Stakeholder Perception Evaluation of Automated Trucking System for Freight Transportation System

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Statement of Significance (Relevance of Research): This research provides essential insights for logistics stakeholders navigating driver shortages, rising costs, and sustainability pressures. By revealing how trucking and receiving companies evaluate CATS versus TTS, it supports evidence-based decision-making, helping industry, policymakers, and technology providers assess adoption readiness and design effective autonomous transport strategies.

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INTRODUCTION

Logistics services form a critical foundation for global economic activity, enabling the efficient flow of goods across international supply chains. However, the sector is currently under pressure from several structural challenges, including persistent driver shortages, ambitious sustainability targets, rapid digitalization, and rising freight volumes [1]. These issues are intensified by global trends such as the expansion of e-commerce, increasing customer expectations for fast delivery, and disruptions triggered by events like the COVID-19 pandemic. A major factor driving interest in autonomous trucking is the long-standing driver shortage: truck driver turnover reached 39% after the 2010 Great Recession [2] and has remained extremely high, between 80% and 92%, since 2012. Additionally, driver-related expenses—including wages and benefits—account for more than 43% of total cost per mile and have consistently been the largest cost component for motor carriers since 2014 [3]. Despite the high cost of drivers, last-mile operators often cannot fully utilize them due to dependencies within multimodal transport systems.

As logistics companies seek solutions that enhance cost efficiency, flexibility, and sustainability, autonomous transport has emerged as a promising option with expected safety, economic, and environmental benefits. Yet research on autonomous trucking remains fragmented, with limited studies addressing the system-wide implementation of Connected and Autonomous Transport Systems (CATS). This highlights the need for a comprehensive information base to support end-users in designing such systems.

In the Netherlands, the SAVED project (Samenwerkend Autonoom Vervoer op Bedrijventerreinen) investigates the challenges of implementing CATS in business parks, with a particular focus on last-mile operations—typically regarded as one of the least efficient segments of multimodal supply chains. CATS is expected to enhance safety, efficiency, and environmental performance and may represent a major shift in road transport. Given that successful implementation depends on stakeholder acceptance, understanding stakeholder perceptions is essential. This study therefore assesses how trucking and receiving companies perceive autonomous trucking, identifying and prioritizing key criteria for container transport. Using the MAMCA methodology [4] the research quantifies these perceptions through criteria indicators to evaluate the potential of autonomous trucking systems.

METHODOLOGY

This study adopts a mixed-methods research design, combining qualitative and quantitative approaches to assess criteria relevant to evaluating Connected Autonomous Transport (CAT) systems in the Dutch logistics sector. The qualitative component centers on semi-structured interviews with 11 purposefully selected stakeholders from diverse operational roles, including terminal operations, trucking, freight forwarding, warehouse management, business park management, and logistics innovation. Participants include operations directors, customer service managers, logistics officers, CEOs, consultants, and strategic

Secondary data analysis supported and validated interview insights through company documents, operational reports, and sector literature. This review focused on KPI frameworks and industry benchmarks, enabling the identification of gaps, trends, and contextual patterns. Thematic analysis of interview transcripts uncovered key themes and stakeholder perspectives, while content analysis of documents quantified sector patterns.

To translate qualitative findings into measurable decision-support outputs, the study employs Multi-Actor Multi-Criteria Analysis (MAMCA). This method integrates stakeholder viewpoints to conduct a structured quantitative assessment of criteria priorities. The Best-Worst Method (BWM) [5] is used by is used to perform pairwise comparisons, allowing participants to rank criteria and generate weighted results via an Excel-based solver, with a consistency ratio ensuring reliable outcomes. The final output is a ranked and weighted set of criteria perceived as most relevant for assessing CAT effectiveness, especially from the viewpoint of trucking and receiving companies.

The research proposes a Criteria Prioritization and Impact Analysis Framework to systematically define, evaluate, and prioritize CAT assessment criteria. The framework includes defining alternatives (traditional vs. CAT systems), identifying stakeholders, selecting and weighting criteria, defining measurable indicators, normalizing indicator data, calculating weighted impacts, and interpreting results. This structured approach offers decision-makers a comprehensive tool to compare traditional and autonomous transport systems and supports evidence-based adoption of CAT solutions at container terminals. **Figure 1** shows the Criteria Prioritization and Impact Analysis Framework.

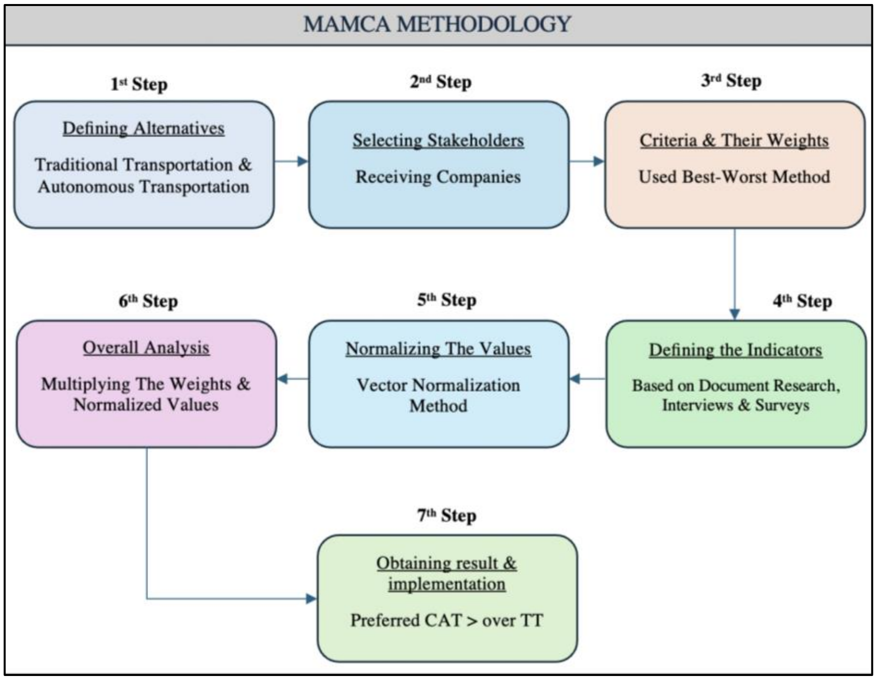

Figure 1 Criteria Prioritization and Impact Analysis Framework

RESULTS

This study compares the Traditional Transportation System (TTS) with the Connected and Autonomous Transport System (CATS) using a structured multi-criteria analysis framework developed to evaluate stakeholder perceptions. TTS represents the current logistics model where human-operated trucks manage container movements, while CATS refers to an emerging setup in which autonomous trucks execute these movements. The analysis focuses on two primary stakeholder groups: trucking companies and receiving companies. These groups were selected because they are directly involved in transport operations and are among the first to experience changes introduced by autonomous technology.

A set of criteria for evaluating TTS and CATS was developed through an extensive combination of literature review, industry documentation, and expert interviews. These criteria reflect essential performance dimensions relevant to stakeholders, including delivery cost, delivery reliability, vehicle efficiency, lead time, operational flexibility, and safety. For each criterion, measurable indicators were defined using industry benchmarks, empirical data, and stakeholder input. These indicators represent real-world performance attributes that logistics companies use to assess transport effectiveness.

To determine the relative importance of these criteria, the study applied the Best–Worst Method (BWM), a multi-criteria decision-making approach. Participants were asked to identify the most important (“best”) and least important (“worst”) criteria from the list. They then compared the remaining criteria relative to these anchor points using a scale from 1 (equally important) to 9 (extremely more important). These pairwise comparisons capture the strength of stakeholder preferences. Using a BWM Solver, weights for each criterion were calculated by minimizing inconsistencies within the comparisons. The individual results from participants were then averaged to generate final, consolidated criterion weights for trucking and receiving companies, providing a clear representation of stakeholder priorities.

Before analyzing performance differences, the study normalized all indicator values because they varied widely in scale and units (e.g., cost in euros, efficiency in percentages, time in hours, safety scores). Normalization converted the values to a common 0–1 range to enable fair comparison. Indicators with positive performance direction (where higher values are better) were normalized differently from those with negative direction (where lower values indicate improvement). After normalization, each indicator value was multiplied by its associated criterion weight. This produced weighted normalized values that reflect the actual influence of each criterion on system performance.

The framework then compared TTS and CATS by calculating the differences between their weighted values. These differences were converted into percentage form to show the relative perceived performance advantages of one system over the other. The results for trucking companies and receiving companies are presented in Table 1 and Table 2, respectively. These tables summarize stakeholder perceptions and should not be interpreted as literal performance changes. Instead, they represent the relative strength of stakeholder confidence in CATS compared to TTS.

TABLE 1 Overall and percentage analysis of Trucking companies

Overall Stakeholder Perception for Trucking Companies		
Criteria	TTS	CATS
Notation	c	d
Vehicle efficiency (+ve)	0,055	0,128
Delivery time (-ve)	0,013	0,029
Delivery reliability (+ve)	0,149	0,158
Operating cost (-ve)	0,028	0,064
Energy consumption (-ve)	0,025	0,035
Environmental (-ve)	0,023	0,039
Safety (-ve)	0,018	0,076
System uptime (+ve)	0,033	0,062
Results	0,29	0,46

Perception analysis in % for Trucking Companies		
Criteria	TTS	CATS
Notation	P_{TTS}	P_{CATS}
Formula	(c-c/c)	(d-c/c)
Vehicle efficiency (+ve)	0%	134%
Delivery time (-ve)	0%	125%
Delivery reliability (+ve)	0%	6%
Operating cost (-ve)	0%	125%
Energy consumption (-ve)	0%	36%
Environmental (-ve)	0%	71%
Safety (-ve)	0%	330%
System uptime (+ve)	0%	90%
Results	0%	60%

Stakeholder Perceptions: Trucking Companies (Table 1)

- According to Table 1, trucking companies perceive considerable performance improvements with CATS. The aggregated weighted score for CATS (0.064) is notably higher than for TTS (0.028). When expressed as percentage differences:
- Delivery cost shows a 125% positive perceived impact in favor of CATS.
- Vehicle efficiency shows a 134% positive impact, indicating strong expectations of more consistent routing and reduced idle time.
- Delivery time shows a 125% positive impact, reflecting expectations of improved punctuality and reduced delays.

- Safety, the most strongly rated criterion, shows a 330% positive impact, indicating high perceived potential for reducing accidents and minimizing human-related errors.
- Overall, Table 1 reflects that trucking companies attribute substantial performance advantages to CATS across all major criteria.

TABLE 2 Overall and percentage analysis of Receiving companies

Overall Stakeholder Perception for Receiving Companies		
Criteria	TTS	CATS
Notation	c	d
Safety (-ve)	0,023	0,099
Delivery time (-ve)	0,035	0,080
Delivery reliability (+ve)	0,130	0,138
Container delivery Cost (-ve)	0,029	0,068
Operation efficiency (+ve)	0,030	0,067
Delivery capacity (+ve)	0,070	0,085
Results	0,29	0,44

Perception analysis in % for Receiving Companies		
Criteria	TTS	CATS
Notation	P_{TTS}	P_{CATS}
Formula	(c-c/c)	(d-c/c)
Safety (-ve)	0%	330%
Delivery time (-ve)	0%	125%
Delivery reliability (+ve)	0%	6%
Container delivery Cost (-ve)	0%	136%
Operation efficiency (+ve)	0%	128%
Delivery capacity (+ve)	0%	20%
Results	0%	49%

Stakeholder Perceptions: Receiving Companies (Table 2)

- Table 2 shows that receiving companies also perceive clear benefits when evaluating CATS against TTS:
- Delivery time shows a 125% positive perceived impact, indicating expectations of more predictable and timely deliveries.
- Delivery cost shows a 136% positive impact, suggesting that receiving companies expect reduced incoming logistics costs.
- Operational efficiency shows a 128% positive impact, reflecting anticipated improvements in warehouse coordination and planning accuracy.
- Safety again stands out, with a 330% positive impact, demonstrating widespread belief that autonomous trucks will significantly improve transport safety.
- The aggregated results in Table 2 indicate that receiving companies perceive CATS as delivering notable improvements across cost, timing, efficiency, and safety metrics.

CONCLUSIONS & DISCUSSION

This study aims to identify, prioritize, and evaluate performance criteria that matter most to two key logistics stakeholders—trucking companies and receiving companies—in the context of container transportation. It further investigates how these stakeholders perceive the Connected and Autonomous Transport System (CATS) compared to the Traditional Transport System (TTS). The research is timely due to industry-wide challenges such as driver shortages, safety concerns, rising operational costs, and the need for higher efficiency and sustainability. A mixed-method approach was applied, combining qualitative interviews with industry actors and quantitative analysis using the Multi-Actor Multi-Criteria Analysis (MAMCA) and the Best–Worst Method (BWM). This combination allowed the study to identify stakeholder-specific priorities and understand their expectations regarding autonomous transport.

For trucking companies, three criteria emerged as the most influential: Delivery reliability (0.22), Operating cost (0.15), and Safety (0.15). Delivery reliability was ranked highest, reflecting the operational necessity of predictable and timely container movements. The emphasis on cost and safety indicates the need for CATS to deliver measurable financial savings and improved safety performance. For receiving companies, Delivery time (0.19), Delivery reliability (0.19), and Safety (0.19) were identified as equally critical. Their convergence around three equally weighted criteria highlights the importance of speed, consistency, and safety in inbound logistics operations.

After combining stakeholder-defined criteria with quantitative indicators derived from literature, interviews, and operational documents, the study evaluated perceptions of TTS versus CATS. Trucking companies showed a strong preference for CATS: normalized scores were 0.064 for CATS versus 0.028 for TTS, interpreted as a 125% perceived improvement in cost efficiency, 134% in vehicle efficiency, 125% in delivery time, and 330% in safety. In total, trucking companies perceive CATS as offering a 60% overall advantage. However, these percentages represent *relative perception strength*, not real-world performance predictions. Receiving companies exhibited similar enthusiasm. They associated CATS with a 125% perceived improvement in delivery speed, 136% reduction in delivery cost per container, 128% increase in operational efficiency, and 330% safety improvement. Overall, their perceived advantage for CATS over TTS amounted to 49%.

Despite overwhelmingly positive perceptions, the text highlights cautionary considerations. Stakeholder expectations may be inflated due to optimism rather than empirical performance evidence, especially regarding very high safety and efficiency scores. Infrastructure readiness, regulatory constraints, system reliability, and real-world variability may limit actual benefits. The differing levels of enthusiasm between trucking and receiving companies also point to potential misalignment in adoption incentives. Broader, more diverse studies and evidence-based pilots are recommended before relying heavily on stakeholder perceptions as predictors of CATS performance.

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