Strategies for Streamlining Last Mile Connectivity with Transportation Management Systems

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Abstract - This scholarly article delves into the importance and effective management of last-mile delivery in supply chain management. With growing consumer expectations for instant and reliable delivery services, strategizing and optimizing last-mile deliveries is of paramount significance. This research examines the utilization of Transportation Management Systems (TMS) as strategic tools to enhance last-mile connectivity, which is often the most challenging segment of the delivery process. Through an extensive literature review, coupled with use cases and interviews with industry professionals, this paper investigates the integration of TMS into existing logistical frameworks to address common challenges in last-mile delivery such as high costs, operational inefficiencies, and customer satisfaction demands. The paper also highlights advanced features of TMS including the use of Artificial Intelligence for route optimization, real-time tracking, event management, and embedded analytics to improve delivery efficiency at reduced cost and carbon footprint. We also explore significant barriers and unique challenges that organizations face in adopting TMS solutions including high investment costs, complex technological integration, and change management. The findings suggest that while TMS can significantly enhance the efficiency of last-mile delivery, careful consideration is required in their implementation to overcome associated challenges. This article aims to give stakeholders a deeper understanding of how strategic techniques can be effectively applied to reap the benefits of TMS to gain considerable advantage in a competitive marketplace.

Index Terms - Supply chain management, TMS, End to End (E2E), Digital Transformation, Route Optimization, Sustainability, Artificial Intelligence (AI).

1. INTRODUCTION

The efficiency of last-mile delivery has become a critical determinant of repeat business and success in today's hyper-paced, customer-centric marketplace. The term "last mile" refers to the final step in the delivery process where goods are transported from a distribution center to the end customer[1,2,7]. This stage, although the shortest in distance, is often the most complex and at times costly. The intricacies of last-mile delivery are attributed to a host of unknown and known parameters, including urban congestion, unpredictable traffic conditions, diverse delivery locations, and the increasing demand for quick and reliable service. For instance, in metropolitan areas like New York City, delivery trucks spend a significant amount of time navigating traffic and finding parking, leading to increased delivery times and costs and lost revenue.

To address these challenges, organizations typically resort to novel and innovative ways to deliver be it by leveraging Transportation Management Systems (TMS), delivery boys (bicycle, scooter, etc.) in congested areas (e.g. Uber eats, Door dash boys), or deploying a suite of boutique home-grown tools and software to stay ahead of the competition. TMS solutions integrate functionalities such as route optimization, real-time tracking, load planning, and predictive analytics to enhance the efficiency of logistics operations for organizations of varying sizes and scales (small medium, and large). For example, UPS has implemented advanced TMS to optimize delivery routes, resulting in reduced fuel consumption and operational costs. Similarly, Amazon's use of TMS enables the company to offer same-day and next-day delivery services for prime customers efficiently, meeting the high expectations of modern consumers [3,4].

Through a thorough deployment review of organizations' theoretical foundations and real-world implementations, this article aims to clarify the influence of various strategies. It approaches transportation logistics by examining their integration, features, business, and customer value in the overall supply chain. This study will also evaluate the possible developments in transportation management optimization and future research directions, including

the incorporation of cutting-edge technology like artificial intelligence and predictive analytics.

2. LITERATURE REVIEW

The complexities and challenges of last-mile delivery have been a hot topic of discussion with Chief Supply Chain Officers in boardrooms citing lost revenue, business opportunities, and declining customer satisfaction scores [5]. Researchers have identified that last-mile delivery accounts for a significant portion of total shipping costs, sometimes up to 53% [Gevaers, Van de Voorde, & Vanelslander, 2014] [12]. This high cost is attributed to inefficiencies arising from urban congestion, traffic unpredictability, and the need for multiple, low-volume deliveries across dispersed locations. Urban areas present unique logistical challenges due to factors such as restricted access zones, limited parking, and stringent delivery time windows, all of which exacerbate delivery inefficiencies and increase operational costs.

The surge in e-commerce has heightened consumer demand for faster and more reliable delivery services with many expecting deliveries in less than 4 hours, let alone on the same day. Hübner, Kuhn, and Wollenburg (2016) [13] emphasize that meeting these expectations is crucial for customer satisfaction and loyalty.

Studies by Coyle, Novack, Gibson, and Bardi (2016) [9] highlight the role of TMS in enhancing supply chain visibility, reducing operational costs, and improving delivery performance. Advanced features such as predictive analytics and automated decision-making enabled by AI and machine learning further enhance the capabilities of TMS, allowing for more efficient and responsive logistics operations [Mckinnon, Browne, Whiteing, & Piecyk, 2015].

Various frameworks such as the Supply Chain Operations Reference (SCOR) model [SCOR Model, 8] and the Total Cost of Ownership (TCO) framework provide structured approaches to evaluating the impact of TMS on last-mile connectivity. The SCOR model, endorsed by the Council of Supply Chain Management Professionals (2016) [8], outlines the processes, metrics, and best practices for optimizing supply chain performance, emphasizing the importance of integrating transportation management with broader supply chain and distribution strategies.

Overall, the literature underscores the potential of TMS to transform last-mile delivery by enhancing efficiency, reducing costs, and meeting customer expectations. However, it also highlights the need for strategic planning and investment to overcome the challenges associated with TMS implementation.

3. METHODOLOGY

This paper employs a combination of methods and approaches (interviews, literature review, discussions with logistics professionals, etc.) to demonstrate the impact of TMS and allied systems on last-mile efficiency. The qualitative interviews explore the practical experiences and insights of professionals using TMS, delving into specific strategies, success stories, and obstacles faced during implementation. Interview questions cover topics such as system integration, high-level cost of implementation, return on investment, and future trends in transportation management. Also, conducted a comprehensive review of existing academic articles, industry reports (Gartner, Forrester analysis) [2,6], and case studies related to last-mile delivery and TMS.

4. ROLE OF TMS IN LAST-MILE DELIVERY

TMS is critical in optimizing supply chain and logistics operations, particularly in the challenging last-mile delivery phase of the order cycle. TMS offers multiple strategic options to streamline and enhance delivery operations. Some of the key offerings are as under –

1) *Route Optimization* – Advanced TMS platforms leverage the power of Artificial Intelligence and sophisticated algorithms to determine optimal and efficient routes for delivery vehicles and carriers [14]. AI models are trained and optimized for unknown variables such as traffic conditions, road conditions, construction updates, carbon emissions, etc. AI generates fuel-efficient routes that facilitate drivers to meet or exceed delivery windows leading to satisfied customers.

2) *Real-time Tracking* – E2E visibility of the delivery process is of paramount importance for both customers and shippers. It enables dispatchers and logistics managers to plan for unexpected and potential delays on the fly thereby being proactive

(not reactive) to unforeseen events such as traffic jams or vehicle breakdowns. For instance, Amazon's TMS provides customers with real-time updates including map views to enhance transparency and customer satisfaction. Customers can track their packages in real-time and receive notifications on the phone about estimated delivery times thereby improving the overall delivery experience.

3) *Data-driven Decisions* – TMS leverages predictive and embedded analytics to enhance decision-making in last-mile delivery operations. With the help of AI models, TMS software analyzes historical data and current trends to suggest proactive recommendations to mitigate potential issues thereby improving the reliability of services. For instance, SAP Transportation Management has Fiori apps which shippers and providers can leverage for what-if simulations and planning the arrival of freight including packages.

4) *Sustainable practices* – Sustainability has been an important consideration for corporate boardrooms, businesses, and customers for the last few years. TMS helps companies meet their sustainability goals and comply with environmental regulations and protocols. For example, Coca-Cola European Partners [6,11] uses TMS (ERP systems) to optimize its delivery routes and reduce its carbon footprint. The company's TMS incorporates eco-friendly routing options and provides contracts to carriers with good track records on environment protection that prioritize fuel efficiency and minimize emissions, supporting Coca-Cola's commitment to sustainability.

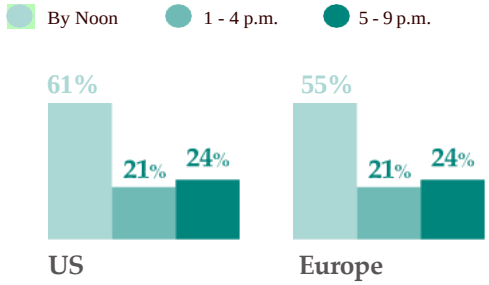
5) *Integration with 3rd party providers* – Integrating TMS with 3rd party service providers and other enterprise systems (such as Warehouse Management Systems (WMS), Enterprise Resource Planning (ERP) systems, and Customer Relationship Management (CRM) systems), organizations can exchange data seamlessly across different parts of the supply chain. This integration ensures orders are picked, packed, loaded, and shipped efficiently thereby reducing the scope for administrative or system delays and improving overall delivery performance.

6) *Innovations in TMS Domain* - Innovations such as drone delivery management, autonomous vehicle integration, and blockchain for transparency are being integrated into modern TMS platforms. These features offer exciting possibilities for future logistics, promising even greater efficiency and reliability. Multiple companies are deploying novel features and exploring drone deliveries to overcome urban congestion in densely populated areas.

The table below [15] illustrates the key role of TMS for leading firms with examples in last-mile delivery operations.

Role	Description	Examples 61%
Route Optimization	Utilizes algorithms to determine the most efficient delivery routes.	UPS reduced delivery miles by 100 million annually.
Real-Time Tracking and Visibility	Provides end-to-end visibility of the delivery process, including vehicle locations and delivery statuses.	Amazon offers real-time delivery status updates.
Managing Delivery Exceptions	Offers tools for real-time monitoring and quick resolution of delivery issues.	XPO Logistics' TMS handles delivery exceptions efficiently.
Scalability and Flexibility	Supports growth and adaptation to changing business needs.	E-commerce companies scaling delivery operations with TMS.
Novel Features and Innovations	Incorporates new technologies like drones and blockchain.	Wing's drone deliveries in urban areas.

According to UPS Pulse of the Online Shopper Global Study, 61% of the customers expect their orders to be received the same day in the USA and around 55% of European consumers want their orders to be delivered the same day if ordered by noon.



5. CHALLENGES IN LAST-MILE DELIVERY

As discussed in the sections above, last-mile delivery is one of the most complex and expensive segments of the supply chain and is fraught with inefficiencies and uncertainties despite sophisticated logistical operations by organizations such as AWS, UPS, and DHL. Some of the leading obstacles are as follows –

1) *Traffic Congestion for Urban Deliveries* – Navigating through densely populated cities with narrow lanes, metered parking, and multiple stops often leads to higher costs and slower delivery times. Companies such as DHL, and Uber Eats leverage bikes and electric vehicles to reduce operational costs.

2) *Failed Deliveries* – At times, customers are not able to receive their packages which frustrate customers despite redelivery attempts. Large firms such as Amazon have addressed this challenge by offering alternative delivery options such as Amazon Lockers for secure retrieval of packages. Other e-commerce and retailers are following suit, particularly in rural areas where deliveries are less dense and delivery networks are scarce, even today.

3) *Technological Integration* - Integrating various technologies for telematics, real-time tracking, event management, and communication tools with dispatchers often requires complex interfaces for seamless data transfer between 3rd party technology providers. Buying licenses and maintaining these systems for robust infrastructure and information sharing is expensive and is a hurdle for many corporations.

4) *Scalability for the Future* - As order volumes and customer base grow, the need for flexible and scalable delivery solutions becomes critical. Peak periods such as Thanksgiving (Black Friday), Prime Day, holidays, and festivals require organizations to plan their infrastructure for future growth and transactional volumes.

5) *Environmental Concerns* – There is increasing demand by regulators and activists for sustainable and greener logistics practices to ensure the planet is habitable and safe [18]. Last-mile delivery is closely intertwined with organizations' environmental policies to reduce carbon emissions and footprint by adopting innovative measures such as green fuels, and electric vehicles thereby adding to costs and additional infrastructure investments.

6. CASE STUDIES WITH OPERATIONAL BENEFITS

Annual reports, SEC filings, and multiple logistics journals were referred to identify and study two case studies from different verticals (Retail, Food & Beverage) to demonstrate the benefits of investing in last-mile technology solutions [10,19.20].

Case Study 1 (Walmart)

Walmart, one of the largest retail chains globally, has heavily invested around USD11B in 2021-22 in capital expenditures with a significant portion allocated to optimizing its last-mile delivery operations. As part of its strategy, Walmart has deployed various last-mile connectivity solutions, including partnering with third-party delivery services, acquiring firms such as Parcel for perishable goods, and leveraging advanced technology such as Transportation Management Systems (TMS). Walmart also partnered with DoorDash, and Deliv to expand its last-mile delivery options and to ensure scalability.

Some of the key benefits are as follows –

1) *Operational Efficiency*- Walmart's integration of advanced TMS and fulfillment centers has generally improved route efficiency by about 15-20% in logistics studies [Council of Supply Chain Management Professional Journal Report CSCMP].

2) *Cost Savings* - Industry reports suggest that companies like Walmart can achieve a 10-15% reduction in delivery costs through optimized routing and fleet management.

3) *Customer Satisfaction Score (CSAT)* – Customer satisfaction scores improved by 10% with reliable and timely deliveries [Walmart Annual Report]. Delivery-related complaints went down by 20% which led to repeat purchases of 15%.

4) *Return on Investment (ROI)* – Walmart's internal reports and benchmark studies by Industry journals highlight a return on investment within 18-24 months.

Case Study 1I (Domino's Pizza)

Domino's Pizza is one of the global leaders in pizza delivery and strives to ensure hot and fresh pizza reaches customers promptly.

1) *Operational Efficiency*- Domino's has reported up to a 25% improvement in delivery times using GPS tracking and real-time data analytics.

2) *Order Volumes* – Per Domino's site and operational reports, Domina order volumes had an uptick of 30% by leveraging in-house drivers and third-party services.

3) *Customer Satisfaction Score (CSAT)* – Brand loyalty and Customer satisfaction scores improved by 10% thereby leading to a marked increase in repeat orders.

4) *Return on Investment (ROI)* – The payback period for Domino's technological investments is typically less than 12 months per their annual statements and financial reports.

In essence, both these case studies underscore the significance of last-mile delivery optimization in enhancing overall supply chain performance and meeting consumer expectations. The experiences of Walmart and Domino's Pizza serve as valuable lessons for other businesses looking to improve their last-mile delivery capabilities.

7. FUTURE TRENDS AND INNOVATIONS

The future of last-mile delivery will be shaped by key emerging technologies and innovative trends to revolutionize the shipment and delivery of goods from warehouses to retailers to consumers' doorsteps. Some of the most promising and developing trends for the transportation and supply chain sector are as follows -

1) *Smart Lockers* - Amazon kickstarted this trend of smart lockers to mitigate and address failed delivery issues [10, 16,17]. Typically, these lockers are installed in convenient locations such as malls, transit hubs (for public transportation), apartment complexes, etc. Customers have the choice to pick up their packages from one of these lockers thereby reducing the need for multiple delivery attempts by parcel or courier agencies. Not only does this trend reduce or eliminate delivery failures but also integrates local businesses into digital commerce platforms for additional foot traffic and potential sales.

2) *Personalization* – With the advent and growing adoption of AI tools and foundational models, customers can personalize delivery options. For instance, trained AI models can analyze customers' preferences and history to tailor delivery windows, and delivery locations which helps create a "wow" factor and increases the likelihood of repeat business.

3) *Inventory Optimization* – Leveraging AI models and integrating them with TMS enables firms to keep track of stock in real time to replenish as needed. This helps reduce the potential for stockouts and backorders and abstains retailers from price gouging.

4) *Sustainable Options* - The push for sustainability has prompted many companies to deploy electric and hybrid vehicles to reduce their carbon footprint. Major logistics companies such as UPS,

DHL, and FedEx are investing in electric and fuel-efficient fleets. Startup ventures such as Rivian are developing electric vans for last-mile delivery [18].

5) *Blockchain Technology* - Blockchain technology has been around for quite some time but has not been deployed to its fullest potential. By leveraging track and trace and immutable records (shipped orders, departure, arrival times), third-party providers accountable for last-mile deliveries would lend more transparency to the order and delivery status.

6) *Hyperlocal fulfillment centers* – Local and strategically located warehouses would continue to grow with time. These centers enable swift deliveries due to reduced distance between products and destinations and help in increasing customer satisfaction scores [21,22].

7) *Smart Sensors* – The use of Internet of Things (IoT) devices such as smart sensors and radio frequency identification tags (RFID) continues to increase their usage for real-time tracking and enhanced visibility. This technology can help reduce lost or stolen packages and improve overall customer satisfaction. For deliveries involving perishable goods or sensitive items, IoT sensors can monitor environmental conditions such as temperature, humidity, and shock to ensure products are delivered in optimal condition.

8) *Autonomous vehicles and Drones* - One of the most talked-about innovations in the last-mile delivery and transportation sector is the use of drones. Companies like Amazon and Google have been testing drone delivery services, which can significantly reduce delivery times and costs, especially in rural or hard-to-reach areas. Regulatory challenges and technical limitations still need to be addressed, but the potential for faster, more flexible delivery options is substantial.

8. CONCLUSION

Last-mile delivery is an integral component of the supply chain and plays an instrumental role in improving the overall customer experience and operational efficiency of businesses. Optimization of the last-mile delivery is imperative for meeting customer demands for speed, reliable services, and efficient operations.

There is a multitude of challenges associated with last-mile delivery, however strategic deployment, and implementation of TMS solutions can effectively mitigate these challenges to stay ahead in ever ever-changing logistics landscape. Integration, adoption, and fine-tuning of Generative AI and machine learning algorithms augur well and promising for future technological enhancements. As companies continue to innovate and refine their logistics strategies, the ability to deliver products swiftly, safely, and reliably will remain a key determinant of customer satisfaction and business success.

In conclusion, last-mile delivery is not just about moving goods from point A to point B, but about creating a seamless, efficient, and satisfying customer journey that drives long-term loyalty and growth.

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