PAVE EUROPE

Safer, Cleaner, More Equitable: Seizing the Opportunities of Highly Automated Vehicles

DECEMBER 2024

PAVE EUROPE

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ABOUT **PAVE EUROPE**

The Partners for Automated Vehicle Education Europe (PAVE Europe) is a broad coalition with one goal: to bring the conversation about automated vehicles technology to the public so that everyone can play a role in shaping our future. PAVE Europe's goal is purely educational — we don't advocate for a particular technology or specific public policies. Our members believe that we can only achieve the potential benefits of driverless technology if the public and policymakers have full transparency about facts related to automated vehicle technology. PAVE Europe aims to raise public awareness of both what is on the roads today and what is possible for the future.

Learn more at www.pavecampaign.eu or follow us on social media.

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PAVE Europe's working groups enable our members to collaborate in focused coalitions, developing essential educational messages tailored to various target groups and communities. This paper represents the collaborative efforts of the "Understanding, Trust and Acceptance" working group.

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GLOSSARY

ADAPTIVE CRUISE CONTROL (ACC)

A driving feature that automatically adjusts a vehicle's speed to maintain a safe following distance from the vehicle ahead.

ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS)

A collection of technological systems that assist drivers with the safe operation of a vehicle.

AUTOMATED DRIVING SYSTEM (ADS)

Hardware and software that enables a vehicle to drive without human intervention. ADS can take over all driving functions with specific conditions.

AUTOMATED LANE KEEPING SYSTEM (ALKS)

An automated driving feature designed to keep a vehicle centered within its lane on highways, adjusting steering as needed.

AUTONOMOUS DRIVING

A form of driving in which a vehicle navigates and operates itself without human intervention using various sensors, machine learning, and mapping technologies.

AUTONOMOUS MOBILITY

A term that encompasses self-driving transportation options, where vehicles operate without a human driver, aiming to provide efficient and flexible movement of people and goods.

AUTONOMOUS VEHICLE (AV)

A vehicle equipped with technology that allows it to drive itself without human input. AVs use sensors, cameras, and artificial intelligence to interpret surroundings and navigate roads.

CITY PILOT

A system designed to enable autonomous driving in urban environments, allowing vehicles to navigate city streets, often at lower speeds and with heightened awareness of pedestrians and other traffic.

COMMERCIAL DEPLOYMENT

The introduction and scaling of autonomous technology or vehicles for everyday commercial use, rather than testing purposes, often in specific, approved areas.

CONDITIONAL DRIVING AUTOMATION

Automation where the vehicle can drive itself in limited situations, but the driver must be ready to take control if requested by the system.

CONNECTED VEHICLE

A vehicle that can communicate with other vehicles, road infrastructure, or cloud-based applications to improve safety, efficiency, and navigation.

COOPERATIVE CONNECTED AND AUTOMATED MOBILITY (CCAM)

A vision for integrated mobility systems where vehicles communicate with each other and with infrastructure to enable safer, efficient, and environmentally-friendly travel.

DEMAND-RESPONSIVE TRANSPORT (DRT)

A flexible mode of transportation that adjusts routes and schedules based on real-time passenger demand. Instead of following fixed routes or timetables, DRT vehicles are dispatched dynamically to pick up and drop off passengers at requested locations.

ELECTRIC-POWERED VEHICLES

Vehicles powered entirely or partially by electricity, including battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs).

FIXED ROUTE SERVICES

Transportation services that follow a predetermined route, often on a set schedule, such as autonomous shuttles on a specific loop.

FULLY AUTONOMOUS VEHICLE

A vehicle capable of performing all driving tasks without any human intervention, under any road or environmental conditions.

GOODS TRANSPORT AND LOGISTICS

The movement of goods from one location to another, which in the context of autonomous vehicles, involves self-driving trucks and delivery vehicles.

HIGHLY AUTONOMOUS VEHICLE

A vehicle that can drive itself in most conditions but may still need human intervention in certain situations or environments.

HOMOLOGATION

The certification process for a vehicle or its components to ensure compliance with government and industry standards, required before they can be sold or deployed.

HUB-TO-HUB

A transportation model where autonomous trucks drive between specific fixed locations, or "hubs," typically over long distances on highways.

LAST-MILE

Refers to the final segment of delivery or transportation, typically from a transportation hub to the final destination, such as the delivery of packages to homes.

LEVELS OF AUTOMATION

A standardized scale from 0 to 5 defined by SAE International that describes the degree of automation in vehicles, from no automation (Level 0) to full automation (Level 5).

LiDAR

A sensor technology that uses lasers to measure distances, creating high-resolution 3D maps of a vehicle's surroundings, essential for autonomous navigation.

MIDDLE-MILE

The segment of the supply chain that moves goods from a manufacturer or warehouse to a distribution center, often handled by autonomous trucks on highways.

MOBILITY-AS-A-SERVICE (MAAS)

A service model where users can plan, book, and pay for transportation through a digital platform, integrating various transport options like ride-hailing, car-sharing, and public transit.

NEW VEHICLE SHARING MODELS / SHARED MOBILITY

Transportation models that offer shared access to vehicles, such as car-sharing, ride-pooling, and subscription-based vehicle use, reducing the need for individual ownership.

OPERATIONAL DESIGN DOMAIN (ODD)

The specific conditions under which an autonomous vehicle or feature is designed to operate safely, such as types of roads, weather, and speed limits.

PARTIAL AUTOMATION

A level of automation where a vehicle can perform specific driving tasks like steering or braking, but the driver must remain engaged and ready to take control.

PASSENGER MOBILITY

The movement of individuals using various modes of transportation, including private, public, and shared mobility options.

PEDESTRIAN DETECTION

A technology that allows vehicles to identify and respond to pedestrians on or near the roadway to enhance safety.

PILOTS

Limited, small-scale deployments of autonomous vehicles or systems to test and demonstrate technology before wider deployment.

PLATOONING

A formation where multiple autonomous or semi-autonomous vehicles travel closely together, often in a convoy, to improve fuel efficiency and reduce traffic congestion.

PRIVATELY OWNED VEHICLES (POV)

Vehicles that are owned and used primarily by individual owners or families, as opposed to shared or fleet-owned vehicles.

RADAR

A sensor technology that uses radio waves to detect objects and measure their distance, speed, and direction, helping vehicles detect other road users.

REMOTE DRIVING

The operation of a vehicle from a remote location, often used as a backup in situations where an autonomous vehicle may require human intervention.

RIDE-HAILING

A service where users can request a vehicle through an app to transport them to a destination, typically with options for single or shared rides.

RIDE-POOLING

A service that matches multiple passengers heading in similar directions into a single vehicle, reducing costs and environmental impact per trip.

ROBO-SHUTTLE

An autonomous vehicle service designed to transport passengers on predetermined routes, often used in closed environments like campuses or industrial sites.

ROBOTAXI

A fully autonomous vehicle that provides on-demand taxi (or ride-hailing) services, allowing passengers to be transported without a human driver.

SAFETY DRIVER

A human driver who monitors an autonomous vehicle during testing to ensure safety and take control if necessary.

SELF-DRIVING

Refers to a vehicle's ability to navigate and control itself without human intervention, often used interchangeably with autonomous driving.

SENSORS

Devices used in autonomous vehicles to detect surroundings and gather information, including cameras, radar, LiDAR, and ultrasonic sensors.

SIMULATION

The process of testing autonomous vehicle technology in virtual environments, allowing developers to model various scenarios safely and efficiently.

TEST / TESTING

Controlled trials of autonomous vehicles and technologies to evaluate performance, safety, and reliability before full-scale deployment.
peed limits.

TRIALS

Real-world testing phases for autonomous vehicles in specific areas or conditions to observe and analyze performance.

TYPE APPROVAL

An official certification given to a vehicle or component, confirming it meets regulatory standards required for it to be sold or deployed in a region.

URBAN DELIVERY

The transportation of goods within a city, where autonomous vehicles can deliver packages or goods to businesses or residences.

URBAN ENVIRONMENTS

Densely populated areas with complex traffic patterns and mixed road use, where autonomous vehicles are tested for use cases in busy, compact settings.

URBAN/PERI-URBAN SPACE

Areas within or immediately surrounding urban centers where autonomous vehicles may operate, often requiring navigation in varied traffic and pedestrian conditions.

USE CASES

Specific scenarios or applications in which autonomous vehicles or systems are deployed, such as urban delivery or highway transport.

USER(S)

Refers to individuals who interact with autonomous vehicle systems, whether as drivers, passengers, or operators.

VEHICLE

A broad term for any mode of transportation for people or goods; including cars, trucks, and shuttles.

VEHICLE-TO-EVERYTHING (V2X)

A communication technology that enables vehicles to connect with each other, infrastructure, and other road users to enhance safety and efficiency.

Some of the technologies listed may be branded differently by some manufacturers. We have aimed to use generic terms, wherever possible.

For further terminology on AVs, please visit https://pavecampaign.org/resources/av-glossary/

EXECUTIVE **SUMMARY**

This white paper aims to provide a holistic perspective on the benefits of autonomous mobility solutions, which operate without a human driver (also known as "self driving" or "autonomous vehicles"), while also considering the status quo of this technology, its benefits and its challenges. This paper presents and describes the most relevant use cases for these solutions to foster a better understanding of the technology, encouraging its use and acceptance. This paper also serves as a navigational guide, equipping the general public, users, as well as non-users of autonomous mobility with a comprehensive understanding of the current landscape, the benefits and the challenges of autonomous mobility solutions.

This white paper is the first of a series of papers which will address different target groups specifically. The aim is to create awareness of the opportunities and challenges of autonomous mobility in different use cases from several perspectives. The increase of trust and acceptance in autonomous mobility requires further approaches and methods which will be addressed as part of this series.*

DISCLAIMER

*The statements in this white paper are based on sector knowledge and information that is publicly available. Industry experts also contributed to the insights in this paper. Efforts have been made to verify information where reasonable. This paper represents PAVE Europe's perspective on autonomous mobility solutions.

1 INTRODUCTION

Building trust in autonomous mobility solutions is key to their acceptance and deployment. From curious individuals to those indirectly influenced by the sweeping changes in mobility, our focus on the public is grounded in our conviction that widespread knowledge is the cornerstone for shaping perception. We aspire to demystify the realm of autonomous mobility solutions, and instead highlight the benefits, and confront the challenges that they present. An informed public is pivotal for fostering these foundations.

The goal is to empower the general public to navigate the complexities of autonomous mobility with confidence; fostering a harmonious coexistence whilst promoting constructive engagement with this transformative technology. This paper will focus on highly automated vehicles (Level 4 according to the Society of Automotive Engineers' [SAE's] definition). However, since the paper also refers to other use cases that currently include lower levels of automation (SAE levels 1-3), Figure One shows the differences between the respective levels.

LEVELS OF AUTONOMY

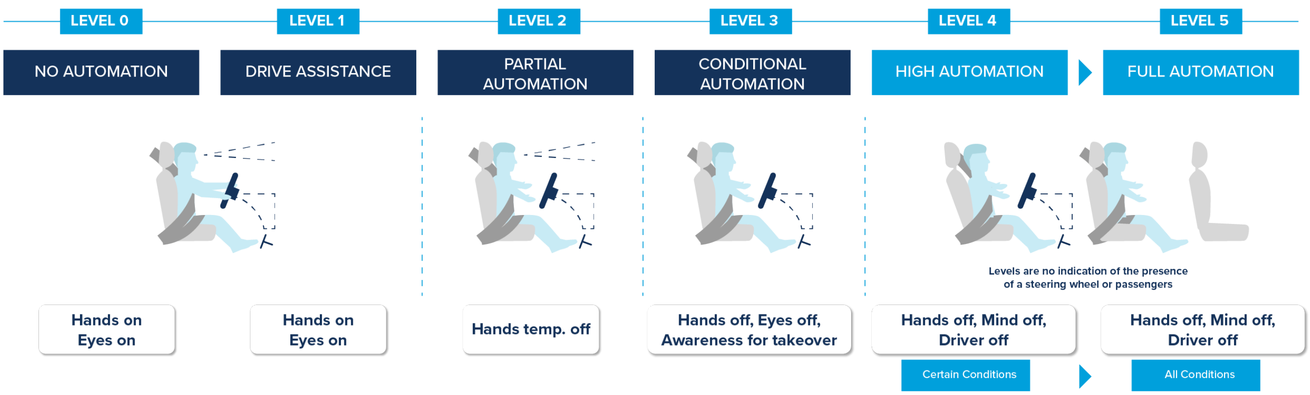


Figure 1. Source: Mobileye

2 STATUS QUO OF MOBILITY

Highly autonomous vehicles can operate in most situations with a hands off and/or mind off approach, handling driving tasks independently in controlled environments without requiring human attention. At the end of 2024, passenger-carrying AVs of various types are navigating dozens of well-mapped city environments - without safety-drivers and with a high degree of autonomy and safety. In logistics, deployments across the world, especially in ports, airports, and other off-highway applications, are providing significant efficiency and safety gains.

Providing a holistic perspective includes looking at their advantages as well as disadvantages. Embracing autonomous mobility brings benefits that include reshaping transportation experiences, transforming lifestyles, unlocking new economic and social opportunities, and saving lives.

2.1 SAFETY IMPROVEMENTS

Autonomous mobility solutions hold the potential to significantly enhance safety on our roads by mitigating the impact of human errors, the leading cause of accidents. In other words, autonomous vehicles don't:

- Drink and drive
- Fall asleep behind the wheel
- Speed
- Text while driving
- Run red lights

As such, AVs are especially poised to be more protective of vulnerable road users (VRUs), such as pedestrians, cyclists, and motorcyclists.

Source: Getty Images

2.2 CONGESTION REDUCTION

As highly automated vehicles are generally fully connected, and in some cases will even able to communicate with each other (V2V, or vehicle-to-vehicle communication), they are designed to be able to travel closer together than human-driven vehicles. What's more, autonomous mobility solutions are programmed to follow traffic laws and avoid collisions. They therefore contribute to a reduction in traffic blockage, which optimizes the utilization of roadways.

2.3 IMPROVING THE MOBILITY ECOSYSTEM'S EFFICIENCY

The integration of autonomous mobility, and specifically shared autonomous mobility has the potential to bring forth a more efficient mobility ecosystem. This manifests in optimized schedules and routes, enhancing the overall effectiveness of transportation networks.

2.4 LIBERATION OF URBAN/PERI URBAN SPACE

The adoption of shared autonomous vehicles could decrease reliance on individual vehicles, liberating valuable urban and peri urban spaces for alternative and more sustainable uses.

2.5 IMPROVED PUBLIC TRANSPORT

AVs are an enabler for enhanced public transport facilities. For example, by offering autonomous, demand responsive transport in less densely populated areas, transport authorities can provide increased flexibility for users, higher uptime, and effective load peak balancing.

2.6 ENVIRONMENTAL BENEFITS

With a focus on electric powered vehicles and new vehicle sharing models, autonomous mobility aligns with environmental sustainability goals, contributing to a reduction in emissions and a greener transportation footprint.

2.7 POTENTIAL FOR INNOVATION

The integration of autonomous mobility solutions can promote continuous innovation and improvement in the transport sector, ultimately leading to more resilient, adaptable and user centered mobility solutions across Europe.

2.8 POTENTIAL SOLUTION TO DRIVER SHORTAGE

Addressing the ongoing challenge of driver shortages, autonomous mobility provides a viable solution, and has the potential to ensure continuous and reliable transportation services.

2.9 ACCESSIBILITY

Autonomous vehicles promote inclusivity and equity by enabling demographic groups traditionally excluded from individual mobility, including the elderly, young individuals, and those with disabilities.

Navigating the landscape of autonomous mobility, however, also involves addressing a spectrum of challenges and limitations that demand careful consideration and strategic solutions. Among these are:

High Investments for Technology and Ecosystem Build Up

The transition to autonomous mobility requires substantial financial investment in a comprehensive ecosystem that can support and sustain this transformative shift.

Continually Evolving AV Regulation and Legislation

Navigating the regulatory landscape on various legislative levels poses an inherent risk of inconsistency. Understanding and addressing these differences is crucial for a harmonized deployment.

Process Description for Homologation, Testing, Type Approval, and Deployment

Simplifying the complex processes involved in homologation, testing, type approval, and deployment is essential for AV deployment. An easily comprehensible process description is instrumental in fostering transparency and understanding.

3 UNDERSTANDING PUBLIC PERCEPTION: ONE ROADBLOCK TO AUTONOMOUS VEHICLE ACCEPTANCE

As we explore the integration of AVs, it is evident that their acceptance is both a technological and social challenge. A study conducted in France[1] paints a positive picture for AVs in urban environments, particularly automated buses. Here, perceived benefits, such as lower fares due to no driver costs, outweigh concerns, indicating a positive attitude towards AV implementation in specific contexts.

These attitudes highlight a crucial aspect of successful AV implementation: user knowledge and understanding. A systematic review found a complex relationship between knowledge of AVs and public attitude.[2] Insights from a novel study conducted in China, which examined public beliefs about AVs further illuminate the complexity of public perceptions toward AV technology.[3] This study uniquely explored 24 beliefs, distinguishing between optimistic and pessimistic views, and identified common misconceptions, such as the premature belief in the market availability of AVs.

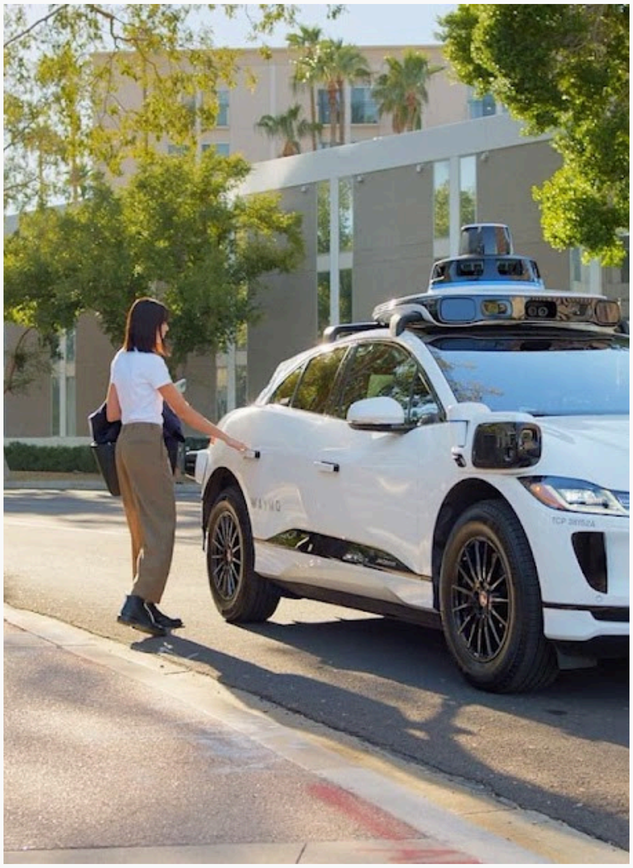
The research revealed four distinct perspectives among participants: "don't know", "neutral to positive", "naïve enthusiasts", and "sober skeptics". For deployments in this environment, it found an ironic correlation: those less informed about AVs ("naive enthusiasts") were more open to the technology, while those with a more accurate understanding ("sober skeptics") expressed greater skepticism.

This variation between European and Chinese studies suggests that simply increasing public knowledge of AVs may not be sufficient to sway public opinion in favor of AVs. Instead, a nuanced approach is needed, one that not only educates but also addresses specific concerns and misconceptions head on. To bridge this gap, it is beneficial to support comprehensive testing in a variety of settings, using a standard nomenclature for AV technology while actively involving potential users.

Direct experience with AVs, through trials and commercial deployments on closed tracks or open roads, has been shown to play a pivotal role in changing perceptions in US deployments. By allowing individuals to experience the benefits and safety features of AVs firsthand, we can begin to counteract the negative shifts in attitude and build a more informed and accepting public view.

A 2023 study by J.D. Power in the United States, which measured consumer confidence[4] for people who had and had not ridden in fully autonomous vehicles, found that:

> Confidence soars, however, for consumers who have ridden in a robotaxi in Phoenix or San Francisco with an MCI index score of 67, which is almost double the index score (37) of those who haven't ridden in a robotaxi and is indicative of experience being critical to full scale AV adoption. These positive firsthand experiences need to be shared with the public to educate, providing balance to the negative news cycle. Consumer comfort is higher in the West region of the country, a region familiar with AV testing and deployments.



Source: Waymo

The journey towards widespread AV acceptance is complex and multifaceted. It requires a joint effort from developers, operators, policy makers, and advocacy groups to not only advance the technology but to also engage with the public in meaningful ways. Addressing fears and misconceptions through a combination of education, clear communication, and firsthand experience is essential in fostering a social climate ready to embrace the benefits of autonomous vehicles.

4 TYPES OF AUTONOMOUS MOBILITY

4.1 PASSENGER TRANSPORTATION

In the rapidly evolving landscape of autonomous transportation, three primary use cases stand out: Privately Owned Vehicles (POV), Mobility as a Service (MaaS), and Goods Transport and Logistics. Each present a unique set of applications, advantages, and challenges for shaping the future of mobility.

For passenger mobility, the transition from owning and operating a private vehicle, to relying on autonomous mobility might take two paths, as exhibited in Figure 2.

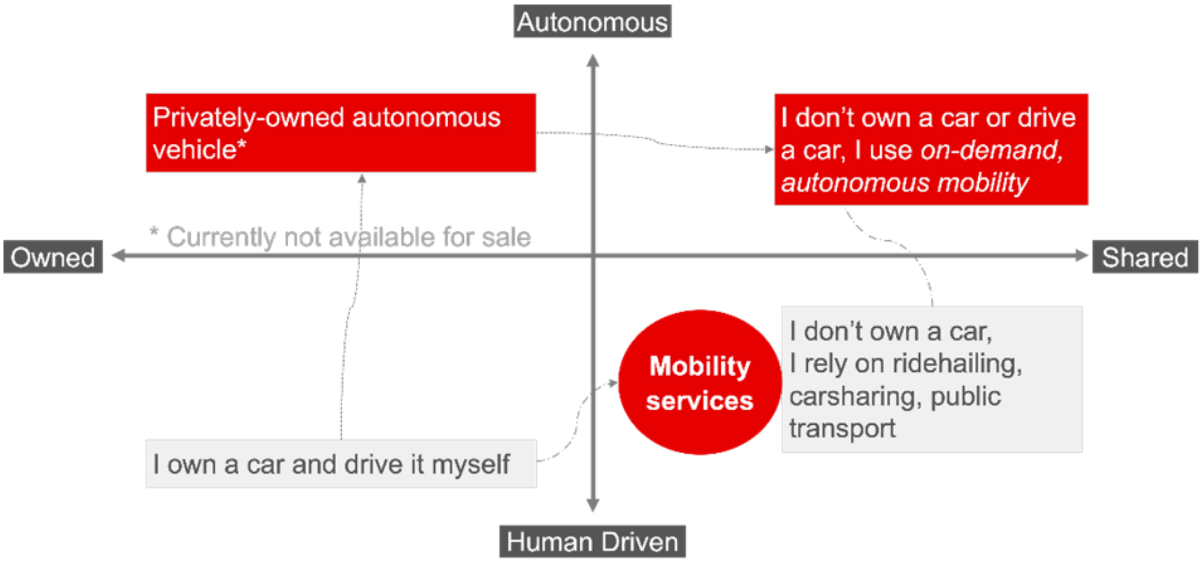


Figure 2. Source: Neckermann Strategic Advisors

Autonomous driving technology revolutionizes individual mobility Assisted Driving features, like automated valet parking, enhancing the driving experience. Highway Pilot, an assisted-driving functionality, enables automated driving on highways; and City Pilot, designed for navigating complex city scenarios with traffic and pedestrians, extends driver support in diverse situations, leading to hands free, eyes free, and mind free driving. Yet, it's crucial to differentiate these from highly or fully (i.e. Level 4 or 5) automated mobility, where driver input is not needed, or even possible.

It is not yet clear when or at what cost fully automated vehicles would be available for purchase, and many of the initial deployments in Europe will focus either on shared passenger mobility or on goods. Regardless of the type of deployment, there are both key potential benefits, and challenges that must be navigated for seamless integration.

BENEFITS

SAFETY IMPROVEMENT

Automated driving holds the potential to significantly reduce road crashes.[5]

REDUCED STRESS AND FATIGUE

Passengers enjoy a more relaxed and stress free experience, by riding rather than driving in a vehicle, and getting time back for productivity or leisure.

IMPROVED TRAFFIC FLOW

Fully automated vehicles can communicate with each other and traffic infrastructure to optimize traffic flow,[6] especially in shared applications such as public transportation.

24/7 OPERATIONS

Autonomy enables continuous operation, improving speed and efficiency in urban areas.

ACCESSIBILITY

Inclusion of parts of the population that are currently excluded from individual mobility, including the young, the elderly, the infirm or impaired.

CHALLENGES

HIGH DEVELOPMENT TIME

Overcoming technical limitations of vehicles equipped with highly automated driving functionality requires identifying and designing the technology so-called “edge cases” via substantial on road, closed course, and simulated testing.

HIGH INVESTMENT

Substantial financial investments are required for technology development and ecosystem establishment, which are primarily driven by the private sector today.

PUBLIC ACCEPTANCE

Navigating public perceptions and dispelling myths surrounding autonomous mobility.

DATA SECURITY

Both actual and perceived levels of data privacy and security need to be ensured in order to allay any concerns by users of the technology.

Figure 3: Potential Benefits and Challenges of Passenger Transportation

The evolution of autonomous mobility extends beyond private ownership and to Mobility as a Service (MaaS).

Robotaxi and robo-shuttle services reduce the necessity for individual transport, and are being rolled out, city by city. There are different business models and use cases for autonomous MaaS: ride-pooling, ride-hailing, and fixed route services. Ride-pooling involves multiple passengers sharing a single vehicle for a similar route or destination. Often, this is achieved via demand-responsive transport (DRT) systems, that optimize routes and pickups to maximize efficiency and reduce costs for users.

Source: Waymo

Unlike ride-pooling, ride-hailing typically offers individual rides for passengers. Users request a ride from a specific location to their destination without necessarily sharing the vehicle with other passengers. Ride-hailing is currently the predominant use-case in early-adopter markets such as the US or China.

Finally, fixed route automated mobility services are scheduled services along defined routes the equivalent of today's trams and buses. Deployments of such automated buses are already on the roads.

Regardless of the respective use cases, autonomous MaaS has the potential to offer several benefits, which include: accessibility, 24/7 availability, safety improvement, and enhanced efficiency.

Hurdles to a more widespread adoption of autonomous mobility systems for the transport of passengers still remain, including high investments, public acceptance dynamics, and the necessity of accurately predicting human behavior on the road in so called "mixed traffic" scenarios (where AVs and humans share the road).

In Europe, pilot projects for autonomous pooling are underway with small fleets in limited service areas, and with time limited funding, often with government support. These projects, often in partnership with public transport, aim to boost efficiency and accessibility.

Pooling-ready Autonomous Shuttle. Source: Oxa

The evidence is clear that enhancing public acceptance of autonomous driving technology occurs most easily by extending opportunities for more people to experience the technology and its benefits firsthand. However, unlike in the US and China where commercial robotaxis and shuttles are operational as of late 2024, Europe still lacks large scale commercial deployments with mature self driving technology.

4.2 GOODS TRANSPORTATION

Besides passenger mobility, autonomous driving technology will transform various aspects of the goods transport and logistics industry, including hub-to-hub logistics, middle-mile and last-mile delivery. It also comes with its own set of benefits and challenges in each of these contexts.

Such deployments in Europe include the automated transport of containers and goods at ports and airports, the delivery of parts between warehouses and distribution facilities (middle-mile logistics), and also the delivery of groceries and other items to users (last-mile delivery). Significant safety, reliability, and efficiency gains have been demonstrated in most of these deployments.

Potential benefits and challenges include:

	POTENTIAL BENEFITS	CHALLENGES
HUB-TO-HUB	EFFICIENCY AND COST SAVINGS Operate 24/7 without the need for breaks or rest, leading to increased efficiency and reduced operational costs. PREDICTABLE SCHEDULING Adhere to precise schedules, optimizing the flow of goods between hubs and minimizing delays. SAFETY Advanced sensor technologies and AI algorithms have the potential to enhance safety by removing the errors associated with human driving. OPTIMIZED ROUTING Dynamically adjust routes based on real time traffic and weather conditions, ensuring the fastest and most cost effective delivery routes.	REGULATORY HURDLES The deployment of AV technology for long haul logistics especially across borders is currently facing regulatory challenges, including compliance with international standards and maneuvering multiple sets of cross border regulations. TECHNOLOGICAL REALIBILITY Autonomous driving systems need to be highly reliable, whether in urban environments, on highways or in rural areas, especially where human operators have been removed as options. INITIAL INVESTMENT Upgrading or purchasing new vehicles with autonomous capabilities requires a significant initial investment, which may be a barrier for logistics companies.
MIDDLE-MILE	SPEED AND CONSISTENCY Maintain consistent speeds and adhere to delivery schedules, improving the speed of middle-mile logistics. DRIVER SHORTAGE PROBLEM As Europe the US, and China all experience a critical shortage of drivers in logistics, AVs have the potential to solve this problem while current drivers are enabled to learn new, non driving tasks. Current jobs therefore will not be lost due to automation. FLEXIBILITY Autonomous vehicles can be deployed for various middle-mile logistics tasks, adapting to diverse types of cargo and delivery requirements.	TRANSFER BETWEEN VEHICLES Middle-mile delivery often involves connecting different distribution centers and hubs. Integrating autonomous vehicles with last-mile delivery solutions means the transfer of goods through additional transfer centers, at significant cost. COMPLEX ENVIRONMENTS Navigating through urban areas, construction zones, or other complex environments during the middle-mile journey requires advanced sensor and decision making capabilities. INTERGRATING WITH EXISTING SYSTEMS Integrating autonomous systems with existing logistics and supply chain management systems may pose technical challenges.

	POTENTIAL BENEFITS	CHALLENGES
LAST-MILE	REDUCED CONGESTION Autonomous delivery vehicles can optimize routes, reducing congestion and minimizing the environmental impact of urban delivery. 24/7 OPERATIONS Autonomy enables continuous operation, improving delivery speed and efficiency in urban areas. IMPROVED LAST-MILE DELIVERY Autonomous vehicles can navigate densely populated areas and deliver packages directly to the doorstep, enhancing last-mile logistics.	INFRASTRUCTURE ADAPTION Urban areas may require infrastructure adaptations, such as dedicated lanes or loading zones, to accommodate autonomous delivery vehicles. PUBLIC PERCEPTION AND ACCEPTANCE The acceptance of autonomous delivery vehicles by the public may take time, and concerns about job displacement and safety need to be addressed.

Figure 4: Potential Benefits and Challenges of Goods Transportation and Logistics

Apart from above mentioned uses, gated areas, such as corporate and university campuses as well as warehouse facilities, also have a great potential for automation.

In general, autonomous driving in gated areas offers a controlled and optimized environment (e.g., predictable traffic patterns, restricted access for individuals such as pedestrians, low speed traffic, dedicated lanes) where autonomous vehicles can operate safely, predictably, and efficiently, making it a beneficial application for various industries such as logistics, transportation, and manufacturing.

EasyMile TractEasy. Source:EasyMile

KEY MESSAGES

AUTONOMOUS DRIVING REVOLUTIONIZES INDIVIDUAL MOBILITY

- Paradigm shift in privately owned vehicles (POV), offering enhanced driving experiences with features like automated valet parking and driving assistance systems.
- Full automation only exists in a few cities globally today but expanding, with regulation and the search for self-sufficient business models still hindering sufficient investment.

ENABLING MOBILITY AS A SERVICE (MAAS) IN URBAN AND PERI URBAN TRANSPORT

- MaaS introduces various models like demand-responsive ride-pooling, ride-hailing, and fixed route services, leveraging AVs to optimize routes, enhance accessibility, and improve safety.
- Challenges include public acceptance, regulatory hurdles, and the need to predict human behavior and of other traffic participants in mixed traffic scenarios.

TRANSFORMING GOODS TRANSPORT AND LOGISTICS WITH AVS

- AVs revolutionize hub-to-hub logistics, middle-mile, and last-mile delivery, offering benefits such as increased efficiency, safety improvements, and reduced congestion.
- Challenges include regulatory hurdles, technological reliability, and integration with existing systems.

POTENTIAL OF AUTOMATION IN GATED AREAS

- Gated areas provide controlled environments for autonomous vehicles, offering predictability and safety, making them ideal for various industries such as logistics and manufacturing.

5 TECHNOLOGICAL CONSIDERATIONS IN THE DEPLOYMENT OF AUTONOMOUS MOBILITY

AV development follows the **Sense Plan Act paradigm,** where sensors gather data (Sense), algorithms process it (Plan), and the vehicle executes actions (Act). The seamless integration of these three components is pivotal for the successful operation of autonomous vehicles.

Regulatory requirements, including Software Update Management System (SUMS), Cyber Security Management System (CSMS), and Safety Management System (SMS), ensure safe operation. The homologation and development process of autonomous vehicles involve multiple approval stages, including test approval, operation approval, service area approval, and type approval. Current pilot projects across Europe typically feature small AV fleets operating in limited or closed areas, focusing solely on specific driving scenarios. However, European pilot deployments cover a significant diversity of different cultural, geographic, regulatory, and even weather scenarios. Sharing the learnings between these deployments will aid in a more universal deployability of highly automated vehicles.

Scalability challenges persist for self driving system providers, with a focus on type approval over operational scaling.

KEY MESSAGES

UNDERSTANDING AV DEVELOPMENT

- The development of autonomous vehicles follows the Sense Plan Act paradigm, integrating sensor data collection, processing algorithms, and execution of planned actions for safe vehicle operation.

Source: Getty Images

CHALLENGES IN AV HOMOLOGATION AND SCALABILITY

- The homologation process for autonomous vehicles involves multiple approval stages, and any type-approvals need to be applicable across a great diversity of deployment scenarios, including even cross-border deployments. This is a higher hurdle than similar deployments in China or the US.
- Scalability poses a challenge for providers, with difficulties in adapting systems to local conditions and a focus on type approval rather than operational scaling.

ADDRESSING HURDLES FOR SAFE UTILIZATION OF AI

- Harmonization and centralization of technical roles are lacking, presenting obstacles to scalable European presence in the AV field.

6 THE SOCIAL IMPACT OF AUTONOMOUS MOBILITY

The European mobility industry is going through profound change and the success of the twin green digital transition plays a key role. Autonomous mobility systems are becoming increasingly important. Autonomous mobility brings the promise of contributing to reduce the number of traffic deaths in the EU to zero until 2050 by improving road safety, as well as reducing pollutant emissions, ensuring accessibility and social inclusion. Educating the general public about a realistic timeframe for the introduction of autonomous mobility and its benefits on public European roads remains a challenge, as large-scale, regular deployments are still subject to various regulatory approval processes. Overly optimistic or pessimistic projections of when the technology will be widely available are not helpful. A realistic view sees certain use cases such as hub-to-hub autonomous transport and autonomous ride-hailing and ride-pooling develop in the second half of the current decade. Progress will be incremental, starting with smaller Operational Design Domains (ODDs) which will expand with technological progress and growing public acceptance.

In addition, there are concerns that automation will endanger certain jobs for humans, although at current, the opposite is true: driverless mobility will help improve the impact of a significant and increasing professional driver shortage on the continent, providing new opportunities.

Another key concern is the potential to leave certain populations behind. The reliance on mobile phones for accessing services could exclude individuals without smartphones or digital literacy, such as the elderly. While this raises important questions about ensuring equal access and inclusion in the future of autonomous mobility, these concerns should be balanced with the benefits that these systems will bring to disabled audiences.

Source: Getty Images

KEY MESSAGES

NAVIGATING THE TRANSITION TO AUTONOMOUS MOBILITY

- Autonomous mobility has the potential to improve road safety, reduce emissions, and enhance accessibility.
- Informing the public about realistic timelines and benefits of autonomous mobility is crucial, emphasizing incremental progress and the development of specific use cases like hub-to-hub transport and autonomous ride-hailing.

BALANCING EMPLOYMENT CONCERNS AND OPPORTUNITIES

- Autonomous mobility offers the prospect of addressing the growing professional driver shortage in Europe.

7 REGULATION AND LEGISLATION TOWARD THE DEPLOYMENT OF AUTONOMOUSD MOBILITY IN EUROPE

Regulating the deployment of autonomous vehicles stands out as a significant challenge alongside the complexities of technology and substantial investments. In Europe, regulators are principally supportive, recognizing the societal benefits of autonomous mobility.

Contrary to common belief, regulatory frameworks for AV deployment on public roads already exist. In Germany, AV laws and regulations have been in place since 2021. Similarly, the United Kingdom and France have enacted national frameworks for highly automated vehicles to be deployed - effective in 2022 and 2025, respectively. These regulations permit the deployment of driverless vehicles in predefined ODDs, subject to approval by regional and local authorities.

Source: Getty Images

Furthermore, as of 2022, the European Commission has implemented Regulation 2022/1426, allowing for the type approval of driverless vehicles. This approval is valid across all EU countries, provided the vehicles meet the functional and safety requirements outlined in the regulation. However, this type approval is currently limited to small series of 1500 AVs per model per year, with regulations for unlimited volumes in the EU expected to be established in 2025.

While the EU handles type approval, the approval of national or local ODDs remains the responsibility of individual member states. France and Germany have already established regulations which have been realized at the same time, and countries such as the Netherlands, Spain, Austria, and Switzerland are actively working on their own national AV regulations, with other EU states expected to follow suit.

The UK is also developing a national framework for AV regulation, part of the government's ongoing work program and based on recommendations from the law commission of England and Wales. However, the lack of highly autonomous vehicles in Europe has resulted in processes for type approval and ODD approval not being firmly established. Simultaneously, the United Nations Economic Commission for Europe (UNECE) is working on a comprehensive regulatory framework for AVs, anticipated to be finalized in 2026, to harmonize safety regulations across jurisdictions.

KEY MESSAGES

NAVIGATING THE REGULATORY LANDSCAPE FOR AUTONOMOUS VEHICLES

- Existing regulatory frameworks in Europe, such as those in France, Germany and the EU, permit the deployment of fully automated vehicles within predefined Operational Design Domains (ODDs) and allow for type approval, with limitations on production volumes.
- Individual member states, including France, Germany, the UK, and others, are actively establishing national regulations for AV deployment, with the aim of ensuring safety and fostering innovation in autonomous mobility.

EU AND UNECE EFFORTS TOWARDS STANDARDIZATION:

- The EU's implementation of Regulation 2022/1426 for type approval and ongoing work by member states in establishing ODD regulations demonstrates a concerted effort towards standardization and harmonization of AV deployment.
- The United Nations Economic Commission for Europe (UNECE) is also working on a comprehensive regulatory framework for AVs, expected to be finalized in 2026, aiming to address challenges like pre homologation testing procedures for non type approved AVs.

8 SUMMARY AND KEY TAKEAWAYS

This white paper highlighted the current status of autonomous mobility, addressing safety, efficiency, environmental and sustainability benefits, while also acknowledging challenges such as technical limitations, high investments, regulatory issues, safety concerns, and ethical considerations. We have illustrated various use cases for the technology in Private Owned Vehicles (POV), Mobility as a Service (MaaS), and Goods Transportation, outlining the unique advantages and challenges of each sector. The exploration also addresses the Sense Plan Act paradigm, regulatory requirements, and the social impact of these technologies, emphasizing the importance of realistic projections and need for public education.

The paper concludes by focusing on AV regulation and legislation, noting existing frameworks and ongoing efforts for standardized regulations at national and international levels. Overall, a comprehensive roadmap for understanding, navigating, and embracing the transformative potential of autonomous mobility in the evolving transportation landscape is provided.

In addition to urging more testing of technology to increase public awareness and understanding, it is crucial to emphasize the usefulness and benefits of highly automated vehicle technologies. The promised improvements in safety, emissions reductions, and congestion relief have yet to be fully demonstrated. Achieving these benefits will require further technological development, a sensible deployment of a sufficient number of vehicles to create a "critical mass," and significant investments. Moreover, for widespread adoption, vehicles and services must be affordable and attractive to ensure that individuals, operators, and cities are willing to embrace and deploy them.

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