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euMOVE 2025 – Autonomous Vehicles in Europe

Project Proposals to implement in Munich
Connecting City and Suburb: Lessons from Hamburg and Copenhagen on AV-Driven Mobility

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ABSTRACT

The uneven distribution of people, resources, and goods makes it hard for people to move around in metropolitan areas. This problem is especially seen in suburban regions that lack good quality in public transport links to the cities. In this report, we have developed comparative on-field research in Hamburg and Copenhagen about how autonomous vehicles (AVs) and creative mobility solutions can contribute to closing this gap and make existing transport networks more inclusive and sustainable. Our interdisciplinary team of students conducted interviews with mobility stakeholders in both cities, conducted ethnography, and examined documents to measure pilot projects of AVs, policy frameworks, and user attitudes in both cities.

Based on these insights, we came up with a concept that meets the premise of demand-responsive and autonomous shuttle networks and fits, as a case study, the Neuperlach Sud-Ottobrunn corridor in Munich, to enhance first and last-mile connectivity with people, as well as students. As our results show, there is room to be enthusiastic about the prospects of AV-controlled on-demand transportation to alleviate car dependency, improve public transport (PT), and avoid car safety risks, as well as skepticism about the long-standing regulatory, infrastructure, and social acceptance obstacles. We conclude by suggesting context-sensitive, adaptive interventions that policymakers, agencies, and urban planners can use in developing better, fairer, greener, and more trustworthy deployment of AVs in suburban regions.

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LIST OF ABBREVIATIONS

Abbreviation	**Definition**
AV	Autonomous vehicle
AS	Autonomous shuttle
PT	Public transport
N/A	Not applicable

01. MOTIVATION

Problem description and approach to solve it

The group sees this project as an opportunity to contribute to alleviating three main issues derived from commuting: congestion, safety issues, and lack of PT opportunities. On the one hand, there is traffic and congestion, as up to 24% of children across all settlement types (urban, suburban, and rural) are driven to school by their parents most days by car (DEKRA, 2019). This phenomenon is known as "Parents-taxi" (*Elterntaxi,* ADAC Stiftung, 2023). If roughly one-fifth to one-quarter of school students in Bavaria are transported by private car, that translates into significant morning and afternoon congestion at schools. This creates both traffic delays and safety hazards through interaction. Thus, targeting primary schools in suburban areas could improve traffic impact during peak hours.

On the other hand, there are safety issues. During 2023, more than 27,000 children were involved in road traffic accidents in Germany, 44 of them were killed (Federal Ministry for Digital and Transport, 2024). Considering this, the need for improvement in accident rates is highlighted, and technology like ASs comes to the fore as an opportunity to improve these problems that go beyond transportation.

To conclude, there is the PT problem. Commuting is, generally, not a choice but a need. Providing good PT as a real option for commuters is a must when looking to improve the situation.

AV as an Opportunity:

1. Traffic Congestion Reduction

- If ~25% of students are driven by parents, replacing a fraction with shared public autonomous shuttles reduces car volume at peak times. This improves flow on suburban roads overall.

2. Improved Safety

- Autonomous shuttles eliminate human error, reduce speeding, distraction, and aggressive driving. For school entrance/exit times, this is relevant to decreasing accident rates.
- They also avoid double-lane-parking disorder, which generally increases in these drop-off zones.

3. Mobility for Underserved Areas

- Many Bavarian suburbs don't justify full-size bus service, but smaller ASs seem appropriate.
- ASs can improve equity in mobility for students with no direct access to school buses.

4. Behavioral Shift

- Pilot projects can normalize shared, sustainable travel from an early age, encouraging future generations to avoid car dependency.

Goals of the project and justification, who benefits?

The primary objective of the project is to enable seamless connectivity between suburban and urban areas through the smart integration of AS into the existing public transport network. This integration is intended to reduce reliance on private vehicles and encourage a shift toward public transportation through a set of targeted pull measures.

In the Munich metropolitan area, morning-peak inbound commutes from suburban home-to-work trips generate about 24% of the city's rush-hour congestion, while school-run traffic from the surrounding districts adds roughly 8%. Together, these two trip purposes are responsible for almost 32% of the total urban congestion during peak hours in Munich (Associate Professorship of Travel Behavior, n.d.).

By facilitating a modal shift from private car use to public transport, the project is expected to contribute to climate targets such as achieving net-zero emissions, as well as to improve road safety and reduce productivity losses associated with traffic congestion.
The primary beneficiaries of this initiative are expected to be working parents and students, who would experience reduced commute times, lower travel generalized costs, and safer, more reliable transport options.

02. STATE OF THE ART

Learnings from the trip: Hamburg and Copenhagen

The group made a 10-day trip to the northern part of Germany, Hamburg, where the UITP (International Association of Public Transport) Summit was held between 15 and 18 June. Afterwards, the group crossed the northern border to get to Copenhagen, Denmark, between 19 and 23 June. This subsection describes the most relevant findings during this trip. Appendix 1 provides the list of interviews held and organizations visited during the trip. Two standout projects were Naerbus in Denmark and HVV hop in Hamburg.

Hamburg: UITP

Hamburg held the 2025 UITP summit. The group took the first of their 2-stop trip between 15 and 18 June in the port city. The summit allowed them to get to know different public transport-related projects, but more importantly, to see how AV can be directly related to solving PT problems.

Copenhagen: PT authorities and NGO’s

19 June, the group arrived in Copenhagen, where they had arranged meetings with NGO’s, public transport authorities, and technical experts. Table 2 lists the meetings held during their stay.
Overall, this trip worked to see how project management, engagement, and stakeholders are key to guaranteeing a successful project. It also strengthened concepts related to the complementary vision of AV and PT.

Interviews with daily users

To complement the interviews, the group conducted a short survey to gather broader public opinions on AVs. The survey included questions on personal background (age, occupation, area type), daily mobility habits, transport challenges, awareness of AVs, and hypothetical adoption scenarios.

Out of 11 respondents, 91% had heard of AVs, and 64% said they would ride one, while 18.2% said no. The main concern was accident/safety risks (73%), followed by software failure and job loss. Open answers revealed both trust in technology and a lack of understanding as key themes. Most participants believed that governments or the EU should regulate AVs. Preferred ways to stay informed included workshops, social media, and test-drive opportunities. Full charts and responses of the survey are presented in Appendix 6.

Learnings and insights

Discussing and hearing from different stakeholders, different perspectives, and ideas enriched the view of the group when it came to the current state of the art in AV and the group's project development. Here, the most relevant and highlighted.

Technology

The current AV technology already allows the deployment of pilot vehicles in an urban environment. Considering that this context is the most difficult in terms of random behavior and vulnerable user-vehicle interactions, this development is remarkable and shows that the operation of AV should not be far from reality.

For the group, almost every concept related to AV was new. From the basics of autonomy, such as lidar and radar, which are the sensors that allow the vehicle to process what's happening outside. An HD map is needed and specially applied to designated routes, like PT bus lines, for example, where detailed information is provided and the vehicle knows what to expect beforehand. Vision-based perception systems (VBPS): in the case of AV, it corresponds to cameras recording and analyzing the surroundings of a vehicle, in contrast to lidars and radars. Roadside units are a specific infrastructure that allows better communication from and to an AV, whether that may be to a control center or to users.

V2X/V2V concepts refer to how information from an AV is transmitted to either another AV (V2V) or to its surroundings, which can be specifically a bus stop, a roadside unit, or online to a user (V2X).

Policy and regulation

This is a topic with two faces. From the road and infrastructure authorities' perspective, AV must be developed and adapted in a way that they don't collide with the current regulations and available infrastructure.

This is particularly important in a context like the European Union, where one regulation is expected to fit many contexts, but there are local differences that can collide technology-wise. Questions arise in this topic: Will there be one regulation for all EU countries? Which signals must the vehicles comply with? Should they be equipped with software that adapts to each EU country? Must each country invest in infrastructure to be able to allow AV to operate within? As there is not yet a common rule for AV in the EU, these questions are still to be answered. With this, the development of AV solutions is context-narrowed, as the infrastructure and regulations from each country differ.

Responsibility is also a relevant factor to consider in regulation. As many stakeholders are involved in an AV project, along comes the question of duties in case of failure. This regulatory framework must be clearly defined, as it will give clarity to authorities, vehicle companies, operators, and each stakeholder will know which part they must act on.

Link with PT

As the development of technology and marketing is especially focused on private AV, the obvious question of how to consider them in PT comes to mind. In this regard, the group found 2 perspectives, with both working towards the same goal: improvement of public transport.

On the other hand, public transport can directly benefit from AV, especially in suburban areas. The fact that there is a lack of bus drivers cannot be overlooked; thus, AV/AS can be a tool to improve transit, where the current diminished operation occurs. Public transport authorities mention that there is a need for between 2 to 3 bus drivers per bus to operate for a whole day, while the people-vehicle rate in the case of AV is 1 to 4, meaning that for a day, an AV would need *half a person*. This can help to improve availability and reduce waiting times in areas with lower density, where it's usually more expensive to provide PT.

Ethics

The development of AV comes aligned with different needs, and, like any technology, breaks the mold when compared to the previous status quo. The group identified three main ethical issues that emerge from AVs: safety and liability, surveillance, and labor displacement. In terms of accidents, and related to the previous subsection, who will be responsible when an accident occurs? What is the number of accidents that will allow an AV to be operated in the city?

Another relevant question is how to deal with the human factor in surveillance and ensure data privacy for passengers and bus users. States must be careful when defining the rules in this sense.

As AV also considers a lower need for human labor, the transition from human-based buses to autonomous ones must be done smoothly. Authorities mention that in the future, there will be fewer bus drivers, thus the transition will be made naturally to AV. If this transition comes before the end of a driver's career, transit operators must consider a complementary transition: from bus driver to control center operator. This will ease fears of AV coming to decrease labor and foster its people's acceptance.

Concept of Nærbus in Denmark

Technical: Nærbus is a demand-responsive transport service operating in Haslev, Denmark, replacing fixed-route lines 265, 266, and 267. All rides must be pre-booked via app, website, or phone. There are no fixed routes or schedules, except for school mornings (07:00–08:00), which follow a fixed route. Afternoon school trips (12:30–15:30) are flexible. Vehicles have 18 seats + 10 standing spots; extra flex cars provide backup capacity. Payments use standard Movia methods (Rejsekort, DOT app, etc.) — not through the Nærbus app. Trips can be pre-scheduled or recurring, and partial integration with Rejseplanen supports planning.

Legal: Nærbus is a two-year pilot project, operating under trial regulations. A key policy is "no child left at the stop" — drivers verify names and pick up children even if bookings are missed. Adjustments have been made where students are no longer entitled to transport, shortening routes accordingly.

Infrastructure: The service covers most of the same stops and areas as the old lines, with some minor route changes for efficiency. The smaller bus fleet is optimized for demand and supported by a digital platform (app, booking site, route optimization backend).

Concept of HVV Hop and AHOI in Hamburg

Technical: The Ahoi project aims to upgrade HVV hop by integrating electric ASs into its existing on-demand fleet in Hamburg-Harburg. The fleet will include up to 48 vehicles, combining manually driven and AS. The project runs from 2023 to 2027 in three phases:

- Manual operation only
- Autonomous testing without passengers

- Passenger-ready autonomous vehicles with full system integration

Vehicles are barrier-free, meet accessibility standards, and are supported by a centralized control system. The project includes scientific research on usability, acceptance, climate impact, and operational strategies.

Legal: Ahoi is backed by €37 million in funding, with €18 million from the Federal Ministry for Digital and Transport (BMV). Operations follow new legal frameworks (§§ 1d ff. StVG, AFGBV) for autonomous public transport. The service remains fully integrated into HVV's tariff system, ensuring it complements, not competes with, existing public transport.

Infrastructure: Harburg's diverse terrain and traffic make it ideal for testing mixed fleets. Autonomous shuttles are electric and powered by 100% green energy, aligned with Hamburg's climate goals. A digital infrastructure is being built to manage vehicle routing, supervision, and user communication within the HVV hop ecosystem.

While both HVV hop and Nærbus offer valuable approaches to enhancing suburban–urban connectivity, this project will primarily focus on suburban areas, with particular emphasis on the Nærbus model. Our goal is to explore how demand-responsive transport can efficiently connect residents to the nearest S-Bahn or U-Bahn stations, improving access to the broader public transport network.

03. CONTRIBUTION TO MOBILITY IN MUNICH

Project Concept: On-Demand AS for Neuperlach–Taufkirchen/Ottobrunn

This project proposes the introduction of a demand-responsive autonomous public transport service inspired by the Danish Nærbus model, Denmark, and the Ahoi project, Hamburg, adapted to the Munich suburban corridor between Neuperlach and Taufkirchen/Ottobrunn.

The target area consists of residential zones with limited or no existing public transport, a notable concentration of schools, and commuter flows between two major S-/U-Bahn stations. Unlike conventional systems, this service does not replace any existing bus lines but instead fills a critical mobility gap, offering flexible, app-based transport across a defined pool of neighborhoods.

The service is designed to benefit both schoolchildren and the public. Like Nærbus, it ensures safe, reliable transport for students, with options for pre-booked and recurring trips, and provides first-/last-mile access to the wider public, connecting them to nearby S-Bahn and U-Bahn hubs.

Key features:

- Environmentally friendly, on-demand via app/phone call/website Autonomous Shuttles
- No fixed routes or schedules, except prioritized morning and afternoon service for schools
- Virtual stops within walking distance
- Fully integrated into the MVGO app and Munich public transport fare system (MVV-MVG)

This model aims to reduce car dependency, support families and students, and enhance sustainable mobility in underserved suburban areas, while generating insight for broader application in the Munich region.

Prototype of the solution

As described, the project focuses on increasing PT availability in a suburban location, with exclusive use for children during school entry and exit times. Figure 1 shows a possible route for the shuttle with skipped and included stops. Appendix 4 shows the problem of the area and how school-age children could be well served by the project, as well as showing the use of the app to book a trip.

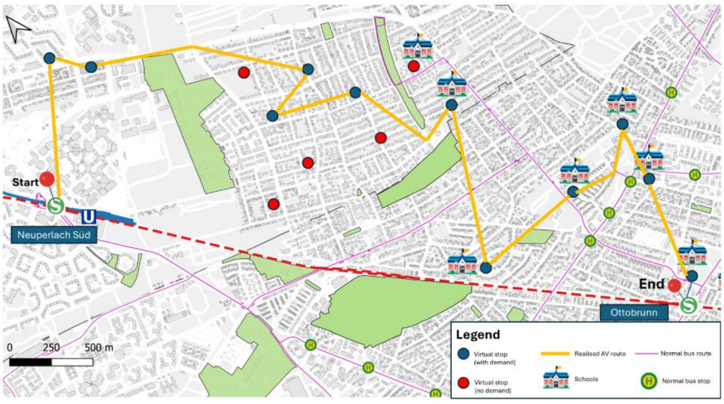

Figure 1: Proposed demand-responsive autonomous transport route in Waldperlach district. Source: own elaboration based on OSM information.

Technology, infrastructure, and operations

How to use the service

1. Book your trip

- **Plan ahead**:
  Reserve via app/phone/website **up to 30 days in advance** by entering:
  Origin → Destination → Time → Ticket type (e.g., school commute, general trip).
- **Recurring rides**:
  Set automatic bookings for daily/weekly trips (e.g., school runs).
- **Confirmation**:
  Receive an **estimated pickup window** immediately after booking.

2. Ticket selection & payment

- **Integrated fares**:
  - Select Existing Ticket if using Deutschlandticket, MVV stripe card, or semester pass.
  - €2 surcharge for autonomous service for post pilot
- **New tickets**:
  Pay via app (credit card/PayPal/SEPA).

3. Ride execution

- **Real-time updates**:
  Get exact pickup time via **SMS/app notification 20-25 mins before arrival**.
- **Smart routing**:

    - **General trips**: Fastest direct route (AI-optimized).
    - **School trips**: morning routes that prioritize school stops; flexible afternoon routing.
- **Child safety guarantee**:
  Unbooked children will never be stranded; drivers accommodate if capacity allows.

4. Service Hours

- **Priority scheduling**:
  School trips (6–9 AM, 12-2 PM), the rest of the day is available for all purposes.
- **24/7 availability**:
  As the priority schedule is for Operates round-the-clock.

Anticipated challenges

Regulatory and governance barriers: as legislation is still up for debate in this matter, the upcoming decisions might put barriers on the development of a project like this.

MVV integration hurdles: Full integration into Munich's public transport fare system (MVV) requires reconciling zone-based pricing with flexible routes. This may necessitate new tariff categories or subsidies, requiring complex negotiations with MVV authorities.

Technical and infrastructure limitations

- **Charging infrastructure gaps**: Suburban areas like Ottobrunn lack sufficient EV charging stations. Thus, coordination with Stadtwerke München is required.
- **Network reliability**: Cellular "not-spots" disrupt real-time routing and booking. The MVGO app depends on Munich's 5G rollout, which remains incomplete in target areas.
- **Cybersecurity risks**: Shared data networks (e.g., between shuttles and MVGO) increase vulnerability to hacking or ransomware attacks, especially with minors onboard

Financial viability pressures

- **High initial costs**: Autonomous shuttles cost more than conventional buses. Munich's labor costs for remote supervision add a considerable amount/year per vehicle.
- **Revenue uncertainty**: Low population density in target areas risks low off-peak ridership. Similar systems (e.g., Berlin's BerlKönig) achieved only 3–5 passengers/hour, necessitating public subsidies

User Adoption and Social Equity Concerns

- **Resistance from car users**: 78% of Munich's suburban commuters rely on cars. (Munich Transport and Tariff Association, 2018). Overcoming "automotive inertia" requires demonstrating time savings >15% versus driving (Boston Consulting Group, 2020).
- **Digital exclusion**: Elderly residents may struggle with app-based booking. Phone-booking alternatives increase operational complexity by 30% (Boston Consulting Group, 2021).
- **School policy conflicts**: Munich schools (e.g., European School Munich) mandate direct staff responsibility for child safety during transit. Integrating unsupervised AVs would require rewriting child protection policies and training staff

Independent boarding and securing wheelchairs:

For wheelchair users, ramps are often too steep, requiring assistance to board. This is a major challenge for autonomous vehicles, as there will be no driver to assist.

Operational and Lifecycle Risks

- **Algorithmic inefficiency**: Dynamic routing in low-demand areas causes "dead mileage" (empty trips). Munich Airport's ShuttleMe reduced this via AI, but residential areas pose sparser demand.
- **Winter Reliability**: Battery range drops by 30–40% in cold weather (Marybeth, & MarybethHi. (2024). Unplowed streets in neighborhoods like Waldperlach may impede access. Sensors (radar, lidar, and cameras) can also be affected by fog and snow.
- **Human Resources:** While autonomous vehicles are expected to alleviate driver shortages by enabling service expansion, they also necessitate the creation of new roles, such as those in "technical supervision".
- **Managing Disruptions Without an On-Site Driver**: A core challenge is that, unlike conventionally controlled vehicles, where a driver can react quickly on-site, autonomous vehicles lack this immediate human presence

Ideal partners & engagement of society

Partners are divided into core operations, implementation, and user groups. First, the group considers automotive manufacturers, PT operators, technology providers, and state agencies. For the implementation, research centers and local administrative offices. And as for users, different societal groups are taken on board to include people's opinions; in this case, the focus is on schools and residents. Appendix 2 shows the details of the organizations considered.

Target groups

Primary Targets

1. **Working parents**
    - *Why*: 62% of children are chauffeured due to unreliable transit (MVV 2023), losing 7–12 hrs/week.
    - *Solution*: Pre-booked school trips + real-time child tracking.
2. **School-Goers**
    - **Ages 6–10**: Remote-supervised rides (Phase III).
    - **Ages 11–14**: Biometric PIN boarding (Phase II).
    - **Ages 15+**: Flexible afternoon routes + MVV semester tickets.

Secondary targets

1. **Elderly/Low-mobility residents**
    - *Why*: 42% in Ottobrunn live >800m from transit (Bavaria 2024).
    - *Solution*: Phone-based booking, priority seating, €1 subsidized fares.
2. **Shift workers** (e.g., Siemens Campus)
    - *Why*: Only 18% use transit for night shifts.
    - *Solution*: Dynamic 5 AM/11 PM routes + employer subsidies.

Strategy for embedding the concept in Munich beyond the project timeframe

- **Institutional Anchoring:** Embed the service in Munich's *Mobility Strategy 2035* via council resolutions, mandating DRT as a solution for underserved suburbs, and secure dedicated funding through Bavaria's *Mobilfonds*.

  Franchise Model: An inspiration from MOVIA in Copenhagen. License the operational blueprint (vehicles, AI, fare integration) to districts like *Freising/Garching*, using a shared-revenue model where MVV collects fares and private operators manage fleets, reducing city costs.
- **Stakeholder Coalitions**: Partner with BMW/Siemens for corporate shuttle hybrids, sharing depot/charging costs.

Cost calculation for the project

Cost projection has 3 main sources: first of all, the acquisition of the fleet; with current market values, the projection is around €3.5-4M (Anderson, R. (n.d.), 2025). The expenses also include software licensing (€1.2M/year), and setting up a centralized control hub (€2.05M). Additional costs cover infrastructure upgrades like charging stations and 5G expansion (€3.15M), training and regulatory compliance (€1.45M), and testing phases (€2.65M). Promotion, community engagement, and a 15% contingency reserve add further €3.175M, ensuring scalability and resilience of the system. The total cost of this project was also inspired by the project costs of ahoi. ("EUR 37 Million for On-demand Fleet of Driverless Vehicles," 2025)
Total costs reach €20.85M to €21.555M, details are shown in Appendix 3.

Time Planning

Phase I: Baseline Development & Manual Operation (1 year)

Goals: Establish operational baseline, community engagement, and infrastructure groundwork.

- **Manual Fleet Deployment**: Launch 5-10 electric shuttles with drivers, mimicking future autonomous routing algorithms. Service operates 6 AM–10 PM, focusing on school peaks (7–9 AM) and first/last-mile connections to S-Bahn U5/Poppenbüttel stations.
- **MVGO App Integration**: Enable real-time booking/payment via MVGO.
- **Winter Readiness Testing**: Validate vehicle performance in Munich's harsher winters (e.g., snow traction, -15°C battery efficiency).
- **Stakeholder Co-Design**: Partner with schools (e.g., Europäische Schule München) and senior centers to define virtual stops and safety protocols via workshops.

Phase II: Supervised Autonomy & Limited Trials (2 years)

Goals: Validate safety and AI reliability under technical supervision, excluding children initially.

- **Autonomous Pilot Fleet**: Introduce 5 Level 4 shuttles (e.g., HOLON Movers) with **onboard safety operators**. Vehicles run **without passengers** for 3 months, collecting data on sensor accuracy in fog/snow. And thereafter a closed group testing as well as testing open to volunteers.
- **Child-Specific Testing**: After safety validation, allow supervised rides for teens (14+), using biometric PINs for boarding. Operators intervene via "Guardian Mode" audio during emergencies.

- **Mixed Traffic Simulation**: Test interactions with Munich's cycling corridors and narrow residential streets.
- **Remote Control Hub**: Establish Operations Control Centre, reducing onboard staff. Human oversight shifts to a central hub monitoring fleet anomaly.

Phase III: Mixed Fleet Integration & Full Public Service (2 years)
Goals: Scale to 10 autonomous shuttles with remote supervision, prioritizing school mobility.

- **School-Centric Autonomy**: 60% of morning slots reserved for pre-booked school trips; unused capacity dynamically allocated to public riders via MVGO.
- **Barrier-Free Upgrades**: Install wheelchair-accessible ramps and multilingual audio announcements.
- **Cold-Weather Deployment**: Extend service to -10°C with heated LiDAR sensors and grid-tied charging stations at U-Bahn terminals.

04. INTENDED IMPACT

Permanent outcomes

- Sustainable Mobility Shift: Reduced car dependency in underserved suburbs.
- Equitable Access: Reliable 24/7 connectivity for schools, seniors, and shift workers.
- Integrated Network: Seamless first/last-mile integration with MVV's S-Bahn/U-Bahn.
- Scalable Innovation: Blueprint for autonomous DRT deployment across Bavaria

Key Performance Indicators (KPIs) by outcome

Displayed here are the main KPI from 4 categories: (1) Modal shift and environmental impact, (2) service quality and connectivity, (3) user adoption & equity, and (4) operational & financial viability. The complete details can be found in Appendix 5.

Area	KPI	Method	Target
Modal shift & environmental impact	AS occupancy rate	Average passengers per km	≥ 65% (peak), ≥ 35% (off-peak)
Service quality & connectivity	First/last-mile efficiency	Door-to-hub journey time vs. walking	≤ 8 mins (avg)
User adoption & equity	Target group penetration	% schoolchildren/seniors using service weekly	40% (students), 25% (seniors) by Y5

Operational & financial viability	System uptime	% service hours without disruptions	≥ 99% (excl. weather emergencies)

Table 1: Key Performance Indicators

05. CONCLUSION

This demand-responsive autonomous shuttle project represents a transformative step toward equitable, sustainable mobility in the Munich Metropolitan Area's underserved suburbs. By bridging first/last-mile gaps and reducing car dependency—especially for schools and vulnerable groups—it lays the foundation for a scalable, user-centric transit model. With strong institutional integration, public-private collaboration, and data-driven expansion, the project can evolve from a localized pilot into a cornerstone of Munich's future mobility network, advancing climate goals and social equity.

As it's shown, it tackles the three main problems that suburban areas face in terms of transportation: (1) an increase in the availability of PT, with a high frequency service that can be operated 24/7 when needed; (2) it lowers labour costs, which in the long term is the highest in transit operation, in exchange of a high initial investment; and (3) it helps to alleviate congestion with an attractive PT alternative and increases safety with vehicles prepared to have near 0 collisions.

In terms of the concerns, as discussed and learnt from the trip, PT can benefit from AVs, people's privacy must be ensured at all times, and labour in a market that needs more people, can work in a transition.

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APPENDIX

1. List of organizations, projects, and representatives met during the trip

Hamburg

Organization	Project	Representative
Hamburger Verkehrsbehörde	Zukunftstaxi	Dirk Ritter
VHH	Ahoi	Konrad Polster
MOIA	Alike	Juan Carlos Aguilera
Hochbahn	Alike	Clemens Horn
Holon	Holon	Julia Hansen
DB Regio	Kira	Kattrin Finger
Hochbahn	Heat	Daniel Göbel
IKEM	Heat	Timon Plass
KAMO	Country to City Bridge	Matthias Vollat
TH OWL	Monocab	Martin Griese et al.
DLR	U-Shift	Jan Grippenkoven

Table 2: List of organizations, projects, and representatives met in Hamburg.

Copenhagen

Organization	Project	Representative
Gate21	Linc	Klaus Asbjørn Madsen
ShippingLab	Greenhopper	Magnus Gary
Denmark Technical University (DTU)	Autonomous maritime transport technology	Roberto Galeazzi
Vejdirektoratet	N/A	Bo Ekman

Movia	Nærbus & transit in general	Peter Rosbak
Green Transition Denmark	Autonomy for logistics	Christian Rohmann

Table 3: List of organizations, projects, and representatives met in Copenhagen.

2. Partners for the development of the project

Core Operational Partners

Partner Type	Entities	Role and Contribution
Automotive OEMs	BMW Group, HOLON	Supply of L4 electric shuttles, development of winter-resilient AV systems, maintenance hubs
Public Transport Operators	MVV, MVG	Fare integration, access to MVV/MVG data platforms, app interoperability, station connectivity
Technology Providers	ioki (DB), MOIA (VW)	Routing algorithms, booking platforms, user interface design, cybersecurity infrastructure
Municipal Governance	Munich City Council, Taufkirchen, Ottobrunn	Land-use approval, public communications, infrastructure upgrades (5G, charging points)

Table 4 Core Operational Partners

Implementation and Trial Partners

Entity	Function in Pilot
TUM MCube Cluster	Regulatory sandbox environment, control center prototyping, AV testbed support
Stadtwerke München	Charging infrastructure rollout, smart grid integration for electric fleet
Bavarian Ministry of Transport (MOT)	Legal oversight for AV trials, permits for school transport under §16 StVG

Table 5 Implementation and Trial Partners

User-Centric Stakeholders

Group	Engagement Strategy	Design Influence
Schools	Partnerships with Europäische Schule München, Gymnasium Ottobrunn	Input on virtual stops, safety policies, timing alignment

Residents	Collaboration with neighbourhood councils and tenant associations	Feedback on service routes, hours, and noise mitigation
Schoolchildren	Youth mobility workshops, gamified app co-design	Preference-driven UI/UX and service planning
Drivers and Safety Staff	Involvement of Verdi union and TÜV trainers	Safety protocols, remote operation roles, training design

Table 6 User-Centric Stakeholders

3. Cost calculation details for the project

Category	Cost Description	Estimated Cost (€)
1. AVs & Fleet Management	Vehicle acquisition (10 vehicles)	€3.5M–€4.2M
	Winter resilience premium (+15%)	Included above
	Software licensing (routing AI & MVGO integration, annually)	€1.2M/year
2. Control Room & Infrastructure	Centralized control hub setup	€ 2.05M
	Remote supervision (Years 2–5)	€3,0M
	Cybersecurity (child data, anti-hacking)	€425,000
3. Training & Certification	Staff & school training	€550,000
	Regulatory compliance & tariff agreements	€900,000
4. Infrastructure Upgrades	Charging stations (20 units + grid upgrades)	€1.1M
	5G network expansion in Ottobrunn	€1.75M
	ADA-compliant virtual stops	€300,000
5. Testing & Validation	Phase I (manual ops, 18 months)	€750,000
	Phase II (autonomy trials, validation)	€1.9M

6. Promotion & Engagement	Community outreach (schools, demos, guides)	€375,000
	Marketing (trial weeks, campaigns)	€250,000
7. Contingency & Scalability	15% reserve for regulatory/demand fluctuations	€2.55M
Total Estimated Cost		**€20.85M–€21.555M**

Table 7: Cost calculation details for the project. Source for cost

4. Definition of the area and depiction of app used to book a trip

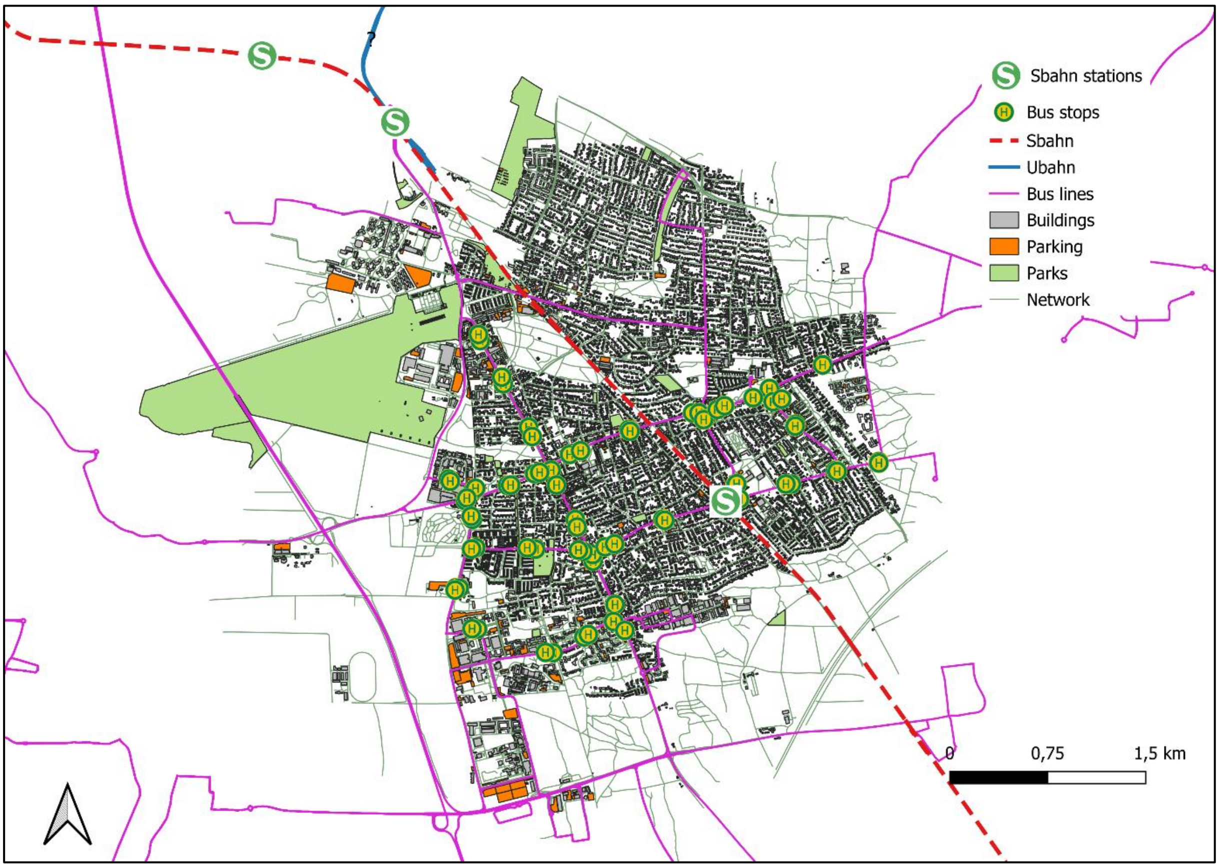


Figure 2: Image of Ottobrun and its transit network. Northern part shows lack of transit coverage. Source: own ellaboration based on OSM.

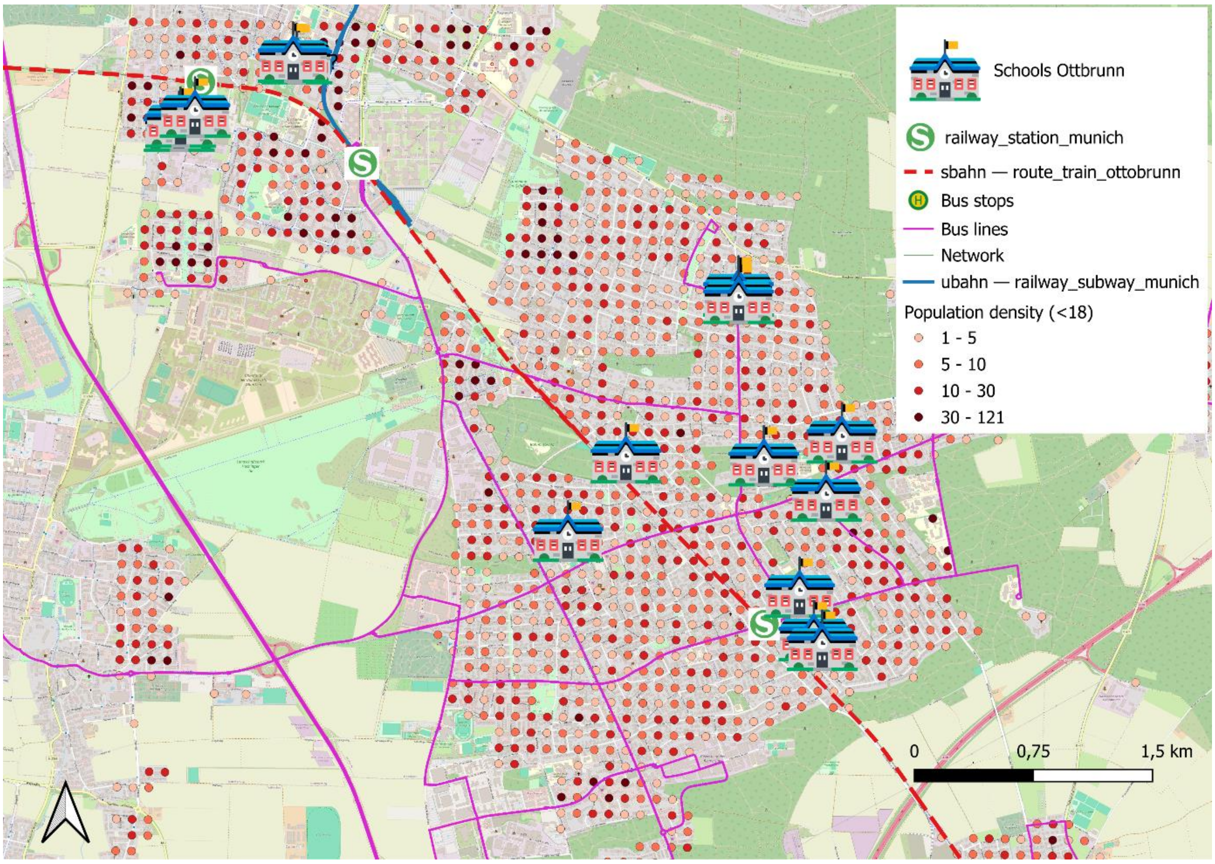


Figure 3: Distribution of <18 y.o. population in the target area. Source: own elaboration based on OSM and 2011 Zensus data.

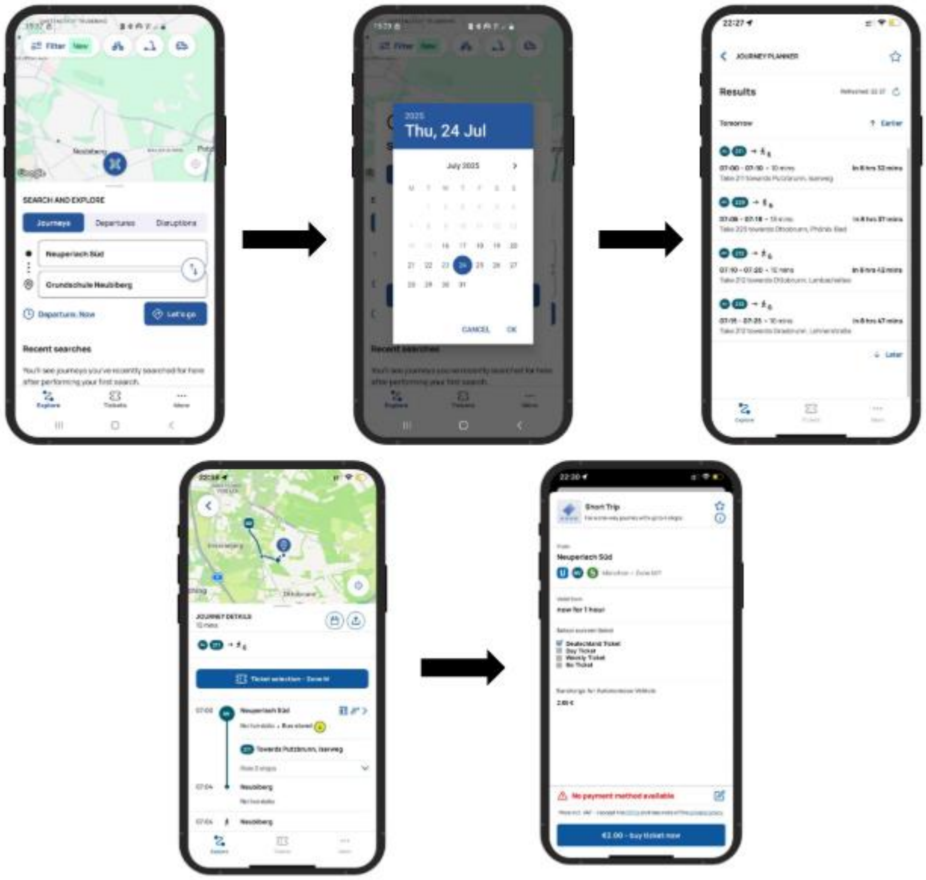


Figure 4: Booking process for AVs in the study area. Source: own elaboration.

5. Project KPI

Modal shift & environmental impact

Indicator	Measurement Method	Target
Car trip reduction	User surveys + MVV ticket linkage	25% decrease in school-run car trips by Y3
CO_2 savings	Vehicle telematics (g/km) vs. replaced car trips	120 tons/year reduction
AV occupancy rate	Average passengers per km	≥ 65% (peak), ≥ 35% (off-peak)

Table 8 Modal shift & environmental impact

Service quality & connectivity

Indicator	Measurement Method	Target

Access equality	% residents within 5-min walk of virtual stops	95% coverage in Taufkirchen/Ottobrunn
School reliability	On-time arrival for pre-booked trips	≥ 98% within 5-min window
First/last-mile efficiency	Door-to-hub journey time vs. walking	≤ 8 mins (avg)

Table 9 Service quality & connectivity

User Adoption & Equity

Indicator	Measurement Method	Target
Target group penetration	% schoolchildren/seniors using service weekly	40% (students), 25% (seniors) by Y5
Night service utilization	Bookings between 10 PM–5 AM	≥ 15 rides/night by Y3
Fare affordability	% low-income users (via subsidized tickets)	≥ 20% of total ridership

Table 10 User Adoption & Equity

Operational & Financial Viability

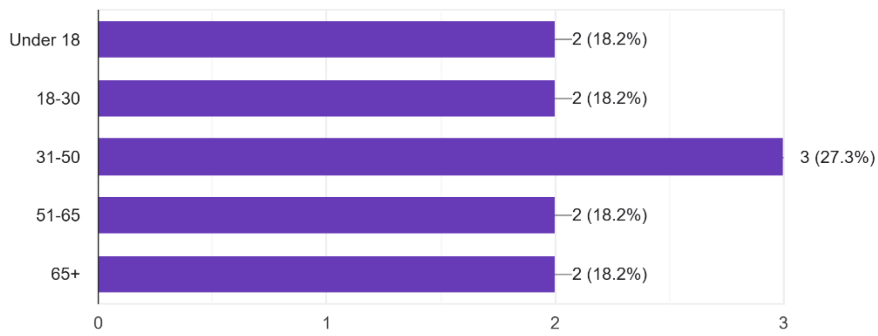
Indicator	Measurement Method	Target
Cost per passenger-km	Operational costs ÷ total passenger-km	€0.85 by Y5 (vs. €1.20 in Phase I)
Subsidy dependency	% operational costs covered by fares	≥ 50% by Y7
System uptime	% service hours without disruptions	≥ 99% (excl. weather emergencies)

Table 11 Operational & Financial Viability

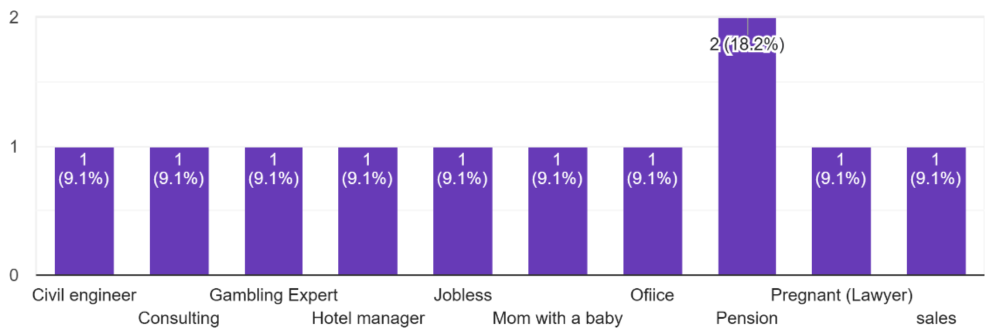
6. Survey Results and User Quotes on Autonomous Vehicles

Section (1): Personal Background

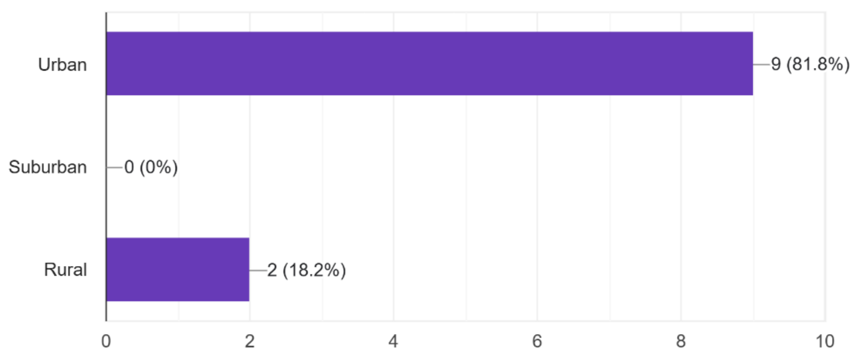
Age
11 responses



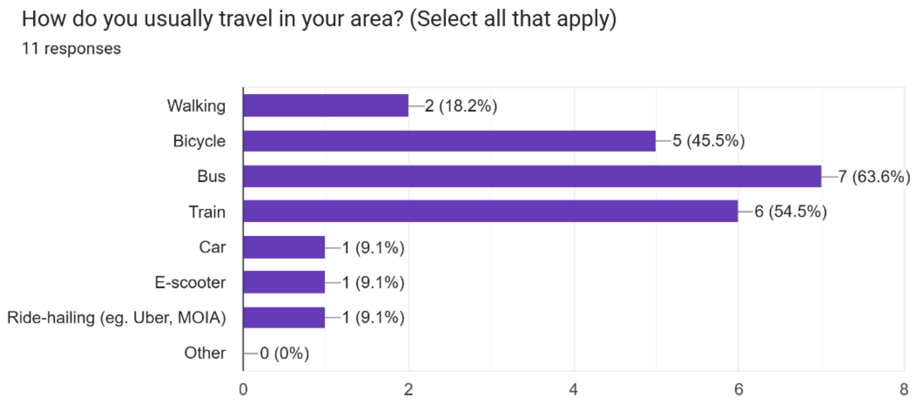
Occupation
11 responses

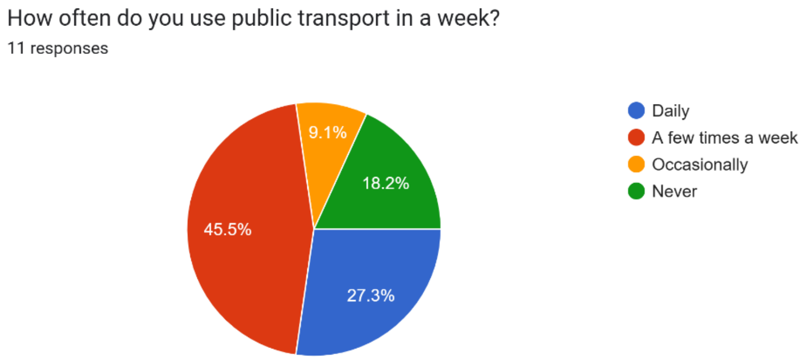


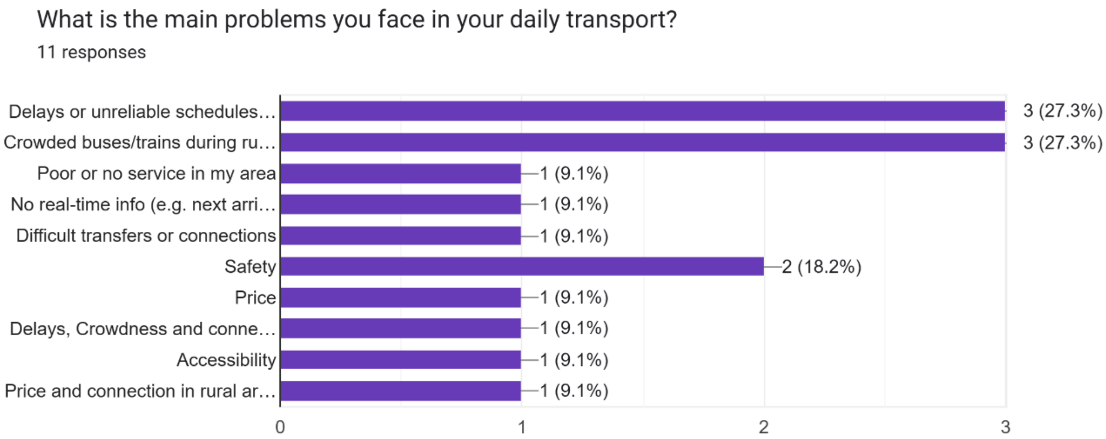
Area type
11 responses



Section (2): Daily Mobility Habits





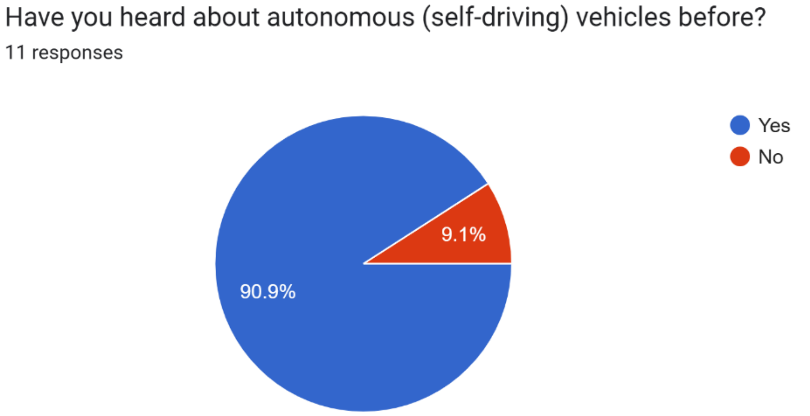


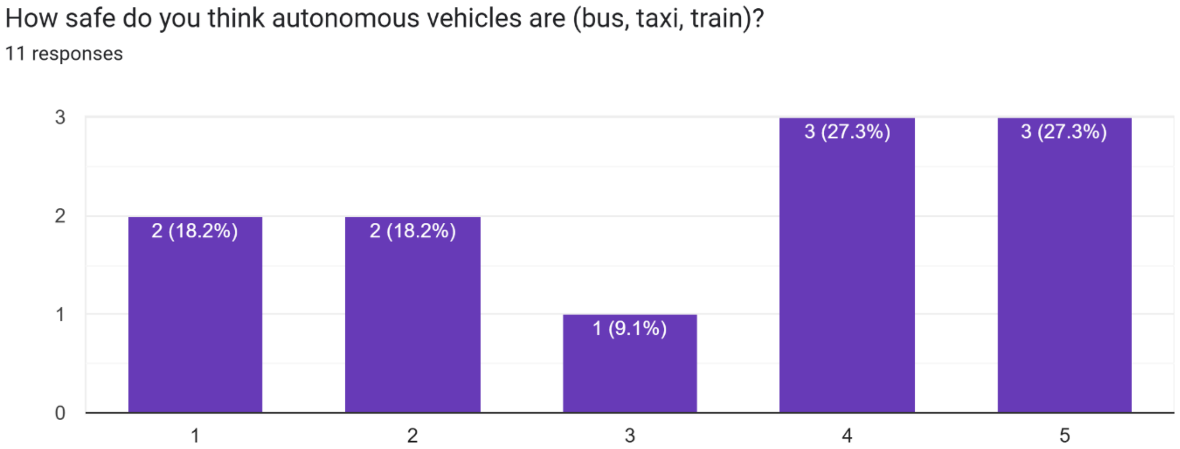
Full options for the above graph:

- Delays or unreliable schedules
- Crowded buses/trains during rush hours
- Poor or no service in my area

- No real-time info (e.g., next arrival, disruptions)
- Difficult transfers or connections
- Safety
- Price
- Delays, Crowdedness and connections between bus and train
- Accessibility
- Price and connection in rural areas

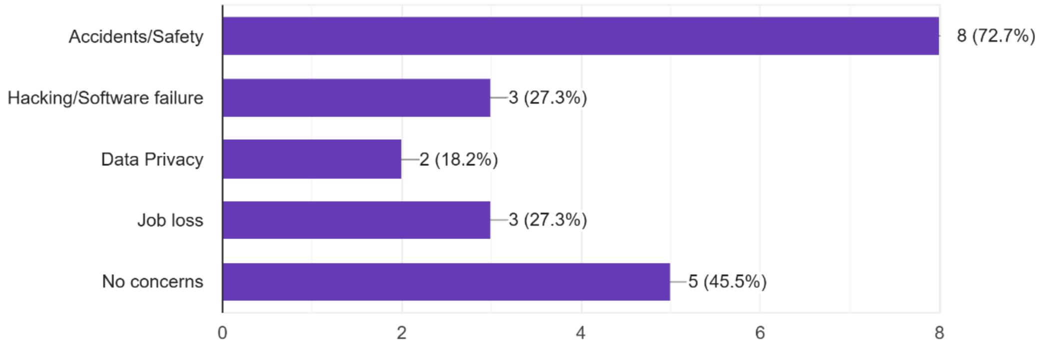
Section (3): Awareness & Experience





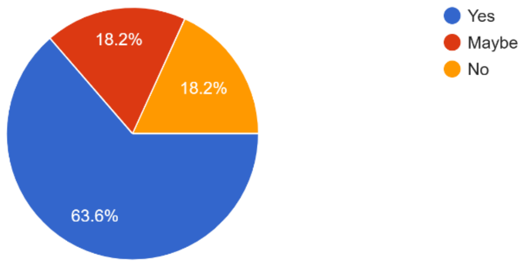
Where 1 is the safest and 5 is the least safe

What concerns do you have about autonomous vehicles? (Select all that apply)
11 responses



Section (4): Open Questions – Technical, Ethical, and Governance Aspects

Would you ride in an autonomous vehicle?
11 responses



Why or why not?
9 responses

Bc of my concerns

Yes, if there were no other option

Ich bin Mutig.

It will increase the punctionality and optimize the transportation mode transfers also might be cheaper due to less stuff members get paid and no human mistakes integrated to the system

I trust technology

I don't understand the concept

I trust the Tech. It should be safer than Humans

Yes, it is the future

What features would make you trust an AV more (more likely to use it)?

7 responses

- Driver inside
- None would make me trust more
- A driver maybe
- If we can more rely on the optimization and the camera detection technologies with less
- No
- Widespread
- If it is out there, I will trust it

Who do you think should oversee regulating AVs and why?

9 responses

- Government
- No but I'm not sure, I'm not that smart
- Government, as they care
- With ensuring safety standards and legal accountability by the governments
- The government
- No
- Government or EU
- Government specially for safety, as private companies care about their benefits

How would you like to be involved or informed about future AV projects?

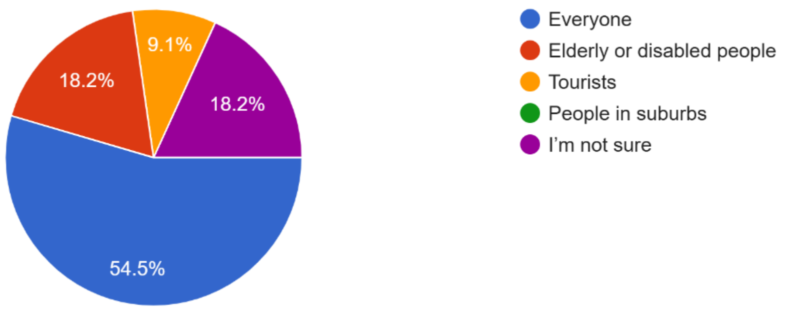
10 responses

- No, I don't want
- I don't want to be informed
- we don't care/ we are old
- Google sagt schon alles. Ich bin mir dessen bereits bewusst.
- National transportation authorities mostly
- Better marketing (social media). Test-drive with vouchers (20 euros/ drive)
- Im dumb
- Through real life workshops
- More info and maybe testing

Section (5): Accessibility and benefits

Who do you think will benefit most from autonomous vehicles?

11 responses



In one word, how do you feel about autonomous transport?

10 responses

Unsafe

Bad

Future

Gut

Promising

curious

Futuristic

Good

FUTURE