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Autonomous driving

Key to the mobility of tomorrow

Abstract

Introduction

Access to mobility is a basic prerequisite for social participation and therefore a core component of public services. Quality of life depends directly on whether people are able to reach their destinations conveniently and reliably. At the same time, mobility is a key factor in the competitiveness of cities, municipalities and companies.

Nevertheless, public transport systems are currently facing major challenges, primarily due to limited public funding and a growing shortage of drivers. In rural areas in particular, this threatens not only everyday mobility but also social cohesion and trust in public institutions. The COVID-19 pandemic clearly demonstrated that when a nurse can´t reach the hospital, the problem is no longer an individual one but a societal issue. Mobility is systemically relevant, and quality of life depends to a significant extent on universal access to attractive and reliable transport services across the country.

Framework conditions

Since 2022, Germany has had a legal framework in place for the operation of fully driverless autonomous vehicles in public transport. At the same time, the technology is already being tested nationwide in pilot projects. Both legislation and technology require a clearly defined operating area as well as continuous monitoring by a remote technical supervisor. This automation level is classified as Level 4.

For local public transport, the necessary technological maturity has therefore been reached. Experts broadly agree that privately owned vehicles capable of operating autonomously everywhere will not be available in the foreseeable future.

In countries such as the United States and China, autonomous vehicles operated by private providers are already in commercial, driverless use. The first so-called robotaxi services have also been announced for German and European cities. While robotaxis are privately operated and typically serve individual trips, autonomous public transport vehicles bundle passengers from multiple bookings and are integrated into an overall transport system that includes buses and rail services.

Objective of the study

This study aims to answer the question of how autonomous driving technology can be deployed in Germany in a way that benefits society as a whole and generates the greatest possible social value.

Scenarios

The study is based on three scenarios that illustrate possible applications of autonomous vehicles in local public transport. The scenarios are deliberately differentiated in order to highlight the systemic effects of different development paths and to enable a structured comparison.

Each scenario describes a possible future state in the year 2045, assuming that autonomous driving technology has been fully established. The focus is on everyday mobility, including commuting, leisure activities and shopping trips, using different modes of transport such as walking, cycling, private cars and public transport.

A detailed traffic analysis was conducted for a representative model region. For every trip, the individual choice of transport mode was simulated based on decision criteria such as cost, travel time and socio-economic characteristics, including income and education level. The results were then extrapolated to the national level.

The Base Scenario

In the base scenario, scheduled bus services organised by public authorities are operated fully autonomously by 2045. Autonomous ride-hailing services such as robotaxis are deliberately excluded in order to isolate the effects of automating traditional public transport. On-demand public transport services remain limited, largely reflecting today’s situation.

The base scenario demonstrates the significant efficiency potential of autonomous driving in public transport. Autonomous vehicles could increase scheduled bus services by 23 percent in terms of vehicle kilometres, while simultaneously reducing operating costs by 14 percent compared with today's levels.

This potential would be even greater if autonomous vehicles were deployed in on-demand services, which are particularly important for area coverage in rural regions. In such cases, operating costs could be reduced by up to 50 percent through automation.

At the same time, the scenario shows that usage will increase only marginally if automation merely leads to moderate service expansion and waiting times and travel-time disadvantages compared to private cars remain largely unchanged.

The conclusion is clear: autonomous driving can make public transport significantly more efficient and help address key challenges such as staff shortages and funding constraints. However, if the technology is used solely to automate existing services, the structural weaknesses of today’s mobility system persist and the full potential of autonomous systems to improve efficiency, attractiveness and nationwide coverage remains untapped.

The Competition Scenario

The competition scenario builds on the base scenario and adds a new element: privately operated robotaxi services. By 2045, these services operate independently of public transport systems, are booked via separate platforms and are not integrated into municipal transport planning.

This scenario shows that introducing autonomous driving through private competition without system integration leads to selective service improvements but produces overall negative effects. Low prices and high convenience encourage users to shift from walking, cycling and rail transport to motorised road transport. Bus users and car drivers are also attracted by the flexibility of robotaxi services.

Due to low prices and a high level of convenience, road congestion in metropolitan areas would increase by up to 40 percent, placing severe strain on existing infrastructure. In rural areas, however, service improvements would remain limited, as profit-oriented providers would focus on densely populated regions.

The assumption that robotaxis could expand mobility services without additional public investment is misleading. As demand shifts away from public transport, fare revenues decline, weakening the overall system and increasing the need for public subsidies. Annual public funding requirements could rise by up to 8 billion euros, while total mobility costs for society could increase by up to 50 billion euros compared to alternative scenarios.

While these effects may initially remain limited with small robotaxi fleets, they would intensify as fleets expand, and prices fall. Subsequent regulation would be politically difficult once strong market interests and user dependencies have been established.

The conclusion: Germany and Europe require their own integrated approach to autonomous driving that reflects infrastructure capacities and the characteristics of the German mobility system.

The Public Services Scenario

The public services scenario describes a comprehensive transformation of public mobility aimed at maximising social and economic benefits. Autonomous vehicles are deployed to significantly improve accessibility, freedom of movement, quality of life and economic strength.

In this scenario, road-based public transport is fundamentally restructured and replaced by significantly more capable autonomous vehicles. This will significantly improve accessibility and reduce waiting and travel times. The existing bus network is accelerated through new routes and complemented by a nationwide on-demand service. By 2045, both scheduled and on-demand public transport services operate autonomously, as assumed in the base and the competition scenarios.

This results in a new level of quality in public transport. Average waiting times between booking and boarding fall to around five minutes in metropolitan areas and 13 minutes in rural regions. In rural areas, waiting times are noticeably reduced by up to 50 percent compared to today. Travel times become comparable to those of private cars and are even shorter on average in metropolitan areas.

As a result, the share of public transport in the modal split more than doubles. A reformed and more advanced fare system ensures the long-term financial viability of the significantly expanded autonomous public transport system. When autonomous vehicles are deployed as part of a nationwide, integrated mobility system, users gain genuine freedom of choice between attractive public transport options and private car use in both urban and rural areas. This freedom of choice increases awareness of the true costs of travelling by car, which plays a stronger role in travel decisions. In contrast, public transport in rural areas today often takes more than twice as long as travelling by car. Consequently, it is not a viable option for many people, leading most to rely on vehicles and to consider mainly running costs rather than the total cost of ownership.

Societal benefits are substantial. Urban congestion falls by up to 11 percent, and motorists switching to public transport save an average of 170 euros per month. Despite major service expansion, public subsidies decline by 20 percent due to efficiency gains and increased user financing. Rural regions become significantly more attractive, potentially reversing urban migration trends, with up to three million people relocating back to rural areas.

The economic impact is equally significant. Nearly one million autonomous buses and shuttles would be required. While the private car fleet would shrink by 25 percent, vehicle sales of German manufacturers could remain stable due to the higher utilisation and shorter service life of fleet vehicles, in case they supply the Level 4 vehicles. Autonomous public transport could generate a 74-billion-euro market for AI-based and digitally enabled products and services.

Private robotaxi providers would not be excluded but could operate as part of an integrated mobility system.

Overall, the public services scenario demonstrates that autonomous driving delivers its full societal benefits only within an integrated transport system and offers a concrete blueprint for a sustainable European mobility model.

Conclusion and outlook

If implemented wisely, autonomous driving can make public transport more attractive and affordable across Germany and can thereby maximise the public good and the benefits for the population. Today, only around 14 percent of the population has access to attractive public transport services. With the targeted deployment of autonomous vehicles, this could become a reality for everyone.

In practical terms, average waiting times would fall to 5 to 13 minutes, and travel times would be comparable to those of private cars. Users switching from car to public transport could save around 170 euros per month, while public transport funding requirements would fall by 20 percent. At the same time, a 74-billion-euro market for AI-driven mobility solutions could emerge.

To achieve this vision, Germany needs a clear strategic direction combined with concrete implementation steps.

The study shows that autonomous driving can only fulfil its potential if technological development, regulatory frameworks and market design are aligned with the goal of an integrated mobility system. Developing such services together with local communities should be the next step. Model regions for autonomous driving can play a central role in testing real-world applications, creating planning certainty for industry and public authorities, and generating reliable evidence for nationwide deployment. In this way, autonomous driving can gradually become a cornerstone of a sustainable mobility system.

The full study is available for download in German here.