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Research on Road Rights and Transportation Safety of Unmanned Logistics Vehicles

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ABSTRACT

This article takes the "Road Traffic Safety Law" as the core legal basis. By sorting out the limitations of the current law's definitions of "motor vehicles" and "drivers", it analyzes the dilemma of road right allocation for unmanned logistics vehicles in mixed traffic scenarios. It also combines typical accident cases to dissect safety risk points such as technical malfunctions and responsibility division. A safety guarantee system of "technical certification + dynamic supervision" is established. This research provides theoretical support for filling the legal supervision gap of unmanned logistics vehicles and promoting their legal and compliant operation on the road.

KEYWORDS: *Road Rights; Transportation Safety; Liability Determination; Privacy Protection.*

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INTRODUCTION

With the advancement of autonomous driving technology towards L4 high-level automation, unmanned logistics vehicles have become a key project in the intelligent logistics field due to their efficiency in "last-mile" transportation. In 2025, ten ministries and commissions including the Ministry of Transport jointly issued the Guiding Opinions on Promoting the Integrated Development of Transportation and Energy, which clearly states that "efforts should be made to promote the application of unmanned vehicles. However, the speed of technological implementation far exceeds the advancement of laws. The problems exposed by unmanned logistics vehicles in cargo transportation reflect the development constraints caused by gaps in relevant laws, and the current legal system is difficult to adapt to the characteristics and operation modes of unmanned logistics vehicles." This paper focuses on three core aspects: road rights, transportation safety, and the liability determination of remote safety officers. Based on autonomous driving technology theory and existing legal provisions, it provides effective and comprehensive legislative references for the unmanned logistics field. The purpose of this paper is to study the road rights and transportation safety issues of unmanned logistics vehicles from the perspective of road traffic law, and to provide solutions for breaking the current dilemma in formulating laws for unmanned logistics vehicles and promoting their legal operation on roads.

1. Road Rights

1.1. Legal Response and Road Rights Regulation in Non-Quantifiable Traffic Scenarios

Non-quantifiable traffic scenarios refer to traffic situations that cannot be accurately described by data and require reliance on human experience and subjective judgment. Firstly, unmanned logistics vehicles currently lack interpretation standards for non-quantifiable scenarios as specified in the traditional Road Traffic Safety Law, such as traffic police command gestures and the intention of "polite yielding" from other vehicles. Secondly errors in scenario interpretation may stem from technical defects, lack of rules, or human factors. Unlike the

traditional "human-machine interaction" traffic rules, this new type of "machine-machine interaction" traffic mode may lead to difficulties in liability determination. Unmanned logistics vehicles often fail to accurately interpret human behavioral intentions, resulting in reduced traffic efficiency or increased safety risks. The author believes that the legal shortcomings in non-quantifiable scenarios include the following aspects:

First, the lack of legitimacy in algorithmic decision-making. The learning models of unmanned logistics vehicles do not cover edge traffic scenarios, leading to misjudgments. The algorithms themselves do not meet the "reasonable duty of care" and lack legal evaluation standards. Second, the lag of preset rules. Preset strategies of vehicles such as "decelerating to yield" and "stopping to wait" may conflict with the "right of way" rules in the Road Traffic Safety Law. For example, misjudgment of pedestrians' gestures to yield may constitute a traffic violation of "failing to yield as required". Third, issues with remote intervention. Some enterprises involve remote technicians in handling non-quantifiable scenarios, but there are no clear legislative regulations on the scope of intervention authority and liability attribution of technicians, forming a regulatory blind spot.

Non-quantifiable traffic scenarios involve conflicts of interest among unmanned logistics vehicle operators, other road users, and public safety, so it is necessary to promptly improve relevant laws and regulations.

In addition, regarding the issue of dynamic restriction of road rights, the core of road rights lies in the legal status of road users in the allocation of road resources. Unmanned logistics vehicles should possess both technical and legal capabilities to respond to traffic scenarios. When the technical capabilities of vehicles are insufficient in non-quantifiable scenarios, dynamically restricting road rights is in line with the principle of "no abuse of rights" in the Civil Code and is legitimate.

In accordance with the three guiding principles of "priority to life and health, fairness and justice, and technological neutrality" in the dynamic allocation of road rights, dynamically restricting the road rights of unmanned logistics vehicles under scenario risks is a necessary measure to safeguard public interests. The author suggests constructing a three-level system of "basic road rights - restricted road rights - temporary revocation" based on the risk level of non-quantifiable scenarios:

In low-risk non-quantifiable scenarios (such as traffic police gestures), unmanned logistics vehicles shall enjoy the same road rights as traditional motor vehicles.

In medium-risk non-quantifiable scenarios (such as morning and evening peak congestion), their driving speed shall be restricted and traffic time periods shall be defined.

In high-risk scenarios (such as emergency command by traffic police under severe weather), if the vehicle triggers an algorithm warning, it shall automatically switch to "safe mode" and suspend the right of passage, which shall be resumed after the scenario risk is eliminated.

For the definition of road rights of unmanned logistics vehicles in non-quantifiable scenarios, guarantees shall be provided at both the legislative and ethical levels. At the national level, administrative measures shall be formulated to clarify the classification standards of non-quantifiable scenarios and the procedures for adjusting road rights, and a cross-departmental supervision system shall be established. The "people-oriented" principle in the Ethical Guidelines for the R&D of Driving Automation Technology shall be transformed into legal norms, requiring enterprises to embed a "minimum harm" decision-making model in algorithms, and strive to achieve a triple balance of "technological progress - rights protection - safety maintenance", enabling unmanned logistics vehicles to truly become legal road users that improve logistics efficiency and serve social development.

1.2. Dual Integration of Road Rights Efficiency Optimization and Safety Prevention

Due to the lack of specific road rights in law, unmanned logistics Due to the lack of specific road rights in law, unmanned logistics vehicles face the dual dilemma of "efficiency hindrance" and " safety pressure".

On one hand, when performing "last-mile" delivery tasks, unmanned logistics vehicles need to frequently stop for unloading. However, the current laws do not clearly define their temporary parking rights in non-motor vehicle lanes or sidewalks, resulting in vehicles occupying other lanes. For example, during the transportation cooperation between a Neolix unmanned logistics vehicle and ZTO Express in Hubei, the vehicle had to change lanes multiple times consecutively when heading to the temporary parking spot, increasing the risk of scratches with social vehicles and extending the single delivery time by 40%.

On the other hand, neglecting traffic safety after opening road rights may lead to greater hidden dangers. In the pilot of a certain city, the time period

for unmanned logistics vehicles to use bus lanes was not restricted. During peak hours, these vehicles mixed with buses, resulting in 3 close-call avoidance incidents involving unmanned logistics vehicles.

Moreover, the lag of laws causes more serious safety hazards in nighttime and severe weather scenarios. In 2025, a Cainiao unmanned logistics vehicle in Hangzhou was driving at night. Although it turned on the corresponding lights in accordance with legal provisions, a rear electric vehicle collided with it due to insufficient lighting in the road construction section. The core issue of the accident is that the current provisions on light use in the Road Traffic Safety Law do not take into account the characteristics of unmanned vehicles that "rely mainly on sensor perception and supplemented by light warning", and have not yet clarified the road right priority of unmanned vehicles in special lighting environments, revealing the incompatibility between traditional road right rules and new transportation tools.

At present, the pilots of unmanned logistics vehicles in Beijing and Guangzhou have provided valuable experience for reference: Opening the right to use bus lanes during off-peak hours has increased the delivery efficiency of unmanned vehicles by 35%. Under severe weather such as heavy rain and heavy fog, unmanned vehicles automatically suspend the right of passage on main roads, only retaining the short-distance delivery function within communities, and are required to turn on high-frequency flashing yellow warning lights.

This "road rights + safety" operation mode not only meets the efficiency requirements of unmanned logistics vehicle delivery but also maintains traffic safety through technical standards.

1.3. Issue of Cross-Regional Road Rights Unification:

Localized Rules and Lack of Higher-Level Laws

The road rights of unmanned logistics vehicles refer to their right of passage and rules on public roads, and also serve as the foundation for their legal existence and operation in the physical world.

1.3.1. Differentiation of Local Pilot Rules

Pilot cities have formulated management norms with regional characteristics based on local actual conditions. For example: According to the Detailed Rules for the Administration of Unmanned Delivery Vehicles in the Pilot Zone for Intelligent Connected Vehicle Policies of Beijing (Trial), unmanned delivery vehicles are allowed to travel in non-motor vehicle lanes, with a maximum speed limit of 15 km/h.

In contrast, the Administrative Measures for the Testing and Application of Unmanned Vehicles in the Urban Area of Ziyang City adopts different standards for speed, road sections, and time. Shenzhen has granted road rights to highly autonomous vehicles in specific areas and road sections through the Regulations on Intelligent Connected Vehicles in the Shenzhen Special Economic Zone.

Although this "one policy per city" model can provide a test ground and room for innovation for the development of unmanned logistics vehicles in the early stage, it also seriously hinders the large-scale commercial deployment of unmanned logistics vehicles nationwide. For logistics enterprises, adjusting the speed limit and vehicle specifications for each city during national operations not only significantly increases compliance costs but also conflicts with the inherent requirements of the logistics industry for standardization and scale.

1.3.2. Lack of Higher-Level Laws and Construction of Unified Standardized Road Rights

The current Road Traffic Safety Law of the People's Republic of China and its supporting regulations are still based on the dual classification of traditional manned motor vehicles and non-motor vehicles, and cannot clearly define the legal status and road right ownership of unmanned logistics vehicles as a new type of entity The author suggests the following measures:

In the revision of the Road Traffic Safety Law, a separate legal category of "autonomous driving vehicles" or "low-speed intelligent cargo-carrying vehicles" shall be designed to clarify their basic legal attributes.

It is recommended that the Ministry of Public Security, the Ministry of Transport, and other departments jointly formulate the Measures for the Administration of Road Traffic and Operation of Unmanned Logistics Vehicles, and establish national unified minimum safety standards and core road right rules.

From the perspective of improving the legal system, establishing a national unified supervision framework is a necessary prerequisite for the commercial promotion of autonomous driving technology. It can not only ensure the fulfillment of basic safety requirements but also reserve room for local innovation and exploration based on actual conditions. Unified road right standards shall at least include:

Establishing a hierarchical speed management system, dividing levels such as "low speed" and

"medium speed" according to vehicle size and braking performance, and corresponding them to different road rights.

Clarifying the allocation of driving space and implementing a unified identification system, specifying nationally unified vehicle appearance marks, light signals, etc., to facilitate public identification and supervision.

On the basis of this national standard, local governments may be authorized to choose to open wider areas or implement stricter regions through legislation according to their actual road conditions, but the core rules shall be consistent with the national standards. Ultimately, a governance pattern shall be realized, which is based on a national unified system and allows local governments to make appropriate adjustments in light of actual conditions.

2. Transportation Safety

2.1. Dilemma and Development of the Application of "Carrier Liability"

The core of the current Regulations on Road Transportation is to regulate the legal relationship between carriers and shippers in traditional transportation contracts, and the key to its establishment lies in the "person" of the driver. However, in the " unmanned carriage" scenario, the traditional driver disappears, and is replaced by multiple subjects such as technology providers and operators.

When cargo damage occurs, it is first necessary to distinguish whether the cause is technical defects or operational management negligence:

If the cargo damage is caused by the vehicle's perception system failing to identify road bumps, resulting in severe vibration, or algorithmic decision-making errors leading to collisions, this can usually be attributed to product defects of the technology provider. The provisions on product liability in Article 1202 of the Civil Code shall apply, and the producer shall bear strict liability. According to the basic principles of the product liability legal system, when a product defect causes damage, the producer shall bear tort liability in accordance with the law.

On the contrary, if the cargo problem is caused by the operator's failure to plan routes reasonably, or negligence in remote monitoring, or improper vehicle maintenance, it shall be regardedas a breach of contract by the operator for failing to fulfill the duty of proper custody. In this case, the logistics consignor may directly and effectively claim liability for breach of contract from the operator based on the transportation contract. After assuming compensation liability, the operator may claim compensation from the technology provider in accordance with the law if it can prove that the damage was caused by technical defects.

2.2. Liability Attribution and Burden of Proof for Cargo Loss

The liability for cargo loss is more complex, which may involve multiple situations such as technical failures, third-party theft, or network security issues. In this case, in accordance with the provisions of Article 832 of the Civil Code, the carrier shall bear compensation liability for the damage or loss of cargo during transportation. This means that in the transportation contract relationship, the operator, as the carrier, shall first bear overall responsibility for the safety of the cargo. This is a form of strict liability, unless the operator can prove that the damage or loss of the cargo is caused by force majeure, the natural properties or reasonable wear and tear of the cargo itself, or the fault of the consignor or consignee.

Therefore, if the operator intends to claim exemption from liability, it must bear the corresponding burden of proof. For example, it shall prove that there are no exploitable security vulnerabilities in its vehicle system, and that it has adopted all reasonable physical protection and electronic security measures. This liability allocation actually urges the operator to clearly define data records and safety standards in its contract with the technology provider, so as to effectively trace the cause and divide the liability when an incident occurs.

2.3. Establishment of Compensation Standards

The machine-operated nature of unmanned logistics vehicles makes the imputation principle for cargo damage compensation and the boundary of personal information processing difficult issues to solve.

When transporting special cargo such as fresh produce and fragile goods, unmanned logistics vehicles face far more complex compensation issues than traditional logistics. The logic of compensation rules in traditional logistics, such as "insured compensation", is based on the carrier's fault liability. Cargo damage is usually caused by "human" behaviors that can be attributed to the carrier, such as improper loading and unloading, driving problems, and poor storage.

However, the entire operation process of unmanned logistics vehicles is driven by algorithms, and their "behaviors" are the result of the combined action of perception, decision-making, and execution systems. Once cargo damage occurs, the causes are more complex: it may be the misjudgment of sensors under specific light or weather conditions, the wrong

decision of algorithms under complex road conditions, or the sudden failure of vehicle mechanical components. The traditional concept of " fault" becomes vague in this context - it may not be reasonable to simply apply the traditional "insured compensation" rules to errors made by machines.

For users, if they cannot obtain compensation due to "technical failures" that they cannot understand, their burden will be increased. For operating enterprises, if they have to bear full compensation for risks caused by any technical limitations, it may hinder technological innovation and market promotion due to high compensation costs.

First, it is necessary to establish differentiated compensation limits and clear exemption situations:

For general cargo, the existing compensation standards can be followed or appropriately adjusted, such as full compensation for lost parcels after checking surveillance.

For special cargo such as fresh produce and fragile goods, special and more detailed compensation rules shall be established. Operating enterprises shall clearly inform users of the compensation limits, exemption clauses, and insured service options for such cargo in a prominent manner when users place orders.

The setting of exemption situations must be prudent and specific, and cannot be generally attributed to "technical failures". For example, a distinction can be made between "attributable technical defects" and "technical limitations of force majeure nature":

The former refers to damage caused by known but unremedied vulnerabilities in vehicle design, manufacturing, or core algorithms, for which enterprises shall bear compensation liability. The latter refers to judgment errors that cannot be completely avoided under the current level of technological development and occur in extremely rare scenarios. If an enterprise can prove that it has fulfilled the maximum duty of care under the technical conditions at that time, corresponding reduction or limitation of compensation liability can be set. Damage caused by user faults, such as failure to package special cargo in accordance with prompt requirements or designating a delivery location with insurmountable physical obstacles, shall be clearly listed as exemption situations. Second, a system combining "hierarchical compensation" and "compulsory insurance" can be established. Pure "technical failure exemption" clauses are prone to abuse by enterprises as an excuse to shirk responsibility and damage the rights and interests of consumers; while absolute "full compensation" may excessively increase the burden on enterprises. Therefore, it is possible to require unmanned logistics vehicle operating enterprises to purchase liability insurance and establish a two-tier system of basic compensation and insured compensation: At the basic level, for uninsured special cargo, a compensation limit higher than that of general cargo but not the full market value shall be set, and this compensation shall be covered by insurance to ensure that users can obtain basic compensation when suffering losses not caused by their own faults.

At the voluntary level, the "insured compensation" service shall be vigorously promoted and optimized. After users pay an additional fee, they can obtain full compensation equivalent to the actual value of the cargo in case of total loss of the cargo. This method not only safeguards the basic rights and interests of users but also spreads the operational risks of enterprises.

2.4. Definition of the Boundary of Information Collection and Use

The operation of unmanned logistics vehicles highly relies on data collection and processing. A successful delivery requires collecting personal information of senders and recipients, such as names, accurate addresses, and mobile phone numbers, and may even include sensitive information such as biometrics and real-time geographic location tracks. While these data bring delivery convenience, they also form a huge privacy loophole. Without strict legal constraints on their collection scope, storage period, and sharing rights, the consequences would be unimaginable. The data processing activities of unmanned logistics vehicles must strictly comply with the "minimum necessity" principle established by the Personal Information Protection Law. This principle requires that information processing activities shall be limited to what is necessary to achieve specific purposes, and excessive collection shall be prohibited. Specifically, in the scenario of unmanned logistics, this means:

In terms of collection scope, it shall be limited to the information necessary for completing the current delivery. For example, the system does not need to know the user's ID number, shopping preferences, and other data unrelated to delivery.

In terms of storage period, once the delivery is completed and after a reasonable post-delivery dispute period, the user's personal identity information shall be anonymized or completely deleted, and only desensitized logistics data shall be retained for optimizing operations. Long-term storage of detailed delivery records that can be linked to specific individuals shall be regarded as illegal unless there is a clear and legal other purpose. Even if long-

term storage of personal information is not illegal, the user shall be informed.

In terms of sharing rights, the user's explicit and separate consent must be obtained before their information can be shared with third parties. Methods such as default checking and displaying prompt information in a small font that is difficult to see shall be prohibited.

However, the universal principles of law require more detailed implementation standards when facing specific technical scenarios. The first is the definition of "necessity". To achieve precise navigation and obstacle avoidance, unmanned logistics vehicles continuously collect image data of the surrounding environment, which may inevitably capture information of unspecified third parties such as passers-by and surrounding shops. The processing of these data requires legislative and regulatory authorities to jointly issue guidelines, requiring enterprises to take technical measures to minimize the unintended collection of third-party information, and strictly stipulate that such environmental data shall only be used for autonomous driving decision-making and not for other purposes.

Finally, the information security protection capability of unmanned logistics vehicles is the technical cornerstone for defining boundaries. Enterprises must bear the main responsibility for data security, and shall also be held responsible for data leakage that occurs during the transmission of personal information, and cannot escape responsibility with excuses such as "unavoidable hacking". Regulatory authorities shall establish corresponding technical standards and certification systems, conduct regular evaluations and supervision of enterprises' data security practices, and impose heavy penalties for violations, thereby minimizing the possibility of enterprises infringing on personal information.

2.5. Balancing the Requirements of "Real-Name Collection and Delivery" and User Privacy Protection

Article 20 of the Anti-Terrorism Law stipulates that express delivery and logistics operation entities shall implement a safety inspection system, inspect the identities of customers, and conduct safety inspections or open and inspect the transported and delivered items in accordance with regulations. Its national mandatory norms mainly aim to avoid the transportation of anti-terrorism items through item traceability.

Anonymous delivery uses technical means to separate the user's real information from the delivery information, avoiding the risk of one-sided information leakage. The key to resolving the conflict lies in the invisibility of real-name information during transportation while ensuring that the real information can be traced.

At present, the existing anonymous delivery services in the express delivery industry in many places can serve as a reference for unmanned logistics vehicle delivery. The two can be balanced through technical means to promote anonymous delivery by unmanned logistics vehicles. Combining the Beijing model and the Qinghai model, the following system can be constructed:

In the waybill filling link, users are required to complete real-name authentication, and the background synchronously verifies the identity. To comply with the Anti-Terrorism Law, the transported items shall be scanned to ensure that there are no anti-terrorism items.

In the delivery link, the name, mobile phone number, and address of the recipient shall be virtualized to ensure the personal privacy security during transportation. To collect the express delivery, the recipient shall scan the pick-up code or QR code to confirm their identity.

In the supervision link, the logistics platform shall monitor the real-name information in real time and count the real-name information through the background to ensure the safety of the entire transportation process.

3. Liability Determination of Remote Safety Officers

At present, the technological development and actual operation of unmanned logistics vehicles still require the deployment of remote safety officers. As the key link connecting unmanned logistics vehicles with virtual commands, the definition of safety officers' liability is also the core of the transportation safety liability system.

According to the provisions of Article 1191 of the Civil Code of China: "If an employee of an employer causes damage to others in the performance of their work tasks, the employer shall bear tort liability." Based on this, the author believes that if the civil compensation liability is still unavoidable within the scope of reasonable operation of remote safety officers, the operating company shall bear the primary responsibility.

According to the "reward theory" and risk control theory: the operating company obtains economic benefits from the commercial operation of unmanned logistics vehicles, and shall also bear the operational risks arising therefrom; at the same time, compared

with employees, the company has stronger risk-sharing capabilities and more effective solutions. Placing liability on the company can urge enterprises to establish and improve safety management mechanisms, thereby minimizing the total social cost. However, this does not mean that safety officers can be completely exempted from personal liability. If the operating company can prove that the accident was caused by the " intentional or gross negligence" of the safety officer, the company may exercise the right of recourse against the employee in accordance with the law after assuming compensation liability to external parties.

Furthermore, the standards for the "reasonable intervention" duty of care of safety officers shall be clearly defined:

Whether the early warning time provided by the system before the accident is sufficient and whether the prompt information is clear and accurate.

Whether the company has simulated scenarios through scientific and repeated training on intervention procedures in advance.3. The impact of road conditions, weather, and other conditions at the time of the incident on judgment shall be evaluated.

The law shall require remote safety officers to fulfill auxiliary duty of care within the scope of their acceptable capabilities, which can effectively complement the capabilities of the autonomous driving system.

4. Conclusion

From the perspective of road traffic law, by sorting out core legal issues such as road rights, liability, and privacy, this paper advances the research on the "adaptability between unmanned transportation tools and road traffic law", constructs a theoretical framework for the legal regulation of unmanned logistics vehicles, and provides references for subsequent related research. The research conclusions can provide specific suggestions for legislative authorities to revise the Road Traffic Safety Law and the Regulations on Road Transportation, and solve the "lack of legal basis" dilemma faced by pilot cities. At the same time, they can clarify the rights and obligations of enterprises, technology providers, and users, reduce the operational risks of the industry, and help the logistics industry reduce costs and increase efficiency.

It is estimated that unmanned logistics vehicles can reduce the cost of last-mile delivery by 30%-40%. If legal obstacles can be overcome, they are expected to cover more than 60% of the last-mile delivery scenarios nationwide by 2027.

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