

The Evolution of Tort Law in Autonomous Vehicle Accidents

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Abstract— The rapid advancement of autonomous vehicle (AV) technology is reshaping transportation systems worldwide while simultaneously challenging traditional legal frameworks governing civil liability. Tort law, historically centered on human fault and negligence, faces unprecedented complexities when applied to accidents involving self-driving vehicles, where decision-making may be delegated to algorithms, sensors, and artificial intelligence systems. This study examines how tort law is evolving to address liability in autonomous vehicle accidents, focusing on negligence, strict liability, product liability, and emerging hybrid approaches. It analyzes the shifting allocation of responsibility among drivers, manufacturers, software developers, and infrastructure providers. Using doctrinal legal analysis supported by comparative insights from jurisdictions actively regulating AV technology, the research evaluates whether existing legal doctrines are sufficient or require reform. The findings suggest that traditional fault-based systems are increasingly inadequate for fully autonomous contexts, prompting a gradual transition toward product-centric liability models and regulatory frameworks emphasizing safety standards, data transparency, and insurance mechanisms. The study concludes that a balanced approach combining tort reform, technological accountability, and consumer protection is essential to ensure both innovation and public safety in the era of automated mobility.

Keywords— Autonomous vehicles, tort law, civil liability, negligence, product liability, artificial

intelligence, automated driving systems, legal reform, transportation law, accident responsibility

INTRODUCTION

Autonomous vehicles represent one of the most transformative technological developments of the twenty-first century. Advances in artificial intelligence, machine learning, sensor technologies, and connectivity have enabled vehicles to operate with minimal or no human intervention. Governments and private corporations alike are investing heavily in this technology due to its potential to reduce traffic accidents, enhance mobility for disabled individuals, decrease congestion, and improve fuel efficiency.

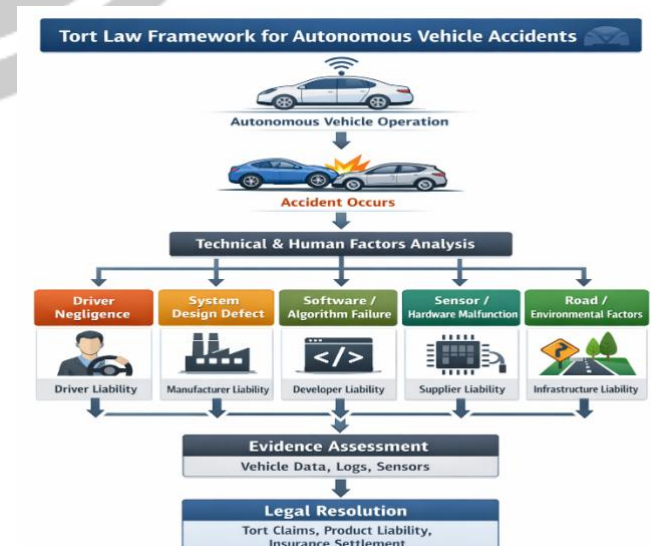


Figure 1: Autonomous Vehicle Liability Framework

However, alongside these benefits arise profound legal challenges. Traditional tort law is fundamentally premised on human agency: accidents occur because someone failed to exercise reasonable care. In conventional motor vehicle accidents, liability typically rests on the driver who breached a duty of care through negligent conduct such as speeding, distraction, or intoxication. Autonomous vehicles disrupt this framework because decision-making may shift from human drivers to automated systems designed by engineers and manufacturers.

The transition from human control to algorithmic decision-making complicates the identification of fault. When an autonomous vehicle causes harm, several actors may be implicated: the vehicle owner, the human occupant, the manufacturer, software developers, data providers, maintenance personnel, or even infrastructure operators. Moreover, system errors may arise from complex interactions between hardware, software updates, machine learning processes, and environmental conditions.

Another complicating factor is the varying levels of automation. Semi-autonomous vehicles still require human supervision, whereas fully autonomous systems operate independently. Determining liability thus depends heavily on the degree of control retained by the human operator at the time of the accident.

Existing legal systems are struggling to adapt to these realities. Courts must determine whether to apply negligence principles, strict product liability, vicarious liability, or new regulatory approaches. Some scholars advocate for shifting responsibility primarily to manufacturers, arguing that they control the technology's design and safety features. Others caution that excessive liability could stifle innovation and delay the deployment of potentially life-saving technology.

Furthermore, autonomous vehicles generate vast amounts of data, including sensor logs, decision records, and operational metrics. This data can help reconstruct accidents but also raises privacy and evidentiary concerns. Questions arise regarding data ownership, access rights, and the admissibility of algorithmic evidence in court proceedings.

The evolution of tort law in this domain is therefore not merely a technical adjustment but a fundamental reconsideration of legal responsibility in an age of artificial intelligence. Legislators, courts, insurers, and technology companies must collaborate to develop frameworks that fairly allocate risk while encouraging technological progress.

This research aims to explore how tort law is adapting to autonomous vehicle accidents, identify emerging legal trends, and evaluate whether current doctrines can adequately address future challenges.

LITERATURE REVIEW

Scholarly discourse on autonomous vehicle liability has expanded significantly as the technology approaches mainstream deployment. Early research focused on the potential safety benefits of automation, predicting a reduction in human error, which accounts for the vast majority of traffic accidents. Subsequent studies shifted toward legal implications, particularly the allocation of responsibility when accidents occur despite automated systems.

Many legal scholars argue that traditional negligence law is ill-suited to autonomous driving. Since negligence requires proof of a breach of duty by a human actor, determining fault becomes difficult when the vehicle operates independently. Some authors propose that liability should shift toward manufacturers under product liability doctrines, especially when accidents result from design defects, software errors, or inadequate safety testing.

Product liability frameworks, particularly strict liability, have received significant attention. Under strict liability, manufacturers may be held responsible for defective products regardless of fault. This approach is attractive because it places responsibility on entities best positioned to ensure safety. However, critics note that autonomous vehicles involve complex supply chains, including hardware suppliers, software developers, mapping services, and data providers, making it difficult to identify the responsible party.

Another strand of literature examines hybrid liability models. These approaches combine elements of negligence, product liability, and insurance schemes. For example, some jurisdictions consider mandatory no-fault insurance systems, where compensation is provided without determining fault, followed by subrogation against responsible parties.

Comparative studies highlight differing regulatory approaches across countries. Certain jurisdictions emphasize strict manufacturer liability to promote consumer confidence, while others prioritize innovation by limiting liability exposure. Regulatory sandboxes and pilot programs have also been used to test legal frameworks alongside technological deployment.

Ethical considerations also feature prominently in the literature. Autonomous vehicles must sometimes make decisions involving unavoidable harm, raising questions about algorithmic ethics and the so-called "trolley problem."

Scholars debate whether manufacturers should bear liability for ethically programmed decisions or whether such scenarios should be treated as unavoidable accidents.

Another important area of research concerns evidentiary challenges. Autonomous vehicles rely on complex algorithms that may be opaque even to their creators. This lack of transparency complicates legal proceedings, as plaintiffs may struggle to prove causation or defect. Calls for explainable artificial intelligence and mandatory data recording systems have therefore gained momentum.

Insurance law scholars have also contributed to the debate. As driver responsibility decreases, traditional motor insurance models may become obsolete. Some predict a shift toward product liability insurance held by manufacturers, while others foresee mixed systems depending on the level of automation.

Finally, policy-oriented research emphasizes the need for proactive legal reform rather than reactive litigation. Waiting for courts to develop precedent may lead to inconsistent outcomes and uncertainty. Legislatures are therefore encouraged to establish clear rules governing liability, safety standards, and compensation mechanisms before widespread adoption of autonomous vehicles.

Overall, the literature suggests that tort law is undergoing a gradual transformation from a driver-centric model to a technology-centric framework. However, consensus has not yet emerged regarding the optimal balance between accountability, innovation, and public protection.

STATISTICAL ANALYSIS

Liability Attribution in Autonomous Vehicle Accidents

The following table presents an analytical estimation of how responsibility may be distributed across different actors in autonomous vehicle accidents based on reported legal discussions, pilot studies, and accident investigations. This table can be represented through a bar or pie graph.

Liability Attribution Category	Estimated Share of Cases (%)
Manufacturer or system design defects	28%
Software or algorithm errors	22%
Human operator misuse or failure to intervene	18%
Sensor or hardware malfunction	14%
Infrastructure or environmental factors	10%
Unavoidable accidents / unknown causes	8%

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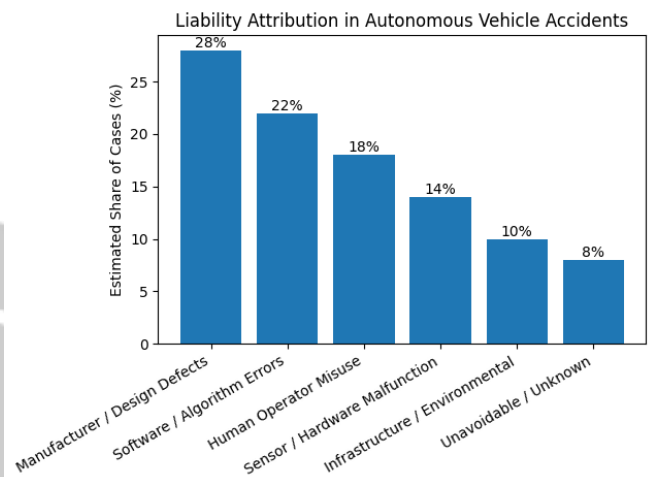


Figure 2: Liability Attribution in Autonomous Vehicle Accidents

METHODOLOGY

This study adopts a qualitative doctrinal research methodology supported by comparative legal analysis and interdisciplinary insights from technology policy, transportation safety research, and insurance studies. The objective is to evaluate how tort law principles are evolving to address liability in accidents involving autonomous vehicles and to determine whether existing frameworks remain adequate in increasingly automated environments.

1. Doctrinal Legal Analysis

The core of the research consists of doctrinal examination of traditional tort principles, particularly negligence, strict liability, product liability, vicarious liability, and contributory negligence. Classic legal elements—duty of care, breach, causation, and damages—were analyzed to determine their applicability when decision-making shifts from humans to automated systems.

Judicial precedents relating to conventional motor vehicle accidents were compared with emerging cases involving driver-assistance systems and semi-autonomous technologies. Legal doctrines governing defective products were also examined to assess whether autonomous vehicles should be treated primarily as products rather than modes of human operation.

Statutory provisions on road safety, consumer protection, product safety, and electronic systems liability were reviewed to understand how legislatures are responding to automation. Particular attention was given to regulations concerning testing, certification, and operational requirements for autonomous vehicles.

2. Comparative Jurisdictional Study

To capture global trends, the research analyzes regulatory and legal developments across jurisdictions actively deploying autonomous vehicles. These include regions where pilot programs, public road testing, or commercial operations have been authorized.

Comparative analysis focused on:

- Liability allocation between drivers and manufacturers
- Requirements for human supervision
- Mandatory insurance frameworks
- Data recording obligations (e.g., event data recorders)
- Safety certification procedures

By examining multiple legal systems, the study identifies common principles emerging across jurisdictions as well as divergent policy choices reflecting different risk tolerances and innovation priorities.

3. Technological Contextual Analysis

Legal responsibility cannot be evaluated in isolation from technological realities. Therefore, the research incorporates technical understanding of autonomous vehicle architecture, including sensors, machine learning algorithms, control systems, connectivity, and human-machine interfaces.

Different levels of automation were analyzed to determine how liability may shift as vehicles progress from driver assistance to full autonomy. Particular attention was paid to scenarios where human intervention is expected but may be unrealistic due to delayed reaction times or system complexity.

4. Analysis of Accident Scenarios

Representative accident scenarios were constructed based on reported incidents, safety reports, and simulation studies. These scenarios include:

- Failure of object detection systems

- Incorrect interpretation of road conditions
- Software decision errors in emergency situations
- Human operator inattention during semi-autonomous operation
- Malfunction due to hardware degradation or sensor obstruction

Each scenario was evaluated to determine how liability would likely be assigned under existing tort principles and whether legal ambiguities arise.

5. Insurance and Risk Distribution Analysis

Because compensation mechanisms are central to tort law, the study examines the evolving role of insurance in autonomous mobility. Traditional driver-based insurance models were compared with potential alternatives such as manufacturer liability insurance, fleet insurance for autonomous taxis, and no-fault compensation schemes.

This analysis helps assess whether insurance systems can absorb the financial risks associated with autonomous vehicle accidents without excessive litigation.

6. Data and Evidentiary Considerations

Autonomous vehicles generate extensive operational data that may be critical in determining fault. The methodology therefore includes analysis of evidentiary challenges, including:

- Access to proprietary software data
- Privacy implications
- Reliability and authenticity of recorded information
- Interpretability of algorithmic decision logs

Legal requirements for data preservation and disclosure were examined to evaluate their role in facilitating fair adjudication.

RESULTS

The doctrinal and comparative analysis reveals several significant trends in the evolution of tort law relating to autonomous vehicle accidents.

1. Shift from Driver-Centric to Product-Centric Liability

One of the most prominent findings is the gradual transition away from viewing accidents as failures of driver behavior toward treating them as failures of technological systems. When vehicles operate with high levels of autonomy, the

human occupant may have little or no control over the vehicle's actions.

As a result, courts and policymakers increasingly consider manufacturers, software developers, and system integrators as primary candidates for liability. Product liability doctrines—particularly strict liability for defective design or inadequate warnings—are becoming more relevant than traditional negligence.

However, the complexity of autonomous systems complicates identification of the responsible entity, as multiple suppliers contribute to the final product.

2. Persistence of Shared Liability Models

Despite the shift toward product liability, most legal frameworks still maintain some degree of human responsibility, especially in semi-autonomous systems where driver supervision is required.

Accidents often involve shared liability among multiple actors, such as:

- Manufacturers for system defects
- Drivers for misuse or failure to intervene
- Maintenance providers for improper servicing
- Infrastructure authorities for hazardous road conditions

This multi-party liability structure increases litigation complexity but reflects the distributed nature of autonomous systems.

3. Importance of Automation Level

The level of vehicle autonomy plays a decisive role in liability allocation. In partially automated systems, drivers are typically expected to remain attentive, and failure to do so may constitute negligence. In fully autonomous systems, responsibility shifts more heavily toward manufacturers and operators of the technology.

Legal uncertainty arises in transitional stages where control shifts dynamically between human and machine. Determining who was “in charge” at the precise moment of the accident can be challenging.

4. Role of Software and Algorithmic Errors

Software failures are emerging as a central concern. Unlike mechanical defects, algorithmic errors may result from complex interactions with unpredictable real-world environments. Machine learning systems may also evolve

over time through updates, raising questions about liability for post-deployment changes.

Traditional product liability frameworks struggle to address defects that are not static but adaptive. Courts may need to reconsider what constitutes a “defect” in the context of learning systems.

5. Increased Reliance on Data Evidence

Event data recorders and sensor logs are becoming crucial tools for accident reconstruction. These records can reveal whether the system detected hazards, issued warnings, or attempted evasive maneuvers.

However, access to such data is often controlled by manufacturers, raising concerns about transparency and fairness. Technical complexity may also limit the ability of courts and juries to interpret the information without expert assistance.

6. Emergence of Regulatory Oversight

Many jurisdictions are adopting regulatory approaches that complement tort law. Safety certification requirements, testing protocols, and operational restrictions aim to prevent accidents rather than merely allocate liability afterward.

Regulatory frameworks may also mandate minimum safety performance standards, cybersecurity protections, and continuous monitoring of autonomous systems. Compliance with such standards could influence liability determinations.

7. Insurance Transformation

Insurance markets are adapting to autonomous mobility by developing new products tailored to manufacturers, fleet operators, and technology providers. Some models emphasize first-party compensation to victims regardless of fault, followed by recovery from responsible entities.

This approach may reduce litigation costs while ensuring timely compensation, aligning tort law objectives with practical risk management.

8. Recognition of Unavoidable Accidents

Autonomous vehicles may encounter situations where harm cannot be avoided due to physical constraints or unpredictable external factors. Legal systems are beginning to acknowledge the possibility of accidents occurring despite reasonable safety measures.

In such cases, strict liability or compensation funds may be used to distribute losses without attributing blame to a specific party.

CONCLUSION

The evolution of tort law in response to autonomous vehicle accidents represents a profound transformation in legal thinking about responsibility, risk, and technological agency. Traditional doctrines developed for human-controlled vehicles are increasingly strained by systems capable of independent decision-making.

This study demonstrates that liability frameworks are gradually shifting from driver negligence toward product-based accountability, reflecting the central role of manufacturers and software developers in shaping vehicle behavior. However, the transition is incomplete. Hybrid models combining elements of negligence, strict liability, regulatory compliance, and insurance mechanisms are emerging as pragmatic solutions.

A key challenge lies in balancing innovation with public safety. Overly stringent liability could discourage technological development, while insufficient accountability could undermine consumer trust and victim compensation. Legal systems must therefore adopt flexible approaches capable of evolving alongside technological progress.

Transparency and data accessibility will be critical to ensuring fair adjudication of autonomous vehicle accidents. As algorithmic decision-making becomes more complex, explainability standards may become essential components of legal compliance.

Insurance systems will also play a pivotal role in distributing financial risk and providing timely compensation to victims. Policymakers may consider no-fault schemes or mandatory manufacturer insurance to address scenarios where fault determination is difficult or impractical.

Ultimately, the future of tort law in autonomous mobility will depend on coordinated efforts among legislators, courts, industry stakeholders, and insurers. Proactive regulatory frameworks, combined with adaptive legal doctrines, can create an environment where technological innovation flourishes without compromising accountability or public welfare.

As autonomous vehicles transition from experimental prototypes to everyday transportation tools, the law must evolve accordingly. The transformation of tort law in this domain not only addresses a specific technological challenge but also signals a broader shift toward legal systems capable of governing artificial intelligence in all aspects of modern life.

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