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Transforming Transport:
Evolution of Mobility Technologies and Services

Technological shifts shaping the future of transportation, from electrification to automation and platform-based services

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Introduction

Over the past two decades, mobility has undergone a dramatic transformation that has been driven by technological innovation and a broader societal shift from ownership to access-based mobility. In many global cities, urban areas have become testing grounds for innovative mobility concepts. Connected travelers and digital natives – individuals who are actively linked to the transportation network with digital tools – often prioritize convenience, on-demand access, and connectivity while also questioning the economic and environmental costs of private car ownership. Cultural shifts – such as the growth of shared and on-demand mobility, reduced rates of licensure among youth, and changing work habits (i.e., telework) – are changing mobility behaviors. For an increasing number of households in urban centers, accessing mobility when needed is more attractive than the costs and burdens of auto ownership, vehicle parking, maintenance, and insurance. Additionally, increasing concerns about air quality and greenhouse gas (GHG) emissions are contributing to this transition. The transportation sector continues to be one of the largest contributors of GHG emissions and accounts for approximately one quarter of global GHG emissions [1]. In response, the public and private sectors are exploring lower emission and shared transportation options to reduce traveler's energy use and emission footprints.

Innovations in technology are also playing a key role in this evolution. The growth of smartphones, global positioning systems (GPS), and high-speed data access are the fundamental enablers of many shared and digital mobility services. Today, travelers can access an array of mobility services via an app that provide real-time information on availability, price, travel time, and other characteristics.

These services enhance the traveler experience but enable travelers to more readily view and compare mobility options.

These same services are supporting the public and private sectors in managing demand, optimizing routing, and improving the performance of the transportation network. Connectivity is also enabling innovative service models, such as the ability to bundle different transportation services together into a single user interface often with multimodal payment options. These macro trends are laying the foundation for innovations in transportation technologies and mobility services.

This white paper provides an overview of innovative and emerging mobility technologies and services; discusses the factors influencing their development and adoption; and examines their broader social, economic, and environmental impacts. It is based upon a multidisciplinary synthesis of recent academic literature, industry reports, and global case studies. We selected sources to capture a range of perspectives—including transportation planning/urban design, engineering, technology, behavioral science, and public policy.

We emphasize the identification of cross-cutting themes, lessons learned, and real-world examples from cities and regions at the forefront of mobility innovations. The analysis offers a holistic understanding of how innovative mobility is shaping the future of transportation across different contexts. The paper is organized into four sections. In the first, we discuss innovations in electrification, alternative fuels, and vehicle automation. The second section explores the growth of shared and on-demand mobility. Next, we explore developments in integrated mobility platforms. The final section concludes with a discussion of potential implications for policy and the future of mobility innovation.

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Electrification, Alternative Fuels, and Automation

Transportation fleets are in the midst of a dramatic transformation, primarily driven by the growing adoption of electric and alternative fuel vehicles and increasing levels of vehicle automation. This represents a notable shift in how the transportation fleet integrates into energy and digital ecosystems. Both electric vehicles (EVs) and automated vehicles (AVs) are particularly significant in this transition.

Electrification of the vehicle fleet, if powered by a clean grid or clean hydrogen fuel cells, addresses several environmental challenges including reducing GHG emissions and local air pollutants.
Further, automation has the potential to transform mobility by improving safety, reducing congestion, enhancing accessibility, and creating new business models in logistics, public transit, and passenger mobility. There are several types of EVs, each with unique powertrains, energy sources, and use cases, summarized in *Table 1*.

Table 1. Types of Electric Vehicles

TYPE	DESCRIPTION	EXAMPLES
Battery Electric Vehicles (BEVs)	EVs are fully electric and rely solely on a battery pack to store energy. They produce zero tailpipe emissions and are typically charged from the electric grid.	Tesla Model 3, Chevrolet Bolt, and Nissan Leaf
Plug-in Hybrid Electric Vehicles (PHEVs)	PHEVs combine a gasoline engine with an electric motor and battery. They can be recharged from the grid and driven short distances in all-electric mode before switching to gasoline.	Toyota Prius Prime and Ford Escape Plug-in Hybrid
Fuel Cell Electric Vehicles (FCEVs)	FCEVs generate electricity through a chemical reaction between hydrogen and oxygen. These vehicles emit only water vapor and offer fast refueling, although they require hydrogen fueling infrastructure.	Toyota Mirai and Hyundai Nexo

The global EV market has experienced rapid growth over the past decade. In 2023, global EV sales exceeded 14 million units, representing more than 18% of all car sales—up from just 4% in 2020 [2]. This growth has been driven by declining battery costs, policy incentives, emission regulations, and increasing model availability. China leads the world in EV adoption, accounting for more than 60% of global sales [2]. Europe and the United States have also seen growth in EV sales and adoption. Several subregions, such as California, Norway, and the Netherlands have emerged as leaders in EV adoption, often due to a combination of regulatory and incentive approaches. In addition to light duty EV adoption, commercial fleets are also electrifying. Delivery vans, buses, and medium- and heavy-duty trucks are increasingly being electrified [3].

Despite the recent growth in EV sales, several critical challenges could impede broader adoption and integration into the mainstream transportation system. One of the most pressing issues is the availability and convenience of charging infrastructure. While home charging meets the needs of many early adopters, public charging remains limited and unevenly distributed, particularly in rural areas, multi-family housing, and underserved communities. This uneven access poses a notable barrier to equitable EV adoption. Another major concern is the resilience of the electric grid. As the number of EVs increases—alongside rising electricity demand from energy-intensive technologies like artificial intelligence (AI) data centers—local grids may experience strain, particularly during peak hours. Ensuring the grid can accommodate this demand will require substantial investment in infrastructure upgrades, smart energy management systems, and the expansion of renewable energy sources.

Affordability also remains a key factor influencing adoption. Although EVs can offer longer-term savings on fuel and maintenance, high upfront purchase prices can deter many potential buyers and lessees. Financial incentives, such as tax credits, rebates, and accessible financing options, are likely needed to make EVs more attainable across income levels.

In addition, consumer perceptions play a vital role. Concerns about limited driving range—commonly known as range anxiety—and the long time required for charging can negatively impact public willingness to switch from internal combustion engine (ICE) vehicles. Overcoming these perceptions will require improvements in battery technology, faster charging strategies, and broader consumer education. Finally, the global supply chain for critical raw materials—such as lithium, cobalt, and other rare earth elements—presents manufacturing and sustainability challenges. Trade tariffs, resource scarcity, and geopolitical tensions can all disrupt battery production. Therefore, robust lifecycle management systems, including battery recycling and safe disposal practices, are essential to ensure the longer-term viability and environmental benefits of EVs relative to conventional vehicles.

Together, these factors highlight the need for coordinated efforts across industry, government, and civil society to support the transition to electric mobility and maximize its potential environmental and societal benefits.

In addition to fleet electrification, increasing levels of vehicle automation across privately owned or leased vehicles, public transit, and shared mobility fleets are poised to significantly influence the broader transportation network. As automation technology advances, it offers the potential to enhance safety, improve traffic efficiency, reduce labor costs, and expand mobility access—particularly for individuals unable to drive.

To provide a standardized framework for understanding these advancements, SAE International—a global organization that develops mobility standards—has defined five levels of vehicle automation [4].

These levels represent a continuum from fully human-operated vehicles to fully automated systems.

- **Level 1** automation includes vehicles that support only a single automated function, such as adaptive cruise control or self-parking, while the driver remains responsible for all other driving tasks.

- **Level 2** vehicles can simultaneously control steering, acceleration, and braking. However, the driver must remain attentive and ready to take over at any moment, as these systems are considered driver-assistance features rather than autonomous capabilities.

- **Level 3** systems allow the vehicle to manage all aspects of driving in certain conditions, enabling the driver to disengage from active control and focus on non-driving tasks. However, the driver must remain available to resume control when the system requests it.

- **Level 4** vehicles are capable of full self-driving within specific operational domains, such as predefined geographic areas or controlled conditions (e.g., low-speed urban environments). Human intervention is not required as long as the vehicle operates within these parameters.

- **Level 5** automation represents full autonomy in all driving environments and scenarios. These vehicles do not require human input at any time and can operate entirely independently, without a steering wheel or pedals.

As automated driving technologies evolve and are deployed in various fleet types, understanding these levels is critical for policymakers, planners, and industry leaders. Their integration will shape future mobility systems, with implications for safety regulation, infrastructure investment, equity, and workforce development. A 2015 study by the U.S. National Highway Transportation Safety Administration (NHTSA) found that approximately 94% of vehicle accidents were due to the driver, compared to about 2% due to a failure in vehicle components and about 2% due to environmental factors [5].

For this reason, proponents of vehicle automation argue that AVs will improve safety. Privately owned AVs offer personal convenience, potentially improving safety, but they risk increasing vehicle miles/kilometers traveled (VMT/VKT). In contrast, automated transit vehicles, such as buses or shuttles, can enhance operational efficiency and reduce labor costs, although they could face challenges related to public acceptance and labor opposition. Shared automated vehicles (SAVs), such as automated or robotaxis, could present additional mobility options, but they also raise concerns about competition with public transportation increased VMT/VKT traveled, and induced demand. Induced demand refers to the phenomenon where expanding transportation options leads to an increase in overall travel. In the case of shared and automated mobility, this occurs when the introduction of services like robotaxis results in more people using roadways. For example, individuals who previously avoided taxis may begin using robotaxis because they are more affordable, are easier to access, and/or are perceived as safer. Others might shift from public transit to robotaxis or choose to live farther from city centers and make more frequent trips because robotaxis offer greater convenience than other modes. In general, several academic studies have found that shared electric AVs (SAEVs) could reduce vehicle emissions (compared to ICE fleets), replace privately owned vehicles, and require less charging infrastructure when EVs are shared [6].

As such, the potential adoption of AVs presents many use cases, opportunities, challenges, and trade-offs for cities and policymakers. However, more research is needed to better understand the complex factors that could influence public adoption, such as the built environment (e.g., urban, suburban, and rural contexts), land use, and public transit accessibility. Nevertheless, the integration of EVs and AVs could create a multiplier effect that has the potential to reduce operating costs, improve fleet management, and facilitate shared mobility. However, realizing the potential of these technologies will likely require navigating complex technological, institutional, and infrastructure challenges.

Shared Mobility

Shared mobility refers to the shared use of transportation modes that provide users with access to a vehicle or service on an as-needed basis. It encompasses a broad range of services across different domains, including ground transportation (e.g., carsharing, bikesharing, ridehailing), aviation (e.g., urban air mobility or air taxis), and maritime transport (e.g., water taxis). Smaller-scale, lightweight modes such as shared bicycles and scooters are commonly referred to as shared micromobility.

Several key characteristics shape how shared mobility services are defined and function. One distinction is between concurrent and sequential sharing. Concurrent sharing involves multiple users sharing the same vehicle or device at the same time (e.g., pooled rides). In contrast, sequential sharing refers to different users accessing the same vehicle or device one after another (e.g., carsharing or bikesharing).

Service models also vary by trip structure. Roundtrip services require users to return the vehicle or device to its original location. One-way station-based services allow users to end their trip at a different designated station. One-way free-floating services offer the most flexibility, enabling users to leave the vehicle or device anywhere within a defined service area. Common types of shared mobility passenger services are summarized in *Table 2*. Common types of last-mile delivery services are summarized in *Table 3*.

Table 2. Common Shared Mobility Passenger Services

Bikesharing (sometimes referred to as shared micromobility).	Bikesharing is a service that provides travelers on-demand, short-term access to a fleet of shared bicycles typically for a fee. Bikesharing service providers typically own and maintain the bicycle fleet. Service providers may also provide bicycle parking and charging for e-bike fleets.
Carsharing	Carsharing is a service that provides travelers on-demand, short-term access to a fleet of shared motor vehicles typically through a membership, and travelers pay a fee for use. Carsharing service providers typically own and maintain the fleet and provide insurance, gasoline/charging, and parking. This includes both roundtrip (trip starts and ends in same parking space) and one-way services that can start and end in different locations.
Microtransit	Microtransit is a privately or publicly operated transit service that typically uses multi-passenger/pooled shuttles or vans to provide on-demand or fixed-schedule services with either dynamic or fixed routing. It can also include sedans.
Personal Vehicle Sharing (also known as peer-to-peer carsharing)	Personal vehicle sharing is a service that provides travelers on-demand, short-term access to a fleet of privately owned vehicles and travelers pay a fee for use. Vehicle owners and guest drivers broker transactions using an online-enabled application or platform (i.e., smartphone apps) provided by a personal vehicle sharing company. The personal vehicle sharing company may provide resources and services to make the exchange possible (e.g., an online platform to facilitate the transaction, customer support, etc.). Personal vehicle sharing companies do not own or maintain a fleet of vehicles.

Table 2. Common Shared Mobility Passenger Services

Adapted from [7]

Ridehailing (also known as transportation network companies/TNCs)	Ridehailing services provide travelers pre-arranged and on-demand rides for compensation using an online-enabled application or platform (such as smart phone apps) to connected travelers with drivers using their personal, rented, or leased vehicles. Digital applications are typically used for booking, electronic payment, and ratings.
Ridesharing (also known as carpooling and vanpooling)	Ridesharing is the formal or informal sharing of rides between drivers and travelers with similar origin-destination pairings. Carpooling typically includes the sharing of rides using vehicles capable of carrying two to six passengers, whereas vanpooling using typically uses vehicles capable of carrying between 7 and 15 passengers.
Scooter Sharing (sometimes referred to as shared micromobility)	Scooter sharing is a service that provides travelers on-demand, short-term access to a fleet of shared scooters for a fee. Companies typically provide fuel/charging (if applicable) and maintenance. Service providers may also provide insurance.
Shared Automated Vehicles (SAVs) (also known as robotaxis or roboshuttles)	Shared automated vehicles are self-driving (SAE Level 4-5) vehicles that provide on-demand or scheduled robotaxi services. These vehicles operate without a human driver and are typically accessed through digital platforms that match riders with available vehicles.
Taxis	Taxis provides travelers pre-arranged and on-demand access to transportation services for compensation and pay a fee each time for usage. Travelers can typically access these rides by scheduling trips in advance, by street hail or by e-Hail. A street hail is performed by raising a hand on the street, standing at a taxi stand, or specified loading zone. E-Hail entails dispatching a driver on-demand using a smartphone app.

Table 3. Common Last-Mile Delivery Services

Adapted from [7]

Courier Network Services (CNS)	A commercial for-hire delivery service for monetary compensation using an online application or platform (such as a website or smartphone app) to connect freight (e.g., packages, food, etc.) with couriers using their personal, rented, or leased vehicles, bicycles, or scooters.
Drone Delivery	A form of for-hire aerial goods delivery using uncrewed aerial vehicles (UAVs) or drones to deliver goods such as packages, food, medical supplies, or other small cargo. These services are primarily used for short-distance, last-mile logistically and are typically operated through an online platform and may function autonomously or semi-autonomously, often using GPS, sensors, and advanced software for navigation and drop-off.
Personal Delivery Devices (PDD)	Personal Delivery Devices (PDDs) are low-speed, ground-based autonomous delivery robots designed to transport goods such as packages, groceries, or meals directly to consumers. These devices typically operate on sidewalks, crosswalks, and other pedestrian pathways, using sensors, cameras, GPS, and onboard computing to navigate environments and avoid obstacles. PDDs are generally electrically powered and are used for short-distance, last-mile delivery. Local and provincial/state regulations may govern their speed, size, and operating domains (e.g., curb, bike lane, on-street, etc.).

There are distinct differences in the evolution of shared mobility services in developed and developing regions of the world [8]. In developed regions, shared mobility has primarily been tech-enabled from the outset (e.g., Uber, Zipcar, Lime apps). These services are typically initiated by large, venture-capital backed companies and designed around digital integration from their initial deployment [8]. In contrast, shared mobility in developing regions have often emerged from informal transport systems like minibuses, motorcycle taxis, and auto rickshaws. These services typically predate technology platforms and are rooted in local entrepreneurial activity. Technological enhancements (e.g., apps) are now being layered onto these systems to improve operations and expand access [8].

The environmental impacts of shared mobility are complex and occur at both micro (per-trip) and macro (systemwide) levels. On one hand, shared mobility can reduce private vehicle use and improve first- and last-mile connections to public transit. In contrast, some studies have found that certain shared modes can draw users away from walking, biking, and public transit—particularly in areas with limited transit coverage or auto-oriented built environments. Operational factors such as fleet rebalancing (in free-floating systems) and empty vehicle miles (in ridehailing, taxis, and self-driving vehicles) can also increase emissions. However, when services employ electric, alternative fuel, or other low-emission vehicles powered by clean energy, shared mobility has the potential to lower air pollutant and GHG emissions, while enabling more multimodal travel behavior. An overview of the impacts of shared mobility is summarized in *Table 4*

Table 4. Overview of Shared Mobility Impacts by Mode

MODE	TRAVEL BEHAVIOR IMPACTS	ENVIRONMENTAL IMPACTS
Ridesharing (Carpool/ Vanpool)	Reduces VMT (4–6% at employer sites; ~1–2% regionally); shifts commuters to pooled trips [9]	Reduces fuel use and GHGs significantly (up to 7.74B gallons saved; up to 68M tons GHG annually) [10]
Carsharing (B2C)	Reduces vehicle ownership (11–26% sold cars) [11]; reduces VMT (27–43% avg) [12]; increased walking, some shifts toward public transit	Reduces GHGs by 34–41% per household; each carsharing vehicle replaces 6–23 private cars [13] [11] [14]
Carsharing (P2P)	Encourages fewer vehicle purchases; increases car access for carless users [15]	Enables vehicle monetization and improved asset use; less data available on emission impact [15]
Shared Micromobility (Bike/Scooter Sharing)	Increases cycling and walking; reduces short car/taxi trips; complements public transit (esp. in low-density areas) [16]	Moderate GHG reductions; calorie burn; lifecycle impacts vary—e-scooters can be more emission intensive [16]
TNCs (Uber, Lyft)	Often substitutes for public transit, walking, and biking (esp. in dense cities); induces new trips; often increases VMT/VKT [17]	Mixed impact—can comprise of 3.5 to 7% of citywide VMT/ VKT (depending on the city and context) [18]; some studies show net GHG increases [17]
Shared Automated Vehicles (SAVs)	Could reduce personal vehicle ownership; may increase VMT/VIKT (esp. due to zero-occupancy trips) [6]	Modeling suggests up to 94% GHG reduction if electric and pooled; risk of increased emissions without pooling [6]

Safety and curbside management are recurring concerns. Shared mobility can introduce modal conflicts—especially at curbs—between vehicles, micromobility users (e.g., scooters, bikes), and pedestrians. This can lead to unsafe conditions and physical obstructions. In response, many cities have implemented policies such as speed limits, geofenced no-ride zones, and dedicated curb infrastructure (e.g., parking areas, loading zones) [16]. Some cities have also placed caps on the number of vehicles or devices in specific areas. To improve oversight and real-time management, standardized data protocols like the Mobility Data Specification (MDS) and Curb Data Specification (CDS) —developed by the Open Mobility Foundation (OMF)—have been adopted [16]. These frameworks enable collaboration between public agencies and private operators to support dynamic, multimodal curb management and policy enforcement.

Equity and access remain critical issues. Shared mobility services are not always evenly distributed and may overlook underserved communities. Barriers such as the need for smartphones, credit cards, or digital literacy can further limit access [19]. To address this, some agencies and providers have introduced cash payment options, discounted fare programs, and partnerships with community-based organizations (CBOs) to improve outreach and adoption. In addition, many providers are incorporating universal design features (e.g., high-contrast text, screen readable apps, etc.) into booking platforms and vehicles to better serve older adults and travelers with disabilities—although gaps still remain [19].

Financial sustainability is another ongoing challenge. Many shared mobility services are unable to fully recover operational costs through fares alone. To bridge this gap, agencies and companies have explored diverse business models including public funding, public-private partnerships, advertising revenue, in-kind support (e.g., discounted parking), and risk-sharing arrangements where public entities or CBOs absorb some financial loss to support service in equity-priority areas (unpublished data Shaheen, Cohen et al. 2026).

Programs that are not financially or operationally sustainable face significant risks. Services dependent on short-term grants, pilot funds, or private subsidies without a clear path to longer-term sustainability can be vulnerable to sudden cutbacks or shutdowns. This can erode public trust—particularly in communities that have come to rely on these services—and contribute to "pilot fatigue," where users grow skeptical of temporary programs that are withdrawn with limited notice. This can also lead policymakers to be more hesitant in supporting such mobility initiatives. Without consistent funding or institutional backing, shared mobility programs risk stalling, scaling back, or failing to reach the communities that need them most—ultimately reinforcing mobility inequities (unpublished data Shaheen, Cohen et al. 2026).

Shared mobility allows travelers the ability to access more modal options and reduce their reliance on private vehicle ownership and use. However, the growth of shared mobility has presented several environmental, safety, aesthetic, equity, and other institutional opportunities and challenges [20].

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[1] The Mobility Data Specification (MDS) is an open-source data standard to enable real-time data sharing between cities and mobility service providers. MDS allows cities to monitor, manage, and regulate mobility services by providing APIs that support trip data, vehicle status, and service areas. MDS can support the dynamic management of curbs and streets, including enforcing operational and parking rules of mobility services.

[2] The Curb Data Specification (CDS) is a standardized data format developed to help cities digitally manage curb space for activities such as loading, parking, delivery, and passenger pick-up/drop-off. CDS enables municipalities to communicate curb regulations and availability in real time to shared mobility service providers. CDS can enhance curb efficiency, safety, and compliance by making curb use machine-readable and programmable.

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Navigating Integration: Opportunities and Challenges to Achieving Digital Integration

Shared mobility services are increasingly being incorporated into app-based platforms that consolidate a range of functions, including trip planning, booking, payment, subscriptions, and, in some cases, both transportation and non-transportation services. These platforms vary by regional context, and three prominent models have emerged globally: 1) mobility on demand (MOD), 2) mobility-as-a-service (MaaS), and 3) super apps [22]. Each represents a distinct approach to digital mobility integration, shaped by local technology infrastructure, market conditions, and governance frameworks.

Mobility on demand (MOD) is a framework developed by the U.S. Department of Transportation in the mid-2010s, which has primarily gained traction in North America. MOD facilitates user access to mobility, goods, and services on demand by leveraging shared mobility services, delivery networks, and public transit systems within an integrated, multimodal transportation network [22]. Central to the MOD concept is the commodification of mobility: transportation services are treated as goods with quantifiable economic values that vary by cost, travel time, wait time, number of transfers, convenience, and other performance attributes. In this sense, MOD aligns closely with consumer choice models and market-driven service design, emphasizing flexibility and efficiency in meeting individual travel needs [21]. While MOD has become relatively mainstream in North America, the concept is evolving, placing greater emphasis on digital fare systems, account-based ticketing, and payment integration across mobility service providers.

In contrast, mobility-as-a-service (MaaS) is grounded in a more centralized and curated approach to mobility integration. Originating in Europe in the early 2010s, MaaS creates a digital marketplace through which users can seamlessly access and combine multiple transportation modes via a single interface. A defining feature of MaaS is its intermediary role: the platform aggregates services from various providers, brokers access, and repackages these offerings into bundled mobility strategies [22]. MaaS emphasizes passenger mobility and often operates on a pay-as-you-go or subscription model, allowing users to plan, book, and pay for multimodal journeys within a unified system. Although initially developed in Europe, MaaS frameworks have since been tested and adapted in diverse global contexts. However, several notable MaaS initiatives have failed to become financially sustainable [22]. The most notable is MaaS Global, a prominent Finnish company behind the MaaS concept that declared bankruptcy in March 2024 [23].

Super apps represent a broader category of digital platforms that incorporate mobility alongside a wide array of non-transportation services, including mobile payments, retail, communications, and logistics. Unlike MOD and MaaS, which are focused exclusively on transportation, super apps serve as multifunctional digital ecosystems. These platforms emerged in several developing regions in the early to mid-2010s—particularly Southeast Asia and parts of Africa—as a means to deliver essential digital services to populations with widespread mobile phone use but limited fixed broadband infrastructure [22]. Super apps such as Gojek and Grab in Southeast Asia and Gozem in Africa, illustrate how mobility services can be integrated within broader digital platforms that address multiple aspects of everyday life. Recently, Gojek and Grab have entered merger discussions in an effort to consolidate business operations and enhance profitability [24].

Despite the potential for MOD, MaaS, and super apps in improving user experience and reducing transaction friction in trip planning and payment, widespread adoption faces several persistent challenges. A key barrier lies in the need to harmonize hardware, software, and data standards across numerous and often competing public and private mobility service providers. Achieving such interoperability requires coordination in the development of both back-end infrastructure—such as application programming interfaces (or APIs), fare collection systems, and routing software—and user-facing interfaces that aggregate and display real-time information.

Beyond technical alignment, institutional and governance challenges present notable obstacles to integration. Effective implementation often hinges on data sharing and governance arrangements among stakeholders, which are complicated by concerns around traveler privacy, proprietary data, and competition. Jurisdictions differ in their approaches: European and East Asian governments have taken a more active role in setting data governance frameworks that facilitate cooperation while protecting user data [22]. In contrast, North American markets tend to rely on private sector negotiation and market-driven coordination, which can lead to fragmented systems and slower innovation in platform interoperability [22].

Looking ahead, the development of consensus-based industry standards—analogous to those of the Payment Card Industry Security Standards Council—may provide a more viable model for advancing ecosystem standardization and establishing robust data governance norms. However, in the absence of such coordinated efforts, the implementation of integrated ticketing systems and mobility wallets will likely continue to face substantial barriers [25]. These tools, which allow users to seamlessly plan, book, and pay for multimodal journeys within a single interface, hold notable potential for enhancing convenience and fostering sustainable travel behaviors. Mobility wallets, in particular, could be leveraged to offer bundled services such as subsidized public transit passes, loyalty programs, or employer-sponsored benefits. Such features not only improve user experience but may also help incentivize modal shifts toward shared and public transportation options.

In summary, the global evolution of app-based mobility platforms reflects diverse strategies for digital integration, each shaped by regional priorities (including urban density, public transit accessibility, land use, etc.), technological capacity, and governance models. While the potential of these platforms to transform urban mobility is considerable, realizing their full benefits will require addressing both the technical and institutional barriers that currently inhibit broader deployment and equitable access.

[3] A mobility wallet is a digital platform or application that enables users to plan, book, and pay for a variety of transportation services—such as public transit, ridehailing, bike- and scooter sharing, carsharing, and parking—from a single account or interface. Often integrated into MaaS systems, mobility wallets can consolidate fare payments, subsidies, discounts, or mobility credits (e.g., for low-income users) and offer seamless, multimodal trip experiences across different service providers.

Conclusion

The movement of people and goods is being reshaped by the convergence of four major trends: electrification, automation, on-demand mobility, and app-based platforms. Together, these forces are transforming transportation into a more multimodal, connected, and data-driven system. While these innovations create new opportunities, they also introduce complex challenges for travelers, urban planners, and policymakers.

Electrification offers a pathway to cleaner mobility, yet its full potential depends on addressing challenges related to electric grid capacity, energy resilience, and critical mineral supply chains. The extraction and processing of these minerals raise concerns about environmental sustainability and the well-being of communities located near mining sites. Vehicle automation presents similar dualities. While it promises enhanced safety and operational efficiency, it also raises difficult questions around labor displacement, liability in the event of crashes, and control over the massive amounts of data generated by automated systems. The question of who owns and governs these data—individual consumers, vehicle manufacturers, or mobility service providers—will play a pivotal role in shaping innovation, regulation, and public trust.

Shared mobility services, enabled by app-based platforms, are expanding access to transportation options, offering users more convenience and flexibility. However, they also bring unintended consequences, such as induced demand, shifts away from public transit, and heightened environmental concerns. At the same time, the growing reliance on digital platforms introduces pressing issues related to data privacy and equitable access. In many places, troubling trends in road safety persist, with increasing fatalities among pedestrians and cyclists. Emerging technologies like AI and connected infrastructure offer potential tools for predictive analytics and real-time risk detection, but these advances must be carefully balanced with concerns about surveillance, consumer privacy, and the ethics of data use.

As the mobility ecosystem continues to evolve, transportation and energy systems continue to be deeply interdependent. The trajectory of future mobility will be influenced by technological capabilities but also by public perception, regulatory frameworks, and economic policy. Energy companies are beginning to diversify their business models, incorporating renewable energy and EV charging infrastructure, further blurring the lines between transportation and the energy sectors.

Looking ahead, both urban and rural communities will need to invest in robust digital and energy infrastructure to keep pace with mobility innovations. Policy tools such as dynamic pricing and digital curb management may offer more efficient ways to manage infrastructure, but they must be implemented with attention to fairness and accessibility. Ultimately, realizing the benefits of these transportation shifts will require thoughtful planning and policymaking, interdisciplinary collaboration, and ongoing research to ensure that technological progress translates into public good.

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[4] Topics areas not covered in this paper include:1) predictive modeling in transportation planning; 2) the future outlook of multimodal travel and the automotive sector; 3) climate change and strategies for the energy sector; 4) smart cities; urban form and the built environment; transportation finance (e.g., pay-as-you-drive/tolling); and 5) a detailed overview of differences/challenges by region.

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