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Assessment of automated mini-bus operation in the Oku-Eigenji area in Japan

Reanne Boersma[1*], Bart van Arem[2], Frank Rieck[3]

1. Delft University of Technology & University of Applied Sciences Rotterdam, the Netherlands (E-mail: a.m.boersma@tudelft.nl)

2. Delft University of Technology, the Netherlands (E-mail: b.vanarem@tudelft.nl)

3. University of Applied Sciences Rotterdam, the Netherlands (E-mail: f.g.rieck@hr.nl)

Abstract

This paper reports about a case study conducted as part of the STAD project in regards to a demonstration with an automated vehicle in Japan. The demonstration was conducted in November 2017 in the Oku-Eigenji area (Japan). The ministry of Land, Infrastructure, Transport and Tourism (MLIT) in collaboration with local government and local police authority organised and funded the demonstration. The goal of the demonstration was to introduce the people to the automated vehicle and to explore technical difficulties with the GPS signal in the mountainous area. Part of the route with low GPS signal was imbedded with MI sensor system magnetic markers. The MI sensor system proved to help the vehicle navigate in the area with low GPS signal. Surveys were conducted during the demonstration. In general the passengers are satisfied with the service the vehicle was providing and they would like to see permanent implementation of the vehicle in the near future.

Keywords: Automated driving, autonomous vehicle, demonstration.

1. Introduction

Many demonstrations or experiments are being conducted with automated vehicles globally. Not all demonstrations are known or well documented in international literature. It is very important to learn from these demonstrations and to share this knowledge. This paper reports about a case study conducted in regards to experiments with automated vehicles in Japan. The case can be found in worldwide media, but not in international literature. This case study is part of the Spatial and Transport impacts of Automated Driving (STAD) project, aimed at learning from practical applications/projects with automated vehicles to get from experiments or pilots to more permanent applications of automated vehicles. Other case studies conducted as part of the STAD project are “Application of Driverless Electric Automated Shuttles for Public Transport in Villages: The Case of Appelscha(1)”, “Rotterdam the Hague Airport: an analysis of the application of automated vehicles at Rotterdam the Hague Airport as part of the tender ‘Marketplace for Infrastructure’’(2), “Driverless electric vehicles at

Businesspark Rivium near Rotterdam (the Netherlands): from operation on dedicated track since 2005 to public roads in 2020 (3)", "Casestudy WEpod: een onderzoek naar de inzet van automatisch vervoer in Ede/Wageningen (in Dutch) (4). The goal of the case study in Japan is to learn from the challenges Japan faced in regards to operating an automated vehicle on public roads. Information about the case is obtained via (online) desk research and by conducting an interview.

Japan has been conducting demonstrations with automated vehicles (5). Thirteen of these demonstrations were conducted at road stations (6). These projects are called demonstrations, because of their short duration. Japan is facing an aging population which causes a shortage of drivers, but increases the demand for transportation. Japan sees automated vehicles as a potential solution for the declining public transport in mostly rural areas and the shortage of drivers (7).

The paper will start with a description of the Oku-Eigenji area in Japan and the goals of the demonstration. Then the route of the vehicle and the type of vehicle will be described. Subsequently, questionnaires filled out by passengers will be explained. Thereafter challenges during the demonstration will be described followed by the conclusions of the study.

2. The Oku-Eigenji area

The area where the automated bus was operating is called the Oku-Eigenji area. There are approximately 320.000 inhabitants in the area. The Oku-Eigenji area is a mountainous area located in the Shiga prefecture, next to the Kyoto prefecture. See figure 1 for the location.

Figure 1: Location of Oku-Eigenseji (Source: GoogleMaps)

The vehicle started at the 'Michi-no-Eki Okueigenji Keiryunosato'. 'Michi-no-Eki' means 'Rest area'. Many rest areas were created twenty years ago throughout Japan. These areas are designed for three purposes:

1. To refresh (rest facilities, restrooms and parking)

2. For the community (cultural centres, tourist attractions and local development facilities to promote interaction of the region)
3. To provide information (about the roads, tourist attractions and emergency care) (8)

The Michi-no-Eki Okueigenji Keiryunosato rest area is designed according to the abovementioned purposes. At this rest area there is a cultural centre, road information, rest area, tourist information and there is a local farmers market. Close to the rest area is a sightseeing point with a lake which attracts tourists. Sometimes the premises are used for local government offices or medical services(9).

Figure 2: Michi-no-Eki Okueigenji keiryu no sato (10)

This differs from the purpose of rest areas in the Netherlands. Rest areas in the Netherlands are primarily designed for a brief interruption of the journey to rest and relax. Secondarily, the rest areas offer the possibility to comply with the legally prescribed rest periods in professional transport (11). Rest areas in the Netherlands are not specifically designed to strengthen the community or to promote tourism as stated in the abovementioned objectives for Japanese rest areas.

The Oku-Eigenji area is challenged with a decline of inhabitants and an aging society. As a result, the public transport network is shrinking. Approximately fifteen years ago the Japanese government deregulated public transport and opened the market for public transport companies to offer their services. Some local authorities subsidize public transport in their area, but not all authorities have the funds to do so. This has created network gaps. When there are not enough passengers to create a positive business case, public transport companies will not offer their services in that region. Thus, bus lines will reduce in low populated rural areas (12).

The local government foresees a decline in bus lines for the Oku-Eigenji area due to the declining and aging population. Because of this aging population, there is a shortage in bus drivers, but there is also a need for transportation to local facilities. Currently, there is a bus operating in the area. This bus operates five times a day between 7 AM and 7 PM (13). Automated transport could solve the transportation problems in the region, because there is no driver needed and the vehicle could operate on demand or with a higher frequency then the current bus.

3. Goal of the project

The goal of the project was to gain experience with automated vehicles and to let the people experience this new technology. Surveys related to social acceptance were conducted and technical issues were investigated. Checking the accuracy of GPS and experimenting with magnetic markers in the road were part of the experiment. Also, the project aimed to not only transport passengers, but to transport goods from local farmers as well (12) (14).

The demonstration was conducted by the ministry of Land, Infrastructure, Transport and Tourism (MLIT) in collaboration with the local government and local police authority. MLIT funded the demonstration. The experiment with the automated vehicle in the Oku-Eigenji area was conducted in November 2017 and lasted five days. (12) (14).

4. System description

4.1 The route

The automated vehicle operated from the Oku-Eigenji rest area to a temple approximately 2.2 kilometres up the road. The vehicle had (including the starting and end point) six stops. The vehicle was not only transporting people, it also transported goods from the local farmers to the farmers market at the rest area. The vehicle made 34 trips during the experiment (14). Figure 3 shows the route of the vehicle.

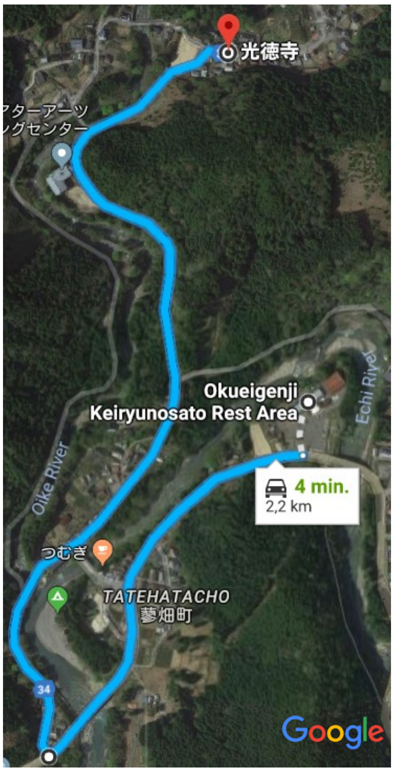

Figure 3: Route of the vehicle (Source: GoogleMaps) & the automated vehicle (14)

There were no warnings displayed in the area to warn other road users of the presence of the automated vehicle. The automated vehicle itself contained several warnings signs on the outside. Also, as commissioned by the local police, there were two traffic wardens present during the experiment. One traffic warden was placed near an unclear intersection. This traffic warden was able to warn other road users that the automated vehicle was approaching. The other traffic warden was placed at a narrow section of the route. This traffic warden also warned other road users of the automated vehicle and asked upcoming traffic to make space for the vehicle. On most occasions with upcoming traffic, the human driver took over control. The vehicle can't swerve around other road users, but reduces speed and/or stops for upcoming traffic. To avoid confusion, the traffic wardens were able to intervene (12).

4.2 The vehicle

During the experiment, a microbus was used. This micro bus is capable to carry up to twenty passengers. The automated driving technology was added to the vehicle by Advanced Mobility Co. Ltd (16). The bus has a maximum speed of 40km/h on automated mode. The bus uses GPS, magnetic markers, gyros and cameras to determine its location (17). LIDARS were added to the vehicle for obstacle detection (16). The bus maintained a steering wheel and gas and brake pedals. The human driver was able to take over control at any time (12). Figure 3 shows the vehicle that was used during the experiment.

5. Evaluation of the demonstration

In this chapter the results of the demonstration will be evaluation. This chapter will start with the public opinion, which was measured via surveys before and after the demonstration. Then two challenges during the demonstration will be described. The first challenge was in regards to the GPS signal. The second challenge had to do with the width of the road which made it difficult to pass other road users.

6.1 The passengers

One of the objectives of the demonstration in the Oku-Eigenji area was to introduce the locals to an automated vehicle and to find out if they would accept such form of transportation. Because of the aging Japanese population, the target group of the surveys was elderly people aged 60 years or older. During the experiment 287 passengers used the automated vehicle. This means 8,4 passengers on average per trip. More than 200 passengers participated in the surveys. Roughly half of the participants came from nearby areas and not the Oku-Eigenji area itself. 40% of the participants were 60 years or older and 60% of the *locals* participating in the survey were 60 years or older. Overall the participants are satisfied with the service (80%). 70% of the participants finds the service convenient and 80% of the participants are positive towards permanent operation of the automated bus.

The participants preferred style of operation of the vehicle is a fixed route with fixed stops (60%) or a fixed route with the possibility to get on or off at any place on the route (40%). 94% of the participants would like to use the automated bus for delivery purposes, as was part of the demonstration. Local farmers stated that they can save time by transporting the goods by an automated vehicle; time which they can use on their land.

The demonstration increased the acceptance of automated public transport in the area; before the experiment 87% of the participants said they were favourable towards the automated bus. After experiencing the automated bus during the experiment, 91% of the participants said they are favourable towards the automated bus (12).

6.2 Interrupted GPS signal

Most automated vehicles use different technologies to find their way. Digital road maps, Light Image Detecting and Ranging (LIDAR) sensor, laser scanners and GPS are often used (17). However, GPS signal might fail in tunnels or under viaducts. The LIDAR and laser scanners might contribute to the positioning of the vehicle, but the reliability can be insufficient at night or under poor weather conditions (18). The mountains at the Oku-Eigenji area interrupted the GPS signal of the vehicle and therefor magnetic markers were used to help the vehicle localize. The red marked area on figure 5 shows where the signal as interrupted.

Figure 4: Interrupted GPS area (14)

Magnetic markers were placed at the interrupted area for the vehicle positioning. The MI sensor system magnetic marker was imbedded in the road at every 2 meter. An MI sensor module was affixed to the vehicle (18). See figure 6 for the magnetic markers used during the experiment and the sensor module affixed to the vehicle.

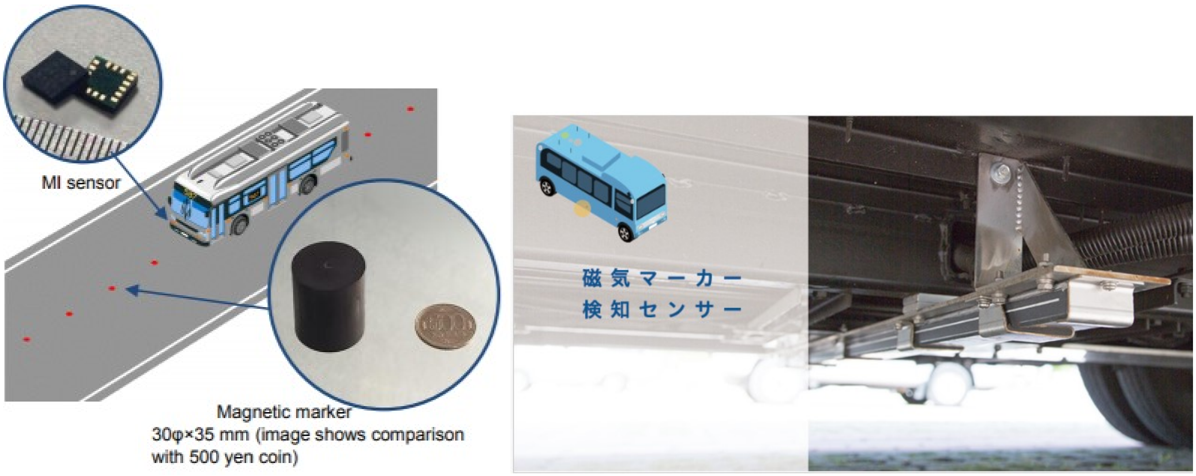

Figure 6: Magnetic markers (18) and Magnetic marker detection sensor (19)

6.3 Width of the road

During the experiment, a driver was present in the vehicle. Since a traditional bus was used, a steering wheel and pedals were present in the vehicle. At some parts of the route, the road was narrow; below 5,5 meters wide. The driver had to take over when upcoming traffic was approaching, because the vehicle was not capable to swerve around upcoming traffic. Figure 7 shows the situation with upcoming traffic.

Figure 7: Upcoming traffic (14)

Not only situations with upcoming or overtaking traffic showed difficulties, also parking alongside the road was challenging for the vehicle. The vehicle is programmed to stay on the side of the road and to brake when obstacles are detected. Sometimes locals would park, although mostly temporary, on the side of the road. The vehicle cannot swerve around the parked cars. Therefor the driver had to overrule the system and take over the driving task (12).

Other than dealing with other traffic, the vehicle had to deal with pedestrians as well. In Japan there are not always sidewalks available. Therefor it is allowed and accepted that pedestrians walk alongside the road. The picture below shows a pedestrian crossing on the route of the automated bus near a school. A few meters further on the right is a staircase for pedestrians. When pedestrians descend the stairs, they cross the road and continue their travels on the left side of the road.

Figure 8: Pedestrian situation (Source: GoogleMaps)

Since the vehicle cannot swerve around objects, or in this case pedestrians, the human driver had to take over control when interacting with pedestrians. The space on the side of the road is very limited, which means vehicles often pass pedestrians closely. The automated vehicle is not capable to pass the pedestrians closely. When a pedestrian or object is too close to the vehicle, the emergency brake will be initiated. To avoid sudden stops, the driver took over the driving task when passing pedestrians (12).

6. Conclusion

The demonstration with the automated vehicle in the Oku-Eigenji area has been completed in November 2017. The goal of the experiment was to introduce the people to the automated vehicle and to explore technical difficulties with the GPS signal in the mountainous area. From this study it can be concluded that the demonstration has reached its goals. The locals were introduced to the technology and got insight in the services automated vehicles can offer. The surveys show that the demonstration has increased a positive attitude towards this technology. In terms of the goals with the troubled GPS signal, the demonstration has shown that a magnetic marker system can be a solution in areas with low GPS signal.

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