Deploying your first autonomous vehicle

What cities and companies can learn from Barcelona's first pilot

pendel

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Foreword

Autonomous vehicles are finally hitting the road. After years of computer-generated images, clunky prototypes, and endless opinion pieces, we are now learning what autonomous vehicles can really do for urban and rural transportation.

Early results point to autonomous vehicles setting a new standard in service provision. Private site operators could improve the reliability of their mobility services with vehicles that follow the optimum cost-effective route every single journey. Public authorities could offer freedom and mobility to aging and remote populations at a scale that has never before been affordable or practical.

But as with any nascent technology, reality has not yet reached this potential. The technology may be reliable, but the specifics of deployment - choosing the optimum route, building a business plan and delivering a comfortable ride - remain more challenging for implementers.

This is why we are sharing Pendel Mobility's lessons for launching your first autonomous vehicle. *Through the insights that follow you'll learn everything we did over the course of our one-month pilot of an autonomous vehicle in the Port of Barcelona.*

We felt it important to share our learnings with other organizations, public and private, to accelerate the implementation of a technology we believe to be the future of safe, efficient vehicle-based mobility.

If there is one piece of advice to take from the guide, it is this: ***now is the time for local authorities, site managers and private companies to develop their autonomous vehicle plan****.*

If you want to take advantage of the value on offer in five to ten years, your planning should start today. Otherwise, the technology may well drive off without you.

BAX & COMPANY
VALUE FROM SCIENCE AND TECHNOLOGY

Rolf Bastiaanssen,
Partner Bax & Company
Advisory Board Pendel Mobility

EasyMile

We are seeing an ever-increasing appetite for innovation in public transport. Projects like this one are critical to the relevancy of autonomous solutions as part of today's transport mix. They validate not only the use case, but the concept overall. They are also an important part of facilitating public acceptability of shared, driverless transport. We are delighted to have been trusted as the technology partner who can help deliver this.

Port of Barcelona

The Port of Barcelona is the main transport and logistics infrastructure in the Mediterranean region. The Port of Barcelona, as set out in its IV Strategic Plan, took the decision to position itself as an innovative port. Based on its own innovation model defined on the basis of the Smart Port concept, the Port of Barcelona's Innovation Plan 2021-2024 sets out the lines of action that will be its roadmap for the coming years:

- *Creating appropriate innovation management structures*
- *Establishing agreements and alliances with its innovative environment*
- *To create an innovative ecosystem focused on the blue economy*
- *Disseminate innovation*

One of the main objectives of the innovation plan of the Port is to become a Blue Sandbox, providing physical spaces to innovative startups and companies to test new technologies and products related to the blue economy. This pilot is part of this initiative that aims to stimulate and support the innovation of the port community of Barcelona.

Carles Rúa Costa, Chief Innovation Officer Port of Barcelona

1. Pendel Mobility

About us

Pendel Mobility is a service integrator and operator of autonomous vehicles for public authorities and private sites.

The company works with autonomous mobility solutions for passenger transportation, logistics and delivery of goods, street and facility management.

After years of experience working in the autonomous mobility sector with different sites across Europe, the team has developed a holistic view of the industry to support its clients to build realistic plans for autonomous vehicles in the short and long term. Pendel Mobility prepares, organizes and evaluates autonomous vehicles projects to accelerate the integration of the technology within new use cases.

Pendel Mobility is a spinoff of Bax & Company, a leading European innovation consultancy working with 100+ cities and regions worldwide on mobility topics. The consultancy is active within leading international projects on autonomous vehicles such as SHOW (Shared automation operating model for worldwide adoptions), PAV (Planning for autonomous vehicles) and SAFE-UP (Proactive safety systems and tools for a constantly upgrading road environment).

Bax & Company works on a multitude of strategic studies to help public authorities and the industry to prepare for autonomous vehicles. Their services include business case analysis for public transport, socio-economic impact assessments, and transitions within the job market.

The two organizations combine deep sector expertise with the practical experience deploying autonomous vehicle operations needed to deliver autonomous vehicle projects to clients across Europe.

Are you interested in autonomous vehicles and want to better understand what it means and can do for your organization? Get in touch with our international team.

https://pendelmobility.com
contact@pendelmobility.com

Our services

Pendel Mobility provides an all-inclusive service for deploying autonomous vehicles for a variety of use cases.

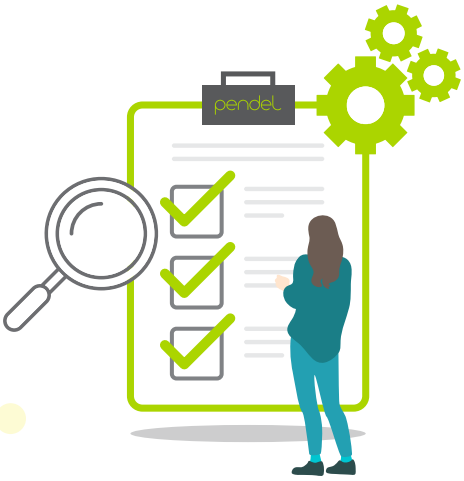
We work with mobility managers on project feasibility, operations and evaluation, and long-term planning.

1. Getting started

We perform a site assessment analysis, identify suitable use cases and define vehicles and infrastructure requirements. We make operational and budgetary estimations and identify required permits and authorizations.

2. On the ground

We design, ship and set up the vehicle to the site, ensure training of safety operators and coordinate overall operations. We lead the permit approval with national authorities.



3. Learn and share

We define an evaluation process through surveys, interviews and data collection from the operations, resulting in a comprehensive report. We coordinate public relations, organise engaging events, define a communication strategy and produce related content.

Pendel works with city planners, private companies and mobility managers to steer autonomous vehicle projects through the complexities and uncertainties of the planning and pilot stage.

2. The pilot project

The pilot project was initiated by Pendel Mobility and the Innovation team of the Port of Barcelona, through the opportunity to join the European project Ride-to-Autonomy. Preparation for the project began in Autumn 2021 when the teams met to discuss potential routes and use cases for the deployment of an autonomous shuttle.

Due to the budget and agenda constraints, the team decided to focus on a short route during a short period, but with a use case that would be well integrated into the Port's operations. It was decided that connecting an on-site employee parking lot to the World Trade Center, where the offices of the Port are located, would be the optimum testing site.

The objective of the pilot was to deploy an autonomous shuttle in real-life conditions and understand the main regulatory and operational steps needed. After months of preparation, the autonomous shuttle launched its operations on May 30th 2022, with Pendel joined by high-level representatives from local organizations and European partners from the Ride-to-Autonomy project.

After one month of operations, the team analyzed the performance of the vehicle and collected valuable feedback from operators and the public. The pilot sparked interest from employees and innovation managers in continuing to explore use cases for autonomous vehicles within the Port of Barcelona.

Training week of Alsa's safety operators.

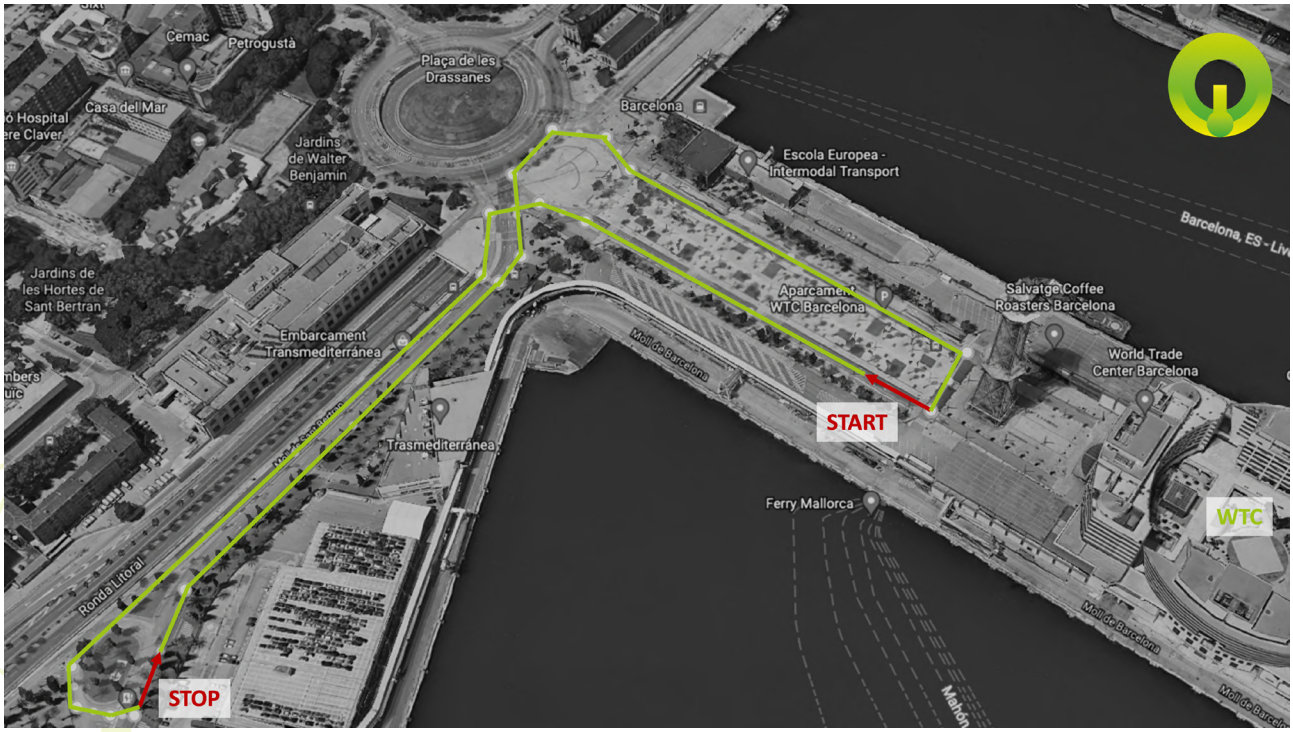
The Route

The autonomous shuttle operated on a public route during the morning from 7:30 to 9:30 and the afternoon from 15:30 to 17:30 from Monday to Friday.
The 1.9km round trip runs through a dense, often congested area with mixed traffic conditions and includes:

- 4 traffic lights
- 2 stops, one at the parking spot and one in front of the World Trade Center
- 2 roundabouts and intersections without priority.

The difficulties of the chosen route presented a valuable test of the autonomous vehicle's capacity to deal with challenging situations. Difficulties included:

- Sharing the route with hundreds of heavy vehicles and taxis accessing the Port daily.
- The reduced speed of the autonomous shuttle (15km/h) compared to the rest of vehicles on the road made this a particular challenge
- The route also included many trees on its borders, which can be challenging for the vehicle because it perceives them as obstacles.



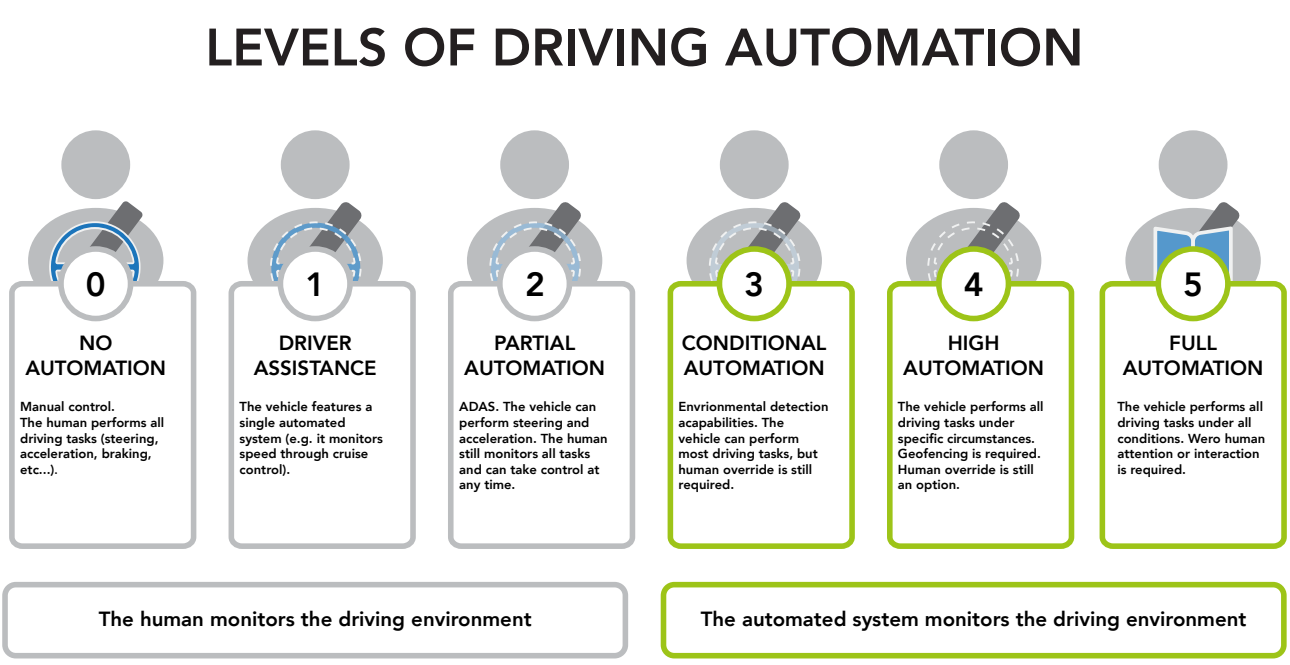
Pendel shuttle's route at the Port of Barcelona.

Levels of automation

To begin with, there is no such thing as a duality with automated vehicles and non-automated vehicles. Instead, between driving and removing the steering wheel, there are different levels of automation that have been defined by the SAE (Society of Automotive Engineers) and are the basis for the industry.

This level ranges from level 0 where there is no driving automation to level 5 where the vehicle disposes of a full driving automation and does not require any human intervention.

In between, the levels fluctuate according to the level of responsibility given to the software, the need for intervention from a human and the environment where the vehicle performs autonomously (e.g a district).



Source: Synopsys

The vehicle

Pendel shuttle operating at the Port of Barcelona.

The autonomous shuttle was provided by one of Pendel's technology partners, EasyMile, based in Toulouse, France. The model used in this pilot is the EZ10 3rd generation, which runs safely and effectively in varying traffic conditions and changing weather conditions. The EZ10 is the most widely deployed autonomous shuttle in the world (300+ locations in 30+ countries). It is 100% electric and has a 12-passenger capacity. The multiple sensors and software installed in the shuttle allows for operations at autonomy level 4 out of 5, but our pilot conditions limited us to level 3.

Although the vehicle ran autonomously most of the time, a safety operator was present within the shuttle to interact with the passengers and to take control in manual mode in case of any emergency. If unexpected objects (people or obstacles) are detected, the bus will either slow down or stop completely.

Stakeholders

Port de Barcelona

*The **Port of Barcelona** was the principal project partner and the host for the pilot scheme. Its high level of cooperation was key to coordinate the different Port departments that had to be included in the preparation of the project with Pendel Mobility. This included the police, the communications department, maintenance teams and local regulatory bodies. The Port also had an important role in facilitating the regulatory permits needed for the autonomous shuttle together with Pendel Mobility.*

*Autonomous vehicle manufacturer **EasyMile** was the provider of the autonomous shuttle. As well as a hardware and software provider, the company supported the project in the permit process and in the training of safety operators.*

__Alsa__ is the leading operator in the Spanish road passenger transport sector. The company collaborated with Pendel Mobility by providing two bus drivers that were trained to operate the autonomous shuttle.

DGT
Dirección General de Tráfico

*The **Dirección General de Tráfico (DGT)**, is an autonomous body of the Spanish government under the Ministerio del Interior responsible for the execution of road policies in Spain. The DGT supported the team to comply with Spanish legislations to obtain the regulatory permits needed for the pilot project.*

Ride to Autonomy

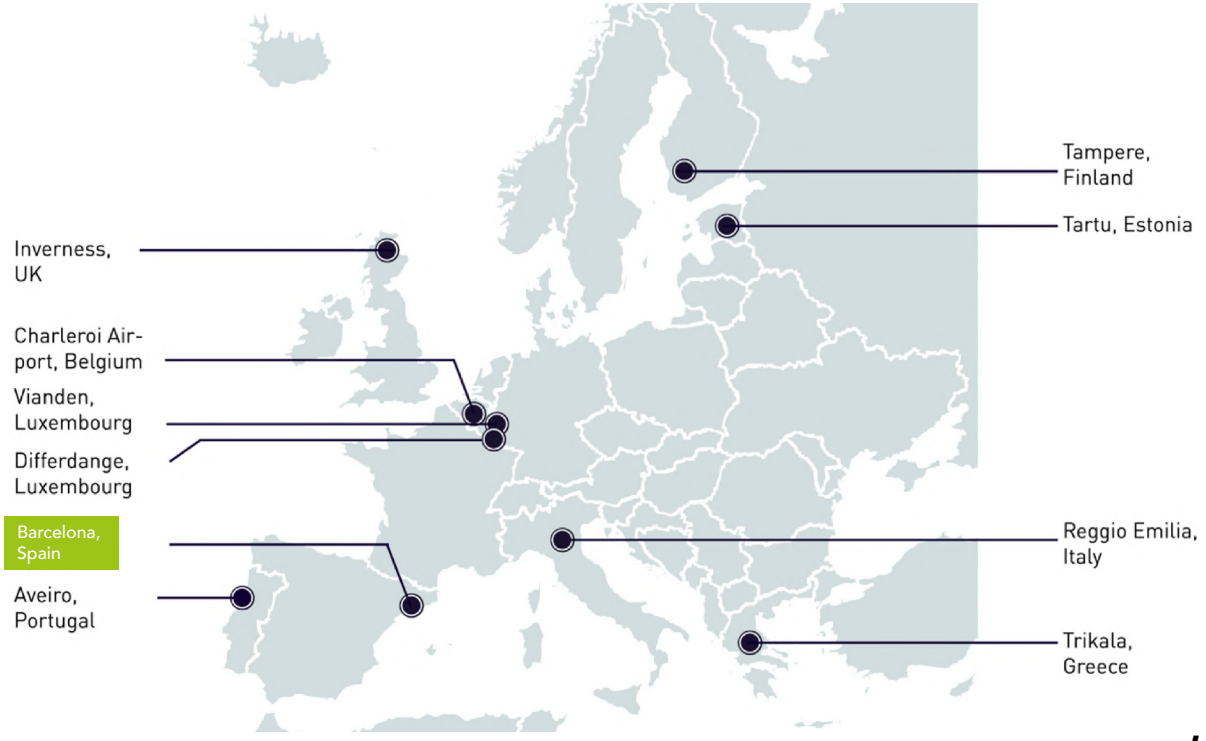
The pilot project at the Port of Barcelona is one of multiple test sites in the EU-funded Ride-to-Autonomy (R2A) project. Its objective is to demonstrate autonomous shuttles' integration into the transport system in ten EU cities: Differdange (LU), Charleroi (BE), Aveiro (PT), Barcelona (ES), Inverness (UK), Trikala (GR), Tartu (EE), Reggio Emilia (IT), Tampere (FI), and Vianden (LU).

The variety in approach and context across the ten pilot sites means the Ride-to-Autonomy project will provide useful guidance for other cities seeking to replicate autonomous vehicle deployment. The project analyzes the system performance in view of safety and environmental impact, as well as multimodal integration into the transport network.

The individual and public response, as well as socio-economic potential of the services, are also considered. Ride-to-Autonomy helps to develop new mobility concepts for passengers that lead to healthier, safer, more accessible, sustainable, cost-effective and demand-responsive transport.

Pendel Mobility is an R2A project partner and main point of contact for the project coordinator, while the Port of Barcelona acts as a facilitator, providing access to the pilot site and is not formally involved in the European project (neither as partner, associated organisation, etc.).

More information on the Ride-to-Autonomy project can be found here.



3. Insights

Operations

The autonomous shuttle successfully drove for four weeks without any major incidents. Below we have summarized the main lessons learnt from the data we collected from the operations and from the surveys and interviews we had.

Trip time regularity

There was no significant difference in the trip time from the WTC to San Bertran or vice versa, taking on average 6 minutes 30 seconds to go from one stop to the other. The standard deviation of the trips was 1.09 minutes (calculated out of a total of 375 trips). This calculation did not include delays due to worksites and roundabout closures, in which shuttle trips took 17 minutes.

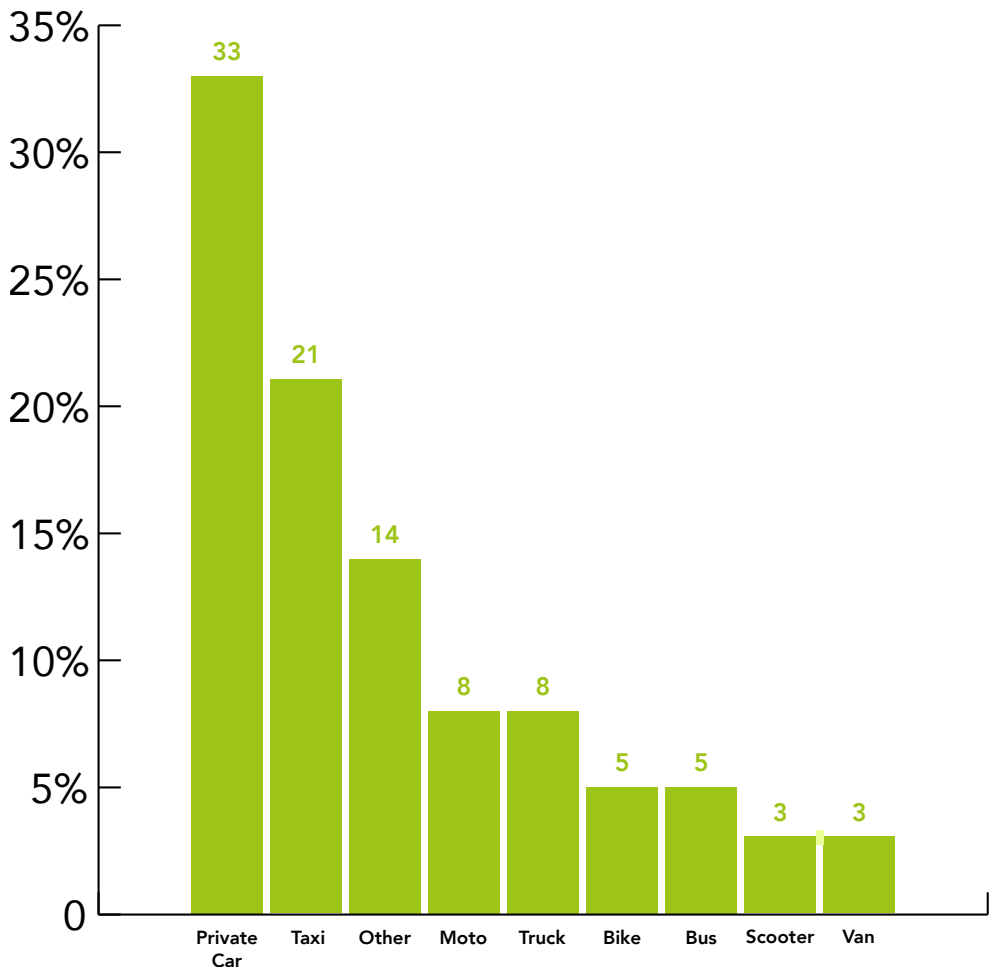
Emergency stops were the main factor in a delayed travel time. In a more controlled environment where the vehicle is less prone to experience emergency stops caused by external agents (pedestrians and other vehicles), travel time variability would likely be lower.

Passengers Numbers

After 379 trips, 103 passengers were carried, of which 52 happened during the launch event, and 51 during regular operations. For a given trip, the maximum occupancy reached only 3 passengers plus the safety operator.

Due to the reduced timespan of daily operations and the particular use case, the number of passengers was lower than expected. The main reasons involved the fact that few port employees commute by car to the Port, instead using public transport. This discovery re-enforces the need for detailed assessment of the actual mobility need at the selected site.

In addition, the marginal difference in travel time between a shuttle ride and walking discouraged passengers from waiting for the shuttle. Notably, a lack of information on the live location of the shuttle was also a deterrent from waiting at the top. Based on several interviews with passengers, there was a consensus that an app or information display to show the location of the shuttle would have been useful.



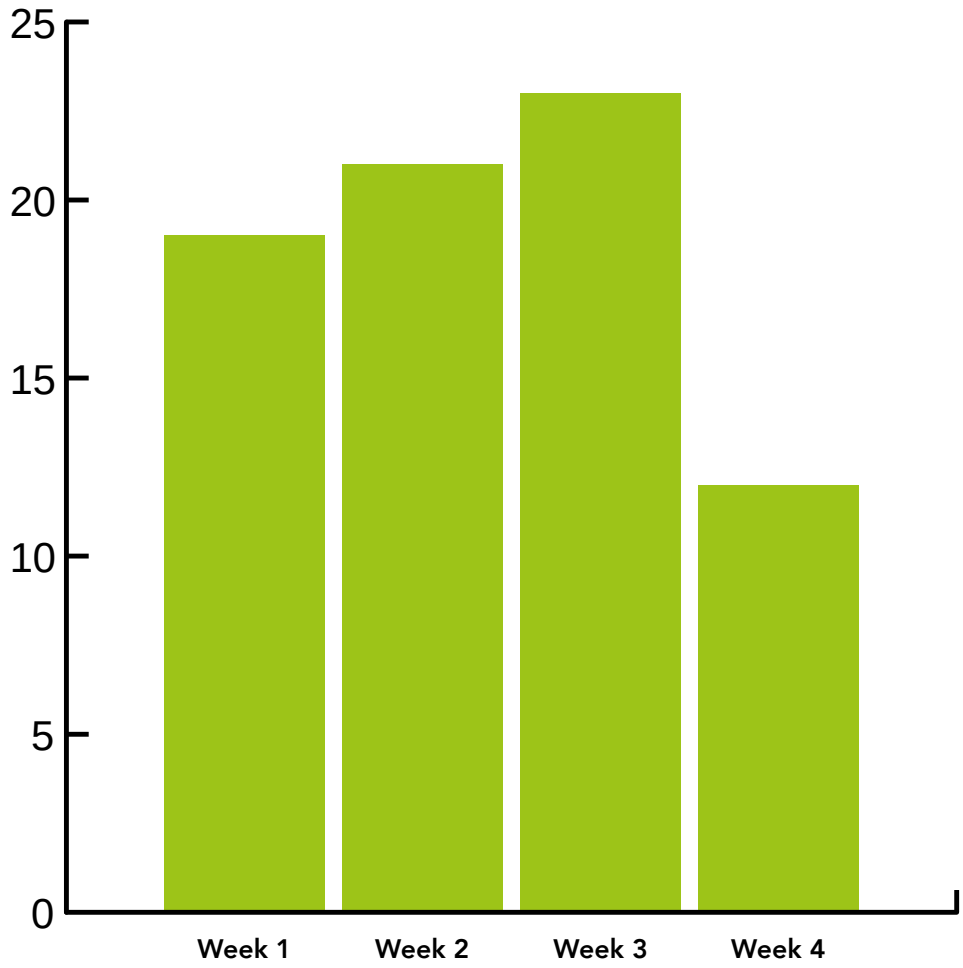
Cause of emergency stops (by vehicle type).

Emergency stops

The safety of passengers and other road users is paramount in an autonomous shuttle operation. The shuttles are programmed to stop when there is a discrepancy between the defined rules and current conditions in what is the safest response for those in and around them. Over 379 trips, 76 emergency stops were recorded. No trip experienced more than 2 emergency stops. In 4 hours of operation (a full day), at most 8 emergency stops were reported. 60 % of the emergency stops took place in the afternoon and 40% in the morning.

The analysis conducted shows that 54% of emergency stops were caused by private cars and taxis, compared to motorbikes or trucks that represented 16%.

These stops were caused by unsafe driving and overtaking maneuvers due to impatience and frustration at the autonomous shuttle's low speed. Overtaking vehicles would come too close to the shuttle, which would automatically trigger the vehicle's safety sensors. The shuttle detected these overtaking vehicles as unexpected obstacles, causing the emergency brakes to activate. Buses, vans, bikes, and scooters accounted for only a small number of stops. Other causes included roadworks, police controls, and roundabout closures.



Number of emergency stops per week.

The role of safety operators

While the goal for completely autonomous shared transport is to physically remove any human attendant from onboard, as with many new industries, the regulations are still evolving and this stage can come later. To comply with current safety regulations, one safety operator was constantly present within the vehicle to intervene when needed. These safety operators were trained by the autonomous shuttle provider EasyMile to monitor the vehicle's performance, its route and its interactions with obstacles. Safety operators could take over in manual mode whenever needed. The following interviews with safety operators provided useful insights into the practicalities of vehicle operations.

Switching from autonomous to manual mode

When an emergency stop was needed, the slow change between manual and autonomous modes led to additional hazards. Insights from safety operators were informative:

> *"Once a taxi got super close on the big roundabout, so the shuttle suddenly stopped, and since it took a while to change to manual mode and move the vehicle out of that crossing, the rest of drivers were stacked, generating a rather stressful situation for everybody".*

> *"Consequently, when riding the shuttle in a dense, heavy- traffic area, it would be nice to have a way to temporarily disconnect/reduce the safety buffer to avoid emergency stops when not needed, under the responsibility of the safety operators".*

The need to keep on changing between manual and autonomous mode is "tough" since the vehicle needs to be precisely located on the programmed route line. The safety operator "cannot know exactly where that virtual line is, so it becomes a trial-and-error exercise". Hence, either "allowing more flexibility to re-enter onto the autonomous mode" or "showing on the vehicle tablet the location of the vehicle and the line to orientate" the safety operator would be helpful.

Route flexibility

Safety operators pointed out that "the vehicle should be able to incorporate several routes simultaneously". For instance, "on the way to the parking lot, the road has two lanes. Yet, in the morning, a long queue of trucks stops on one lane, and in the afternoon [they stop in] the other one".

Allowing a safety operator to choose between routes and lanes would improve operational flexibility and reliability, reducing the need for operators to enter into manual mode.

Remaining challenges

The Port of Barcelona pilot serves as a proof of concept for autonomous vehicles in a public setting. Results indicate that even at the current level of technology, there are challenges for autonomous vehicles to operate in a dense traffic environment.

The main operational challenge encountered in this pilot was the number of vehicles in the road overtaking the shuttle in potentially dangerous conditions, passing at narrow distances inside the safety buffers of the autonomous vehicle. This produced emergency stops more often than expected and slowed operations.

Overall, "the technology works", yet the set of "safety measures evoke a large sum of emergency stops", turning the ride rather "complicated" for the safety operator and "uncomfortable" for the passengers.

Our analysis of data and interviews suggests that closed-environment routes - such as logistic parks or segregated bus lanes - offer a far higher degree of reliability in deployment. This is because "the vehicle would be exposed to fewer external agents, the number of emergency stops [would reduce]". Operating a vehicle that cannot deviate from a pre-established route offers notable safety benefits in these contexts, eliminating the risk of human drivers trespassing in sensitive areas.

User experience

Through surveys and interviews with users, we collected the following perception from passengers:

Safety

Overall, users felt safe within the autonomous shuttle. They had a positive perception of preventive emergency stops, but felt that the suddenness of stops presented a hazard when standing up. A smoother stopping motion would likely increase perceived safety.

Speed

The autonomous shuttle was perceived as slow. The vehicle maximum speed limit was set at 15 km/h for safety reasons. Certainly, compared to the speed limit of 50km/h on the road tested, the vehicle was slower than most other road users.

To improve service quality, it is crucial to work towards a higher average speed while maintaining an adequate level of safety.

Frequent stops

User comfort was negatively impacted by the emergency stops, which were frequent. The shuttle does encounter 'edge scenarios' in which a non-threatening object - such as a plastic bag or a branch - would cause unnecessary stops. The sensitivity level for emergency stops varies between providers and should be a consideration when planning an autonomous vehicle pilot. A further issue came from the abruptness of stops. On the vehicle tested there was no way to gradually slow the vehicle, which caused discomfort for some passengers.

Improvements in the detection and analysis of obstacles is an important step to ensuring smoother, more efficient operations with a higher level of comfort for passengers.

Usefulness

Users only took the shuttle when they coincided with the shuttle waiting at a stop. There were no instances of passengers waiting for the bus because it would have taken longer to wait to take the bus than walk the distance of the route. Furthermore, users had no information on the live location of the shuttle and when it would arrive at the bus stop, which discouraged waiting at a stop.

Route

Users suggested that the autonomous shuttle would have been more useful to link the World Trade Center to the metro rather than the parking lot. This was a valuable insight into the kind of last-mile solutions that an autonomous vehicle should offer.

Project Reception

Launch event

The launch event for the pilot gathered 70+ attendees at the World Trade Center. It welcomed high-level representatives from the Region of Barcelona (incl. representatives from Generalitat Catalunya, Autoritat del Transport Metropolita, Sagales, Alsa) and European project partners from the Ride-to-Autonomy consortium.

The launch event started with presentations from the main pilot partners' including **Christian Riester** (Co-founder of Pendel Mobility), **Rolf Bastiaanssen** (Partner of Bax & Company), **Santiago Garcia-Milà** (Deputy Executive Director of the Port of Barcelona) and **Benedikt Sperling-Zikesch** (Head of Business Development at EasyMile). Following the presentations, the launch event continued with an informal networking event where participants were invited to test the autonomous shuttle which had just begun operations.
The launch event received a large media coverage in Barcelona, with a wide variety of newspapers and televisions who wanted to better understand the technology and what it meant for Barcelona. The president of the Port, Mr. Damià Calvet and the General Mobility director of Generalitat de Catalunya were present alongside Mr. Sebastiaan Van Herk to answer the questions of the press.

Coverage included LaVanguardia, ElPeriodico, 3/24, La Xarxa de Comunicació, Barcelona TimeOut, Barcelona Secreta.

Launch event with Mercè Rius i Serra (Directora General de Transport i Mobilitat, Generalitat Catalunya), Damià Calvet (Presidente, Port de Barcelona), Sebastiaan van Herk (Partner, Bax & Company).

Pendel shuttle operating at the Port of Barcelona.

Launch event presentation by Christian Riester (Pendel Mobility co-founder and CTO).

Comments on a facebook article about the launch of the autonomous shuttle.

Online public perception

As media outlets posted the story of the pilot on social media, a live experiment began to test public opinion on self-driving vehicle pilots and the technology more widely. Overall, the most prominent reactions can be summarized as followed:

- A fear of robotization and automation in the society
- Concerns related to job loss
- A feeling of potential increased safety compared to the current intimidating traffic from taxis and bus drivers

Reactions through social media typically had a negative slant. It is critical for future projects to better communicate the raison d'être for the technology and the benefits that it can bring to society - namely:

- **Safety:** autonomous vehicles have the potential to reduce up to 90% of traffic accidents due to human mistakes

- **Efficiency and coverage:** autonomous vehicles have the potential to expand public transport coverage and frequency due to reduced operation costs and increased route flexibility

Overall, the pilot showed how these deployments can be an excellent opportunity to gather relevant stakeholders from the transportation sector and the civil society to debate on the technology.

4. Main takeaways for future deployments

Choose your use case and route carefully

As the technology is still at an early stage, the performance of the vehicle is very dependent on its surrounding environment. This includes the density and type of traffic and the surrounding vegetation. For now at least, a (mostly) enclosed route such as a business park or a university campus is likely to enable the highest service quality.

Wherever an autonomous vehicle pilot is deployed, it is important to anticipate potential route hazards - including roadworks, road closures or any kind of alterations to the route - ahead of time. This will help to avoid issues for an autonomous vehicle that has difficulty deviating from a set path.

Anticipate the performance of the autonomous vehicle

Depending on the location chosen for deployment, it is important to anticipate the context-specific speed and quality of the transportation service.

A good understanding of the performance will help you to better communicate about the service. Is it an 'additional route for experiment'? Or is it a fully-fledged integrated transportation service, such as a last-mile connection to a train station? Getting this right is important for managing user expectations and for the overall perception of a 'successful' project.

To understand this, it is important to be familiar with the performance levels of different vehicle providers. Different autonomous vehicles have different safety protocols written into their algorithms. For example, some vehicle providers prefer to be more "careful" and have more emergency stops than other manufacturers, valuing service performance over safety. Finding the right balance for your pilot involves careful research.

Find engaging ways to collect user feedback

Collecting feedback is important to understand performance, service quality and passenger satisfaction levels. A key learning from the Port of Barcelona pilot was that asking people to answer a survey following their ride was typically not sufficient to receive valuable feedback. We advise planning incentives into your

feedback collection to increase response rates. Further, gathering feedback from all stakeholders - most notably safety operators - will provide useful, actionable insights that passengers were unable to provide.

Involve citizens to engage and reflect on the technology

Public perception on autonomous vehicles remains controversial. It is crucial to engage with the general public to explain the value propositions of autonomous vehicles. This includes the safety and coverage mentioned above, combined with specific benefits like relieving drivers from monotonous shuttle routes. We strongly advise to use autonomous vehicles experiments as a space for debate with different stakeholders including associations, NGOs and the general public.

Develop an autonomous vehicle roadmap today to benefit from future autonomous vehicles advances

Autonomous vehicle technology has advanced rapidly in the last decade, and this trajectory seems likely to continue. But while public authorities and companies are becoming familiar with how the technology works, implementation strategies and business planning are lagging behind.

We recommend that local authorities, transport planners and private mobility organizations have a clear roadmap on how to improve the service quality and business model of the autonomous vehicles.

With regulation evolving and technology maturing, there is real potential for high-quality, cost-effective use cases for autonomous vehicles to become viable. But an organization's level of preparedness will determine how much they benefit from these opportunities.

For example, technology will eventually allow safety operators to move from inside the vehicles to remote control rooms, which will allow them to supervise more than one vehicle. This can unlock financial savings for transportation providers, but only for those who have planned ahead and installed the necessary infrastructure.

5. Potential future applications

Our experience running pilot projects refined our view of the potential future use cases for autonomous vehicles. The strongest potential use cases include:

Passenger transportation service with autonomous shuttles

Our learnings from the pilot suggest that transportation in public and private controlled environments and suburban areas have the most immediate potential for autonomous vehicle deployment. This can be of particular value for shuttle services covering the first and last mile between a public transport hub and a destination. Potential use cases include:

Connecting a train station to a University campus
Pendel's most recent pilot delivery connected a university campus to a train station in Hannover during off-peak hours. Autonomous technology provided value by relieving bus drivers from a mundane route during quiet hours.

Connecting buildings within a business or innovation park
Autonomous vehicles have the most potential for a high level of service quality within wholly enclosed spaces. The brand image of a business or innovation park would also benefit from the inclusion of a highly innovative mobility solution.

Providing transport solutions for private enclosed spaces like a golf course or resort
Autonomous vehicles follow predetermined paths. This can be especially useful in situations where a business may want to prevent human drivers from accessing an off-limits area of an enclosed private site.

Logistics and delivery of goods

Though Pendel's Barcelona pilot concentrated on passenger transport, there is arguably a stronger use case for goods delivery by self-driving vehicles. Future use cases include delivery of food or baggage handling and package delivery among others.

These applications already demonstrate a good level of service quality and come with much lower risk - an absence of passengers means that the speed of the vehicle can be set higher and that emergency stops do not have safety implications. Potential use cases include:

Autonomous towing to solve airport pain points
Autonomous towing vehicles can improve cargo and baggage handling performance at airports hubs. By automating these flows, air transport players can save time and increase efficiency.

Delivery of food and goods
Large and smaller autonomous vehicles can improve food and package deliveries, offering customers new efficient services and making local delivery fast, smart and more cost-efficient.

Luggage carrying assistants
An autonomous vehicle could also helps guests carry their luggage. Working in 'follower mode', the vehicle waits for holidaymakers who arrive by public transport. The robot follows them through to their holiday destination and then returns on its own to help new arrivals.

Street and facility maintenance

From automated sweet sweepers to airport monitors, maintenance use cases for autonomous vehicles are perhaps the most straightforward to implement. Without one specific customer as the end user (unlike passenger transport and goods delivery), room for experimentation is higher. We foresee efficiency gains being made in event management, airport maintenance and street cleaning, all while maintaining a comparable level of service quality. Potential use cases include:

Autonomous street sweeping
Autonomous vehicles can provide street cleaning in both closed areas and in public streets to reduce costs of operations and noise emissions while offering a safe driverless service.

Autonomous technical assistant in cities
An autonomous vehicle could be used as an assistant to many types of public servants and technicians, carrying equipment in 'follower mode'.

Autonomous construction site assistant
Autonomous vehicles can be equipped with a platform with extended sides for the transport of bulky objects. This makes an autonomous vehicle a valuable asset to a building site. It can be adapted to a wide range of activities, including carrying materials and fetching tools.

Spring, S100N robot sweeper.

Starship Technologies, delivery robot.

EasyMile, TractEasy vehicle.

6. Conclusion

After 4 weeks of operation, Pendel Mobility successfully demonstrated the use of an autonomous shuttle in a port environment under real-life conditions.

We are proud to say that despite a challenging environment, the pilot project maintained service throughout the entire pilot duration with no major incidents. The Port of Barcelona has expressed their interest in further experiments with the technology, exploring new routes and use cases where autonomous vehicles can operate in favorable conditions.

The experiment provided relevant insights into the operations of an autonomous shuttle within a dense traffic situation shared by many different road users. We observed that:

- Autonomous vehicle technology is able to deliver a safe, functioning service, but remains very sensitive to its surrounding environment.
- Despite semi-regular emergency stops, users generally reported feeling safe when traveling in the autonomous shuttle.
- The performance of the vehicle is highly dependent on its use case and route. Public authorities and private sites should consider carefully the viability of their route, as it can have a large impact on service quality. If planned well, specific use cases can already provide a good level of service quality.

We advise public authorities and private sites consider the following when planning their own deployments:

- Choose the pilot use case and route carefully, anticipating the performance of autonomous vehicles and the potential hazards.
- Discuss the potential for a pilot with mobility experts and gather data from previous autonomous vehicles deployments to monitor the current state of the technology.
- Ensure that autonomous vehicles projects engage all local stakeholders and record insights from all actors involved in deployment.

Autonomous vehicles can make existing services more reliable and open the possibility for new service provisions previously unaffordable. But to achieve this, mobility providers need smart planning and effective implementation strategies to get your autonomous vehicle pilot to follow the road to value.

For public authorities, transport planners, and private sites considering their own autonomous vehicle pilot, Pendel Mobility can offer tailored insights. Email us at contact@pendelmobility.com to start a discussion on your pilot idea.

Contact

Are you interested in autonomous vehicles and want to better understand what it means and can do for your organization? Get in touch with our international team in English or in our own language.

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