to prepare for and respond to unforeseen challenges with greater agility. Additionally, the integration of predictive analytics within the PLM environment allows organizations to anticipate future demand fluctuations and adjust their logistic strategies accordingly. This proactive approach minimizes disruptions and ensures a more responsive and resilient supply chain.

PLM's inherent focus on optimization transcends product development and translates to the realm of logistics. PLM-based simulations empower organizations to meticulously fine-tune transportation routes, warehouse layouts, and inventory management strategies. By simulating different scenarios with varied transportation costs, fuel efficiency data, and storage capacities, organizations can identify the most efficient combinations for their specific needs. This optimization extends to inventory management, where historical data and demand forecasts can inform optimal stock levels, minimizing the risk of stockouts or excess inventory that ties up capital.

In essence, PLM in logistics simulation represents a paradigm shift towards a more integrated and comprehensive approach to supply chain management. This synergy between product lifecycle considerations and logistical simulations equips organizations with the necessary tools to navigate the complexities of modern business environments with superior agility, precision, and a unwavering commitment to sustainability. Ultimately, this translates to enhanced operational efficiency, cost reduction, and a significant competitive advantage.

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