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## AUTONOMOUS VEHICLE IMPACT ON ROAD SAFETY

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Road safety is among the most pressing challenges of the modern world, directly influencing the population's standard of living, the performance of the economy, and the effectiveness of the transport system. Every year, millions of traffic incidents occur worldwide, resulting in severe human and material losses. A substantial share of crashes is commonly attributed to human factors—namely driver fault, including errors, inattention, fatigue, aggressiveness, and intentional violations of traffic regulations—an assessment supported by international research. Against this background, the

emergence of autonomous vehicles, whose influence extends beyond technology and reshapes human-related aspects of mobility, becomes an especially relevant subject of study.

Autonomous vehicles are capable of making driving decisions—often faster and with greater consistency than human operators—thanks to artificial intelligence, advanced data-processing methods, and multisensor perception systems. These technologies are widely viewed as a key opportunity to improve road safety.

The present article examines how autonomous vehicles affect traffic safety, analyzes their benefits and potential consequences, and considers directions for future development.

Autonomous vehicles represent a complex technical system in which hardware components and computational algorithms cooperate to enable travel without direct assistance from a human driver. To “understand” the environment, such vehicles are typically equipped with lidar, radar, video cameras, and ultrasonic sensors, allowing them to monitor surroundings in real time from multiple angles. The incoming information is then processed by an artificial intelligence system that determines control actions independently and adjusts them continuously to changing road conditions. In this context, the international SAE classification system provides a structured framework for vehicle autonomy, distinguishing six levels:

- Level Zero — No Automation.

The vehicle offers no automated assistance. The driver performs all operations independently: braking, acceleration, speed modulation, and lane-keeping, using a conventional mechanical vehicle without supporting automation tools.

- Level One — Driver Assist.

The system can execute limited functions—such as a traffic stabilizer or a parking assistant. However, primary responsibility remains with the driver, who continues to handle acceleration, braking, and continuous control of the traffic situation. In this configuration, the technology functions primarily as assistance rather than a direct source of safety.

- Level Two — Partial Automation.

The vehicle may support both steering and speed control, thereby reducing some elements of driver workload. Nevertheless, the driver retains significant responsibility. They must remain fully attentive and prepared to intervene at any moment, as the delegation of control does not eliminate the driver's obligations. This level is currently one of the most widely adopted categorization schemes among manufacturers.

- Level Three — Conditional Automation.

The car uses sensors and lidar to perceive the road environment. Under safe conditions, the driver may temporarily disengage from essential operational tasks such as braking and acceleration. At speeds up to 60 km/h, the vehicle can manage cruising without continuous driver monitoring. This represents a qualitative step beyond Level Two, as technological systems assume a larger share of operational burden while still depending on driver responsiveness in specific scenarios.

- Level Four — High Automation.

The system can perform nearly all driving functions, including steering, braking, acceleration, lane changes, turns, and signal use.

Before entering autonomous mode, the driver receives a notification indicating that safe operation conditions are met, after which they can transition control responsibilities to the vehicle. At the same time, the system may not be able to manage highly complex traffic situations such as severe congestion patterns or intricate junctions. During such operation, the driver is largely a passive participant, although the capability to resume control may still be required when conditions exceed system limits.

- Level Five — Full Automation.

The vehicle operates without dependence on an accelerator or steering wheel: conventional driving controls may be unnecessary. The system manages the entire driving process, continuously monitoring surroundings and responding to unusual circumstances, including traffic jams or emergencies. The driver does not perform driving functions in normal operation.

The human factor remains the most pervasive underlying cause of road crashes, as traffic safety statistics repeatedly indicate. It is widely recognized that people are

inherently prone to mistakes, exhibit delayed reactions, and cannot simultaneously manage every dynamic condition on the road. Fatigue, stress, distraction, and other cognitive or physiological influences can significantly erode driving performance. For this reason, automating the human driver—or at least augmenting the driver’s task—could reduce accidents dramatically. A central advantage of having vehicles “watch” the road from within is that automated systems can observe their surroundings around the clock. Unlike human drivers, machines do not tire, drift in attention, or lose situational awareness; consequently, they can maintain continuous monitoring of safety-critical conditions. Moreover, autonomous vehicles are capable of processing vast quantities of information in extremely short timeframes, allowing them to respond instantly to evolving traffic patterns. This capability naturally aligns with vehicle-to-everything communication, particularly vehicle-infrastructure interaction.

Technologies such as V2V (vehicle-to-vehicle) and V2I (vehicle-to-infrastructure) can share real-time information about road conditions and thereby reduce accident risk to a minimum. Together, these systems may enable an intelligent mode of transportation, featuring traffic optimization and meaningful safety enhancements. Even so, the path toward widespread deployment is not straightforward. A primary obstacle—among many others—is the technical sophistication required for autonomous technologies. Despite rapid progress, autonomous systems can still generate errors, particularly in challenging, atypical, or non-standard driving scenarios. Adverse weather further complicates reliable perception: heavy rainfall, snow, and fog can degrade sensor performance and undermine perceptual accuracy.

Cybersecurity is another major concern. Self-driving vehicles rely on complex electronic architectures, which makes them potential targets for cyberattacks. Unauthorized interference with control systems could produce severe and immediate consequences; therefore, robust and well-established protective measures must be prioritized. At the same time, appropriate attention must also be directed toward legal considerations. Liability in the event of an autonomous-vehicle crash remains a complex matter. Existing legal frameworks were not designed for these circumstances, and new regulations will be necessary to ensure clarity, accountability, and fair

adjudication.

Equally important is the status and capability of the road infrastructure. For autonomous transport to function effectively, high-quality lane markings, advanced navigation support, and accurate high-precision digital maps are essential. Vehicles must also be integrated into the broader vision of smart cities, where infrastructure, data, and transportation systems operate cohesively.

The social dimension is equally vital. Public confidence—cultivated over time—is the foundation required for autonomous transport to move from experimentation to everyday reality. Society must adapt to this transformation, gradually reshaping attitudes toward how transportation should be managed and how safety responsibilities are shared.

Economic implications also deserve consideration, including potential job displacement within parts of the transport industry. Nevertheless, despite these challenges, the outlook for autonomous transportation remains promising. Over the coming decades, such technologies are likely to become increasingly common, contributing to a substantial reduction in crashes, more efficient traffic management, and improved safety for all road users.

In sum, autonomous vehicles offer significant opportunities to enhance road safety by substantially reducing—or in many cases eliminating—the human role in the accidents that arise from error. At the same time, a spectrum of technical, legal, ethical, and infrastructural barriers must be addressed. Ultimately, successful adoption of autonomous transport will be achieved only through a system-wide approach, integrating technological development, strengthened legal frameworks, and meaningful social change. Over time, autonomous vehicles have the potential to reshape our transportation system into one that is safer, more efficient, and better aligned with human wellbeing.

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## **METHODS AND MODELS FOR CARRIER SELECTION**

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In the current era of globalization and intensified market competition, supply chain management has become a decisive determinant of organizational performance. Within this system, carrier selection occupies a particularly high-impact position: it directly shapes total logistics costs, delivery velocity, cargo safety and integrity, as well as the level of satisfaction experienced by the end customer. The core difficulty of this task stems from the need to harmonize cost minimization with service quality maximization under conditions of market uncertainty [1].

*Carrier Selection Criteria* To ensure a well-founded decision, it is essential to establish a clear, measurable set of evaluation criteria. In earlier logistics practices, the central emphasis was often placed on tariffs and transportation lead times. However, contemporary SCM logic requires a broader, more analytical approach. Empirical studies indicate that—particularly for high-value-added products—operational reliability and service quality frequently outweigh purely price-based considerations [2].

The modern criterion framework may be organized into several key dimensions:

### 1. Operational Indicators and Service Quality

This group forms the practical basis for a carrier's capability to move cargo effectively and safely.

- On-Time Performance: the share of shipments delivered within the agreed schedule; one of the most important KPIs.

- Transit Time: the average duration of delivery from origin point A to destination point B.

- Freight Integrity (Damage-Free Delivery): the percentage of shipments arriving without damage or shortages.