# Results from the PAV pilots:

## Summary of innovative products and services

# Introduction

The PAV project has conducted several pilots in different urban environments to evaluate the performance of autonomous vehicles (AVs) and their impact at the customer, business and technology levels. These pilots tested different products and services to assess the viability of AVs in urban environments.

The products tested included innovative procurement and cooperation with second-hand vehicles from public transport operators (PTOs) in Varberg, innovative procurement of AV shuttles through extensive market consultation and subsequent restricted procurement in the Hannover region, a custom-designed delivery robot for outdoor use on islands in Inverness, and the use of visualisation software to gain insights into future AV deployment and socio-economic impacts in Almere.

In addition to the tested products, the PAV project also evaluated several services related to the deployment of autonomous vehicles in different urban environments. These services included an AV last-mile connection for tourists in a popular beach environment in Varberg, the integration of an autonomous shuttle bus into public transport across city boundaries in the Hannover region, an autonomous logistics and delivery system tested in a remote island location in Scotland (Orkney Islands), and a demonstration of a new transport service using AVs to connect private sites such as a university campus and a nearby business park in Inverness. In addition, in Almere, the project tested a service for the virtual integration of AV technology into the public transport system of a new district development programme.

This report provides an analysis of the impact of these products and services at different levels and a summary of the challenges and opportunities encountered during their implementation. By highlighting the specific products and services tested in each location, this report provides a comprehensive view of the different approaches taken by the PAV project to assess the viability of AVs in urban environments but also highlighted the challenges and opportunities involved in their deployment. The findings of this report can serve as a valuable resource for policy makers, transport experts, and other stakeholders interested in the future of mobility and the deployment of AVs.


# Inverness

## SCOTLAND'S FIRST AUTONOMOUS VEHICLE SERVICE

# Inverness AV pilot

New autonomous vehicle service at Inverness Campus offering transport between UHI Inverness and the Inverness Retail and Business Park. Inverness Campus is a world-class business location with pioneering facilities, bringing together businesses, researchers, academia and scientists.

## Service: Autonomous Vehicle at Inverness Campus

Approx. 2,000 people on-site everyday (pre-Covid 19), with a mixture of students, businesses and locals. Student accommodation on-site. Provides an eco-friendly route and fits well with the strategic vision of the Campus to promote multi-modal travel and improve accessibility without use of a car.

## Impact

### Customer

- Chance to trial new technology for the area.
- Offering a different type of transport service at Inverness Campus.
- Opportunity to learn more about autonomous vehicles and potential future uses.

### Business

- Knowledge & understanding of the viability of autonomous vehicles
- Skills development for the area of trialling a new technology
- Chance to test a new route and address potential demand

### Technology

- Opportunity for residents to experience new technology first-hand.
- Opportunity to link with STEM activities, schools and university studies.
- Investigate future uses for the technology across the region.


## Impact

### Challenges

- Vehicle Faults resulting in manual operation and slow operating speed in manual mode.
- Maintenance challenges.
- Adapting to changes in the surrounding area, such as developments at the campus.

### Opportunities

- Operate the vehicle on a scheduled route plus demand responsive to offer the flexibility of usage.
- New route potential with the new National Treatment Centre at Inverness Campus.
- Engagement with community and schools.

# Product: New AV Procurement Approach

## Procuring AV provider and operator separately

Separate procurement for AV providers and operators to provide opportunities for local operators to be involved in the new technology – resulting in new skills developed and knowledge of how the vehicles could be used in the future.

## Impact

### Customer

- Local operators provide familiar service for customers
- Customers can ask operator questions about the service
- Service can be integrated easier into existing transport options

### Business

- Local businesses are given the opportunity to bid for the contract.
- Create new skills and knowledge. around autonomous vehicles
- Provider and operator work together to solve challenges.

### Technology

- AV provider handled technical details but also trained local operators.
- Challenges with technology are learning experiences.
- Opportunity to try out new technology for the first time in the area.

### Challenges

- Maintenance fixes can be time-consuming as the provider is not based in the area.
- Operations therefore delayed while fixes are in progress
- Keeping regular communications between project leads, operator, and provider.

### Opportunities

- New skills and knowledge for the local area.
- More opportunity for integration with existing transport modes.
- Helps to look to the future and address where technology could be implemented after having local experience.


# Almere

INTEGRATION OF AVS INTO THE FUTURE PT-SYSTEM OF ALMERE PAMPUS

# Almere AV pilot

In the Almere virtual AV pilot, 3 scenarios for the deployment of CCAM in the future Pampus district in Almere were developed. Pampus is currently still undeveloped but is foreseen to house over 50,000 and provide employment to over 15,000 by the year 2050.

## Service: AV integration in Almere's public transport system

The 3 scenarios differ by the type of vehicles deployed and the demand responsiveness of the PT system. In scenario 1 the BRT system that also operates in the rest of the city is largely continued, featuring semi-autonomous buses. In scenario 2, a shuttle network for the first and last mile is provided on top, while in scenario 3 the BRT network is replaced by a demand-driven network of fully autonomous mid-size buses and small shuttles.

## Impact

### Customer

- For users, scenario 1 is preferred by those that reject autonomous vehicles and/or those that are satisfied with the current BRT system.
- Scenario 2 is appreciated for its ability to bring passengers to within a minute's walk of their destination.
- Scenario 3 is fully flexible in routing and time, offering passengers optimal connections to origins and destinations within the Pampus district. The complete lack of staff on board however gives rise to concerns over social and driving safety.

### Business

- For the municipality of Almere as the entity responsible for (organising) public transport services, scenario 1 (and to some extent scenario 2) is the safe and proven choice – the BRT as such is successful and the separate bus lanes in the city allow for high operational speeds. Scenario 3 would require a completely different way of thinking about public transport, with a potentially better passenger service. Fully autonomous PT could also boost the city's image as a centre of innovation.


## Technology

- Scenario 3 in particular depends heavily on the ability to deploy level 5 autonomy.

## Challenges

- A key challenge to designing and implementing new PT concepts facilitated by CCAM (such as autonomous first and last-mile solutions and autonomous demand-responsive systems) is to model passenger behavior/demand. This challenge is aggravated by the fact that Pampus as such does not yet exist.

## Opportunities

- The 3 scenarios demonstrate that the deployment of fully autonomous vehicles in an urban public transport system could open the door to radically different ways to organise the public transport system. Offering the Pampus development team the unique opportunity to design a new district from the ground up with these new opportunities.

# Product: Software for visualisation of impact of AV deployment

## Procuring an AV provider and operator separately

The visualisation is an animatic of several minutes, showing the different ways public transport (fuelled by autonomous vehicle technology) could be organised in the future district of Pampus, in conjunction with various other policy measures such as promoting or discouraging car usage and sharing systems, and the effect this has on the spatial planning and land use of a city district. The animatic and insights generated (see below) primarily aim to facilitate the work of urban and regional authorities in Almere and elsewhere.

## Impact

### Customer

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### Technology

- The animatic enables simulating level 5 autonomy (not feasible yet in reality).

## Challenges

- A key challenge in developing the visualisation is to select and present the information in such as way that the viewer is provided with a clear and comprehensive message in a limited amount of time (just several minutes). It should cover all the main points to be made while refraining from going into unnecessary details that will distract from the bigger picture. The animatic intends to display future policy choices to be made.

## Opportunities

- During presentations of the 3 CCAM scenarios developed for Pampus we experienced that it is very difficult to present the scenarios in such a way that both the individual scenarios, as well as the key differences between them, are clear to the audience. The visualisation, complemented by a voice-over, is a very strong tool to convey the scenarios in a clear and compelling way and might also be a solution for other situations where the opportunities of CCAM are to be communicated.


# Hanover

## OPERATING AN AUTONOMOUS SHUTTLE-BUS ON A REGULAR BUS LINE

# Hanover AV pilot

The project was intended to analyse safety-related, technical, and societal issues concerning autonomous vehicles. In addition, it was expected to have learning effects for future projects with autonomous vehicles in public transport. The autonomous shuttle bus nemoH operated from the beginning of September until the beginning of November 2022.

## Service: nemoH

Fully integrated into the local public transport system, the autonomous nemoH-Shuttle supported a normal public transport bus during low-demand periods. nemoH operated on a regular bus line with a total route length of 2 km and with a headway of 10 minutes during its operation times. In the end, more than 350 km have been conducted by nemoH. The vehicle selected was the EZ10 model from EasyMile.

## Impact

### Customer

- Service improvement.
- Increasing the attractiveness of public transport.

### Business

- The application of new technologies.
- Attractive public transport to win new customers and enhance the image of the technology.

### Technology

- Technology for regular use inline operation is currently not 100% ready for use.
- Driving speeds are too low compared to conventional scheduled buses.


## Impact

### Challenges

- Low maximum and average speed of the shuttle (max: 15 km/h, Avg: 5,9 km/h.
- Capacity of the persons that can be transported: 6 seats.
- Multiple emergency brakes (Avg./Day: 10,1).

### Opportunities

- Testing an autonomous vehicle in a real environment.
- Planning the integration of an autonomous vehicle into the existing public transport system.

# Product: Market consultation and procurement of AV shuttle

## Extensive market consultation and procurement of AV shuttle

Systematic discussions with all AV vehicle manufacturers operating on the European market in person on-site or via telephone or video conference to identify suitable vehicle/software models for the Hanover/Garbsen use case. Conducting a negotiation award based on the findings.

## Impact

### Customer

- Consideration of specific local customer needs (students, research, university staff).
- Identification and provision of the appropriate vehicle.

### Business

- Enabling an economical procurement process.
- Application of new technologies.
- Attractive public transport to win new customers and enhance image of the technology.

### Technology

- Exchange with cities/municipalities promotes the potential for improvement.
- Vehicle manufacturers are required to act economically.

### Challenges

- Limited vehicle market leads to few offers and complex negotiations.
- Short duration and low budget reduces the attractiveness of bidding.
- Map the complexity of the subject matter in the leanest possible process.

### Opportunities

- Market consultation enables targeted invitations to tender.
- Learnings for other cities and municipalities.
- Learning effects for future AV projects.


# Varberg

## HARD DEMONSTRATION ENVIRONMENT PROVIDED USEFUL INSIGHTS

# Varberg AV pilot

as part of the PAV project, Varberg carried out an AV shuttle bus ton the shores of Varberg. The test was located in Apelviken a popular beach location south of the city of Varberg. The pilot ran for two weeks in June 2021.

## Service: Last-mile transport at beach location

The AV service in Apelviken must be seen as ineffective for visitors. The frequent breakdowns and slow service significantly hindered its usefulness. However, as a demonstrator and joyride experience, the vehicle provided interesting insights into how an AV service could work in Varberg in the future. Additionally, it demonstrated that a demanding traffic environment like a busy beach location might not be the best place for an AV service.

## Impact

### Customer

- The vehicle was intended as a last-mile transport connecting different parts of the beach to regular public transport and parking areas.
- Unreliable performance made the service less attractive, but as a test ride the vehicle proved very popular.

### Business

- The deployment of the vehicle attracted people to visit the test site and thus more clients for restaurants and cafes in the area.
- The testing nature of the deployment gave no immediate business to the provider.
- The unreliable nature of the vehicle didn't support a short-term business for the service provider.


## Impact

### Technology

- The technology of this early version and the demand traffic environment made the test interesting but made the service solution rather unattractive.
- The technical challenges did provide a lot of insight for future planning for AVs.

### Challenges

- Unreliable technology made the AV service rather ineffective. The vehicle was slow and the large number of emergency stops made travel challenging. A number of breakdowns also made service problematic.

### Opportunities

- Even though the vehicle didn't perform according to expectations the demonstrator ride gave a lot of important lessons. The vehicle was n attraction in Apelviken, but more as a joy ride and to try out new solutions than as a service for beach visitors.

# Product: Market consultation and procurement of AV shuttle

## A fruitful cooperation between local authorities, regional public transport, and innovative service provider

In order to start the pilot in Varberg the city turned to Nobina. Nobina is the current provider of city buses in Varberg on contract with the regional public transport company Hallandstrafiken. Through an agreement between Varberg and Hallandstrafiken on an extension of traffic for the city buses Nobina provided one of their second-hand Easy mile vehicles as a test bed in Varberg.

## Impact

### Customer

- The procurement solution gave access to a free ride on an AV vehicle in Apelviken Varberg.
- This gave the customers or user access to try out vehicles under live conditions.

### Business

- By extending a contract already in place a test vehicle could be easily accessed.
- For Hallandstrafiken this meant seeing how an AV worked.
- Nobina could provide a vehicle and make an example for future procurements.

### Technology

- Using a first-generation Easymile vehicle proved to be challenging. The technical solutions are in many aspects immature, which proved difficult in an demanding environment like Apelviken.


## Impact

### Challenges

- The first generation vehicle provided by Nobina carried out the task, however, proved unreliable and could fully perform in its intended way.
- This provided an interesting case but did not convince local planners and the general public of the usefulness of an AV vehicle in public transport.

### Opportunities

- The case proved very fruitful in cooperation between Varberg, the regional bus company Hallandstrafiken and the service provider Nobina. Apart from giving the possibility to demonstrate an AV vehicle in operation it also made way for further discussion on future innovative cooperations.

# Conclusions

The PAV project conducted several pilot trials in different urban environments to evaluate the performance of autonomous vehicles (AVs) and their impact at the customer, business, and technology levels. Pilot partners tested various products and services related to the deployment of AVs in urban environments, including innovative procurement and collaboration with public transport operators, custom-designed delivery robots, and the use of visualisation software to gain insights into future AV deployment and socio-economic impacts.

**The following are some key findings and conclusions:**

Innovative procurement strategies can accelerate AV deployment. The pilots demonstrated that innovative procurement strategies, such as cooperation with public transport operators, extensive market consultation, and custom-designed solutions, can accelerate AV deployment and contribute to the development of new business models. Customer acceptance and satisfaction are crucial for the viability of AV services. The pilots revealed that AV services need to be designed with the needs and preferences of customers in mind and provide a seamless, comfortable, and reliable experience. The opportunity to learn and experience new technology first-hand is beneficial for residents and stakeholders.

Despite the challenges encountered during the pilots, such as vehicle breakdowns, maintenance issues, and adapting to changes in the environment, the opportunities identified provide valuable insights into the future deployment of autonomous vehicles. In addition, the project provided a platform for collaboration and knowledge sharing among stakeholders, which contributed to the development of new and innovative ideas.

One of the key benefits of the pilots was the opportunity to test new routes and address potential demand. This enabled a better understanding of customer needs and preferences, as well as the potential benefits and challenges of AV deployment. In addition, the pilots provided opportunities to develop the skills of the local workforce. The project's findings can serve as a valuable resource for policymakers, transport experts, and other stakeholders interested in the future of mobility and the deployment of AVs.

# Results from the PAV pilots:

## Summary of innovative products and services

Interreg North Sea Region PAV
European Regional Development Fund
EUROPEAN UNION

HI TRANS
THE HIGHLANDS AND ISLANDS TRANSPORT PARTNERSHIP

Gemeente Almere

Region Hannover

VARBERGS KOMMUN