Self-driving Shuttle Bus Use Case in City of Tallinn

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Abstract. Autonomous vehicles (AVs) are entering from test areas to the streets, which is one of the key components of smart cities and the future of mobility as a service (MaaS). In 2020, two AV services were operated in Tallinn. This paper focuses on one of the services, including how it was set up. The route was set up in Ülemiste City, a tech park with 10,000 people daily working in the area. It connected the offices with the airport and a shopping centre. Autonomous shuttle iseAuto was used for the service (streets with heavy traffic, including some complex crossings). Our findings associated with the Ülemiste experiment in the context of legal requirements set upon autonomous vehicles to be street legal are pointed out. Events that took place during the operation (including an accident) are addressed. Summary of the feedback from clients is presented. Further studies should focus on the extended concept of smart cities with a roadmap for the nearest future.

Keywords: Autonomous vehicle, smart city, self-driving vehicle

1. Introduction

Autonomous driving is revolutionizing transportation and will change the whole paradigm in near future. The autonomy is divided into 5 levels by SAE J3016 \cite{1} where level 0 has no autonomy at all and level 5 means full autonomy in any conditions. Most of today's advanced and wellknown self-driving cars like Tesla autopilot, are in level 2 while low-speed autonomous vehicle (AV) shuttles are up to level 4. Last-mile (AV) shuttles have been gaining a lot of interest recently by cities to pilot new transport opportunities in the specific area or route to extend the main public transport lines. The pilot experiments allow us to introduce self-driving technology to citizens of the community and test their maturity in real traffic and urban environments. Tallinn University of Technology (TalTech) started to develop a self-driving autonomous last mile shuttle - iseAuto \cite{2,3} in June 2017 in cooperation with a private company Silberauto. By using open source software and a chassis of existing electrical vehicles it was feasible to achieve a fully functional AV shuttle with one year intensive development time only. The first prototype shuttle called “iseAuto” was ready a year later in 2018 for the university anniversary celebrations. The next logical steps taken were to get the vehicle into real traffic, with an ultimate goal to create a whole new autonomous traffic solution with a safer and environmentally sustainable mobility. Based on the prototype vehicle several more mature vehicles were created by the industrial partner AuVe Tech - the successor of Silberauto.
IseAuto 2020 has been developed to the level (according to both Estonian and EU rules) of being street legal. Simultaneously during the past summer months, two pilot testings in real traffic were created. The focus was on the shuttle usage by all demographics and several groups of public transport users, whether for business or pleasure under two different kinds of density of traffic. In 2020, in Tallinn, two AV services were operated. Both projects were funded by European Commission, one called Sohjoa Baltic [4] and the other FABULOS [5]. In the Sohjoa project, which was run in a recreational park area of Kadriorg, a French Navya Evo shuttle was used, but in FABULOS, that had its Estonian leg of test area in Ülemiste City (a techpark with offices for thousands of people and Estonian international Tallinn Airport in the area) - the Estonian iseAuto. FABULOS brought together 4 partners - TalTech, Auve Tech, Fleet Complete and Modern Mobility. In Estonia, there were also some outside consortium partners like Ülemiste City, Ministry of Economic Affairs and Communications, Tallinn Transport Authority, Estonian Road Authority, Bercman Technologies, and Ericsson Eesti. In the Sohjoa project, a mobility acceptance factor was investigated [6] and specific feedback gathered. In this paper, the feedback is analysed and findings are presented.

2. Use Case in Ülemiste City

Cities around the world are experimenting with driverless autonomous vehicles, in particular AV shuttles to be prepared for future mobility. Several studies in the US [7] and Europe [8] are demonstrating that innovative cities are willing to deploy autonomous shuttles in the near future and citizens have mostly positive attitudes towards AV shuttles on the streets. Setting up the use case in Ülemiste as required by the project, several modifications and upgrades were necessary in order to get legal permission to drive on the public roads. So far iseAuto has been tested in closed areas only (e.g., on a dedicated road in the university campus), but the initial idea was to turn iseAuto also into the first street-legal autonomous vehicle in Estonia. This process generally is, and in this case was, closely observed by all different traffic authority parties - The Estonian Road Authority, the Police and Estonian Rescue Board. The legal environment is not yet mature for self-driving vehicles and differs country by country quite a lot even within Europe. Detailed analysis was conducted by the Sohjoa Baltic project which also included Baltic sea region legal environment [9]. First, they tested the hardware (like they do with every vehicle) whether the lights, windows, seats, tires etc are in adequate condition. Then test drives in designated testing spaces were conducted, where they followed how the safety person operates the shuttle in case of need and emergencies. For example, how the control of the bus from automated driving was taken over to manual control. The ability of the braking system to identify objects in different sizes while driving in automated mode was tested, and how it acts when it has problems with IT systems. Last but not least, also a driving exam was created in the area where iseAuto started to operate, to see all different situations in traffic and how it acts in reality on crossings and with other members both static and moving, including people. After tests and modifications according to the predefined rules of the authorities, the shuttles met the standards and were granted permission to enter the public road traffic as EU M1 category vehicle. In parallel, new intelligent functions like human-autonomous vehicle interaction methods [10] were experimented in TalTech campus by the Autonomous Vehicles research group.

The route was chosen due to its different kinds of crossings, turns and the density of both traffic and people to connect the offices of Ülemiste City with a large shopping mall and a hotel in the area and the Tallinn International Airport. The route and list of bus stops are shown in figure 1.
Figure 1. Internet interface for passengers about the map and stops in Ülemiste City

Three AV shuttles were dedicated to the service, with engineers and technicians working on the details daily to advance the busses and make them better for the service. Also, the operator’s interface was developed on the accompanying tablet of controls connected to the controls of the shuttle. The important function under the testing was teleoperation, see remote operation workstation in figure 2. Teleoperation enables the vehicle to be taken over in case human supervision is needed. This happens usually when unexpected situations occur on the route and shuttles cannot handle them on their own.

Figure 2. Teleoperation engaged in Ülemiste remote operation station.

Shuttles were not provided any special separate lanes but were mixed with real traffic. The maximum speed allowed on the route was 30 km/h, but the speed was kept around max 20, just for the safety reasons. The drive included both left and right turns, crossing the streetcar and bus lanes prioritized for public transport, which serviced the Airport. At the same time, it was important not to forget the pedestrians, bikes and especially electrical scooters of the people working in a tech savvy
environment. For passengers, it was free of charge to use the services and the operational schedule was
daily between 10:00 and 16:30. All vehicles on the route and the backup bus doing the demo ride can be seen in figure 3.

![Figure 3. iseAuto AV shuttle deployment in Ülemiste City](image)

One of the main ideas was also to test smart bus stops, with real life info about the arrivals and departures, displayed all the time in the stations, while also recalculating, if there had to be longer stops on the way, or if the shuttle had to be taken off from the rotation. These stops were crucially located two in the business park, one at the public transport hub of the airport (where also city trams and busses had their airport stations, linking the whole route also to the city center) and the second between the hotel and the shopping center. Since the test pilot ran only during summer months, we could not test the operation in that drastic weather conditions like occasionally Estonia has during autumn and especially winter months, but there was heavy rain and winds in the mix of mostly nice and sunny weather. There were cars parked wrong on the shuttles predetermined way, but since it can easily pass obstacles, nothing more severe than a sudden stop happened. But as all the passengers have to wear a seatbelt and be seated, then nobody was bothered (according to our survey on board and over the internet during the service). The aim of the survey was to get to know more about what people really think and to reflect their experience. The only reasons to postpone the start of the day or sometimes stopping the service were connected to making technical updates to the shuttles.

3. Use case survey

Altogether we had 514 passengers. The operation on the public streets lasted for two months (mostly June and July of 2020). The length of the route was 2.4 km and the total mileage the shuttles gathered was 2500km.

During the pilot, we also conducted a survey. While talking with the passengers during their drive, they expressed their opinion that once using the AV, they appreciated it more than they thought they would. For the project, this is also shown by the unexpectedly high marks on the safety. While 10% (51) of all the passengers participated in the survey, some examples of the research results are presented in tables 1 and 2 and in the charts in figures 4 and 5.
Table 1. Pedestrian feedback about safety and attitude

|                              | Average score          |
|------------------------------|------------------------|
| Average score for overall experience | 6.57 (out of 7,00 maximum) |
| Average score for traffic safety     | 5.95                   |
| Average score for personal safety   | 6.27                   |
| Average score for ease of use       | 6.45                   |

Table 2. Pedestrian feedback about the usage intention

| Usage Intention                              | Percentage (out of 51 pax) |
|----------------------------------------------|----------------------------|
| I would use automated shuttle bus during day-time | 94.1%                     |
| I would use automated shuttle bus during night-time | 59.9%                     |
| I would never use automated shuttle bus       | 0.04%                     |

Figure 4. Two charts about passengers safety perception

Figure 5. Survey results about passengers’ estimations of AV shuttles

4. Conclusion

As the project introduced many new challenges that had not been tested before, it also gave a lot of new insight and pointed out daily what changes are needed to make shuttles safer and more convenient.
for both the operators and the clients. People are interested in trying autonomous vehicles, although quite many seem to be sceptical of its chances to ever fully take over the vehicles in the traffic.

Since through this use case, iseAuto has received licence to drive in real traffic, the developments towards becoming part of MaaS components in public city transport have taken a huge step forward. We have received valuable feedback from daily users, that confirms the need and safety expectations of AV shuttles coming into service. After the successful pilot in Tallinn, a pilot under FABULOS consortia was taken to the streets of the Greek city Lamia. The two major next steps to follow these 2020 projects are a shuttle service without any operator onboard in 2021. The aim is to create transport corridors, to service rural areas and to focus on the overall AV integration into the public transport ecosystem in 2022. The ultimate goal is to encourage more and more people to use public transport instead of contributing to ever intensifying traffic on the streets with their private cars.

Acknowledgments

The research is supported by the EC H2020 project Finest Twins (grant No. 856602). Experiments and pilots were supported by Fabulos and Sohjoa Baltic EC projects.

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