

Insights: Automation in public transport

# BUS DEPOTS – THE GATEWAY TO AUTOMATION





# Why bus depots offer the greatest potential for automation

**The automotive industry is undergoing a major change with the rise of autonomous driving and other technologies. For bus operators, depots will likely be the first arena where buses can operate without drivers. And this is just the beginning.**

**In recent years** we have seen numerous autonomous projects around the world within the automotive industry and the public transport sector. The pace of development will only intensify. Besides the economic advantages, autonomous solutions can also help tackle many of the challenges faced by growing urban societies. By 2030, we could be almost a billion more people on Earth than we are today and most of this population increase will take place in our cities. This growth will increase mobility demands and intensify the need for the development of infrastructure. We'll have to find new ways to reduce emissions, noise and traffic congestion whilst increasing safety. And we'll have to do all this in a sustainable way.

**When it comes to** autonomous technology in the bus industry, an increasing number of bus operators and public transport operators are now investigating the potential offered in bus depots.

The bus depot is vital in the eco system of public transport, but it is not without its challenges. Often situated on expensive central-located property in order to minimize dead mileage, this is where buses are prepared for the next shift. Here the bus is taken through activities such as maintenance and inspection, refueling or charging, washing and interior cleaning.

Bus depots also require large over-night parking areas so that the vehicles can be picked up by the driver for the next shift. The work done in the bus depot requires additional time of the drivers just to move the buses from station to station with specialist staff carrying out the individual operations. Having so many buses moving around in such a cramped space requires tight maneuvering. Staff, space, safety, and keeping an efficient flow through the depot stations are some of the challenges facing bus depot operations.

**What makes bus depots** interesting in terms of autonomous buses is the fact that it is a restricted area, where you don't have to take into consideration pedestrians, bicycles, cars, animals and other vehicles and traffic situations that you find on public roads. Here the engineers can create a map of the bus depot and record the predictable route of the bus, creating an autonomous world where the buses can be driven from station to station without the supervision of a driver.

**The opportunity** to save time, money and increase safety in the bus depot, makes the autonomous bus a realistic business case and a sought-after opportunity in the near future.

# Autonomous buses in depots can save EUR 100,000 a year

**A recent study undertaken by a team of researchers at the Karlsruhe Institute of Technology in Germany, looked into the potential benefits of self-driving vehicles in a bus depot in Stuttgart-Gaisburg.**

Each day, 150 local public transport buses pass through the depot, stopping at multiple stations for refuelling, cleaning (exterior and interior), maintenance and repairs, inspection and parking. The study found that the movement between most of these stations could be performed by self-driving vehicles using existing technology. The only function that could not be delegated was the interior cleaning and damage inspection, which are too complicated to be performed

by robots. It is estimated that a transfer to autonomous handling would save the depot more than €100,000 per year in personnel costs. It would also have the added benefit of increased throughput, fewer minor accidents and collisions, and would free up personnel for tasks such as vehicle service and other assignments that increase quality.

**“What was really surprising** to me was how little effort is required to achieve a cost reduction,” says Professor Eric Sax, from the Karlsruhe Institute of Technology and co-author of the study. “Of course, software needs to be developed to calculate the trajectories, but this is based on common sensors in the vehicle. They capture ordinary signs such as traffic lights and road marks,

and of course recognise obstacles in the vehicle’s planned route. Without much additional equipment on the vehicle and no additional infrastructure, our study showed that there is a strong business case for automation and a real opportunity.”

**The study** also argues that the concept applied to the Stuttgart-Gaisburg depot is scalable to other depots and that its findings could be used in the planning of future depots. “The Stuttgart-Gaisburg depot was a very compact area, with short distances, and only 150 buses. There are many other depots that are even better suited to automation, where the savings could be even greater. It depends on the number of buses and how many minutes drivers spend in the vehicle,

but clearly the opportunities are out there.”

After their successful study into the Stuttgart-Gaisburg depot, Professor Eric Sax and his colleagues are now working in close cooperation with selected public transport companies in Germany, to help realise their concept in real operation. Professor Sax believes that this could be an important starting point for autonomous driving in general.

**“We have a long way** to go before we can operate a self-driving vehicle in regular city traffic, because there are still so many unanswered questions,” he says. “However, starting in a small niche, like a bus depot, is a wonderful first step. It helps us learn and gain experience in situations that we can control, which will help us to take the next steps.”



*“What was really surprising to me was how little effort is required to achieve a cost reduction.”*

ERIC SAX

Professor  
Eric Sax, at  
the Karlsruhe  
Institute of  
Technology in  
Germany



# This is what an autonomous bus can do in a bus depot

When buses go into depots they have to stop at multiple stations for refuelling, cleaning (exterior and interior), maintenance and repairs, inspection and parking. All of this requires a large number of drivers. This is what an autonomous bus can do in a bus depot.



# 1.

## WASHING & CLEANING

**An autonomous bus** can manoeuvre into the washing and cleaning area without damaging the bus, keeping an efficient flow through the station.



# 2.

## SERVICE & WORKSHOP

**In the workshop** an autonomous bus can perform tight manoeuvring without damaging the bus and it can detect people to avoid accidents. With autonomous buses the staff allocated to driving can instead be used to other assignments, like service and maintenance.



# 3.

## CHARGING

**When charging** or refuelling the autonomous buses can drive closer to each other, creating a more efficient flow through the depot station.



# 4.

## PARKING

**The tight manoeuvring** made possible by autonomous buses also enables them to park closer to each other, saving valuable parking space and creating greater turning radius for other manoeuvres.



# 5.

## DRIVER PICK-UP

**Instead of the driver walking** to the parking space to pick up the bus for the next shift, the autonomous bus can come to the driver, saving time and creating a safer pick-up situation.

# The technology enabling autonomous buses

**Volvo Buses is currently developing and testing autonomous technology for the 12-metre Volvo 7900 Electric equipped with numerous sensors and navigation controls.**

**The test bus** comes with a Volvo Autonomous Research Platform software that is connected to key controls such as its navigation system, as well as multiple sensors. This includes light detection and ranging sensors (LIDARS), stereo-vision cameras that capture images in 3D, and an advanced global navigation satellite system that uses real-time kinematics. This is like any global positioning system (GPS), but uses multiple data sources to give pin-point location accuracy of up to one centimeter. The system also includes an inertial management unit (IMU) that's used for navigation and control.

**“In a bus depot** the tricky part is that you are switching between outdoors and indoors. If we only have GPS as a sensor, that won't work, so we need to rely on other sensors such as LIDARS for indoor driving,” says Joakim Jonsson, project leader Volvo Buses.

The next step is adding a comprehensive artificial intelligence (AI) system to manage

the Volvo Autonomous Research Platform. In March 2019 Volvo Buses demonstrated the world's first full size autonomous electric bus in collaboration with Nanyang Technological University, Singapore (NTU Singapore). The comprehensive AI system developed by NTU researchers not only operates the various sensors and GPS systems on the bus, but also enables it to navigate autonomously through dense traffic and different weather conditions.

“We have progressed quite far. We already now can show how the vehicle navigates and stops for an obstacle on a test track,” says Joakim Jonsson.

**One of the 12-metre** Volvo buses will undergo tests at a bus depot managed by Singapore's public transport operator SMRT. It will provide a real-world environment to assess the vehicle's ability to autonomously navigate into vehicle washing bays and park safely at charging areas.



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JOAKIM JONSSON

# “Automation will be a game-changer for bus operators”



**In recent years, Volvo Buses has taken considerable steps and made major investments in autonomous technology. Marie Carlsson, Director Business Solutions, Volvo Buses explains why.**

#### **Why are automated solutions important for Volvo Buses?**

“When we look at the areas that are most important to our customers – uptime, energy efficiency, safety, driver performance and passenger satisfaction – automation is set to have a big impact. The potential for operations in bus depots is especially interesting in the short-term perspective.”

#### **When will we see a fully autonomous bus from Volvo on public roads?**

“The autonomous journey is complex, and it might not happen for another ten years. But we need to start thinking about it now, and we believe bus depots will be a good first step.”

#### **Can customers buy autonomous technology from Volvo Buses today?**

“Automation is likely to be introduced in stages, through increasingly automated solutions, with fully automated vehicles being the likely end point. We already today have systems for supporting the driver that uses automated technology such as active safety systems.”

#### **What is Volvo Buses hoping to achieve with autonomous buses?**

“Ultimately the reason for exploring automation is to make buses and the operation of them safer, smarter, cleaner, more comfortable and more efficient, and we are already on that path.”

*“Automation is likely to be introduced in stages, through increasingly automated solutions.”*

MARIE CARLSSON

