Institute of Transport Economics
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ENGLISH Summary

Autonomous vehicles and transport system organization

Shifting boundaries, mandates and responsibilities

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Autonomous vehicles (AVs) are likely to transform urban mobility. By focusing on transport systemic dynamics, organizational structures, and user practices, we present a conceptual framework that has four AV scenarios and eight non-mutually exclusive pathways for potential AV introduction. The complexity and multiplicity of future system configurations underscores that we cannot take for granted how new technologies will be provided, used and regulated. Current mobility business models, legal frameworks, land-use practices, and enforcement policies must be updated. Recognizing the political nature of AV integration, system stakeholders must work actively to ensure access to AV mobility without exacerbating social inequities, climate emissions, excessive land-use, and economic inefficiency.

Introduction

The integration of autonomous vehicles (AVs) into transport systems represents a pivotal shift in both private and professional mobility. While early discussions around AVs focused on their technical feasibility, today's advancements highlight their broader implications for the organization and operation of transport services. This report addresses the uncertainties and opportunities presented by AVs, aiming to help public sector actors navigate this transformative period. By analysing potential pathways to AV adoption, it explores the organizational structures and systemic changes necessary for their successful integration.

The future of AVs cannot be taken for granted. Whatever outcomes emerge will be the result of deliberate choices made today. It is up to policymakers and public authorities to ensure that AVs contribute to accessible mobility for all, while avoiding outcomes that exacerbate inequality, waste urban space, degrade natural environments, strain public finances, or increase carbon emissions.

Building on insights from existing studies, such as the Oslo Study, this report shifts the focus from predictive modelling of user behaviour to a qualitative examination of roles, responsibilities, and organizational dynamics within the transport system. It introduces a conceptual framework centred on three dimensions of AV use – distance to access, timing of service delivery, and type of occupancy – to help policymakers evaluate various scenarios for AV integration in urban and peri-urban areas.

Additionally, the report examines the legal and regulatory frameworks that will shape AV adoption. For instance, the Norwegian Vocational Transport Act, which defines boundaries between public and private transport services, may require updates to accommodate AV technologies. Similarly, the unique role of county governments in regulating taxis and purchasing public transport services highlights their potential to influence how AVs are integrated into the transport system. By focusing on these organizational and legal aspects, the report provides a foundation for public authorities to consider how AVs can align with broader mobility goals while addressing local and regional needs.

Research Approach

The research approach adopted in this report is conceptual, grounded in innovation studies, economic reasoning and supported by insights from political science. The central aim is to investigate the underlying dimensions of AV use and the role of political decision-making in shaping market outcomes, including service levels, societal utility, and the necessity of regulatory interventions. This report lays out pathways for AV introduction and explores the reorganization of transport services and their implications for the broader mobility landscape.

A key theoretical underpinning of the report is the multi-level perspective (MLP) framework, modified to reflect the complexity of urban mobility as a multi-regime system. Within this framework, AVs are positioned as an innovation that could disrupt the current socio-technical regimes of automobility and public transport. The study examines how these regimes might evolve under pressure from landscape-level trends such as digitalization and climate change.

We also discuss AVs in the context of Mobility as a Service (MaaS) by drawing on prior studies to highlight how different organizational structures could influence AV integration. Whether AVs are introduced by private companies, public transport authorities (PTAs), or through public-private partnerships, the organizational and regulatory context will be critical in determining their role within the mobility system.

We identify three core practices – storage, maintenance, and operation – that are central to motor vehicle use and explore how these could be reconfigured in an AV future. These form the basis for four scenarios of transport system organization: business-as-usual, commercial AV systems, public AV systems, and private-commercial AV systems. To further articulate the transition pathways to these scenarios, we use three dimensions of AV use – timing (fixed vs. on-demand), geography (station-based vs. door-to-door), and occupancy (exclusive vs. shared) – to define eight potential pathways. These pathways and scenarios are conceptual tools that are not mutually exclusive but represent corner solutions, providing policymakers with a structured framework to evaluate the organizational implications of AV adoption.

Scenarios for transport system organization with AVs

The three practices that form the basis for forming our scenarios are:

- **Storage**: While vehicle storage is often associated with ownership, it applies to other segments such as leasing, subscriptions, car sharing, and rentals. AVs have the potential to reduce the need for private storage by enabling vehicles to operate more continuously, but commercial or public storage will remain necessary.
- **Maintenance**: Currently, maintenance responsibilities are largely tied to ownership and leasing, with providers covering these tasks in other segments. With AVs, maintenance will mainly fall to service providers, reducing consumer involvement.

- **Operation**: AVs will fundamentally shift operational responsibilities from consumers to providers. In segments such as ridesourcing and taxis, this shift aligns with existing practices, but for private ownership, and leasing, it marks a significant departure.

We categorize transport segments into three groups: private car use (ownership, leasing, and subscriptions), access-based car use (e.g., car sharing, ridesourcing, taxis), and public transport. Each segment is analyzed to show how responsibilities for the three sub-practices might evolve with AVs. The analysis highlights that private car use would undergo the most significant changes, with users relinquishing operational responsibilities to the service providers. For access-based and public transport segments, the shift primarily reinforces existing practices, with providers (either public or private) managing storage, maintenance, and operation. Four scenarios are developed to articulate differences in roles and responsibilities given these practices and segments:

1. **Business-as-Usual (BAU)**: Private ownership remains dominant, with consumers relinquishing their operational role; current structures for storage and maintenance are maintained.
2. **Public-Private Service (PPS)**: Personal vehicles are largely phased out in favor of a system dominated by commercial transport services. Providers assume nearly all responsibilities for storage, maintenance, and operation, with public transport maintaining its current structure.
3. **Public Transit Scenario**: All transport services, including AVs, are integrated into a unified public transport system under the oversight of public transport authorities. This scenario envisions the most significant shift toward a public-centric model.
4. **Private Commercial Scenario**: Both personal vehicles and public transport are replaced by private commercial operators. This scenario emphasizes efficiency but risks creating inequities in service provision, particularly in less profitable areas.

Pathways to Scenarios

Using three key dimensions of AV use – geography, timing, and occupancy – we identify eight potential pathways for AV introduction. Each pathway represents a unique combination of these dimensions, offering conceptual a tool to articulate system change:

1. **Geography**: ranges from fixed stations or stops, typical of public transport, to dynamic, door-to-door services as seen in taxis and personal vehicles, and a middle ground, involving pick-up/drop-off (PUDO) points.
2. **Timing**: AV services could operate on a spectrum from fixed schedules, mirroring traditional public transport, to fully on-demand services akin to ridesourcing platforms.
3. **Occupancy**: spans exclusive use, where passengers control who they share the vehicle with, to shared use, where strangers co-occupy vehicles. A middle option involves selective sharing, catering to specific groups or memberships.

The eight pathways emerge from different combinations of these dimensions. Each pathway highlights trade-offs between user convenience, system efficiency, and environmental impact. They offer insights into how transport systems might evolve based on regulatory choices, market responses, and societal preferences. The pathways also underscore the importance of aligning AV integration with broader urban planning and sustainability goals. The following table shows the eight pathways for AV introduction (colours represent expected outcomes as problematic, mixed or promising):

Pathways	TIME	DISTANCE	OCCUPANCY
P1	Dynamic	D2D	Exclusive
P2	Dynamic	D2D	Shared
P3	Dynamic	S2S	Exclusive
P4	Dynamic	S2S	Shared
P5	Fixed	D2D	Exclusive
P6	Fixed	D2D	Shared
P7	Fixed	S2S	Exclusive
P8	Fixed	S2S	Shared

Discussion

Shared AV systems offer the potential to dramatically reduce parking demand by maximizing vehicle utilization, but exclusive-use models could increase congestion due to idling and non-use. Policymakers must rethink parking norms, shifting from minimum requirements to innovative regulations that encourage sustainable mobility and land use. Enforcement mechanisms, like time limitations and fines, must adapt to prevent AV-related inefficiencies, such as vehicles circumventing restrictions by idling or relocating. Additionally, strategically consolidating parking into hubs, leveraging underground facilities, and integrating parking with public transport hubs can optimize land use and ensure accessibility while reducing congestion.

Ensuring minimum levels of service for mobility across diverse geographic contexts presents complex challenges. PTA) face competing mandates to both provide high-quality alternatives to private car use in urban areas and maintain minimum service levels in rural regions for non-car owners and vulnerable groups. High-frequency and well-connected public transport systems are essential to meet urban mobility goals and attract car users. However, rural and low-density areas require coverage-oriented solutions, such as specialized routes, taxi services, or exclusive contracts with providers. The rise of AVs presents opportunities to rethink service delivery in these areas, potentially offering more efficient and inclusive options while addressing the challenges of balancing equity and efficiency across geographic contexts.

Autonomous vehicles will change the economics of mobility for all transport segments, both public and private. From economic reasoning we expect that irrespective of which transition pathway is followed, there will be a decrease in generalised cost, the economic term for the sum of disutility associated with transport, including out of pocket expenses, travel time and inconvenience. Exactly how much will vary from trip to trip, and among different organizational models, and depend on a series of factors that are presently unknown. Still, we argue that some outcomes are more likely than others.

Firstly, the impact on the PT system is likely to come through two mechanisms. 1) lower reliance on drivers, which is currently a major cost constraint on service; a restructuring of the costs associated with vehicle operation are likely to reduce overall costs, and 2) new services added to the system, which are likely to increase costs. This raises a series of questions relating to distribution, accessibility and desired levels of service. Secondly, and following the first mechanism, the current socio-technical regime is likely to be challenged. Today's distribution of responsibilities between tiers of government and public and private actors needs to be reconsidered. However, exactly how is not obvious. Thirdly, and following the second mechanism, if the PT system is to expand, this raises a series of questions relating to the role of public versus private mobility. Again, the exact outcome is not clear. What is clear is that a comercial, open-access-based systems will be very different from an organisation built around an expanded PTA, with tendering or licensing as policy instruments. Lessons can be drawn from the recent introduction of Mobility-as-a-Service (MaaS) and e-scooters. Fourthly, the vehicle segments that are likely to consolidate or disappear in the face of competition from AVs are

the current on-demand modes for car-sized vehicles; taxis, ridesharing, and car sharing. These roles could all be served by on-demand access to AVs.

Key areas for future study include understanding customer responses, such as trust, willingness to pay, and preferences for services, with metrics developed to assess these along dimensions like distance, timing, and occupancy. The financial implications of AV deployment also demand attention, including the costs to governments, consumers, and the private sector, and the required public investment to ensure equitable and sustainable systems. Additionally, the compatibility of AV technology with various transport modes must be explored to identify viable niches that can be nurtured for transitions toward optimized regimes. The changing symbolic meaning of car ownership in an AV future also warrants examination, as shifting perceptions of the car as a cultural and material artefact could influence adoption patterns and user behaviour. Finally, public and political reactions to significant mobility changes require investigation to anticipate resistance and ensure that interventions are realistic, effective and socially acceptable.