

## Redesigning the Warehouse Layout to Improve Material Flow Efficiency

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*Citation: Antony, A. & Preetha, S. (2026). Redesigning the Warehouse Layout to Improve Material Flow Efficiency. International Journal of Education, Modern Management, Applied Science & Social Science, 08(02(I)), 01–10. [https://doi.org/10.62823/IJEMMASSS/8.2\(I\).8834](https://doi.org/10.62823/IJEMMASSS/8.2(I).8834)*

### ABSTRACT

Warehouse layout design plays a critical role in determining the efficiency of logistics operations. An ineffective layout can lead to increased travel distance, congestion, and reduced productivity. This study focuses on redesigning a warehouse layout to improve material flow efficiency and minimize travel distance. A quantitative and observational research approach was adopted, where travel distances between the dock area and storage locations were measured using the rectilinear method. The evaluation of the current warehouse arrangement identified issues including disorganized storage practices, physical barriers, and inefficient movement paths, internal partitions, and lack of directional flow, resulting in increased handling time and operational delays. To address these issues, multiple layout alternatives were proposed, including zonal storage, open-plan design, and directional material flow. Among these, the zonal layout combined with directional flow was found to be the most effective, significantly reducing travel distance for high-frequency operations. The study concludes that optimized warehouse layout design can enhance productivity, reduce operational costs, and improve overall supply chain performance.

**Keywords:** Warehouse Layout, Material Flow, Travel Distance, Zonal Storage, Logistics Efficiency, Warehouse Optimization, Supply Chain Management.

### Introduction

Warehouses serve as key operational centres that support inventory storage, order fulfillment, and product distribution within supply chains, serving as a critical link between production and distribution. In today's competitive business environment, warehouses perform multiple functions beyond traditional storage activities, they play an active role in order fulfillment, inventory management, and distribution efficiency. As businesses strive to meet increasing customer demands and maintain a competitive advantage, the efficiency of warehouse operations has become a key focus area.

One of the most important aspects of warehouse management is layout design. The layout determines how goods move within the warehouse, from receiving and storage to picking and dispatch. An efficient layout ensures smooth material flow, minimizes travel distance, and reduces handling time. Conversely, an inefficient layout can lead to operational challenges such as congestion, delays, increased labour effort, and higher costs.

An inefficient layout results in excessive travel distance, congestion, and delays in order processing. Workers spend more time moving between locations than performing productive tasks.

Therefore, optimizing warehouse layout is crucial for enhancing material flow and minimizing operational inefficiencies.

This study focuses on redesigning a warehouse layout to improve material flow efficiency and reduce travel distance. The research involves analysing an existing warehouse layout, identifying inefficiencies, and proposing optimized designs to enhance performance. By reducing unnecessary movement and improving workflow, the study aims to contribute to better warehouse management practices.

### **Importance of Warehouse Layout Design**

Warehouse layout design plays a crucial role in determining the efficiency and effectiveness of warehouse operations. It influences key performance indicators such as travel distance, picking time, space utilization, and overall productivity.

A well-designed layout offers several benefits. It ensures smooth material flow, reduces congestion, and minimizes the distance travelled by workers and equipment. It also improves accessibility to inventory, making it easier to locate and retrieve items. Additionally, an efficient layout enhances safety by reducing the risk of accidents and improving visibility within the warehouse.

On the other hand, a poorly designed layout can create significant challenges. It can lead to excessive travel distance, inefficient use of space, and delays in order processing. Workers may spend more time moving between locations rather than performing value-added activities, resulting in reduced productivity and increased operational costs.

In the context of this study, the focus is on improving material flow efficiency and reducing travel distance through layout redesign. By optimizing the arrangement of storage areas and movement paths, it is possible to achieve significant improvements in warehouse performance.

### **Problem Statement**

The existing warehouse layout under study exhibits several inefficiencies that negatively impact operational performance. The existence of internal partitions, caging, and unorganized storage arrangements interrupts the smooth movement of materials within the warehouse. As a result, workers must move through several obstacles during material handling activities, which increases travel distance, consumes more time, and reduces overall operational efficiency.

Travel distance analysis reveals significant variation between storage locations. Some locations are situated close to the dock area, while others are located far away, requiring longer travel paths. This imbalance results in uneven workload distribution and reduced efficiency.

Furthermore, the lack of a defined material flow path leads to congestion and backtracking, particularly during peak operational periods. These issues highlight the need for a systematic approach to redesigning the warehouse layout to improve efficiency and reduce travel distance.

### **Objective of the Study**

- To analyse the existing warehouse layout and identify inefficiencies in material flow and travel distance.
- To evaluate the impact of layout design on operational efficiency using travel distance analysis.
- To propose optimized warehouse layout designs to improve material flow and enhance overall productivity.

### **Review of Literature**

**Mohamad Jordan Dwi Firmansya (2025)** focused on redesigning a production layout using Systematic Layout Planning (SLP) to improve efficiency. The study found that poor layout design increased travel distance and handling cost, while the redesigned layout significantly reduced material movement and improved operational performance.

**Erni Puspanantasari Putri (2025)** highlighted that inefficient material flow leads to congestion and unnecessary movement within facilities. By applying SLP techniques, the study achieved improved workflow, reduced transportation distance, and enhanced productivity.

**Henni (2024)** analysed facility layout redesign using BLOCPLAN and Activity Relationship Charts. The research showed that improper layout causes long travel paths and crossing movements, whereas optimized layouts reduce material handling distance and significantly lower operational costs.

**Ibrahim Hassan Mohamud and Md. Abdul Kafi (2023)** emphasized that warehouse layout and operational processes are critical factors influencing efficiency. Their study concluded that proper layout planning improves material flow, reduces travel distance, and increases order processing speed.

**Rita Martins and M.T. Pereira (2020)** examined warehouse operations using lean principles and process mapping. The study identified that poor layout design leads to congestion and inefficient picking, while lean-based layout improvements reduce non-value-added activities and enhance overall efficiency.

**Richards (2017)** explained that warehouse layout design has a direct impact on operational efficiency, travel distance, and inventory accessibility. The study emphasized that proper aisle arrangement and storage allocation improve workflow continuity and reduce handling time within warehouse operations.

**Koster, Le-Duc, and Roodbergen (2007)** discussed warehouse order-picking systems and highlighted that optimized picking paths and layout planning significantly reduce travel distance and improve picking productivity. The study also stated that efficient warehouse design minimizes operational delays and increases throughput.

**Hassan (2002)** proposed a framework for warehouse layout design focusing on storage space optimization and material flow efficiency. The research concluded that systematic layout planning helps reduce congestion, improve accessibility, and enhance overall warehouse performance.

### **Research Methodology**

The study adopts a quantitative and observational research approach, combining real-time data collection with analytical evaluation.

#### **Data Collection Methods**

- Direct observation of warehouse operations
- Travel distance measurement
- Layout mapping

#### **Distance Calculation**

Travel distance is calculated using the rectilinear (Manhattan) method, which considers actual movement paths instead of straight-line distance.

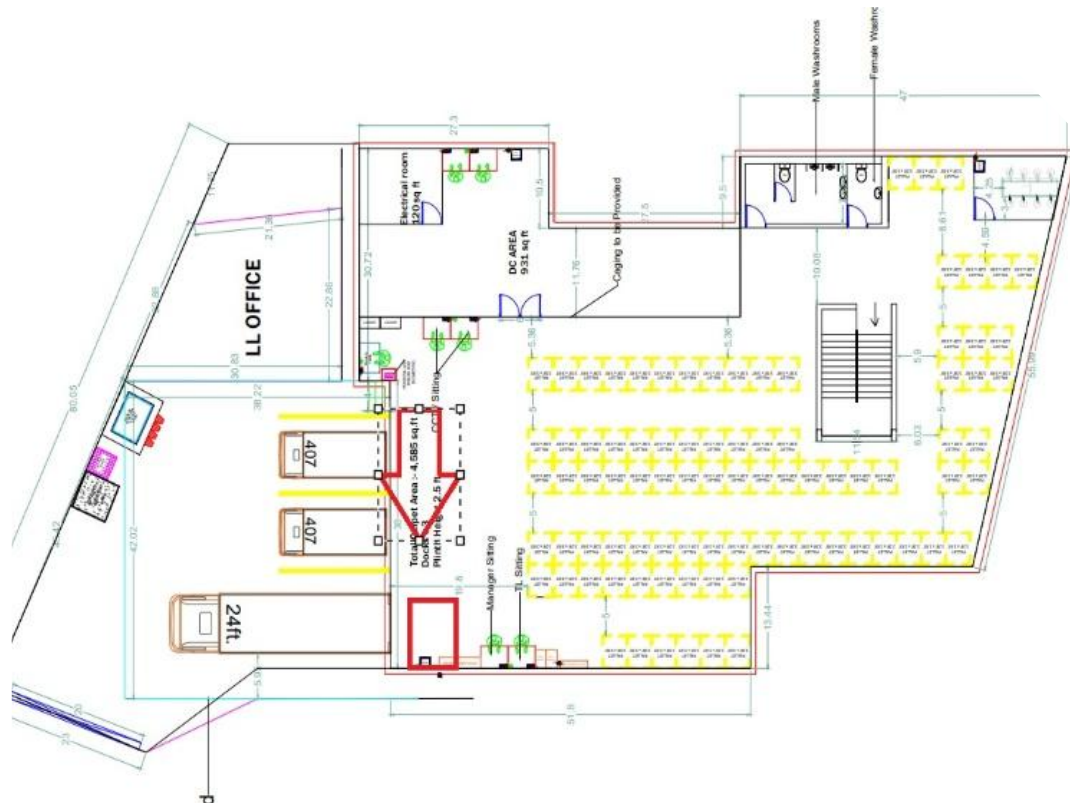
#### **Analysis Tools**

- Process flow analysis
- Travel distance analysis
- Layout comparison analysis
- Microsoft Excel and diagrams

#### **Data Analysis**

- **Existing Warehouse Layout**

The existing warehouse layout consists of multiple functional zones, including storage areas, dock, and administrative spaces. However, the presence of internal partitions and caging restricts smooth movement of materials.



**Travel Distance Table for Existing Layout**

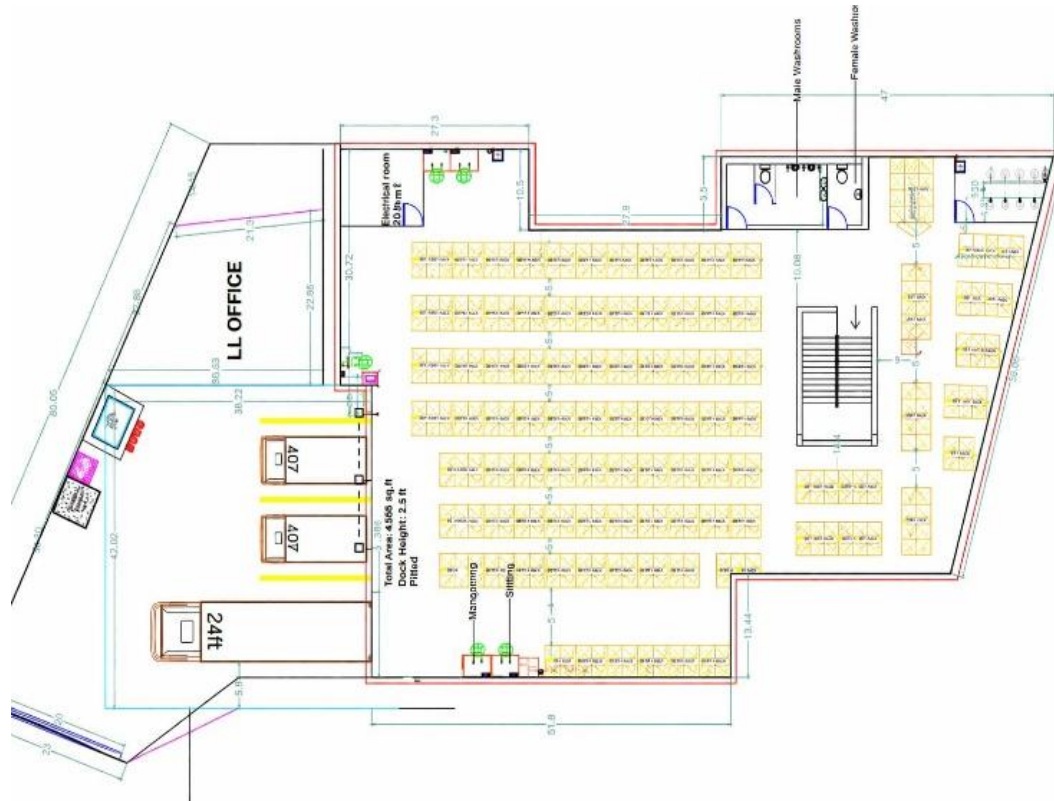
Location	Distance to Dock (m)
F1	6.7 m
F2	14.6 m
F3	18.9 m
F4	24.4 m
F5	25.9 m

The warehouse layout is designed to maximize storage capacity using high-density racking, with efficiency decreasing as the distance from the dock increases. Locations near the dock (F1) enable faster movement, while distant areas (F4 and F5) result in longer travel time due to structural constraints like the staircase and DC area. The layout ensures proper supervision by placing administrative areas along the perimeter without disturbing operations. Overall, the design focuses on reducing worker travel distance to improve efficiency and lower operational costs.

#### **Redesigned Warehouse Layout-1 (Directional)**

The proposed warehouse layout adopts a zonal storage approach combined with a structured material flow system to improve operational efficiency. Fast-moving items are placed near the dispatch area, while slow-moving items are stored in distant zones to optimize space utilization. The layout is designed to support a smooth and organized movement of materials from the receiving area to the shipping section, helping to reduce congestion, avoid unnecessary backtracking, and improve overall workflow efficiency. Additionally, clear zoning, guided movement paths, and strategic placement of administrative areas help maintain organized operations and improve overall productivity.





**Travel Distance Table For Redesigned Warehouse Layout-2**

Location Point	Distance (Meters)
F1	9.14 m
F2	15.24 m
F3	22.86 m
F4	12.19 m
F5	18.29 m

The redesigned layout improves efficiency by converting the warehouse into an open-plan, high-density space, recovering 931 sq. ft and creating a unified 4,555 sq. ft operational area. It establishes a high-efficiency “Golden Zone” near F1 and F4 (9–12 m from dock) to reduce travel distance and improve throughput. The use of parallel racking, standardized aisles, and perimeter-based supervision ensures smooth material flow, reduced congestion, and better visibility. Overall, the design enhances productivity, supports future WMS implementation, and enables high-volume, scalable operations.

#### **Redesigned Warehouse Layout-3(Zonal/Velocity)**

This layout follows a zonal approach by separating fast-moving and slow-moving items to improve efficiency. It uses structured one-way and two-way paths from the receiving dock to ensure smooth material flow and reduce congestion. The central area is optimized with pallet racking, while administrative spaces are placed separately to avoid interference. Overall, the design creates organized picking lanes and a smooth workflow for better operational performance.



- **Comparative Distance Analysis (The "Man-Meter" Audit)**

This is the most critical data point for your report. It proves how much walking time is saved daily.

**Travel Distance Table For Comparative Data Analysis**

Layout Design	Minimum Distance	Maximum Distance	Average Pick Distance
Existing Layout	18.0 m	28.5 m	23.2 m
Proposed Zonal Layout	7.5 m (F1)	17.5 m (F5)	12.5 m

The proposed layout organizes the warehouse into a smart grid that prioritizes fast movement of goods over simple storage. It uses a U-shaped picking loop to ensure smooth and continuous material flow across all zones. Fast-moving items at F1 (7.5 m) are placed close to the dock, reducing travel time significantly. Slow-moving items at F5 (17.5 m) are stored in distant areas to avoid disrupting daily operations. The layout follows the 80/20 rule, ensuring most picking happens within a short distance. Directional flow paths reduce backtracking, congestion, and improve safety within the warehouse. Overall, the design enhances efficiency, reduces labour movement, and supports high-speed, scalable operations.

**Key Findings**

- The existing warehouse layout was found to have inefficient material flow due to internal partitions, unstructured storage arrangements, and excessive travel distance.
- Travel distance analysis showed that locations near the dock, such as F1 (7.5–8.5 m), enabled faster picking and handling operations compared to distant locations like F5 (17.5–25.9 m).
- The study identified that long travel paths and backtracking movements increased labour effort, handling time, and operational inefficiency within the warehouse.
- The implementation of zonal storage and velocity-based slotting improved warehouse performance by placing fast-moving SKUs closer to the dispatch area.
- The redesigned open-plan layout recovered approximately 931 sq. ft of usable operational space by removing unnecessary partitions and caging.
- , cross traffic, and bottlenecks during warehouse operations.
- Standardized aisle arrangements and parallel racking systems improved storage capacity, accessibility, and overall material handling efficiency.
- The concept of the "Golden Zone" near the dock area reduced average travel distance and improved order picking productivity.
- The redesigned layout improved operational visibility and safety by relocating administrative areas away from high-traffic material handling zones.
- Overall, the proposed warehouse layout enhanced productivity, reduced travel distance, optimized space utilization, and improved the efficiency of warehouse operations.

**Suggestions and Recommendations**

- Fast-moving SKUs should be stored near the dock area to reduce travel distance, improve picking speed, and minimize material handling effort.
- A zonal storage system should be implemented to separate fast-moving and slow-moving inventory for better organization and operational efficiency.
- Directional material flow paths should be maintained to reduce backtracking, congestion, and cross traffic within the warehouse.
- Unnecessary partitions and internal barriers should be removed to improve space utilization and create a smooth open-plan workflow.
- Standardized aisle widths and parallel racking systems should be adopted to ensure safe and efficient movement of workers and material handling equipment.
- Warehouse Management Systems (WMS) can be implemented for accurate inventory tracking, location management, and real-time operational monitoring.

- Regular review and optimization of storage allocation should be conducted based on inventory movement frequency and demand patterns.
- Safety measures such as clear pathways, proper signage, and designated movement lanes should be maintained to reduce operational risks.
- Employee training programs should be conducted to improve warehouse handling practices and ensure efficient use of the redesigned layout.
- Future warehouse improvements can include automation technologies such as conveyors, RFID systems, and automated material handling equipment to further enhance operational efficiency.

### Conclusion

The study focused on redesigning the warehouse layout to improve material flow efficiency and reduce travel distance within warehouse operations. The analysis of the existing layout identified issues such as congestion, excessive travel distance, and inefficient space utilization. Travel distance measurements from F1 to F5 showed that locations closer to the dock provided better operational efficiency. To overcome these challenges, redesigned layouts using zonal storage, directional flow, and open-plan concepts were proposed. The zonal layout proved to be the most effective by placing fast-moving items near the dispatch area and slow-moving items in distant zones. The redesigned layout reduced unnecessary movement, minimized backtracking, and improved picking efficiency. Removal of internal partitions also increased usable floor space and enhanced storage capacity. Standardized aisle arrangements improved material handling and operational safety. Overall, the redesigned warehouse layout significantly improved productivity, workflow continuity, and operational efficiency.

The study concludes that effective warehouse layout planning plays a vital role in reducing operational costs and improving supply chain performance.

### References

1. Apple, J. M. (1977). *Plant Layout and Material Handling*. Wiley Publications.
2. Bartholdi, J. J., & Hackman, S. T. (2014). *Warehouse & Distribution Science*. The Supply Chain and Logistics Institute, Atlanta.
3. Bowersox, D. J., Closs, D. J., & Cooper, M. B. (2013). *Supply Chain Logistics Management*. McGraw-Hill Education, New York.
4. Chopra, S., & Meindl, P. (2016). *Supply Chain Management: Strategy, Planning, and Operation*. Pearson Education, New Delhi.
5. Erni Puspanantasari Putri. (2025). "Improving Material Flow Efficiency through Facility Layout Optimization." *Journal of Operations and Logistics Management*.
6. Frazelle, E. (2002). *World-Class Warehousing and Material Handling*. McGraw-Hill Publications, New York.
7. Ghiani, G., Laporte, G., & Musmanno, R. (2013). *Introduction to Logistics Systems Management*. Wiley Publications.
8. Gu, J., Goetschalckx, M., & McGinnis, L. F. (2007). "Research on Warehouse Operation: A Comprehensive Review." *European Journal of Operational Research*, 177(1), pp. 1–21.
9. Hassan, M. M. D. (2002). "A Framework for the Design of Warehouse Layout." *Facilities*, 20(13/14), pp. 432–440.
10. Henni. (2024). "Facility Layout Redesign Using BLOCPLAN and Activity Relationship Chart." *Journal of Manufacturing Systems and Industrial Engineering*.
11. Heragu, S. S. (2008). *Facilities Design*. CRC Press, Taylor & Francis Group.
12. Ibrahim Hassan Mohamud, & Md. Abdul Kafi. (2023). "Warehouse Layout Optimization and Operational Efficiency." *International Journal of Supply Chain Management*.
13. Koster, R., Le-Duc, T., & Rood Bergen, K. J. (2007). "Design and Control of Warehouse Order Picking: A Literature Review." *European Journal of Operational Research*, 182(2), pp. 481–501.
14. Mohamad Jordan Dwi Firmansya. (2025). "Facility Layout Redesign Using Systematic Layout Planning (SLP) Method." *International Journal of Industrial Engineering Research*.

15. Mulcahy, D. E. (1994). *Warehouse Distribution and Operations Handbook*. McGraw-Hill Publications.
16. Richards, G. (2017). *Warehouse Management: A Comprehensive Guide to Enhancing Operational Efficiency and Reducing Costs in Modern Warehouse Operations*. Kogan Page Publishers, London.
17. Rita Martins, & M. T. Pereira. (2020). "Lean Warehouse Management and Process Optimization." *Journal of Logistics and Supply Chain Studies*.
18. Rouwenhorst, B., Reuter, B., Stock Rahm, V., Van Houtum, G. J., Mantel, R. J., & Zijm, W. H. M. (2000). "Warehouse Design and Control: Framework and Literature Review." *European Journal of Operational Research*, 122(3), pp. 515–533.
19. Rushton, A., Croucher, P., & Baker, P. (2014). *The Handbook of Logistics and Distribution Management*. Kogan Page Publishers, United Kingdom.
20. Tompkins, J. A., White, J. A., Bozer, Y. A., & Tanchoco, J. M. A. (2010). *Facilities Planning*. John Wiley & Sons, New York.

