State of art:

Autonomous buses applicable in the project **Färdplan Färingsö**

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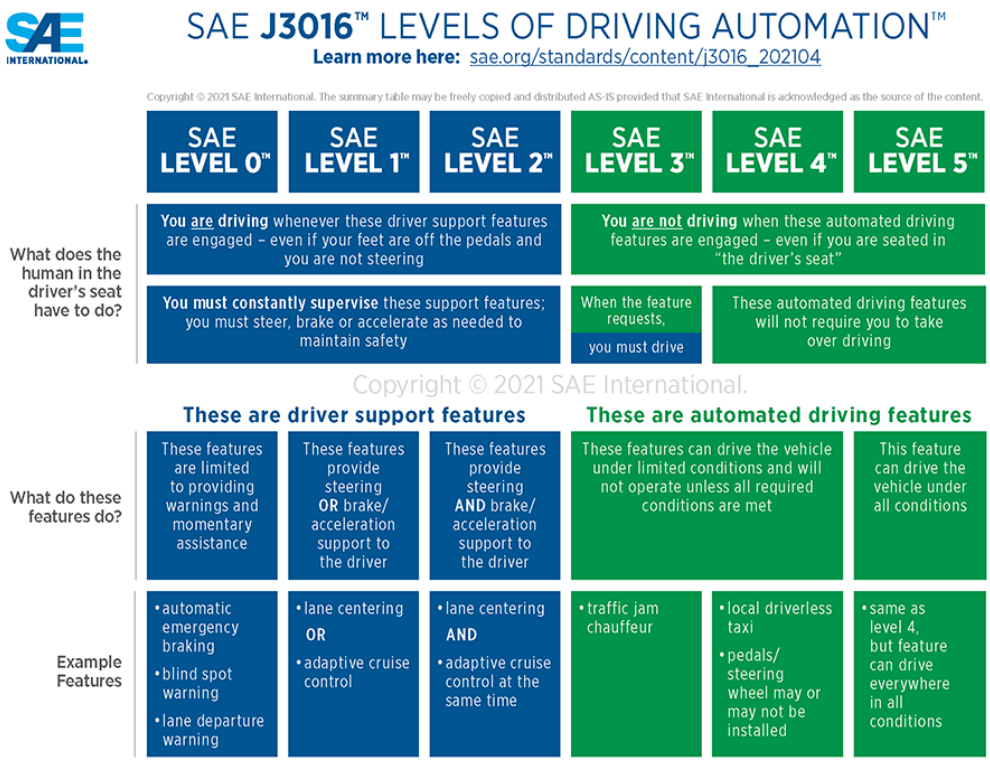
Sustainable Innovation

Summary

The objective in the project is to evaulate the prerequisites for a system solution with a strong passenger perspective where not one route but a system of existing bus lines with many routes is analyzed to be replaced with autonomous small buses.

The requirements when it comes to passenger capacity, number of vehicles, requirements of road and weather conditions based on the scenario above states the following:

- 5 passengers in each vehicle
- a total of 10 vehicles
- autonomous driving on dirt roads with no or limited guiding
- summer and winter conditions (snow and ice, frequent snow removal during winter)
- speed of +50 km/h
- on demand service in Access app
- range needed during an average operating day approximately 30 km
- in limited areas meeting traffic in needed to take place in sections with extra sidespace
- SAE level 5 with teleoperation



The SAE (Society of Automotive Engineers) J3016 Levels of Driving Automation is the official definition of autonomy level. | Image credit: SAE International.

The project aims for an on demand solution with a vehicle with a small number of passengers but on a specific route which means that we are in the market of public transport presented but also as part of the overall RoboTaxi market. According to a

research report "Robotaxi Market by Application (Goods and Passenger), Level of Autonomy (L4 and L5), Vehicle (Cars and Vans/Shuttles) the global robotaxi market, by value, is estimated to be USD 0.4 billion in 2023 and is projected to reach USD 45.7 billion by 2030.

Leading companies such as Waymo LLC (US), General Motors (US), Nissan (Japan), Volvo (Sweden), and others have invested billions of dollars in the development of autonomous cars. The robotaxi is an upcoming megatrend in the automotive industry. It is a disruptive technology that is expected to lead to the development of new mobility models and provide opportunities for infrastructure development. Governments of various countries, such as US, Germany, China, Singapore, Sweden, France, Japan, Norway, etc., have relaxed the legal hindrances for testing self-driving vehicles.

The California Public Utilities Commission (CPUC) has on Aug. 10, 2023 approved Resolutions granting additional operating authority for Cruise LLC and Waymo LLC to conduct commercial passenger service using driverless vehicles in San Francisco. The approval includes the ability for both companies to charge fares for rides at any time of day.

Europe's first autonomous bus, the EZ10 operates on Level 4, which means that it is independent and has no onboard supervision, making it the market's most intelligent autonomous shuttle provider.

Ruter AS is the public transportation authority in the Oslo and Akershus counties in Norway. With ambitious plans to automate its public transportation fleet, they believe self-driving vehicles will play a vital part in the future of mobility. For autonomous vehicles to become mainstream, they must work in all weather conditions.

Tampere, Finland, Auvetech: Driverless shuttles improving public transportation: Hervanta area is connected to the city center with a tram connection, which has created a need to improve the accessibility of tram traffic. During the winter, the area also experiences frequent sub-zero temperatures and snowy conditions. Auve Tech proposed a solution that would provide two 8-seated autonomous vehicles transporting residents during weekdays from 7:00 to 17:00. The route is 3.1 km long and operates in an open traffic environment with a speed limit of 40-50 km/h.

The overall objective of this project is to increase the service level of the public transport system in the island of Färingsö in specific and evaluate if a scalable solution based on small autonomous buses as part of the public transport system would be applicable in the many similar rural areas in Sweden and elsewhere. In order to scale financial viability in combination with increased service level is a prerequisite. The approach in this feasibility is targeting long term production cost neutrality with the present traditional production.

An estimate of increased operation in kilometers would be 7-8 times more that todays operation with traditional buses with drivers which indicates a potential for radical

increase of service level. Also the on demand service that the new solution enables is reasonably in itself an added positive effect of the service level.

Short term aspects are to verify economical and technological viability in detail for a system demonstration in Färingsö. Technology partners are to be decided in order to initiate autonomous permits from the transport authority which is likely a 18-24 months process.

Investment levels are crucial for a system demonstration such as Färdplan Färingsö and therefore it is highly recommended that a cooperation with recent research pilots in the Nordics is established. Examples of such pilots are presented above in the chapter “Pilot cases possible contributing to a Färdplan Färingsö pilot”.

The overall conclusion is that short term needs are detailed technological and economical verifications based on specific prerequisites in this project and that a system pilot demonstration in operation is possible to launch 24 months from Q4-2023.

Project requirements of rural autonomous service

The objective in the project is to evaluate the prerequisites for a system solution with a strong passenger perspective where not one route but a system of existing bus lines with many routes is analyzed to be replaced with autonomous small buses. In this way, efficiencies and increased attractiveness in backbone lines can be included as well as societal benefits from a system perspective.

The scenario of exchanging the traditional busses with autonomous smaller vehicles on the dirt roads of the island of Färingsö is based on an assumption that this can increase the experienced value of public transports in these rural areas as an on demand service with a small vehicle better corresponds to the needs than today's low frequency of scheduled departures.

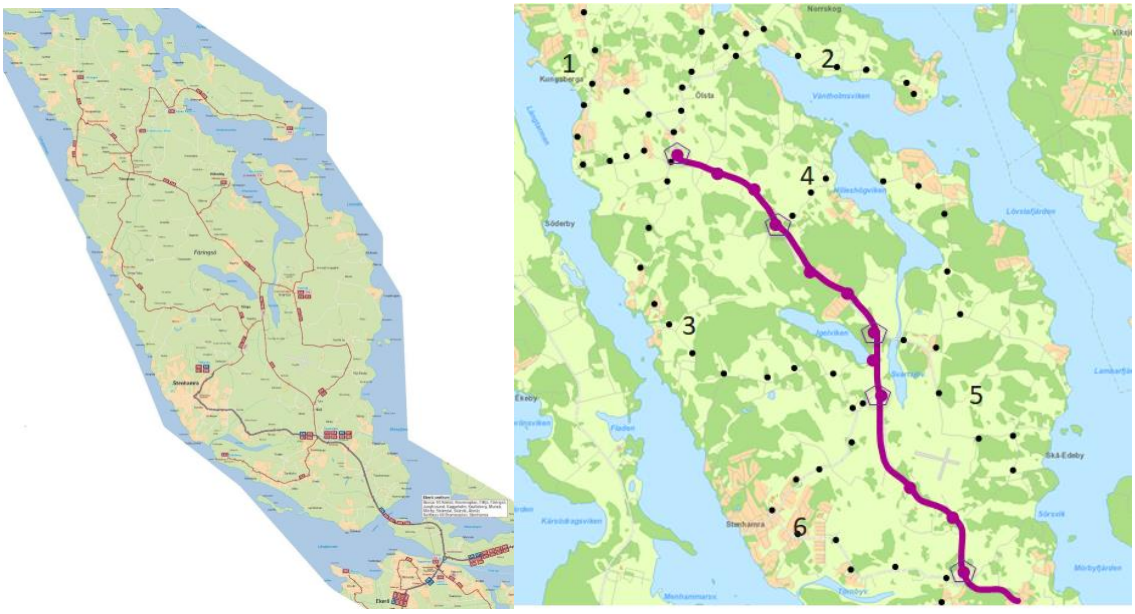
Conceptual solution

With new technology traffic can be made call-controlled through an app or similar, traffic can also be redirected according to the needs of the travelers, i.e. instead of a fixed route, a route can be created based on the current demand. One theory is that if this is combined with a frequent line, the opportunities for travel increase, both by traveling with small vehicles to the frequently used line as well as the traveler getting to its stops in their own way.

Call-controlled traffic has been tested in several rounds and has recently been introduced in traffic agreements in sparsely populated areas in the northern part of the Stockholm region. Call control often results in long lead times for the traveler as a requirement for pre-ordering without offering much added value in exchange. Here,

new solutions need to be tested for both the remaining public transport and the call-controlled part.

Since October 2018, Region Stockholm has run traffic with autonomous vehicles as scheduled traffic on open streets in Barkarbystaden. Lessons learned from there show that when the technology is further developed, the type of technology and vehicles used there should be able to solve the travel needs in sparsely populated areas for at least shorter distances.



The idea is to replace the above bus line network (left above) with the following (right above): a trunk line (purple line) as well as stops for boarding (purple dots) and transfers from/to DRT to trunk line (purple dots with a pentagon around them). The black dots symbolize former bus stops that we assume will be used for boarding and disembarking for the DRT traffic.

Overall requirements

The requirements when it comes to passenger capacity, number of vehicles, requirements of road and weather conditions based on the scenario above states the following:

- 5 passengers in each vehicle
- a total of 10 vehicles
- autonomous driving on dirt roads with no or limited guiding
- summer and winter conditions (snow and ice, frequent snow removal during winter)
- speed of +50 km/h
- on demand service in Access app
- range needed during an average operating day approximately 30 km
- in limited areas meeting traffic in needed to take place in sections with extra sidespace

- SAE level 5 with teleoperation

From the analyses we conclude that about 20 vehicles should be enough for the entire Färingsö and about 10 when area 6 (see map above) is excluded if the capacity of the vehicles is mainly 5 (at least higher for part of the fleet if area 6 is included).

In the most relevant/realistic scenarios the autonomous vehicles drive about 2000+ (2063-2157) kilometers per day.We have estimated that 10 vehicles are needed which means an average transport work of approximately 2000/10=200 km per vehicle and day on average.
With some margin and taking into account uneven utilization of the vehicle fleet and driving distance to the bus terminal a range of about 300 km should be reasonable (given depot charging once a day).

The project targets using such vehicles in rural parts of the Region of Stockholm, but is applicable in many parts of Sweden and the Nordic countries.

The project timeline also sets requirements on the autonomous applications readiness to market. This feasibility study will evaluate the possible solutions and when they can be in pilot under normal operational standards.

After this feasibility a system demonstration project is a possible next phase based on if technical, regulatory, economical and user experience prerequisites are in place. This means a pilot in practice can be operative during 2026.

Financial viability

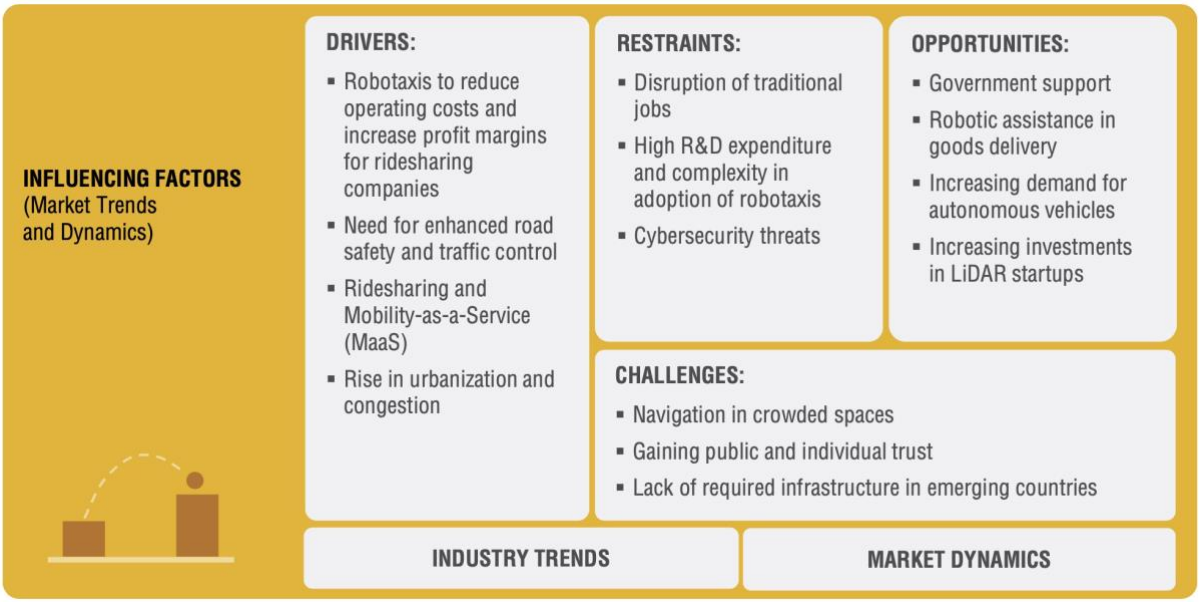
The overall objective of this project is to increase the service level of the public transport system in the island of Färingsö in specific and evaluate if a scalable solution based on small autonomous buses as part of the public transport system would be applicable in the many similar rural areas in Sweden and elsewhere. In order to scale financial viability in combination with increased service level is a prerequisite. The approach in this feasibility is targeting long term production cost neutrality with the present traditional production. In the K2 report in this project there is a comparison between today's cost per kilometer for traditional buses with a driver and the regional healthcare transport service with 8-12 seater vehicles with a driver where the production cost ratio is approximately 1:4. The healthcare transport corresponds to the capacity needed and vehicle size of the autonomous vehicles for the proposed solution. The cost of the driver is approximately 80% of the total for vehicles under 3,5 tonnes, which is the case here. Teleoperation means approximately 1 driver per 5 vehicles and autonomous technology is a cost driver. Therefore savings are estimated to half the cost reduction of the driver which means that a estimate of increased operation in kilometers would be 7-8 times more that todays operation with traditional buses with drivers which indicates a potential for radical increase of service level. Also the on demand service that the new solution enables is reasonably in itself an added positive effect of the service level.

Short term needs are a detailed technological and economical verification based on specific prerequisites in this project and according to it´s recommendations of possible cost and time efficiency of cooperating with existing pilots in the Nordics. Medium term a possible system pilot - if proven technological and economical viable - is recommended for verifying the solution in operation.

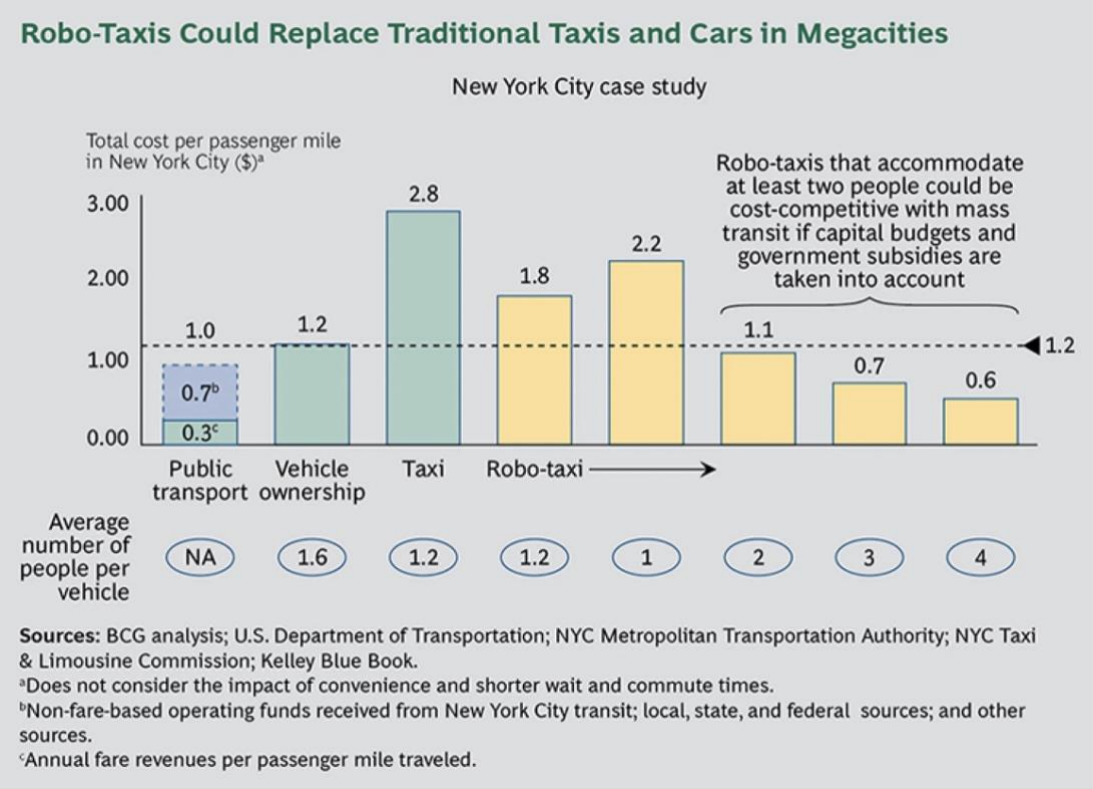
Market

The market analysis below has a focus on the RoboTaxi market but also comprises and separates autonomous public transports. The project aims for an on demand solution with a vehicle with a small number of passengers but on a specific route which means that we are in the market of public transport presented below but also as part of the overall RoboTaxi market.

According to a research report "Robotaxi Market by Application (Goods and Passenger), Level of Autonomy (L4 and L5), Vehicle (Cars and Vans/Shuttles), Service (Rental and Station Based), Propulsion (Electric and Fuel Cell), Component and Region - Global Forecast to 2030", published by MarketsandMarkets, the global robotaxi market, by value, is estimated to be USD 0.4 billion in 2023 and is projected to reach USD 45.7 billion by 2030, at a CAGR of 91.8% from 2023 to 2030.



Among the drivers in the market (see above) this project has a focus to increase the level of service for commuters with an on demand autonomous pod (e.g. minibus) meaning that operating costs and MaaS are main drivers in this application. However road safety is a prerequisite.



Source: Boston Consulting Group: Robo-Taxis and the New Mobility

"Public transportation companies will need to reconsider their infrastructure investments as shared AVs blur the frontier between public and individual transportation. What will change when public transportation and mass transportation are no longer synonymous?"

Boston Consulting Group: Robo-Taxis and the New Mobility

International outlook – Pilot cases and industry development

Leading actors and countries

Leading companies such as Waymo LLC (US), General Motors (US), Nissan (Japan), Volvo (Sweden), and others have invested billions of dollars in the development of autonomous cars. The robotaxi is an upcoming megatrend in the automotive industry. It is a disruptive technology that is expected to lead to the development of new mobility models and provide opportunities for infrastructure development. Governments of various countries, such as US, Germany, China, Singapore, Sweden, France, Japan, Norway, etc., have relaxed the legal hindrances for testing self-driving vehicles. Industry experts state that the introduction of the robotaxi will help reduce the cost of ownership and improve fleet management. These taxis are expected to provide a safe, convenient, and economical mode of transportation in the future. Thus, OEMs, autonomous driving system providers, and fleet managers are focusing on launching robotaxis.

By level of autonomony, Level 4 segment is estimated to account for the largest market size during the forecast period.

Ease of deployment and operation of level 4 autonomous robo-taxis are the main reasons for growth. Lack of technological advancements and safety issues are the hurdle for level 5 autonomous vehicles for mass deployment. As per industry experts, the first few deployments would be on level 4. Post that, with technological advancements in the robo-taxi market in countries such as the US, Germany, and China, more vehicles are projected to move to level 5 autonomy.

Also, there has been a significant increase in investment in autonomous vehicle technology in recent years, with companies such as Waymo, Uber, and Lyft all investing heavily in the development of level 4 vehicles. This investment has helped to accelerate the development of the technology and has made it more likely that level 4 vehicles will be commercially available in the near future.

For Instance, In May 2023, DiDi Autonomous Driving and Valeo announced a new strategic cooperation and investment agreement. Valeo intends to invest in DiDi Autonomous Driving and the two partners will develop intelligent safety solutions for L4 Robotaxis together.

By vehicle type, the Cars segment is estimated to account for the largest and the fastest market during the forecast period.

Autonomous vehicle manufacturers and operators are investing heavily for the deployment and testing of self-driving vehicles. At present, developments and testing are seen in vans, shuttles, and cars. But as per the industry experts, due to the rise in ride-sharing services, the autonomous car market will dominate the overall market. Companies are working in partnerships to bring robotaxis into existence. For example, Hyundai (Japan) and Motional, Inc. (US) plan to begin transporting public passengers in the Ioniq 5 robotaxi in 2023, starting in Las Vegas and expanding to major cities in US. On February 1st, 2022, Cruise LLC, a division of General Motors specializing in autonomous vehicles, made level 4 robotaxis available in San Francisco.

Asia Pacific is expected to be the largest market during the forecast period

The main drivers influencing the industry in China include the rapid testing of autonomous vehicles, the existence of several technology providers and ride-hailing companies, and ambitions to deploy robotaxi fleets for widespread use. The biggest market for automobiles is in the Asia Pacific area, which includes developed countries like Japan and China as well as growing economies like China and India. The growing concerns about pollution and the rise in the number of vehicles on the road, which has resulted in traffic congestion, are the main factors driving the robotaxi business in China. For the testing and use of robotaxis, the Chinese government has also established systematic rules. These regulations have inspired several businesses to conduct vehicle testing in China. In addition, the increasing demand for electric vehicles

and availability of infrastructure are expected to lead to the increasing deployment of robotaxis.

Some of the key market players are:

- Waymo (US),
- Cruise LLC (US),
- Baidu (China),
- AutoX (China),
- EasyMile (France),
- Navya (France),
- Optimus Ride (US), and many more...

Pilot cases possible contributing to a Färdplan Färingsö pilot

Ruter AS is the public transportation authority in the Oslo and Akershus counties in Norway. With ambitious plans to automate its public transportation fleet, they believe self-driving vehicles will play a vital part in the future of mobility.

For autonomous vehicles to become mainstream, they must work in all weather conditions. The climate in Norway is typically Scandinavian, where rain, snow and harsh temperatures are common. Ruter was looking for self-driving vehicles that work year-round in all weather conditions.

Ruter was looking for a partner who could provide self-driving vehicles and take them one step closer towards permanent autonomous service. This was the start of the international partnership between Ruter, Holo, Toyota Motor Europe and Sensible 4.

Toyota Motor Europe chose Sensible 4 to automate the vehicles to be used in the project due to Sensible 4's all-weather driving capabilities. With a long history in outdoor robotics and a proven track record in testing self-driving software in challenging conditions in Finnish Lapland, Sensible 4's autonomous driving software was seen as the perfect match for Ruter's needs.

The autonomous service was launched at the beginning of 2021 with two autonomous Proace vehicles that drove for a period of one year. The project was part of developing the strategic partnership into a long-term collaboration and providing new sustainable mobility solutions to the people living in the area.

"One major concern for Ruter's ambitions for shared automated public transport has been the Scandinavian weather. Sensible 4 proved the viability of automated transport in winter climate. A significant step towards sustainable mobility for all."

Lars Gunnar Lundestad, Project Manager Self-driving, Ruter

Project in Numbers

- Vehicle: 2x Toyota Proace
- Driven 16 214 km and 1280 operating hours
- Max speed: 30 km/h
- Partners: Sensibile 4, Ruter, Holo
- Other projects and launches

Tampere, Finland, Auvetech: Driverless shuttles improving public transportation

Challenge for client: Hervanta area is connected to the city center with a tram connection, which has created a need to improve the accessibility of tram traffic. While it would be possible to implement a solution based on traditional bus traffic, it is not sufficiently cost-effective. During the winter, the area also experiences frequent sub-zero temperatures and snowy conditions.

Solution: Auve Tech proposed a solution that would provide two 8-seated autonomous vehicles transporting residents during weekdays from 7:00 to 17:00. The route is 3.1 km long and operates in an open traffic environment with a speed limit of 40-50 km/h. On the route, there are seven main road intersections, three give-way intersections, two roundabouts, and 24 pedestrian crossings. The route has six bus stops for transporting passengers from the residential area to the tram stop.

Cruise LLC and Waymo LLC

SAN FRANCISCO, Aug. 10, 2023 – The California Public Utilities Commission (CPUC) today approved Resolutions granting additional operating authority for to conduct commercial passenger service using driverless vehicles in San Francisco. The approval includes the ability for both companies to charge fares for rides at any time of day.

Since late 2022, thousands of SF residents across all neighborhoods have relied on our fully autonomous Waymo One service to get around the city 24/7.

https://sensible4.fi/cases/case-moove/

https://sensible4.fi/cases/case-gacha/

https://www.helsinkismart.fi/portfolio-items/sohjoa/
Hop on the driverless SOHJOA robobus

https://www.automobilwoche.de/article/20180627/NACHRICHTEN/180629908/kooperation-von-zf-und-ego-robo-bus-startet--in-serie
Kooperation von ZF und eGO:
Robo-Bus startet 2019 in Serie

https://www.heise.de/select/ct/2018/10/1526008148939708
Robobus
Wo und wie autonome Busse jetzt schon fahren

https://www.innoz.de/de/robobus-wo-und-wie-autonome-busse-jetzt-schon-fahren
Robobus: Wo und wie autonome Busse jetzt schon fahren

https://vaaju.com/switzerland/20-minutes-we-took-the-robo-bus-into-the-future/
We took the robo bus into the future

https://www.sott.net/article/305182-Robo-bus-Driverless-buses-are-coming-to-America
Robo bus: Driverless buses are coming to America

https://www.salzburgresearch.at/en/2019/this-was-the-citizen-debate-on-automated-mobility-in-salzburg/
This was the Citizen Debate on Automated Mobility in Salzburg

Europe's First Fully Autonomous Bus Is Now on the Road

EasyMile, a Toulouse-based technology company, has announced that it is the first in Europe to be authorized to operate without a human attendant on a public road in mixed traffic. The authorization comes from France's Ministries of Transport and f Environmental Transition, following extensive test runs in partnership with Alstom in the southern city of Toulouse. EasyMile passed rigorous tests and dry runs to obtain the permissions, demonstrating the technology's safety and reliability.

Europe's first autonomous bus, the EZ10 operates on Level 4, which means that it is independent and has no onboard supervision, making it the market's most intelligent autonomous shuttle provider.
Despite eliminating onboard supervision, it has introduced remote surveillance, which keeps in constant contact with the vehicle concerning where it is, what it sees, or what it will do next.

Besides being run on Level 4, the latest version of EZ10 seats 12 people and includes cushioned seating, safety belts, and an automated ramp and wheelchair anchor points

for passengers with disabilities. In January 2021, EasyMiles announced that it had upgraded the sensor suite of the EZ10 and collaborated with German startup Sono Motors to integrate solar cells and extend the vehicle's range.

https://blog.getmyparking.com/2022/09/23/europes-first-fully-autonomous-bus/

The prospect of launching a pilot within 24 months

Autonomous buses, shuttles and taxis have the technology ready for some applications and regulatory frameworks are progressing and legal permits to autonomous services have been approved in some areas.

The growth of the market is influenced by the rising demand for ride-hailing services, high R&D investments, and government focus on reducing emissions, infrastructure development, and growth of the electrification of vehicles.

The autonomous bus pilots are multiplying, and autonomous taxi services are now in operation. Manufacturers have also announced commercial launches of autonomous bus fleets.

Short driverless shuttle buses operated in private areas are not something new (we could mention, for instance, Navya and Easy Mile from the side of the industry, while ZF is quite active in this concern).

Robotized local charging – full operational autonomy

Autonomous buses should preferably have local and robotized charging in an application like this one as rural areas. With such solutions the bus can operate autonomously in its local area where it is in operation on a daily basis without extra milage and/or personal supervision for charging the battery. The FFI project Fully electric freight distribution with optimized charging system (Fullelektrisk godsdistribution med optimerat laddsystem, Vinnova Dnr 2016-02552) piloted a charging solution for a DHL distribution vehicle in a similar size and energy capacity need as a 12-seater autonomous bus. The solution was based on ground based electric road technology with static charging and a connector mounted under the vehicle. This pilot was based on Elonroad technology and was in operations in Malmö for years after the pilot ended. Such solution or similar is cost efficient and easy to implement and could therefore be part of a system solution when piloting Färdplan Färingsö in order to reach full operational autonomy.

Recommendation

This recommendation is based on all segments of this feasibility study comprising baseline analyses by Stockholm Region, data modeling and scenario analyses by K2, commuter behavior and attitude survey and analyses by K2 and technical as well as research pilots with focus on implemented pilots with corresponding prerequisites and

statements from industry actors with focus on short term (1-2 years) operational plans and targets.

The market readiness with substantial investments has helped to accelerate the development of the technology and has made it more likely that level 4 vehicles will be commercially available in the near future. The technological readiness and the scaling of accessible vehicles for pilots with SAE level 5 with teleoperation under the project prerequisites and scale (5-20 vehicles depending on scenario) is realistic to be set in operation within a time frame of Q4-2025/Q1-2026.

Investment levels are crucial for a system demonstration such as Färdplan Färingsö and therefore it is highly recommended that a cooperation with recent research pilots in the Nordics is established. Examples of such pilots are presented above in the chapter “Pilot cases possible contributing to a Färdplan Färingsö pilot”.

It is also recommended to evaluate the possibility of comprising a robotized local charging for full operational autonomy in a system demonstration pilot, see segment “Robotized local charging – full operational autonomy” above.

The overall conclusion is that a system pilot demonstration project based on the prerequisites in this feasibility study is possible to launch 24 months from Q4-2023.

International development and pilots

Navya

Navya gets €7.5M subsidies from France government to pilot four high-tech projects. It’ll work on a driverless Bluebus e-bus

Navya has been awarded 7.5 million euros of subsidies (mainly non-repayable) to pilot four high-tech projects, three of which are part of the Government initiative ‘France Relance’ program.
The France Relance program was introduced by the Prime Minister in September 2020 and its objective is to build the France of 2030 with 100 billion euros deployed to promote strategic initiatives and face the Covid-19 crisis.

One of the projects, carried out with Actia, Bluebus and Keolis, is aimed at developing and industrializing an autonomous bus based on the Bluebus electric bus.

he 5G-AV project (5G for Autonomous Vehicles) intends to operationally implement the technological contributions of 5G in autonomous driving for the benefit of customers, in partnership with Orange. In particular remote assistance, cybersecurity and the

processing of data analyzed by Artificial Intelligence deported to the operators' computing centres. This initiative will follow on from the level 4 fully autonomous experimentation carried out in Châteauroux in June 2020. This project is a prize-winner of the France Relance program.

Iveco autonomous bus under development (with EasyMile)

Iveco autonomous bus prototype is coming in early 2021. It is being developed in the framework of STAR project and thanks to a wide range of partnerships between Iveco Bus and a group of companies and laboratories. The main partner is anyway EasyMile, a French company that already developed and presented a driverless electric shuttle (they were present at last UITP Summit as well).

To do this, Iveco Bus, together with a group of companies and laboratories (see below), is equipping its prototype with electronic components and sensors. Its partner, EasyMile, a world leader in intelligent mobility solutions, is providing its technology as well as its experience in platform integration, deployment and autonomous vehicle fleet management.

100 passengers on the driverless concept

Launched in 2017, the STAR project, Rapid Autonomous Transport System, which aims to develop the first driverless, autonomous standard bus, capable of operating under conditions similar to real operation, should produce a prototype in early 2021.

The first Iveco autonomous bus will be 12 meters long and capable of carrying around a hundred passengers. The bus aims to achieve speeds of up to 40km/h, all without a driver. The bus will be capable to execute level 4 autonomous operations under real conditions. Of course, initially the bus will operate in reserved areas or on dedicated roads, evolving towards integration into the normal traffic flow. No information are so far provided about the model and kind of drivetrain of the bus that will be protagonist of the pilot.

https://www.sustainable-bus.com/its/iveco-autonomous-bus-under-development-with-easymile/

UK's first full-sized autonomous bus hits the road

The UK's first full-sized self-driving bus will take to the roads this week as part of a government-sponsored autonomous vehicle project.

The Project CAVForth pilot, which is funded by the UK government's Centre for Connected and Autonomous Vehicles (CCAV), will see five single-deck autonomous buses – each manned by a safety driver – operate in and around the Edinburgh region over the next two weeks.

Bus firm Stagecoach, in partnership with technology company Fusion Processing, bus manufacturer Alexander Dennis, and Transport Scotland, will carry out initial passengerless on-road testing in preparation for the launch of a passenger service this summer.

Sam Greer, Regional Director for Stagecoach in Scotland, said: "This is a hugely exciting project for Scotland and we are pleased to be starting live testing on roads.

"This is a major step forward in our journey to fully launch the UK's first full-sized autonomous bus service and will provide easy access to a brand-new bus route in the heart of East Scotland."

Routes

The buses will travel at speeds of up to 50mph (80 km/h) on their 22.5-kilometre route, which will mostly involve motorways. On part of their motorway journeys, the vehicles will operate in bus lanes on an 'actively managed hard shoulder', but will also have to navigate minor roads and a business park site.

Sensors enable the buses to run on pre-selected roads without safety drivers having to intervene or take control, but each will have an experienced driver monitoring the system.
When the passenger service launches later this year, each vehicle will also have a 'bus captain' on board who will talk to customers about the service.

Jim Hutchinson, Fusion Processing CEO, said: “CAVForth will provide a useful service to local people as well as being a great demonstration of Fusion’s automated vehicle technology.

“On-road testing is an exciting milestone in the development of autonomous commercial vehicles and we look forward to welcoming passengers onboard in a few months’ time.”

When fully operational for passengers, the buses will provide a service capable of carrying up to 36 people, with a capacity of 10,000 a week.

SAE level
There are currently six levels of driving automation as defined by the Society of Automotive Engineers (SAE) – ranging from zero (fully manual) to five (fully autonomous).

During the initial trial, the vehicles will operate at SAE level four, meaning no driver attention is required for safety but self-driving is only supported in limited areas or circumstances.

CAVForth project
Welcome to CAVForth, the world’s most ambitious and complex autonomous bus pilot. Together with our partners; Fusion Processing Ltd, Stagecoach Plc, Alexander Dennis Ltd, Transport Scotland, Napier University and Bristol Robotics Lab, we’ll be rolling out a fleet of five fully autonomous full sized buses and operating a scheduled service across the Forth Road Bridge. The 14-mile (22.5Km) route runs from the Ferrytoll Park and Ride in Fife, across the Forth Road Bridge Public Transport Corridor, to Edinburgh Park, carrying up to 10,000 passengers per week.

The buses will be operating at AV Level 4, meaning they have a trained safety driver onboard, but the driver will not be expected to touch the controls whilst the vehicle is in autonomous mode.

The route takes in a range of infrastructure, from pedestrianised bus & train stations, mixed single carriageway roads, 50mph motorway and dedicated bus lanes. The autonomous buses negotiate traffic light-controlled and normal roundabouts whilst integrating with live traffic.

CAVForth will be a showcase for the most advanced autonomous public transport pilot anywhere in the world, and we’re sharing the technology, timeline and why this is a key milestone environmentally friendly transport.
https://cities-today.com/uks-first-full-sized-autonomous-bus-hits-the-road/
https://www.cavforth.com

Yutong

Yutong has a 13% market share in the global bus market and aims at a worldwide expansion together with the increasing electric bus deployment outside China. Europe and Latin America are already in the spotlight, with batches of vehicles running in Scandinavia (mainly in Bergen, Norway) and France and a large e-bus fleet delivered by the Zhengzhou-based manufacturer in Santiago de Chile.

A new interview dated November 2020 shows that the brand is betting strongly on Nordic countries, with a focus on a direct presence on the European markets. And the road is paved for the commercialization of the U12 in parallel with the E12. Notably, Yutong has reached a 60% market share in the Danish market regarding e-buses.

Focusing on the Yutong Xiaoyu 2.0 recently crowned with the Red Dot Award in the category ‘Commercial vehicles’ (where brands such as Volvo, Mercedes, MAN have been awarded during the years), the autonomous bus has entered the stage of massive distribution in Guangzhou, Nanjing, Sansha, Changsha and Zhengzhou. Yutong points out that the implementation has requested over 700 days, reaching 360 thousand trips and 7.1 million kilometers of operations for open roads. Xiaoyu 2.0 is also China’s first autonomous bus which is introduced into tarmac test in Changsha airport.

Yutong Xiaoyu 2.0 features 5G V2X transmission technology that allows interactions between vehicle and traffic lights. Just like the victory of ALPHA GO, upon variety of radars embedded inside vehicle, Xiaoyu 2.0 brings together computing strategy, braking distance, timing and smoothness.

5,500 millimeters long, the driverless bus can accomodate a maximum of 10 seated passengers and is powered with a 70 kWh LFP battery. Automatic driving speed limit is set at 40 km/h. The bus, indeed, is equipped with a variety of sensors such as laser radar, millimeter wave radar and camera to achieve L4-level autonomous driving (High Automation).

The Yutong Xiaoyu 2.0 developed by the Chinese group – the largest bus builder in the world for production volumes - the 5.5-meter shuttle bus stands out for being the world's first autonomous bus has been awarded the design prize 2021 Red Dot Award.

https://www.sustainable-bus.com/its/yutong-xiaoyu-2-0-autonomous-bus/

The Israeli government will fund half the cost of the two-year pilot program, expected to result in commercially operated autonomous bus lines

The Ministry of Transport, the Israel Innovation Authority and Ayalon Highways today have announced that four consortia will carry out an autonomous bus pilot in Israel. In the coming months the winning corporations are expected to begin a two-year pilot program operating autonomous buses, at an investment of NIS 61 million. Half the sum will from government funding. Upon completion of the program, the winning corporations are expected to operate the bus lines commercially using autonomous buses.

The pilot program will be in two stages. During the first stage, the winning companies will run autonomous buses in a closed experimental area and in operational areas, with the aim of proving technological, regulatory, safety and business feasibility. In the second stage, the companies will operate autonomous bus lines on public roads, with a range that will increase during the two-year pilot period.

The winning companies are:
Metropolin (a large bus operator in Israel), B.G. Motors, Karsan (Turkey), Adastec (Michigan, USA), Applied Autonomy (Norway) and Ottopia (Israel). The technology companies in the group have experience with previous autonomous public transport pilots worldwide, including in Michigan, the US, and Norway.

Egged and a French technology company that has a vehicle in use in various environments in over 20 different countries.

Dan, Via (Israel), EasyMile (France), Enigmatos (Israel) and Ottopia (Israel). EasyMile, which will provide the autonomous vehicles, has proven global experience in running autonomous minibus services in urban areas.

Nateev Express and Imagry, an Israeli start-up company that is developing a software platform for autonomous driving. Imagry recently received funding from the Israel Innovation Authority for a pilot program running an autonomous, driverless shuttle at the Sheba Medical Center.

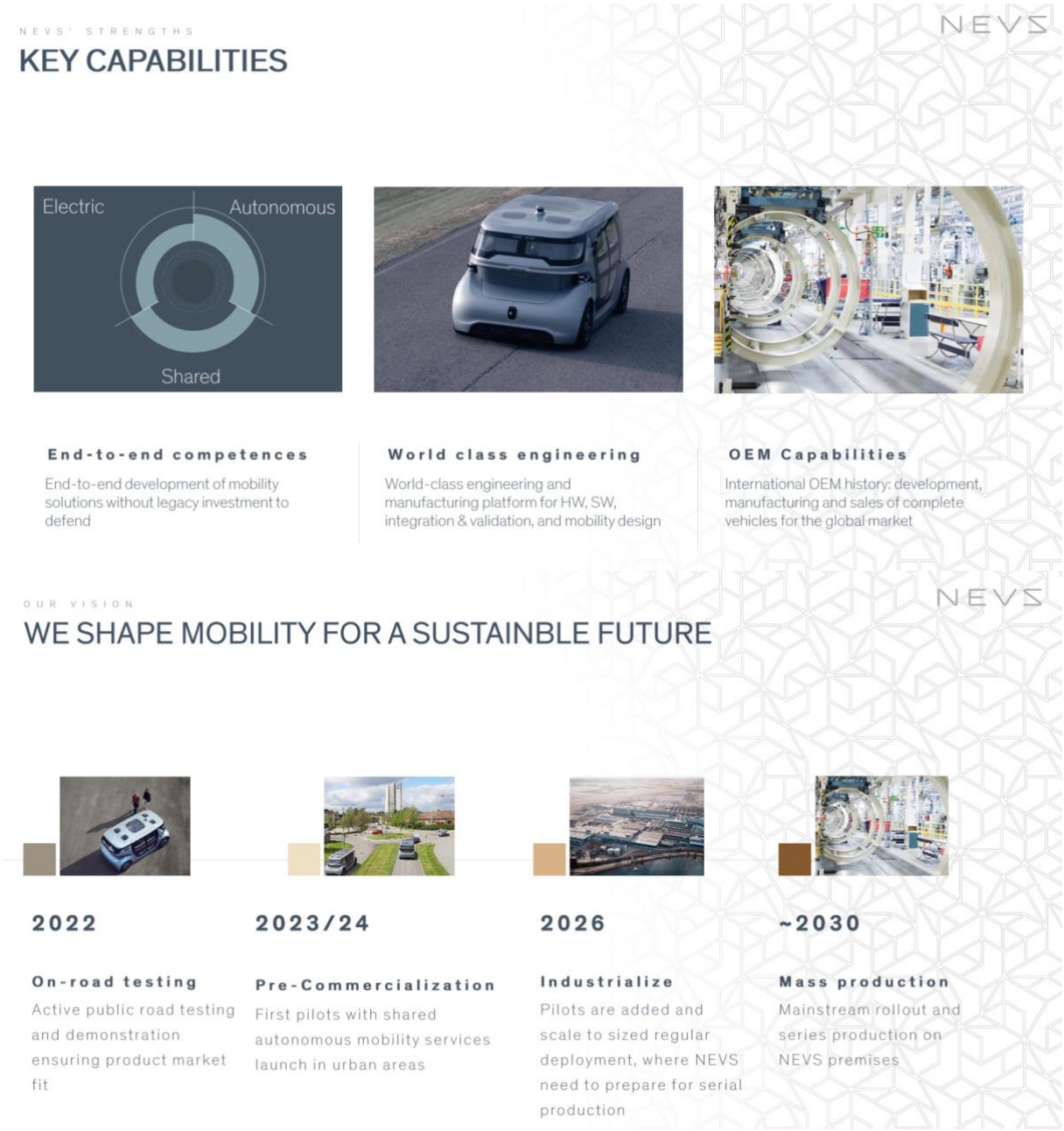
https://en.globes.co.il/en/article-four-groups-1001429005

Swedish initiatives

In Sweden both NEVS and the start-up CabiBUS shows interesting concepts corresponding to the findings in the projects commuter survey. However both companies are now stalled due to lack of funding.

NEVS

Nevs concept for autonomous have had developed based in Sweden and the outcome is a vehicle that corresponds well to the project demands in its size and layout. However the company is now without funding and not able to be part of a pilot for now.



https://www.youtube.com/watch?v=X0AOW_ql1I4

CabiBUS

CabiBUS is a compact, self-driving (autonomous Level 4), electric car with 3 doors on each side for a total of 6 passengers. It also have a rear cabin bookable for wheelchair passenger, baby stroller or luggage. It's more convenient, safe, reliable and sustainable than any other means of local and regional travel. It's also suitable for children and persons with disabilities. CabiBUS can be produced in vastly larger volumes than buses and trams, which provides economies of scale and low cost per seat. It's truly the game changer in public transportation that can replace a substantial part of the private car traffic.

The design of the CabiBUS for passengers correspond well to the requirements and possible hinders that commuters state in the survey performed during this project concerning personal space, safety and it also provides possibility to work.

However this project lacks team and funding for developing a prototype and take next steps towards a pilot.

Related Drive Sweden projects

The strategic innovation program Drive Sweden has a portfolio of projects with focus on shared, connected and autonomous mobility. The projects most related to Färdplan Färingsö are as follows:

Network Automated Driving Regulations

International and EU regulations for automated driving are in the middle of a jump. There will be extensive regulatory activities during the project period 2023-2025. Together with extensive work by the legal experts, the project aims to:

- bring clarity to issues related to the interpretation of current and upcoming regulations
- monitor upcoming and new international initiatives and regulations
- proactively influence international and Swedish legislation
- prepare for infrastructure adaptation.

Project period: June 2023 - May 2025

Drive Sweden Policy Lab (DSPL)

DSPL is a platform for joint policy development with actors from business, authorities and research that enables smart mobility which can support as an independent examiner in trials with automated vehicles.

Roadmap for sustainable mobility solutions based on autonomous driving in a complex city environment

The project (also called Autonomous Mobility Roadmap) has investigated, defined and inventored the conditions for autonomous mobility. Among other things, it has examined what prerequisites are needed for the technology regarding regulations and policies, physical and digital infrastructure, business models and service design, such as the public's acceptance of autonomous mobility and mobility needs.

The project has continued to build on existing knowledge and experience within the field of autonomous and sustainable mobility solutions and take the "next step" in that direction by investigating the requirements regarding:

- Deployment of autonomous vehicles in complex urban environments, including different types of vehicles and different types of mobility solutions
- Deployment of autonomous vehicles at increased speed, relative to previous pilots, so they comply with the road regulations of the ODD and are good enough for the users of the service
- The urban planning and design challenges of autonomous mobility
- Necessary tests at test site and in urban environment

In addition, the project has investigated the feasibility of the following characteristics of autonomous vehicles in a complex urban environment:

- Removing the safety driver and allowing a human driver to intervene from remote when needed
- How to create an urban environment where autonomous mobility from different providers runs on the same roads and at the same time

Time period: August 2022 - February 2023

Contact: Maria Håkansson, Afry: maria.hakansson@afry.com

Partners
AFRY, AstaZero, CEVT, Keolis, Klimator, NEVS, Nobina, Skanska, Trafikkontoret Göteborg

Preparation project Testbed AV Trollhättan

In a nine-month project, the City of Trollhättan, together with NEVS and AstaZero, is investigating how the process for testing autonomous vehicles on public roads can be made more efficient.

Period: August 2022 - May 2023

Contact: Jörgen Einarsson, City of Trollhättan: Jorgen.Einarsson@trollhattan.se

Partners
Trollhättans Stad, Asta Zero, NEVS

Digital platform

The cloud platform Drive Sweden Innovation Cloud is used as a base for several projects that have funding from Drive Sweden, for example, several pilot tests with connected self-driving vehicles and new mobility services have been completed.

Time period: April 2022 - april 2023

Contact: Stig Persson, Ericsson: stig.persson@ericsson.com

Partners: Qlik, Saab Combitech, VOI Total

Synergetic Autonomous Transport

The project has developed endpoints for autonomous deliveries and connected self-driving minibuses and delivery robots. The goal has been to contribute to making future urban freight and passenger transport more sustainable, efficient, accessible and safe.

Important sub-areas addressed in the project have been vehicle technology, transport efficiency, user perspective, business models and urban development.

Time period: January 2022 - June 2023

Contact: Sara Berge, Hugo Delivery: sara@berge.io

Business models for robotaxis

This project intends to explore in what cases a fleet of robotaxis could be an option for certain types of public transport in Sweden. For robotaxis to be successful and

introduced to our streets an increased level of knowledge about what factors that drive this development and what legal and business related challenges hinder the development is needed. The project will gather new insights on this in a handbook.

Purpose and aim

The project intends to explore in what cases a fleet of robotaxis could be an option for certain types of public transport in Sweden. In order to do so, a deeper level of understanding is needed and this could be reached by creating a strategic framework intended to clarify what prerequisites and factors drive or hinder development and a sustainable operation of robotaxis in Sweden.

Expected effects and results

The project intends to create a tool box which could be used for creating the required preconditions for new mobility solutions that are based on an effective, connected and automated road transport system. The tool box could be used by a variety of actors, like vehicle manufacturers, cities, regions, authorities and academia.

Time period: November 2020 - August 2021

Contact: Erik Wetter, Stockholm School of Economics: erik.wetter@hhs.se

Countryside selfdriving vehicles

How could autonomous vehicles be used to improve rural public transport in Sweden? Through a combination of interviews, workshops and an RFI (Request for information, a first step towards procurement) we have explored the question from the perspective of four specific municipalities – Lund, Gotland, Eskilstuna and Skellefteå.

Project period: January 2020 - March 2021
Contact: Håkan Burden, RISE: hakan.burden@ri.se