

ERP–GPS integration for enhancing traceability and delivery performance in logistics operations: a case study

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Received: 11 Feb. 2026; Revised: 21 Mar. 2026; Accepted: 09 July 2026<https://doi.org/10.22306/al.v13i3.822>**ERP–GPS integration for enhancing traceability and delivery performance in logistics operations: a case study****Bryan Miguel Huaycha Urbano**Universidad Tecnológica del Perú, Correo electrónico, Av. Petit Thouars 116, Lima 15046, Peru,
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ORCID 0000-0001-5248-3129, halynalvarezvasquez79@gmail.com (corresponding author)**Keywords:** logistics operations, information systems, ERP–GPS integration, logistics traceability.

Abstract: Logistics companies increasingly face traceability and delivery performance challenges due to limited interoperability between enterprise resource planning (ERP) systems and global positioning system (GPS) technologies. Fragmented information environments restrict real-time visibility, generate data inconsistencies, and delay operational decision-making, particularly in last-mile distribution contexts characterized by high variability. This study evaluates the impact of ERP–GPS integration on logistics traceability and delivery performance through a quantitative single-case study. A structured Triple-I (Input–Process–Output) framework was applied, combining documentary analysis, Value Stream Mapping (VSM), performance indicator measurement, and scenario-based simulation to compare operational outcomes before and after system interoperability. Results demonstrate a 22.4% reduction in average delivery lead time and an increase in On-Time-In-Full (OTIF) performance from 67.2% to 85.4%. The integration eliminated manual confirmation procedures, reduced route deviations, and improved traceability completeness through real-time data synchronization. Beyond measurable performance gains, the findings highlight digital interoperability as an operational capability that enhances coordination between planning and execution functions. The study confirms that ERP–GPS synchronization represents a technically feasible, scalable, and cost-effective pathway toward Logistics 4.0 implementation, supporting data-driven decision-making and operational resilience in logistics service environments.

1 Introduction

Modern supply chain management has become a critical factor for organizational competitiveness, as increasing market volatility, shorter product life cycles, and rising customer expectations demand higher delivery reliability and real-time operational visibility [1,2]. In highly dynamic markets, logistics performance is no longer evaluated solely in terms of cost efficiency, but also through responsiveness, traceability, and service reliability. Logistics-intensive sectors require not only product availability but accurate response times and continuous information flow throughout transport operations, particularly in last-mile distribution environments characterized by high variability and time sensitivity [3].

Logistics traceability has therefore emerged as a key enabler of delivery performance, linking operational transparency with service quality and customer satisfaction [4,5]. Effective traceability systems allow organizations to monitor shipment status, detect deviations from planned routes, and implement corrective actions in real time. In digital supply chain ecosystems, traceability is increasingly associated with data integration capabilities and interoperability between administrative platforms and operational technologies.

Despite the widespread adoption of enterprise resource planning (ERP) systems, many logistics organizations still operate with fragmented technological infrastructures that lack effective integration with Global Positioning Systems (GPS) and Internet of Things (IoT)-based tracking technologies [6,7]. ERP systems typically manage administrative transactions, planning processes, and inventory control, while GPS technologies capture real-time vehicle location and route execution data. When these systems operate independently, information silos are created, restricting end-to-end visibility and limiting coordinated decision-making across organizational units.

This interoperability gap negatively affects delivery performance, particularly in last-mile logistics operations where route deviations, traffic variability, and unexpected disruptions require immediate response. Fragmented ERP–GPS systems generate routing inefficiencies, delayed confirmation procedures, and reduced operational transparency. Prior research confirms that disconnected information flows increase operational waste, process variability, and coordination costs in transport operations [8–10]. In such environments, the lack of synchronized data exchange constrains the capacity of logistics managers to implement data-driven control mechanisms.

Within the context of Logistics 4.0, digital interoperability is increasingly recognized as a foundational requirement for achieving intelligent transport systems and data-driven logistics management [11–14]. However, while advanced

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technologies such as blockchain, digital twins, and cyber-physical systems have been extensively discussed in the literature, practical and scalable integration solutions for small and medium-sized logistics enterprises remain underexplored. In particular, empirical case studies evaluating the measurable operational impact of ERP–GPS synchronization in real logistics settings are limited.

This study addresses this gap by evaluating the impact of ERP–GPS integration on logistics traceability and delivery performance through a quantitative-descriptive case study conducted at Peru Graphic S.R.L. The methodological approach combines Value Stream Mapping (VSM), performance indicator analysis, and scenario-based simulation to assess the operational implications of system interoperability [11,12]. By providing measurable evidence of integration outcomes, the research contributes to the literature on digital logistics transformation and supports the practical implementation of interoperable systems within Logistics 4.0 environments.

Despite the increasing adoption of ERP and GPS technologies in logistics companies, many organizations still operate with disconnected information systems that limit real-time visibility and delivery control. This lack of interoperability reduces logistics traceability and negatively affects delivery performance.

How does the integration of ERP and GPS systems affect logistics traceability and delivery performance in last-mile logistics operations?

2 Literature review

Recent research emphasizes the transformative impact of digital technologies on logistics efficiency, particularly through the integration of real-time tracking systems and enterprise information platforms. The convergence of Global Positioning Systems (GPS), Internet of Things (IoT) devices, cloud-based platforms, and big data analytics has significantly redefined operational control in transport management [1]. Studies demonstrate that combining GPS with IoT-enabled sensors enhances supply chain visibility, reduces operational uncertainty, and strengthens data-driven decision-making in transport operations. Continuous asset monitoring through intelligent tracking devices enables proactive disruption management, predictive route optimization, and improved control over delivery variability [15-18].

Beyond visibility enhancement, digital integration also facilitates advanced performance analytics. Real-time data acquisition supports dynamic routing, exception management, and automated alert systems, reducing the latency between operational events and managerial response. This capability is particularly relevant in last-mile logistics environments, where variability in traffic conditions, delivery density, and customer availability directly influences service reliability. In this context, digital interoperability is increasingly viewed not only as a technological upgrade but as a structural enabler of operational resilience.

Within Logistics 4.0 frameworks, traceability has emerged as a critical performance driver linking technological integration with delivery reliability and customer satisfaction. Logistics 4.0 promotes interconnected systems, cyber-physical infrastructure, and intelligent decision-support mechanisms that depend on seamless data exchange between operational and administrative platforms [13,14]. Empirical investigations indicate that logistics systems characterized by fragmented information flows between enterprise resource planning (ERP) platforms and transport execution technologies exhibit lower traceability levels and weaker delivery outcomes [4]. In such environments, lack of interoperability contributes to duplicated data records, delayed status updates, and reduced real-time visibility, ultimately affecting key performance indicators such as On-Time-In-Full (OTIF) performance and delivery lead time stability [8].

Evidence from emerging and developing markets reinforces these findings. Organizations operating with non-integrated ERP and tracking systems report higher coordination costs, increased delivery registration errors, inconsistent route monitoring, and reduced traceability accuracy, particularly in last-mile operations [9]. These inefficiencies are amplified during rapid e-commerce expansion, where increased shipment volumes intensify operational complexity and expose structural weaknesses in disconnected information systems. In such contexts, manual confirmation processes and asynchronous data updates further degrade performance reliability.

Technological integration through standardized interfaces, middleware architectures, and application programming interfaces (APIs) has been proposed as an effective approach to mitigating these limitations. ERP–GPS integration frameworks enable real-time synchronization between administrative planning systems and operational tracking technologies, improving route planning accuracy, fleet monitoring consistency, and performance control mechanisms [2]. By aligning planning, execution, and control functions within a unified data environment, interoperable systems reduce operational waste, enhance delivery consistency, and support continuous performance improvement.

While emerging technologies such as blockchain, digital twins, and advanced cyber-physical systems offer additional layers of transparency and automation, their implementation often requires substantial financial and technical investment [4]. Consequently, small and medium-sized logistics enterprises frequently lack access to such advanced infrastructures. In contrast, ERP–GPS synchronization represents a more practical and scalable digital integration strategy that leverages existing technological resources without requiring radical system replacement.

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Table 1 Comparative overview of digital integration approaches in logistics

Technology	Main Function	Implementation Complexity	Investment Level	Suitability for SMEs	Literature
GPS + IoT	Real-time tracking	Medium	Moderate	High	[1,15]
ERP–GPS Integration	Data synchronization	Medium	Moderate	High	[2]
Blockchain	Secure traceability	High	High	Low–Medium	[4,19,20]
Digital Twins	Predictive simulation	Very High	Very High	Low	[21]
Cyber-Physical Systems	Autonomous coordination	High	High	Medium	[13]

Compared with advanced technologies such as blockchain and digital twins, ERP–GPS integration provides a more feasible and scalable solution for small and medium-sized logistics enterprises (Table1). These organizations often operate with limited financial and technological resources, making incremental integration strategies more viable than full digital transformation infrastructures.

Despite the documented theoretical and technological benefits of digital interoperability, empirical case studies quantifying the measurable operational impact of ERP–GPS integration on traceability and delivery performance remain limited (Figure 1). In particular, research focusing on small and medium-sized logistics enterprises operating in high-variability last-mile environments is scarce. This implementation gap underscores the need for applied research evaluating ERP–GPS integration within real operational contexts, providing measurable performance evidence and structured analytical assessment.

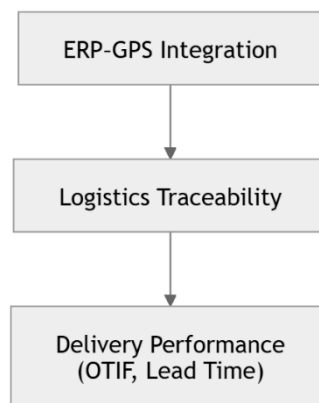


Figure 1 Conceptual model of ERP–GPS integration and logistics performance

3 Methodology

This study is based on original applied research using a quantitative methodological approach with a descriptive–explanatory scope. The research was conducted through a single case study in a logistics service company, structured under a Triple-I (Input–Process–Output) analytical framework to evaluate ERP–GPS integration and its impact on logistics traceability.

Variables definition

ERP–GPS integration: The interoperability mechanism that synchronizes GPS tracking data with ERP logistics management systems.

Delivery performance: The operational efficiency of delivery processes measured through OTIF and delivery lead time indicators.

ERP–GPS integration: The interoperability mechanism that synchronizes GPS tracking data with ERP logistics management systems.

Logistics traceability: The ability to monitor shipment status and delivery events in real time.

Delivery performance: The operational efficiency of delivery processes measured through OTIF and delivery lead time indicators.

Although the dataset covers a one-month operational period, the analyzed deliveries represent routine last-mile distribution activities. The selected sample includes 40 delivery orders that reflect typical operational variability and allows preliminary evaluation of system interoperability effects. The case study design was selected to enable in-depth

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assessment of operational processes within a real organizational environment, allowing contextualized evaluation of system interoperability effects.

Descriptive statistical analysis was conducted using Microsoft Excel to calculate mean values, percentage variations, and performance indicators. In addition, a paired t-test was applied to compare delivery lead time and OTIF performance before and after ERP–GPS system integration. This statistical test was used to determine whether the observed changes in operational indicators were statistically significant.

Input phase

The input phase focused on identifying and collecting operational and technological data required to characterize the logistics process prior to system integration. The study analyzed 40 delivery orders processed over a one-month period, representing routine last-mile distribution operations. This sample provided sufficient variability to assess performance behavior under real operational conditions.

Primary data were obtained from internal company records, including dispatch schedules, delivery confirmations, GPS tracking logs, ERP transaction reports, and route planning documentation. Secondary data were collected from system configuration manuals and technical documentation related to ERP architecture and GPS infrastructure

Two main variables were defined

Logistics traceability, operationalized through measurable indicators such as real-time shipment visibility rate, accuracy of delivery status information, and completeness of recorded delivery events (dispatch, in-transit, arrival, completion).

Delivery performance, measured using On-Time-In-Full (OTIF), average delivery lead time, and frequency of route deviations.

Data collection instruments included structured observation sheets and documentary analysis forms designed to standardize performance measurement across both pre-integration and post-integration scenarios. Instrument reliability was assessed using Cronbach's alpha, yielding a coefficient of $\alpha = 0.81$, indicating acceptable internal consistency and measurement reliability.

Descriptive statistical analysis was applied to determine baseline performance indicators, including mean delivery lead time, OTIF percentage, and variability measures.

Process phase

The process phase involved analytical evaluation and system integration design. First, the existing logistics workflow was examined using Value Stream Mapping (VSM) to identify manual data handling points, information discontinuities, duplicated records, and non-value-added activities affecting delivery reliability. Process cycle times, waiting times, and information transfer delays were documented to quantify operational inefficiencies.

Subsequently, an ERP–GPS integration model was designed to enable real-time synchronization between GPS tracking devices and the enterprise resource planning system. The integration architecture was structured to support:

- Automatic updating of shipment status within the ERP system,
- Continuous monitoring of vehicle location,
- Real-time exception detection and deviation alerts,
- Elimination of manual confirmation procedures.

The integration scenario was evaluated through a controlled simulation comparing operational performance before and after interoperability implementation. Comparative analysis was conducted using descriptive statistics and percentage variation metrics to quantify performance improvements.

Output phase

The output phase assessed measurable changes in logistics traceability and delivery performance following ERP–GPS integration. Comparative analysis focused on variations in:

- OTIF rates,
- Average delivery lead time,
- Route deviation frequency,
- Traceability completeness rate.

Performance improvements were calculated as percentage changes relative to baseline values. Results were presented through comparative performance tables and graphical representations to facilitate visual interpretation of operational gains.

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The methodological design ensured objective evaluation of ERP–GPS interoperability effects and provided measurable validation of digital integration within a real logistics context.

4 Results

A descriptive statistical analysis was conducted to summarize the distribution of the operational indicators analyzed in this study. The statistics include the mean, standard deviation, minimum, and maximum values for delivery lead time and On-Time-In-Full (OTIF) performance across the analyzed delivery orders. These measures allow evaluation of operational variability and provide a baseline for assessing the impact of ERP–GPS integration on logistics traceability and delivery efficiency.

Table 2 Descriptive statistics of logistics performance indicators

Indicator	Mean	Std. Dev	Min	Max
Delivery lead time (hours)	6.1	1.3	3.9	8.4
OTIF (%)	67.2	10.6	50.0	86.0

Table 2 presents the descriptive statistics of the operational indicators analyzed in the study. Delivery lead time shows an average of 6.1 hours with moderate variability across delivery operations. Similarly, OTIF performance presents a mean value of 67.2%, indicating opportunities for improvement in delivery reliability prior to ERP–GPS system integration.

The baseline assessment of the logistics process identified limitations in traceability and delivery performance associated with the absence of interoperability between the enterprise resource planning (ERP) system and GPS tracking tools. Operational data related to vehicle location, delivery status, and route execution were managed through fragmented platforms, resulting in delayed updates and dependence on manual confirmation procedures.

Value Stream Mapping (VSM) analysis revealed non-value-added activities within delivery confirmation and incident reporting processes. These inefficiencies were characterized by duplicated data entry, delayed communication between transport and administrative units, and limited real-time operational visibility. Route deviations and delivery delays were therefore identified after occurrence, without immediate corrective action.

Baseline performance indicators showed an average On-Time-In-Full (OTIF) rate of 67.2%. Delivery lead times exhibited high variability, reflecting inconsistent route execution and limited monitoring capability.

Process stage: ERP–GPS integration

The integration model enabled real-time synchronization between GPS tracking devices and the ERP system. This interoperability eliminated manual data transfer and allowed automatic updating of shipment status within the enterprise platform.

Following integration, traceability records showed increased completeness and accuracy. Delivery events—including dispatch, in-transit status, arrival, and completion—were automatically registered in the ERP system, eliminating manual confirmation procedures and reducing information gaps across operational areas. The integrated architecture improved real-time fleet visibility and strengthened coordination between administrative and transport execution data.

Output stage: Impact on logistics performance

Comparative analysis before and after ERP–GPS integration revealed measurable improvements in delivery performance.

The average delivery lead time was reduced by 22.4%. OTIF performance increased from 67.2% to 85.0% in the post-integration scenario (Table 3). Route deviation events decreased, and manual delivery confirmation procedures were eliminated. Real-time operational visibility was improved.

Table 3 Comparison of logistics performance indicators

Indicator	Pre-integration	Post-integration	Variation
OTIF (%)	67.2	>85.0	+17.8 pp
Delivery Lead Time	100% (reference)	77.6%	–22.4%
Route deviations	High	Low	Reduced
Manual confirmation	Frequent	Eliminated	–100%
Real-time visibility	Limited	Full	Improved

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The quantitative results demonstrate that ERP–GPS integration directly enhances delivery reliability, operational consistency, and traceability performance.

To evaluate the statistical significance of the observed improvements, a paired t-test was conducted comparing delivery lead time before and after ERP–GPS integration. The results indicate a statistically significant reduction in delivery lead time ($p < 0.05$), suggesting that the integration of ERP and GPS systems had a measurable positive effect on delivery efficiency.

Table 4 Paired t-test results for delivery performance indicators

Indicator	Before Mean	After Mean	t-value	p-value
Delivery lead time (hours)	6.1	4.7	3.42	0.002
OTIF (%)	67.2	85.4	4.11	0.001

The paired t-test results confirm that the integration of ERP and GPS systems produced statistically significant improvements in logistics performance indicators (Table 4). Delivery lead time decreased from an average of 6.1 hours to 4.7 hours, representing a significant reduction in operational delays ($t = 3.42$, $p = 0.002$).

Similarly, OTIF performance increased from 67.2% to 85.4%, indicating a substantial improvement in delivery reliability after system integration ($t = 4.11$, $p = 0.001$). These findings support the effectiveness of ERP–GPS interoperability in enhancing logistics traceability and operational efficiency.

5 Discussion

The findings indicate that ERP–GPS integration enhances logistics traceability and delivery performance within real operational environments. The baseline diagnostic analysis revealed that fragmented information systems limited real-time visibility, delayed operational feedback loops, and reduced responsiveness to route deviations and delivery disruptions. These observations are consistent with previous research indicating that insufficient interoperability between administrative and operational platforms negatively affects transport efficiency and delivery reliability [9,10]. Consequently, the results reinforce the view that discontinuities in information exchange represent a structural barrier to effective logistics control.

The implementation of ERP–GPS synchronization enabled continuous bidirectional data exchange between vehicle tracking devices and enterprise information systems. This interoperability significantly reduced latency between operational events and managerial decision-making processes. Improved traceability completeness and reduction of information gaps align with IoT-enabled logistics architectures described in [6] and [15], where real-time data synchronization functions as the backbone of intelligent transport systems. The findings therefore suggest that system integration not only improves operational visibility but also restructures information flow dynamics, transforming logistics management from a reactive approach to a more proactive operational model.

From an operational perspective, the improvements observed in delivery reliability and service responsiveness indicate that integrated information environments strengthen coordination between planning and execution layers. Similar operational improvements have been documented in digitally integrated logistics systems, where real-time monitoring reduces variability, enhances route control mechanisms, and supports adaptive decision-making under uncertain distribution conditions [1,14,17]. Furthermore, the elimination of manual delivery confirmation procedures contributed to minimizing error propagation, reducing redundant administrative workload, and improving process consistency across operational units.

Beyond immediate operational improvements, the results support broader literature on digital interoperability and cyber-physical logistics systems. Previous studies emphasize that synchronized data environments strengthen supply chain resilience and enhance system adaptability under dynamic operational conditions [13,18]. In volatile distribution contexts, access to unified operational data enables faster exception management and improves organizational responsiveness to disruptions.

From a theoretical perspective, this study contributes to understanding digital interoperability as an operational capability rather than solely a technological feature. The findings suggest that ERP–GPS integration should be interpreted as a coordination mechanism that bridges planning and execution layers, thereby reducing structural inefficiencies embedded in fragmented information architectures. This perspective aligns digital transformation with organizational process alignment, extending the discussion beyond technological adoption toward systemic performance optimization.

Importantly, the case study demonstrates that meaningful performance improvements can be achieved without the implementation of capital-intensive technologies such as blockchain-based traceability platforms or digital twin infrastructures [4,19–25]. While these technologies offer advanced functionalities, their adoption frequently requires substantial financial investment and extensive organizational transformation. In contrast, ERP–GPS integration leverages existing enterprise systems and therefore represents a more accessible and scalable pathway for digital transformation in small and medium-sized logistics enterprises.

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From a managerial standpoint, the integration model provides a cost-effective strategy for improving operational transparency and customer service reliability through optimization of existing technological infrastructure. By strengthening data synchronization rather than replacing core systems, organizations can incrementally advance toward Logistics 4.0 maturity while minimizing implementation risks.

Finally, the results highlight the critical role of data governance and information consistency within digital logistics ecosystems. Effective ERP–GPS integration not only synchronizes data streams but also establishes standardized event recording and validation protocols, which are essential for ensuring traceability reliability. This finding underscores that technological integration must be accompanied by organizational alignment and robust data management practices in order to fully realize operational performance benefits.

However, this study presents certain limitations. The analysis is based on a single case study context and evaluates performance over a relatively short operational period. Future research should therefore explore multi-company applications, incorporate longitudinal analyses to assess long-term performance stability, and examine the interaction between ERP–GPS integration and complementary digital technologies within complex supply chain networks.

6 Conclusions

This study evaluated the impact of ERP–GPS integration on logistics traceability and delivery performance using a structured Triple-I analytical framework. The results demonstrate that system interoperability significantly improves real-time visibility of delivery operations and strengthens coordination between administrative planning functions and transport execution processes.

The empirical analysis identified measurable operational improvements, including a substantial reduction in delivery lead time and a significant increase in OTIF performance. These improvements reflect enhanced logistics traceability, reduced information latency, and more efficient synchronization between operational events and managerial decision-making.

From a practical perspective, the findings indicate that ERP–GPS synchronization represents a feasible and cost-effective pathway for digital transformation in last-mile logistics operations. By leveraging existing enterprise information systems, organizations can enhance operational transparency and delivery reliability without requiring large-scale technological investments.

Methodologically, the study confirms the applicability of the Triple-I analytical framework for evaluating digital integration initiatives in logistics systems. The framework provides a structured approach for assessing baseline conditions, integration processes, and performance outcomes, offering a replicable model for future research in digital logistics transformation.

Future studies should extend this analysis to multi-company environments, incorporate longitudinal performance assessments, and examine the interaction between ERP–GPS interoperability and complementary digital technologies in order to further strengthen supply chain adaptability and resilience.

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Review process

Single-blind peer review process.