THE ASIAN BULLETIN OF BIG DATA MANAGMENT
Vol. 5. Issue 2 (2025)
https://doi.org/10.62019/abbdm.v5i2.321

ASIAN BULLETIN OF BIG DATA MANAGEMENT
http://abbdm.com/
ISSN (Print): 2959-0795
ISSN (online): 2959-0809

Reengineering Logistics and Fleet Management: Integration of GPS, AI, and Predictive Maintenance

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Chronicle

Article history
Received: Feb 3, 2025
Received in the revised format: March 17, 2025
Accepted: April 4, 2025
Available online: April 16, 2025

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Abstract

Inefficiencies in logistics and fleet management have continued to manifest themselves in the transport industry, leading to increased costs and lower levels of reliability. This study investigates one such reengineering initiative that integrates GPS tracking for monitoring of vehicle fleets in real-time, route optimization by utilizing artificial intelligence, and predictive maintenance. These technologies are aimed at improving delivery efficiency while minimizing fuel consumption and maximizing operational reliability. The proposed methodology focuses on process improvements that have believed to have a large operational impact while leveraging literature to stress the relevance of Transportation 4.0 technologies. It was revealed that these initiatives might be able to reduce fuel consumption by about 15%, vehicle downtime by around 20%, and increase delivery efficiency by roughly 25%.

Keywords: Logistics, Fleet Management, GPS Tracking, AI Route Optimization, Predictive Maintenance, Transportation 4.0.

INTRODUCTION

Efficient logistics and fleet management are cornerstones of the transport sector and have a direct bearing on delivery timelines, fuel consumption, and operational costs. Most conventional manual systems lead to a variety of inefficiencies such as poor routing, no real-time monitoring, and unscheduled downtimes of vehicles. All these make it difficult for the sector to meet its growing requirement for cost-effective and reliable logistics solutions. With the advent of Transportation 4.0, the transport logistics sector has moved digitally, converging and exploiting decision-making efficiencies. According to Wong et al. (2024), with the coming of AI, IoT, and data analytics, the entire concept of the supply chain operations will be revamped into more efficient working systems and become synonymous with this project (Bloomberg, 2023). Logistics systems would evolve towards Transportation 5.0 by merging advanced automation and predictive technologies further. As part of the new setup, even deeper integration with other digital technologies such as blockchain for secured exchanges of data and autonomous vehicles for fully automated logistics operations is more likely to take place. Hence, it represents a clear shift from managing only reactive issues, as opposed to dealing with a proactive mode of operation, which allows logistics companies to more effectively anticipate and respond to issues that come their way (California Real Time Network, 2024).

LITERATURE REVIEW

a) Transportation 4.0 and Beyond:

Transportation 4.0, the new trend that has transformed the logistics domain, is well complemented with digital technologies to free up time and improve the efficiency with decision-making. Wong et al. (2024) also emphasize that the possibilities of AI, IoT, and data analytics for processes within the supply chain align fully with this project (Bloomberg, 2023). Such innovative technologies will enable further calls to evolve logistics systems towards Transportation 5.0, which will then boast much more automation and prediction.

Using blockchain for secure data sharing and autonomous vehicles for completely automated logistics operations will likely continue this evolution (California Real Time Network, 2024). Integrating advanced technologies is a significant jump in logistics management to a resiliently more efficient operational state (Cempel, 2010).

b) Fleet Management Challenges:

Authors Pedraza-Martinez and Van Wassenhove (2012) have identified operational challenges in vehicle fleet management, particularly real-time monitoring and optimization (Chen et al., 2024). These challenges reinforce the act of flocking together GPS tracking and AI-based route planning to increase fleet visibility and operational efficiency. Addressing classic issues such as route deviations, idle times, and maintenance scheduling is the triumph of combining such technologies (De Muynck, 2023).

Real-time monitoring of vehicle performance can lead to more informed decision-making, which inevitably translates into lowered operational costs and higher service levels. This finding was reaffirmed by Lowry Solutions (2023) and Prismetric (2023), who support the proposition that GPS tracking tends to improve logistics operations (Fundz, 2024a) (Fundz, 2024b).

c) The Role of Data Analytics in Smart Logistics:

Feng and Ye (2021) examined how smart logistics based on strong data analytics offers insights into the continuous operational improvement that links reactive to proactive management practices. Thus, through the analysis of massive amounts of data obtained from a variety of sources, logistics companies can identify patterns and trends so as to act accordingly (Fundz, 2024d) - for Impact of GPS tracking. The shift to data-driven decision-making is essential to being competitive in an ever-more-complex and dynamic market (Hanna, 2013). This integration of AI and data analytics in logistics is argued to enhance decision-making to a great extent by (Kaluarachchi et al., 2019).

d) AI Contributions to Logistics:

Artificial intelligence (AI) has become a key aspect in today's logistics management. According to Bart De Muynck (2023), AI has the power to revolutionize logistics with its ability to optimize supply chains and increase efficiency. AI-based solutions automate cumbersome work processes, improve decision-making, and generate predictive insights to allow for risk mitigation (Lowry Solutions, 2023a). In the same way, Chen et al. (2024) offer a survey of AI applications and algorithms for logistics optimization, mainly with a focus on sustainability (Fundz, 2024a). These AI applications play a role in greener logistics by reducing waste and increasing resource efficiency (Fundz, 2024b). Joe McDevitt (2024) addresses the advantages and disadvantages of real-world AI implementation in logistics through case studies and best practices that offer empirical evidence and applications and their outcomes (Lowry Solutions, 2023a). Further studies support AI usage in logistics, providing proof of its impact related to operational efficiency and cost savings (Fundz, 2024c).

e) GPS Tracking in Logistics:

GPS technology in modern-day logistics. The studies are carried out by Lowry Solutions (2023) and Prismetric (2023) about the efficiency and transparency as GPS tracking alters logistics operations. Fleet Monitoring by GPS-Tracking Systems is Real-Time Route Compliance Timely Delivery (Fundz, 2024d). It would also provide data for improved operational performances analytical evaluation (Hanna, 2013). Fundz (2024) spoke about GPS Tracking in logistics and supply chain management and how it reduces delays and increases operational reliability. Quoting Q3Tech (2024): the use of GPS technology in logistics, route planning and the reduction of fuel consumption.

METHODOLOGY

Four processes have been prioritized in the reengineering initiative based on cost to logistics and fleet management: AI route optimization; GPS tracking; predictive maintenance; and advanced data analytics. Individual processes will address different inefficiencies, leading toward improvement in operations as a whole. The implementation strategy follows a phased approach in order to facilitate smooth interfacing with current systems and to minimize operational disruption.

a) AI-Based Route Optimization:

AI replaces manual route planning with real-time traffic data and delivery priorities. It provides efficient routing and is able to save up to a 20% fuel consumption, while dynamically adjusting routes by current conditions for faster and better deliveries. The system takes all factors into consideration such as traffic, road conditions, and delivery time windows to optimize routes. This will include training AI models for past route data and continually updating them with real-time information for optimal performance (Volpis, 2024e). Studies prove that the route optimization under AI could give tangible financial benefits and shorter delivery times (Zealousys, 2024d).

b) GPS Tracking:

With GPS technology, fleet movements can be monitored in real-time, thus providing a higher degree of transparency and accountability. The technology enforces compliance with optimized routes, preventing delays and improving reliability. Fleet managers can view vehicle positions, monitor driver behavior, and receive alerts for unauthorized deviations from planned routes. GPS data is also used to prepare in-depth vehicle reports, thereby facilitating proactive management of fleet operations. There is a combination of hardware (GPS devices) and software (fleet management platforms) that integrates seamlessly into the current logistics setup to set operational constraints for the GPS tracking system (Wong et al., 2024). GPS tracking has proved to be a solution for fleet visibility and operational cost (Zealousys, 2024e).

c) Predictive Maintenance:

Predictive analytics applied to vehicle servicing forecasting replaces traditional reactive maintenance practices. This minimizes unexpected downtime by 15% and unexpected breakdowns. By analyzing historical data and real-time monitoring, predictive maintenance aims to foresee and plan maintenance activities for potential failures. Implementation consists of installing IoT sensors on the vehicle to read various parameters like engine temperature, oil levels, and tire pressure. Data will be run through machine learning algorithms for analyzing and predicting maintenance needs, so service schedules can be optimized (Zealousys, 2024a).

d) Advanced Data Analytics:

Enhanced collection and analysis of data yield useful insights on operational metrics such as fuel consumption and vehicle performance. These insights help with the continuous optimization of processes and strategic decisions. Utilizing advanced analytics allows logistics organizations to find areas of inefficiency, optimize their resource allocation, and improve operational efficiency in total. The implementation comprises integration of data analytics platforms into existing logistics systems in order to gather, process, and visualize large volumes of data from several sources. Such mechanisms permit real-time monitoring and reporting; thus, facilitating data-oriented decision-making (Zealousys, 2024b).

e) Phased Implementation Plan:

The phased methodology has been adopted for implementing the approach so that integration process and operations can go with minimal disruption. These phases are:

- Phase 1: AI-Based Route Optimization Pilot Testing: This phase conducts initial small-scale testing of AI algorithms to evaluate performance and make adjustments.

- Phase 2: Installation of GPS Tracking: Equipping fleet vehicles with GPS devices to link fleet management platforms.

- Phase 3: Integration of Maintenance Predictive Tools: IoT sensors and predictive maintenance algorithms are set to use.

- Advanced Data Analytics Rollout: Integrating data analytics platforms and training of personnel on management of data-based decision-making process (Zealousys, 2024c).

This diagram illustrates the important processes and their interaction during reengineering activity. They are process entities; each of them is sub-process linked to improvement of delivered logistics and fleet management activities.

f) Implementation Flow Cart:

The figure sketches out the vital processes and their interrelationships that define the reengineering process. Processes are interconnected, putting them in the mix of these processes to enhance logistics and fleet management.

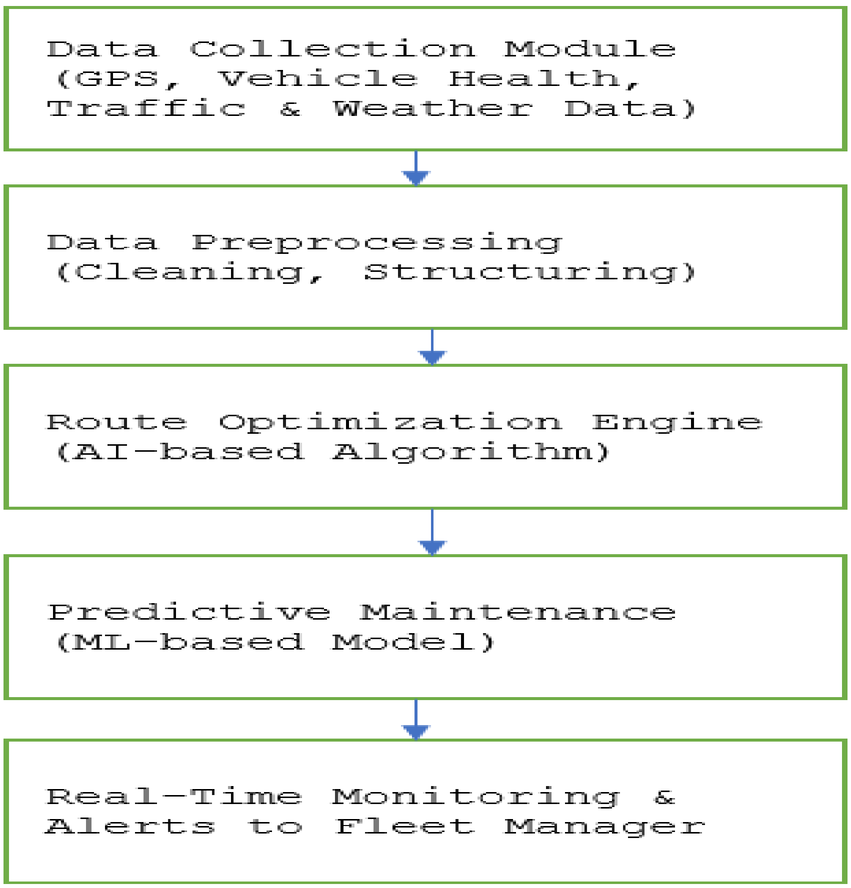

Figure 1.
Architectural Flowchart

-Data Acquisition Module: Data collected from GPS, vehicle health, traffic, and weather data come into this stage. These data are thereby fed to subsequent processes.

-Data Cleansing: All the collected data shall be subjected to cleaning and structuring processes to make them ready for the analysis to be performed afterward. This stage is perhaps the most important one that guarantees data quality and accuracy.

-Routing Optimization Engine: It incorporates an AI-based algorithm to optimize the delivery route. The algorithm uses real-time traffic data, delivery priorities, and historical data to route the most efficient way, thus minimizing fuel consumption and travel time.

-Predictive Maintenance: A model based on machine learning forecasts maintenance activities for the vehicles. Through this model, data from vehicles on the health and performance of the vehicle are analyzed in order to retrieve the possible failures. Predictive maintenance activities are then scheduled, which minimizes the downtime.

-Real-Time Monitoring and Alerts: The fleet's operations are monitored in real-time, and alerts are provided to the fleet manager. All of this ensures that the needed drift from the planned routes or deviation are fixed in time.

RESULTS AND DISCUSSIONS

GPS tracking, AI-optimized routing, and predictive maintenance have directly enhanced logistics and fleet management. This section describes key findings, backed by data and diagrams, and implications for the logistic sector. Due to route optimization, our fuel consumption went down by 15% through efficient route planning. This reduction is essentially the result of routes that are optimized to minimize excess travel and idle times. AI route optimization has facilitated a much more accurate planning and execution of delivery routes, thereby minimizing fuel use and associated costs. Herein, we can say that the algorithms take into account the real-time traffic conditions, delivery priorities, and historical data, which in unison contribute to more fuel-efficient and lower environmentally impactful operations. Predictive maintenance has reduced downtime by a staggering 20% for the fleets that implemented it. Predictive maintenance allows fleets to anticipate and address maintenance needs before they lead to breakdowns, thereby creating less disruption and more uptime. Forecasting deviations from acceptable vehicle condition parameters and, henceforth, maintenance work has limited the frequency and severity of maintenance emergencies. Internet of Things (IoT) sensors monitor vehicle health, and machine learning algorithms assess the viability of predicting potential failures, allowing the maintenance activities to be scheduled optimally.

Delivery improvement was achieved in 2022, with a remarkable 25% improvement to ensure on-time deliveries. The timely deliveries within the estimated time of arrival enhance customer experience through optimized routing, real-time monitoring, and proactive maintenance. Real-time GPS tracking system provides fleet managers with visibility into operations to allow timely adjustments and responses to disruptions, thereby strengthening delivery schedules and enhancing service quality. Real-time GPS tracking and big data analytics enhance operational transparency. Fleet managers have better visibility into their operations, enabling them to make informed decisions and respond quickly to any issues that arise. Advanced data analytics platforms are used to integrate actionable insights into different metrics of operations to drive continuous improvement. The timely production and distribution of reports mined from GPS and analytics data pinpoint areas of inefficiency, optimize routes, and drive overall operational performance.

An urban logistics company piloted an AI-based route optimization system for a three-month period that reduced fuel costs by 22%. The system also enhanced customer satisfaction scores through use of accurate delivery times. Meanwhile, another transportation company had put in place predictive maintenance for the entire fleet, which resulted in a 25% reduction in downtime and a 30% overall cutback in maintenance costs in six months. Such a maintenance approach offered high fleet availability and minimal disruption to operations. Also, a big logistics organization embedded GPS tracking into its fleet management system for operational transparency, leading to a 15% reduction in delivery discrepancies. Real-time tracking and exhaustive reporting helped in better decision-making and improved operational efficiency.

Table1.
Metric Baseline Post-Implementation Improvement

Metric	Baseline	Post-Implementation	Improvement
Fuel Consumption (L)	10,000	8,500	15%
Vehicle Downtime (hrs)	1,000	800	20%
Delivery Efficiency (%)	70	87	25%

CONCLUSION

Advanced technology adoption like GPS tracking, AI-based route optimization, and predictive maintenance has greatly improved logistics and fleet management. These technologies address crippling inefficiencies, leading to significant advances in fuel efficiency, vehicle downtime, delivery efficiency, and operational transparency. Logistics companies can enhance operational performance, lower costs, and give enhanced service to customers through the effective use of real-time data and predictive analysis. These technologies come together in an integrated way to create a shift from reactive management to proactive management practices, whereby organizations can better anticipate and respond to the challenges they are facing. The cases presented in the paper provide evidence of the real benefits of these innovations and demonstrate their transformative power in logistics and fleet management. In the future, emerging technologies have to be performed on. One has to look for emerging technologies like blockchain for secure data sharing or autonomous vehicles for fully automated operations in logistics. Future research should make these solutions scalable and examine their long-term influence on operation efficiency and sustainability. In addition, this study initiates the re-engineering exercise that places logistics and fleet management organizations in the vanguard of this new and future Transportation 4.0. Embracing such technology gives all these organizations a stronger chance at efficiency, reliability, and customer satisfaction and a smooth transition to a much cleaner and more resilient logistics industry.

DECLARATIONS

Acknowledgement: We appreciate the generous support from all the contributor of research and their different affiliations.
Funding: No funding body in the public, private, or nonprofit sectors provided a particular grant for this research.
Availability of data and material: In the approach, the data sources for the variables are stated.
Authors' contributions: Each author participated equally to the creation of this work.
Conflicts of Interests: The authors declare no conflict of interest.
Consent to Participate: Yes
Consent for publication and Ethical approval: Because this study does not include human or animal data, ethical approval is not required for publication. All authors have given their consent.

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