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OPTIMIZING STORAGE AND SPACE UTILIZATION FOR FIRST MILE OPERATIONS

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Abstract: The research is primarily focused on the effectiveness of storage and efficient use of space within first-mile (FM) delivery operations, which is a significant aspect of the logistics and supply chain industry, as well as a problem that needs to be addressed. With the increases in global trade and the amount of goods purchased through e-commerce, effective warehouse management is becoming more and more imperative to reduce operational costs while also improving order accuracy and delivery on time. The research observes the degree to which modern storage solutions, better layout design, and strategic storage solutions can improve the scale and efficiency of first-mile logistics.

The research starts with a discussion on the various responsibilities of the logistics sector, as well as the importance of warehousing in the first stages of delivery. Through site visits and structured questionnaires to warehouse and logistics professionals, the research uncovers many inefficiencies, including congested areas, inconsistent locations being allocated for inventory, and a lack of appropriate storage systems. The research examines the efficiency of a number of storage methods including: block stacking, the use of drive-in and selective pallet racking, the utilization of mezzanine floors, and automated storage systems to achieve the most efficient warehouse space possible.

The conclusion leads into a group of recommendations for implementing strategy changes to improve adequacy of space as well as implement vertical storage solutions, and also to optimize their racking systems based on type and volume of inventory. Overall, the investigation has illustrated that proper and planned storage use will maximize storage space and provide a way to improve its use.

Keywords: First-Mile Delivery, Warehouse Space Optimization, Storage Solutions, Logistics Efficiency, Inventory Management, Vertical Storage Systems, Cross Docking.

I. INTRODUCTION

The logistics and supply chain industry is essential to global trade and commerce because it is about the management of the movement of goods, services and information from the point of origin all the way to the end user. The components of logistics and supply chain are procurement and sourcing, transportation and distribution, warehousing and inventory management, order fulfilment and last-mile delivery, supply chain planning and forecasting, information and technology systems and customer service and relationship management. In this case to highlight this point, we will reference the components of logistics and the supply chain as a whole titled the warehousing and distribution centres, where the vital role is the temporary storage of shipments. In addition, an Integrated Fulfilment and Distribution Centre (IFDC) is a hybrid logistics facility that is used to support multiple supply chain operations, such as B2B, D2C, and middle-mile supply chain operations.

There are three stages of delivery - first mile, middle mile, and last mile. This research focuses on first mile delivery, which begins with the gathering of goods from the producers or manufacturers, another step to packaging, and then finally starts of the shipment. Once the shipment is collected from the vendor is will be stored in hubs until it moves to the main hub. Therefore, the goods can be stored notably using either block stacking and/or pallet racking, so the distribution centre is confronted with challenges associated with storage and low space utilization. Warehouse

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optimization is important to first mile operations, to allow for more efficient methods of storing, sorting, and dispatching goods. The use of good space efficiency, inventory management, and automation solutions can increase warehouse productivity, assist in reducing costs of operations, and reduce delays. With the rapid growth of e-commerce, globalization, and digital transformation it is essential to improve the storage system to improve the operation gaps.

This research assesses warehousing and storage practices in first-mile delivery operations in logistics and supply chain networks, pinpointing areas for inefficiencies in space utilization, storage methods, and inventory usage. It aims to focus on understanding the efficiency of storage, outline the relationship between storage optimization and performance, and present ways of increasing efficiency, operational productivity, and cost-effectiveness of modern logistics hubs.

II. STATEMENT OF THE PROBLEM

The First Mile (FM) logistics operations face fundamental problems in optimizing their warehouse areas or space due to limited storage capacity. Limited storage capacity results in congestion, wastefulness, inefficient use or space, and congestion in any possible storage use. Space utilization in FM logistics operations can fluctuate further because of uncertainty in shipment volumes. Uncertainty can lead to under-utilized storage usage with low shipment volumes due to low shipment volumes, or congestion and overcrowding with high shipment volumes. Also, with logistics operations scaling, existing storage solutions can often not scale to accommodate their ever-increasing shipment and administrative function demands long-term. Poor use of storage areas can also increase order sorting, packing, loading and dispatch times unnecessarily, and slow down the delivery speed and quality overall. Disordered storage and workspaces can not only be an overall lost shipment issue, but inconsistency from added processing times can possibly also lead to missed, delayed, or disrupted shipment deliveries of all possible variety and a disruption supply chain integrity. All of these are reasons why the objectives of this opening study are to investigate the existing storage practice and clearly identify the key space utilization metrics to establish a true on boarding value chain. The study will also indicate or explore the possible optimized data-centric solutions that can better optimize both warehouse operations and scalable and effective logistics operations when fully operational.

III. REVIEW OF LITERATURE

Felix M. Bergmann (2020): In this research, it was stated that integrating first-mile pickup and last-mile delivery operations can provide up to 30% gain in routing efficiency, but these gains are constrained by exogenous factors, for example vehicle capacities. This study argued that leveraging the strategic properties of urban e-commerce delivery logistics can, ultimately, reduce the costs and carbon emissions associated with transport.

Álvaro M. Majluf-Manzur & Rosa G. González-Ramirez (2021): This research, stated to assist, a hierarchical optimization model that would support first-mile logistics for small fresh-produce growers through coordinating their harvest and routing activities, thus reducing operational costs and cut down on food wastage.

Iván Giménez-Palacios (2022): In this research, it was stated that First-Mile logistics is a dynamic and complicated process relative to cargo features and disruption. Each episode of delivery and activity encompassed by First-Mile logistics requires alternative vehicle routing approaches and packing methods to successfully movement within a warehouse.

Sarah K. Schaumann (2023): This research said that time windows and vehicle capacities can interfere with routing efficiency and productivity when integration of first-mile and last-mile logistics is conducted. Therefore, time and vehicle constraints may limit the expected benefits of operation efficiency when operations of these two parts of last-mile delivery and despatch systems are necessarily integrated.

Tamás Bányai (2018): In this research, it was stated that Industry 4.0 innovations improve the efficiency of first and last-mile logistics through smart scheduling and introducing integrated delivery solutions using intelligent metaheuristics for optimization.

Elżbieta Macioszek (2017): The research evaluated in this section stated that the first and last mile aspects of the overall freight transport are the most expensive point of the freight transportation, which is impacted by fragmentation of the shipment induced by various destinations and the overall logistics efficiency of cyclists.

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IV. RESEARCH METHODOLOGY

This research will undertake a systematic evaluation of the storage and space utilization in first mile operations. It integrates survey material from the research project alongside the literature, which identifies challenges and opportunities for improvement.

RESEARCH DESIGN

A descriptive research design uses a systematic method for examining the current storage methods and space utilization of first mile operations. This is done without manipulating any variables. Primary (surveys and observations) and secondary data (organization reports and literature) provides actual data that is conducive to identifying current problems in efficiency, challenges with storage, and trends in space management. It offers the ability to determine the strength and weaknesses of current storage methods and recommends data driven suggestions in the warehousing process.

DATA COLLECTION METHOD

The study provides an analysis of both primary and secondary data to assess the storage practices and space utilization in first mile operations. Primary data collection involved a structured survey and observations focusing on the issues of warehouse space utilization/storage methods, the inventory management process, and worker productivity. Secondary data collection involved determining the current storage method and dimension, which identified trends in the utilization of space, capacity challenges in storage, and the layout and use of warehouses.

DATA ANALYSIS TOOLS

The data collected was then processed and analysed using SPSS (Statistical Package for the Social Sciences) software. Several statistical tools were used as follows:

- **Correlation analysis** is a statistical analytic tool to measure the strength and the direction of a relationship between two or more variables.
- **Regression analysis** is a statistical analytic tool to study the relationship of one dependent variable and one or more independent variables to make predictions about outcomes or to examine patterns.

V. SIGNIFICANCE OF THE STUDY

This study is significant because it addresses problems with space and storage optimization issues in first-mile operations. Proper management of warehouse space is fundamental for improving total logistics performance, while simultaneously decreasing operational costs and improving delivery time. The results of this study investigate current practices of operators, identify deficiencies, and provide data on why they need to take care of the deficiencies which lead to being more effective at space or storage improvements. This research will also help to collate leading practices in logistics and supply chain for managers like automations and new racking systems to ensure properly updated space and optimized area utilization, and to use advanced storage methods that improve the productivity of their warehouse. The results of the paper can be used by decision-makers who are searching to make data-driven change in their planning of storage and layout concepts and improved performance through better operational effectiveness and ultimately increased customer satisfaction.

FINDINGS

The current study shows that current storage method of block stacking and pallet storage reduced vertical space utilization and ultimately impacted overall storage efficiency. Manual stacking can create delays in retrieval due to reliance upon human labour, and a lack of dynamic, product slotting based on frequency of movement can also impact space utilization. The study also determined that outdated space-use guidance and limited data analysis means that there is often over stocking or lack of space during busy seasons. Most companies are still using outdated software tools, such as Microsoft Excel, or relying too heavily on WMS that is advanced, but business culture does not support the usage and development of effective inventory management. Spatial challenges presented as a result of overstocking and limited visibility of stored items result in blocked aisles that create added logistical challenges. Most distributions centres leverage technologies such as RFID, barcoding, etc., but can still improve with priority on accurate inventory tracking with future investment into technological systems and training. Unloading and receiving zones were also identified as congestion points that are being overloaded with overstocked items and poor unloading equipment within the designated areas.

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CORRELATION ANALYSIS

		Types of storage systems used	Warehouse space utilization rate
Types of storage systems used	Pearson Correlation	1	.345*
	Sig. (2-tailed)		.014
	N	50	50
Warehouse space utilization rate	Pearson Correlation	.345*	1
	Sig. (2-tailed)	.014	
	N	50	50
*. Correlation is significant at the 0.05 level (2-tailed).			

INFERENCE

The correlation analysis reveals a moderate positive relationship between the types of storage systems used and warehouse space utilization rate, with a Pearson correlation of 0.345 and a statistically significant p-value of 0.014. This suggests that more efficient or optimized storage systems contribute to better utilization of warehouse space. The findings imply that investing in advanced storage technologies, such as automated systems or high-density shelving, could lead to improved space efficiency, reducing costs and enhancing operational productivity. Therefore, selecting the right storage solutions is crucial for optimizing warehouse space and improving overall efficiency.

REGRESSION ANALYSIS

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.858	3	3.953	3.880	.015[b]
	Residual	46.862	46	1.019		
	Total	58.720	49			
a. Dependent Variable: Frequency of storage issues						
b. Predictors: (Constant), Size of warehouse facility, Type of WMS used, Years of experience in warehouse space management						

COEFFICIENTS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.769	.754		1.019	.313
	Years of experience in warehouse space management	-.334	.131	-.384	-2.543	.014
	Type of WMS used	.249	.223	.149	1.120	.269
	Size of warehouse facility	.636	.222	.435	2.869	.006
a. Dependent Variable: Frequency of storage issues						

INFERENCE

The regression analysis used to determine the impact of key operational variables on the frequency of storage issues in first-mile delivery warehouses yielded a statistically significant model (p = 0.015), indicating that the combination of

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staff experience, warehouse size, and WMS type predicts issue frequency. Significant predictors included warehouse size ($\beta = 0.435$, $p = 0.006$) and years of expertise ($\beta = -0.384$, $p = 0.014$). This implies that professionals with greater expertise are associated with fewer storage issues, but larger facilities report more frequent challenges. Although WMS type did not have a significant effect ($p = 0.269$), its positive coefficient suggests a possible benefit that could be realized with better implementation or a larger dataset.

VI. DISCUSSION

To maximize storage and space usage for first-mile logistics activities, several possibilities exist. The first is to install vertical racking systems, maximizing available ceiling height to increase storage capacity. The second option is to install mezzanine storage floors, which increases the available storage area within the same footprint. The implementation of cross-docking operations will reduce the storage time in a first-mile logistics centre. Goods arriving at inbound docks should be transferred directly to outbound docks to reduce storage time. In periods of heavy activity, BP vehicles could be utilized as temporary mobile storage to alleviate congestion. The existing layout of a first-mile logistics centre needs to be continuously examined and modified according to handling volume to avoid wasted space increase. A Warehouse Management System (WMS) will automate the allocation of space, and inventory control and will also minimize errors associated with human usage. Employee training in Early Standard Operating Procedures (SOPs) and space allocation will ensure measures and active best practices are adhered to. Real-time monitoring systems can provide vital information on shelf availability and the use of space to facilitate flexible planning of available space. Furthermore, cooperation with suppliers to maximize shipping container volume while reducing the size of deliverables or to standardize bags, will provide maximum stacking efforts and limit wasted space for expedient shipment utilization.

VII. CONCLUSION

In conclusion, increasing space in first-mile logistics operations within a warehouse can allow for more efficiency and eliminate unnecessary operating costs. Logistics companies can implement strategies using more vertical space with racking systems, always explore whether a mezzanine floor would enhance throughput, utilizing cross-docking appropriately, and/or maximizing real-time assessment of the warehouse operations. Logistics companies can optimize storage capacity by enhancing storage intelligence and workflow efficiency. Advanced technology, such as Warehouse Management Systems (WMS), automation tools and technologies, using digital twins of the current warehouse operations financed with similar technology will help reduce errors, collusion and delay. Utilization of the best practices and collaborative technique to disinfecting the warehouse of supplier's needs, investment, training and development programs that allow for joint problem solving can eliminate operational costs for all. The more the demand for logistics speed and efficiency will compound the requirement for the evaluation of the space utilized in first-mile processes with a view for adapting that space utilization and operational space as a core component to retain competitive advantage for essential logistics operations.

REFERENCES

[1]. F. M. Bergmann, "Integrating first-mile pickup and last-mile delivery on shared vehicle routes for efficient urban e-commerce distribution," J. Transp. Res. Part E: Logistics Transp. Rev., vol. 138, pp. 1-12, 2020.
[2]. Á. M. Majluf-Manzur and R. G. González-Ramirez, "An operational planning model to support first-mile logistics for small fresh-produce growers," Comput. Ind. Eng., vol. 157, no. 1, pp. 1-11, 2021.
[3]. Giménez-Palacios, "First-mile logistics and vehicle routing: A dynamic approach to handling cargo features and disruptions," Int. J. Adv. Manuf. Technol., vol. 122, no. 3, pp. 1321-1335, 2022.
[4]. S. K. Schaumann, "Route efficiency implications of time windows and vehicle capacities in first- and last-mile logistics," Transp. Res. Part E: Logistics Transp. Rev., vol. 149, pp. 153-166, 2023.
[5]. T. Bányai, "Smart scheduling: An integrated first mile and last mile supply approach," J. Intell. Manuf., vol. 29, no. 6, pp. 1457-1471, 2018.
[6]. E. Macioszek, "First and last mile delivery – Problems and issues," Logist. Transp. Res., vol. 17, no. 3, pp. 22-34, 2017.

