

Emerging Solutions and Technologies for Smart Mobility and Vehicle Safety in Transportation

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1. Introduction

The rapid evolution of transportation technologies and the growing integration of artificial intelligence (AI) are transforming the landscape of road safety and smart mobility. As transportation systems become increasingly complex and interconnected, research is expanding beyond traditional safety measures toward intelligent mobility ecosystems that combine vehicles, infrastructure, communication networks and data-driven decision-making. In this broader context, improving road safety and mobility efficiency requires not only technological innovation but also a deeper understanding of human behaviour, system interactions, and the operational challenges associated with deploying intelligent transportation solutions.

This Special Issue, entitled “Emerging Solutions and Technologies for Smart Mobility and Vehicle Safety in Transportation”, was conceived to explore how emerging technologies contribute to safer, more efficient and more sustainable transportation systems. Particular attention is given to AI-driven decision-making, advanced driver-assistance systems (ADAS), intelligent transportation systems (ITS), vehicle-to-everything (V2X) communication, connected and autonomous vehicles, and data-centric approaches to traffic safety and mobility management.

The papers published in this Issue reflect the multidisciplinary nature of modern transportation research, addressing topics such as driver behaviour analysis, crash prediction and prevention, automated driving, adaptive traffic management, smart infrastructure, and predictive analytics. Although diverse in their specific application domains, these contributions collectively demonstrate that the future of transportation safety and smart mobility will be shaped by the convergence of artificial intelligence, connectivity, automation, human-centred design, and evidence-based operational strategies.

2. A Detailed Summary of the Contents of This Special Issue

The contributions included in this Special Issue reflect the rapidly evolving and multidisciplinary nature of research on smart mobility and vehicle safety. Recent advances in artificial intelligence, data analytics, intelligent sensing, connected and automated vehicles, digital infrastructure, and human-centred technologies are reshaping transportation systems and creating new opportunities to improve safety, operational efficiency, sustainability, and user experience. At the same time, the increasing complexity of mobility ecosystems requires integrated approaches that combine technological innovation with infrastructure planning, energy management, communication networks, and an improved understanding of human behaviour and technology acceptance. Collectively, the studies presented in this Special Issue provide valuable insights into these emerging developments



Received: 15 June 2026

Revised: 22 June 2026

Accepted: 23 June 2026

Published: 28 June 2026

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and contribute to the ongoing transformation toward safer, smarter, and more sustainable transportation systems.

To begin with, Temmen et al. [1] addressed the challenge of generating scalable and realistic synthetic environments for the development and validation of automated driving functions. The authors proposed a modular generative framework that reconstructs three-dimensional environments from sparse inputs, including road definitions and basic contextual parameters such as country and area type. The framework combines map-based data generation, semantic city generation and detailed 3D environment rendering and was validated by training a perception network using mixed real and synthetic datasets. The results showed that the generated synthetic data could replace up to 85% of real-world data without significant performance degradation, demonstrating the potential of synthetic 3D environments to reduce dependence on costly field data and support rapid scenario exploration for safety-critical automated driving applications.

Jagatheesaperumal et al. [2] investigated the application of the Artificial Intelligence of Things (AIoT) to enhance transportation safety in smart cities through the integration of intelligent sensing, communication and real-time monitoring technologies. The authors proposed a comprehensive AIoT-based vehicle safety framework that combines eye-blink, ultrasonic, alcohol and environmental sensors with IoT connectivity and AI-driven analytics to detect hazardous driving conditions and support proactive safety interventions. The study demonstrates how the integration of these technologies can improve driver monitoring, collision avoidance, emergency response and traffic management while enabling continuous data exchange across smart city infrastructures. The proposed framework highlights the potential of AIoT to create safer, more connected and more responsive transportation systems, offering a scalable foundation for next-generation intelligent mobility and urban safety applications.

Moreover, Bajpai [3] reviewed the potential of emerging vehicle technologies and autonomous vehicles to address key urban mobility challenges, with particular emphasis on their implications for safety, congestion, sustainability, and urban development. Through a comprehensive analysis of technological trends and planning perspectives, the study examined both the opportunities and potential unintended consequences associated with the large-scale deployment of autonomous mobility solutions. The review highlighted the potential of these technologies to reduce crashes, improve mobility for vulnerable populations and enhance transport efficiency, while also identifying challenges related to urban sprawl, congestion, infrastructure adaptation, and regulatory frameworks. The study underscores the need for integrated planning and policy approaches that combine technological innovation with sustainable urban development objectives to maximize the societal benefits of emerging vehicle technologies.

In a similar study by Goumiri et al. [4], the authors presented a comprehensive survey of the Smart Mobility concept, examining its role in supporting fast, sustainable, affordable and intelligent transportation systems for future smart cities. The review analyzes the major challenges associated with key components of smart mobility, including intelligent parking, traffic management, traffic routing, emissions reduction, and road safety, while critically assessing the strengths and limitations of existing approaches proposed in the literature. The study highlights the growing importance of integrating advanced communication technologies, artificial intelligence, and data-driven decision-making to improve urban mobility performance and sustainability. The review provided valuable insights into future research directions and offered a comprehensive reference framework for researchers, practitioners, and policymakers working toward the development of safer and more efficient smart mobility ecosystems.

In addition, Singh [5] examined the role of real-time distributed systems in improving mobility, transportation efficiency and road safety within smart city environments. The study presents a comprehensive framework integrating distributed computing architectures, edge and cloud computing, machine learning, and adaptive scheduling mechanisms to enable low-latency data processing and intelligent decision-making for transportation applications. Drawing on examples from intelligent transportation systems and urban traffic management, the analysis highlights how predictive analytics, real-time communication and dynamic resource allocation can enhance traffic operations, emergency response, and infrastructure resilience. The proposed RT-SYNC framework demonstrates the potential of AI-enhanced distributed systems to support scalable, reliable and data-driven mobility services, while identifying future challenges related to interoperability, cybersecurity, privacy preservation and energy-efficient computing in next-generation smart transportation systems.

In a recent work, a comprehensive survey of the smart mobility concept was implemented, examining the technological advances and challenges associated with developing fast, sustainable, affordable and environmentally friendly transportation systems for smart cities [6]. The review focuses on key components of smart mobility, including intelligent parking, traffic management, traffic routing, emissions reduction and road safety, while critically evaluating existing approaches and identifying their strengths and limitations. The analysis highlights the growing role of intelligent technologies and data-driven solutions in addressing urban mobility challenges and improving transportation efficiency and safety. With the detailed synthesis of current knowledge and the identification of the research gaps and promising future directions, the study provided a valuable reference for researchers, practitioners and policymakers working toward the development of integrated and sustainable smart mobility ecosystems.

Moreover, Xu et al. [7] investigated the optimal placement of electric taxi charging stations in severe cold regions, addressing a critical gap in existing charging infrastructure planning that often overlooks the effects of low temperatures on vehicle performance and charging demand. Using Urumqi, China, as a case study, the authors integrated large-scale GPS trajectory data, driver questionnaire responses and meteorological information into an integer linear programming optimization framework. A key innovation of the study was the introduction of a dynamic temperature-correction coefficient that accounts for battery degradation, increased energy consumption and reduced driving range under extreme cold conditions. The results demonstrated substantial improvements over conventional planning approaches, including lower lifecycle costs, reduced queuing times, higher charging demand coverage and greater station utilization, highlighting the importance of climate-adaptive infrastructure planning for the large-scale deployment of electric mobility in cold-region cities.

Interestingly, Rahman et al. [8] provided a comprehensive overview of connected and automated mobility systems, examining their potential to transform the movement of people and goods while addressing growing transportation challenges in increasingly urbanized environments. The key components of connected and automated mobility were reviewed, including connected and automated vehicles, intelligent infrastructure, transportation data systems, and real-world deployment initiatives, alongside policies related to safety, communication technologies, cooperative driving automation, cybersecurity, privacy, and navigation systems. It further discusses mobility services, parking, and land-use planning, as well as legislative frameworks and public perception issues that influence technology adoption and user acceptance. Overall, the study emphasized that achieving the full potential of connected and automated mobility requires coordinated policy frameworks, strategic infrastructure investments and strong collaboration among techno-

logical, regulatory, and societal stakeholders to enhance transportation safety, efficiency, and sustainability.

Michelaraki et al. [9] conducted a comprehensive review of post-trip safety intervention technologies aimed at improving driving behaviour and reducing crash risk across four transport modes: cars, trucks, buses, and rail. Drawing on commercially available solutions and an extensive review of the scientific literature, the study examined the effectiveness of smartphone applications, in-vehicle monitoring systems, web-based platforms, gamification techniques, and reward-based interventions in providing personalized post-trip feedback to drivers. The findings indicated that smartphone applications and web-based platforms are the most widely adopted and user-friendly solutions, while gamification and incentive mechanisms can effectively motivate safer driving behaviour when combined with coaching and support strategies. The review also identified a significant gap in the lack of holistic, cross-modal post-trip intervention systems validated in real-world environments, highlighting important opportunities for future research and the development of integrated driver mentoring solutions.

Another study examined the evolving role of public authorities in governing smart mobility services, with particular emphasis on emerging Mobility as a Service (MaaS) initiatives in Finland and Norway [10]. Through a review of new mobility service typologies and a comparative analysis based on established transition frameworks, the research explored the interaction between regulatory institutions and rapidly evolving digital mobility solutions. The findings indicate that although the two countries currently face similar practical challenges and offer comparable smart mobility services, their long-term regulatory approaches and policy instruments may diverge significantly. The study emphasized the importance of proactive governance, adaptive regulatory frameworks and strategic public sector involvement to ensure that smart mobility innovations contribute to sustainable transport objectives while avoiding unintended increases in private motorized travel.

Furthermore, Alotaibi et al. [11] investigated the impact of smart mobility solutions on urban transportation efficiency in Saudi Arabian cities within the context of the country's Vision 2030 and sustainable development objectives. Using a comprehensive public survey, the study examined user awareness, travel behaviour, perceived benefits and barriers to the adoption of technologies such as smart buses, ride-sharing services, e-scooters, and real-time traffic management systems. The findings revealed a strong willingness among respondents to embrace smart mobility solutions, while highlighting infrastructure limitations, insufficient public awareness, and affordability concerns as the primary obstacles to wider adoption. The results highlighted the need for strategic infrastructure investments, targeted awareness campaigns, and integrated public transport policies to accelerate the transition toward more efficient, sustainable, and user-centred urban mobility systems.

Singh et al. [12] examined the integration of the IoT with autonomous vehicles as a key enabler of intelligent mobility and sustainable urban transportation systems. The chapter reviews how IoT technologies facilitate real-time communication among vehicles, infrastructure and road users, enabling enhanced traffic management, cooperative driving, predictive maintenance, and data-driven decision-making. It further discusses the role of connected sensing, cloud computing and intelligent communication networks in improving transportation safety, operational efficiency, and user experience, while addressing challenges related to cybersecurity, privacy, interoperability, and large-scale deployment. The analysis highlighted the transformative potential of IoT-enabled autonomous mobility and also emphasized the need for robust technological frameworks and coordinated policy development to support the evolution of safer, smarter, and more sustainable transportation ecosystems.

Another interesting paper, implemented by El Yanboiy et al. [13], presented a comprehensive review of the integration of the Internet of Vehicles (IoV) with ADAS, highlighting their combined potential to enhance transportation safety, connectivity, and operational efficiency. The study examines IoV architectures, vehicle-to-everything (V2X) communication frameworks, intelligent sensing technologies, and ADAS functionalities, emphasizing how real-time data exchange and localized decision-making can improve situational awareness and proactively mitigate traffic risks. The analysis identified significant opportunities for creating an interconnected mobility ecosystem capable of predicting and responding to dynamic road conditions while also discussing key challenges related to network latency, cybersecurity, interoperability, standardization, and regulatory frameworks. The results underscored that the convergence of IoV and ADAS represents a critical step toward safer, more efficient, and more sustainable intelligent transportation systems, while highlighting the need for coordinated technological and policy development to support large-scale implementation.

Koti et al. [14] presented SmartYatra, an intelligent road-safety framework that combines dynamic driver behaviour profiling with real-time vehicle condition monitoring to reduce accident risk and promote safer driving practices. The proposed system integrates sensor-based data, weighted safety scoring, adaptive speed regulation, instant alerts and periodic performance reports to provide personalized safety interventions and proactive vehicle maintenance recommendations. Simulation results demonstrated approximately 90% accuracy in driver profiling, up to a 78% reduction in overspeed exposure for aggressive driving profiles, and measurable improvements in unsafe-event detection and adaptive speed estimation compared with conventional rule-based telematics and Intelligent Speed Assistance systems. The study highlighted the potential of edge-based, low-bandwidth intelligent safety platforms to support next-generation connected transportation systems while providing a scalable foundation for future applications such as driver fatigue detection and autonomous vehicle integration.

Lastly, Damsara and de Barros [15] conducted a systematic review of the factors influencing user acceptance of ADAS, recognizing that widespread adoption is essential for maximizing their road safety benefits. Following the PRISMA methodology and a systematic classification process, the review synthesized evidence from existing international studies and examined the applicability of established technology acceptance and behavioural models. The analysis identified fifteen key factors affecting ADAS acceptance, revealing that several influential determinants extend beyond traditional technology acceptance frameworks. The study highlights the need for a dedicated ADAS-specific user acceptance model and provides valuable insights for researchers and vehicle manufacturers seeking to improve user awareness, trust, and the successful deployment of intelligent driver assistance technologies.

Overall, the contributions in this Special Issue demonstrate that the future of smart mobility and vehicle safety will be shaped by the convergence of multiple interconnected technological and societal developments. Progress in artificial intelligence, connected and cooperative transportation systems, intelligent sensing, data-driven decision-making, and advanced driver assistance technologies is increasingly complemented by innovations in sustainable mobility planning, electrification, digital infrastructure, and human-centred design. At the same time, the studies emphasize that technological advances alone are insufficient; successful deployment also depends on robust regulatory frameworks, resilient communication architectures, cybersecurity, user trust, and widespread public acceptance. These contributions reinforce the need for integrated, multidisciplinary approaches that bridge engineering, data science, transportation planning, behavioural research, and public

policy, ultimately supporting the development of safer, more efficient, more resilient, and more sustainable mobility ecosystems.

3. Future Directions

The contributions published in this Special Issue highlight significant advances in smart mobility, intelligent transportation systems and vehicle safety technologies. At the same time, they reveal several research challenges that require further investigation to support the deployment of safe, efficient, and user-centred transportation systems.

A first priority concerns the development of robust and trustworthy artificial intelligence for safety-critical applications. While several studies demonstrated the potential of AI-driven perception, monitoring and decision-support systems, future research should focus on improving explainability, transparency, and validation under diverse real-world conditions. The ability of AI systems to operate reliably in rare, uncertain, or adverse scenarios remains a critical requirement for widespread deployment in automated and connected vehicles. A second research direction relates to the integration of connected vehicles, intelligent infrastructure and energy systems into unified mobility ecosystems. The studies on vehicle-to-grid services, charging infrastructure planning and cooperative transportation systems illustrate the growing interdependence between transportation and energy networks. Future work should investigate scalable architectures that enable seamless communication among vehicles, infrastructure, power grids and traffic management centres while ensuring cybersecurity, privacy protection, and operational resilience.

Human factors remain equally important. Several contributions emphasized the role of driver attention, visual behaviour, user trust and technology acceptance in determining the effectiveness of advanced driver assistance systems. As vehicles become increasingly automated, further research is needed to understand human–machine interaction, driver adaptation, behavioural changes, and trust calibration. Personalized assistance systems that account for individual driving styles, cognitive characteristics, and contextual conditions represent a promising avenue for enhancing both safety and user acceptance. Another important challenge concerns the validation of emerging technologies through large-scale and real-world testing. Although simulation environments, synthetic data generation, and digital modeling tools provide valuable opportunities for accelerating development, future studies should focus on bridging the gap between virtual testing and operational deployment. Digital twins, high-fidelity simulation platforms, and hybrid validation frameworks combining synthetic and real-world data may play a key role in supporting the safe introduction of connected and automated mobility solutions.

Finally, future research should adopt increasingly multidisciplinary perspectives that combine engineering, data science, behavioural sciences, urban planning, and public policy. The transition toward smart mobility will depend not only on technological innovation but also on regulatory frameworks, infrastructure readiness, public acceptance, and societal benefits. Addressing these interconnected dimensions will be essential for creating transportation systems that are safer, more sustainable, more resilient, and more responsive to the evolving needs of users and communities. Overall, the papers in this Special Issue demonstrate that the future of transportation lies in the convergence of artificial intelligence, connectivity, automation, infrastructure intelligence and human-centred design. Continued research across these domains will be fundamental to realizing the full potential of smart mobility while ensuring that safety remains at the core of transportation innovation.

Acknowledgments: The authors sincerely thank the editorial team of *Vehicles* for their support in organizing this Special Issue. The authors also wish to thank all the contributing authors for their valuable work and the reviewers for their thoughtful comments and suggestions.

Conflicts of Interest: The authors declare no conflicts of interest.

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