ADDITIONAL GRADUATION PROJECT
CIE5050-09

STUDY ON THE IMPORTANCE OF STEWARDS IN SHARED AUTONOMOUS VEHICLES

by

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Abstract

Shared autonomous vehicles (SAV) is coming up as an effective and sustainable first and last mile mobility solution that can integrate itself well into the existing transport network. Currently it is mandatory to have an on-board steward in the SAV. The technology has been maturing to have completely autonomous vehicles without the need of steward on-board. However, there are many obstacles, some of which are addressed in the study; namely perceived safety, emergency control, accessibility for elderly population, infrastructural modifications, added vehicle features required, additional training required for stewards and technological awareness. The effect of these factors on different scenarios formulated are done using a multi-actor multi criteria analysis (MAMCA). The actors chosen for the analysis are the road authority and the public transport operator. The analysis show that the scenarios with stewards obtain a better score than the scenarios without, which is expected. As for the scenarios without stewards, the one with the highest score is when the SAV runs on dedicated infrastructure with a fixed schedule for both the actors. In addition, a questionnaire study is done to gather the opinion of stewards as well. The questionnaire results show that extra training is indeed required for the stewards to manage any emergency situations. Moreover, the stewards report that the frequency of such emergency situations is high and that the technology has a long way to go for SAVs to function without stewards on-board. The questionnaire results along with the analysis provides good insight into the current situation and for the future.

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1. Introduction

As Kevin Roberts, Automotive Transportation Senior Analyst at EY put it: “Future mobility is about striving towards an environment-friendly, integrated, automated and personalized travel on demand”. Autonomous vehicle (AV) technology is one such innovation that checks almost all boxes. Rapid urbanization has paved its way to enable AV technology to gain traction. The age of AV is fast approaching, with many companies on the race to be at the front line of this new era. But this brings forth many challenges as well, like serving people with restricted mobility, technological limitations, effect on the existing transport infrastructure, finding a balance between cost and benefit, public perception (trust in the technology), safety implications and so on. Therefore, urban transport policies and sustainability goals focus around the effective utilization of public transport, resulting in the shift from privately owned vehicles to shared or service-based mobility [1].

Shared Autonomous Vehicles (SAV) is an extension of the AV technology that uses the concept of mobility as a service (MaaS). The SAVs mentioned in this study refers to small shuttles running on electricity with a capacity of 10 or less passengers. The services can run on demand or with a fixed schedule, with dedicated lane or mixed traffic, and with a minimum level 4 of automation in the SAE classification [2]. In principle, the main objective of SAV is to act as an effective and sustainable first and last mile mobility solution that can complement the existing public transport network or serve as a substitute for taxis. This would essentially relieve the pressure on urban mobility for the existing transport infrastructure [3]. The question of the hour right now is whether the SAV can function without a steward on-board and how that can affect the business model of the operator.

This study aims to find the importance of stewards on-board (often referred to as on-board personnel or supervisor) and how the SAV can function in different scenarios in terms of infrastructure, schedule and with or without steward on-board. The research background and motivation are explained in Chapter 2, followed by the formulation of the research question in Chapter 3. The research methodology with the proposed research methods is explained in Chapter 4. The results of the research are then explained in Chapter 5. Lastly, discussion and further comments of the research are described in Chapter 6.

2. Research background

2.1 Background and motivation

SAV networks can serve as a first and last mile mobility solution to the public transport (PT) networks, seamlessly integrating itself into the existing system. It offers more benefits like zero emission, increased accessibility to people with mobility challenges, reduced private vehicle ownership that can lead to lower number of parking spaces demand, reduced waiting time and travel time [4][5][6]. However, one challenge still stands in the way of a fully functional SAV, and that is the requirement of an on-board personnel. The autonomous vehicle legislation in The Netherlands still requires vehicles on public roads to have a driver on-board [7]. The Dutch cabinet has adopted a bill where it states that in the near future, it will be possible to conduct experiments with self-driving vehicles without a driver being physically present in the vehicle on public roads. Therefore, until then the SAV companies can ask for exemption on the regulation under specific requirements and can run trials on experimental grounds. Hence collection of data and analyzing the effectiveness of the system parameters defined for each pilot run of the SAV is challenging. Therefore, the intention of this study is to tackle this challenge and to clear this cloud of uncertainty.

2.2 Scientific relevance and research gap

There is extensive research currently being done that mainly focuses on the passenger perspective of SAV. Accommodating such SAV systems into the existing public transport networks is a hurdle that is currently being addressed, but due to the lack of research on SAV as a mode specifically and because of limited technology acceptance, the process is time consuming. The effect of integrating SAV into the existing network can have both positive and negative effects; the main stakeholder with the highest stakes is the operator. Additionally, how the presence or absence of stewards on board the SAV can affect the system is still yet to be investigated from an operator perspective. Furthermore, in order to significantly reduce the optimal fares, more than 50% of the current driving cost must be saved [8]. Therefore, this study aims to fill in that research gap so that the importance of stewards on-board is explored much into detail so that aspects like remote supervision, infrastructural modifications and control strategies are addressed. This could then be used to create a business model to provide the operators with more certainty on how the many factors at play can affect the system as a whole.

3. Research question

3.1 Research question and research objective

From the research gap discussed in the previous section, the following research question is formulated.

"How does the presence of an on-board steward affect the operations of Shared Autonomous Vehicles and how cost factors for different scenario alternatives influence their business model?"

The research question can be answered by dividing it into sub questions that can address separate aspects of the main research question.

a. What is the role of stewards in SAVs and how do they handle emergency situations?

b. What are the factors that affect the business model for SAVs in different scenario alternatives with and without steward on-board?

3.2 Research approach

The research follows mainly 4 steps as listed below:

a. Questionnaire survey
b. Study on existing pilots
c. Scenario formulation
d. Scenario Analysis

As there is a scarcity of data specific for SAV as a mode, the main source of gaining insights on the topic was with people directly involved with SAV pilot projects, which is primarily the stewards. Therefore, a questionnaire survey is done to gather insights from them to know how each pilot works in the different operational domains. Parallel to that, existing pilots are investigated to see how well they are performing/performed, what difficulties they faced, the specifications of the system and the correlation with the infrastructure or type of service. Factors can then be identified which can be used to define the scenarios, as well as assess them. This definition step supports the third step of scenario formulation in the stepwise approach [9] for scenario formulation where the complete scenario is defined, and the factors identified are used to address the benefits and drawbacks of each scenario.

There are some assumptions followed in this research that is made due to insufficient data or to ensure that the factors that are unknown right now does not affect the research. The research and the results that follow hold only under these circumstances. The assumptions used are split into categories and are as follows:

- Policy
    - Advent of 5G will be supportive of the SAVs
    - Policy changes is supportive to the introduction of SAVs

    - Sustainability policies (like zero emission goal by 2030) that ensures green and electric future support successful SAV implementation

- Pricing scheme
    - SAV runs with seamless integration into the existing OV-chipkaart system to enable easier transition into the existing PT system
    - All users have an OV-chipkaart subscription

- System
    - The SAVs are wheelchair friendly for users with mobility challenges
    - Pressing the emergency button in the SAV leads to stopping at the nearest service road or slower lane if running on public roads, whereas in dedicated lanes it will stop immediately.
    - The average waiting time for both on-demand and fixed schedule is assumed to be almost the same.
    - The pick-up of passengers in the on-demand service can be seen as an empty trip. Hence it is assumed that the SAV is parked at the nearest parking spot after dropping all passengers until a new passenger requests the service which is closest to the SAV.
    - Additional signages and road markings are required for the SAV to communicate to the other road users that it is moving at a lower speed.

Under these assumptions, the scenarios are created using a categorization as follows:

1. Infrastructure used (Dedicated lane or Mixed infrastructure)
2. Schedule of SAV (Fixed or On-demand)
3. With or without steward

A combination of these factors is used to create scenarios. Finally, the formulated scenarios are analyzed using a Multi-Actor Multi-Criteria Analysis (MAMCA) method and results are formulated. The actors included in the MAMCA analysis are the road authority and the public transport operator. These results are then compared using the questionnaire data gathered from the stewards and conclusions are made.

4. Research methodology

4.1 Questionnaire

Questionnaire survey is done in order to collect responses from stewards who were part of the many SAV pilot projects in the Netherlands. These stewards are contacted through 'The Future Mobility Network'. The questionnaire focuses on the role of the steward in the SAV and how emergency situations are handled by them. Also, opinions about the stewards' physical presence inside the SAV and about remote supervision is also asked. The questionnaire was created and shared using the Qualtrics platform and Google forms. The questionnaire is attached in the Appendix-1.

4.2 Study about pilots

There are many pilots that have been done or operating in Europe. However, only very few have reached the level of operation advanced enough that can operate amongst traffic without a steward on-board due to the existing legislations and limited technological developments [10]. A study found that travellers have a preference for systems on dedicated lanes or roads with clear demarcations [11]. They also preferred the presence of a transit employee aboard the vehicle, while only 13% of respondents agreed that they would travel even without an employee on-board. Then there is the go-no-go initiation in The Netherlands that is required to be done by a steward in an SAV at an intersection. The steward must assess the intersection and only until the steward approves it is safe to move ahead, the forward movement is initiated. Hence it is clear that there are many obstacles and uncertainties that stands in the way of an SAV without a steward on-board. Therefore, a study about the pilots in Europe was done to collect more information about how they operated and under what conditions it was attained.

The research done by Hagenzieker et. al. [12] provides an inventory of all the autonomous bus pilots done in Europe. The details of relevant pilots were taken from the study and an overview is shown in Table 1.

Table 1: Comparison of different pilots

Pilot	Location	Type of road	Infrastructure used	Max speed	Capacity	Steward (y/n)
Appelscha	Ooststellingwerf (NL)	Public	Mixed	15 kmph	10+2	Yes
WE Pod	Wageningen (NL)	Public	Mixed	25 kmph	6	Yes
Rivium ParkShuttle	Rotterdam (NL)	Public	Dedicated	32 kmph	20	No
Haga	Hague (NL)	Private	Mixed		8+1	Yes
ESA ESTEC	Noordwijk (NL)	Private	Mixed	20 kmph	8+1	Yes
Drimmelen	Drimmelen (NL)	Public	Mixed	18 kmph	11	Yes
Ruter Autobus	Oslo (Norway)	Public	Mixed	18 kmph	8	Yes
Digibus	Austria	Public	Mixed	20 kmph	11	Yes

This is used to get an overall idea of the current SAV scenario. It can be seen that the operational speed of most of the SAV pilots are low. The speed of the vehicles currently has to remain low to guarantee the safety of travellers and other traffic participants [13].

The study done on the Appelscha pilot mentions that the vehicle used, that was manufactured by Easymile, does not have a steering wheel and can be manually operated only by a joystick [14]. Due to this reason, the stewards assigned inside the vehicle must be given additional training. The survey done in another study indicate that the awareness about the automated system accompanied by the perception of higher safety of autonomous vehicles and by higher willingness to use the autonomous vehicles in the future [15]. This is supported by another survey of public opinion about autonomous and self-driving vehicles in the US, the UK and Australia [16]. Therefore, additional training for the stewards for emergency situation control and awareness of the technology is included in this study.

Waymo by Google have been running their on-demand autonomous vehicle service and has shown promising results [17]. However, the service requires a level of digital literacy that usual population do not dispose of. This can be more challenging for elder population as they are a vulnerable group in terms of mobility and tend to live in rural areas [18]. Hence, the effect of on-demand or fixed schedule, its impact on the accessibility of elderly population and the correlation with the type of city needs to be investigated.

The Ruter autobus at Oslo is at the third phase of their testing where the shuttles communicate with the infrastructure and hence the onboard operators don't have to manually take over in crossings with traffic lights [19]. This could have a substantial effect on the go-no-go initiation which is required now. Additionally, the service has currently implemented a limit of six passengers and several other precautions to reduce the Covid-19 infection from August 6^{th}, 2020. Therefore, the Covid-19 precautionary measures can have an effect on the capacity of the SAV and can even be extended to the type of service; the 1.5 m norm would be easier to implement in on-demand service than a fixed schedule.

In the Digibus trial done in Austria, there were planned safety stops at intersections used for security reason similar to the go-no-go initiation. At this point, the operator has to manually trigger the left turn on priority roads. The passengers who travelled in this trial reported that they had the feeling of safety because an operator was on board. So, it can be assumed that the passengers' sense of safety decreases if the system becomes completely driverless [20]. In the CityMobil2 shuttle bus project done in Finland, infrastructural modifications were made to accommodate the system like road signs, road markings and cat's eye/road stud. Additionally, on-street parking had to be removed due to the safety reasons [21].

It was found that the travellers in the shuttle has a preference for systems on dedicated lanes. Also, the presence of a public transport operator employee aboard the vehicle was considered to have a positive effect on the willingness to use the shuttle [13]. The study also says that investing in the infrastructure needed to accommodate dedicated lanes is very expensive, since the technology and the legislation is restricting the SAV to operate amongst mixed traffic. This higher cost should be considered for the assessment of scenarios.

The main factors identified from these studies are used for the formulation of the key factors necessary for defining the scenarios and to assess them. It is also used as justification for assigning values to the scenarios under each attribute.

4.3 Scenario formulation

4.3.1 Formulation of key factors

The key factors needed for the scenario formulation are identified by listing them all down first and then shortlisted based on differences and grouped based on similarities. The factors were filtered out using this process and is illustrated in the table shown in Appendix 2. The main factors that is identified from this process (highlighted in green) are used to define the scenarios. Similar or dependent factors with a correlation are grouped for a more elaborate scheme as shown below:

1. Infrastructure used
   - Interaction allowed
   - Maximum speed of SAV

2. Schedule of SAV
   - 1.5 m norm
   - Type of city
   - Capacity of SAV

3. With or without steward

4.3.2 Scenario definition

This categorization is then used to create the eight scenarios as illustrated in Figure 1.

1. SAVs running on **mixed** infrastructure, **fixed** schedule and **with steward** on-board

2. SAVs running on **mixed** infrastructure, **fixed** schedule and **without steward** on-board

3. SAVs running on **mixed** infrastructure, **on-demand**, and **with steward** on-board

4. SAVs running on **mixed** infrastructure, **on-demand**, and **without steward** on-board

5. SAVs running on **dedicated** lane, **on-demand**, and **with steward** on-board

6. SAVs running on **dedicated** lane, **on-demand**, and **without steward** on-board

7. SAVs running on **dedicated** lane with a **fixed** schedule, and **with steward** on-board

8. SAVs running on **dedicated** lane with a **fixed** schedule, and **without steward** on-board

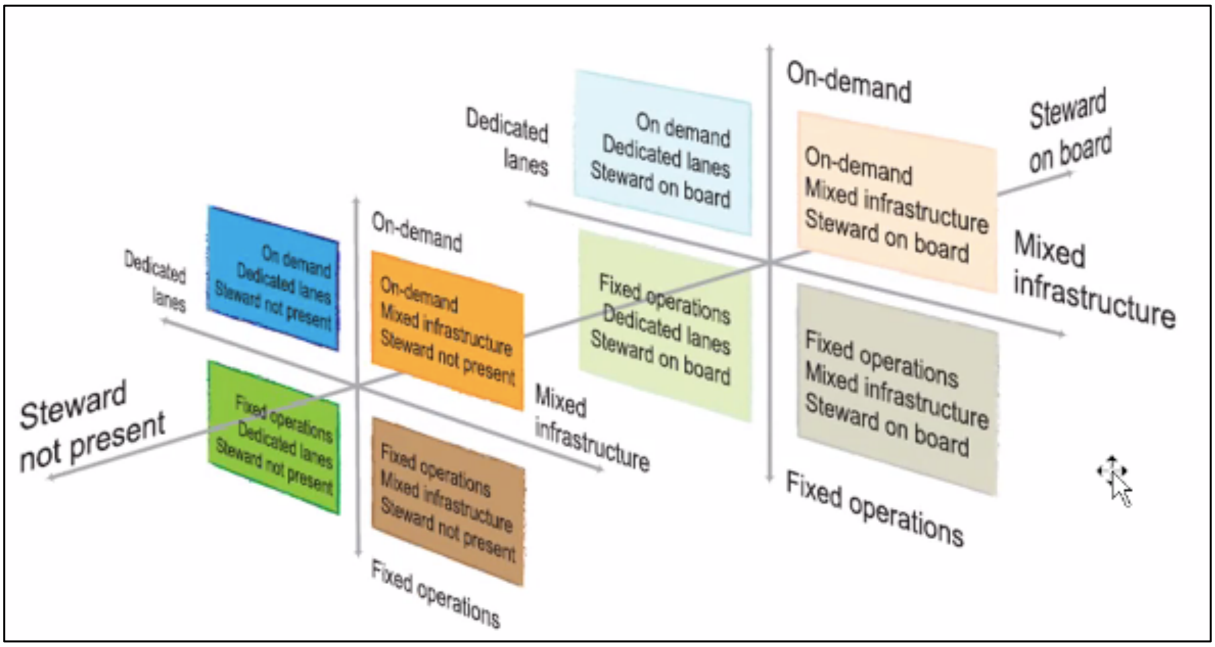

Figure 1: Scenario formulation *Source: Irene Zubin*

The factors that are used to further define the scenarios in detail are taken from the table in Appendix-2 (highlighted in blue) and structured into four layers as shown in Figure 2. These fours layers are not exactly disjoint, but in a way, are related to each other. For instance, with good awareness of SAVs to the general public, the perceived safety would increase and therefore less vehicle modifications/features would be required to make the passengers feel safer.

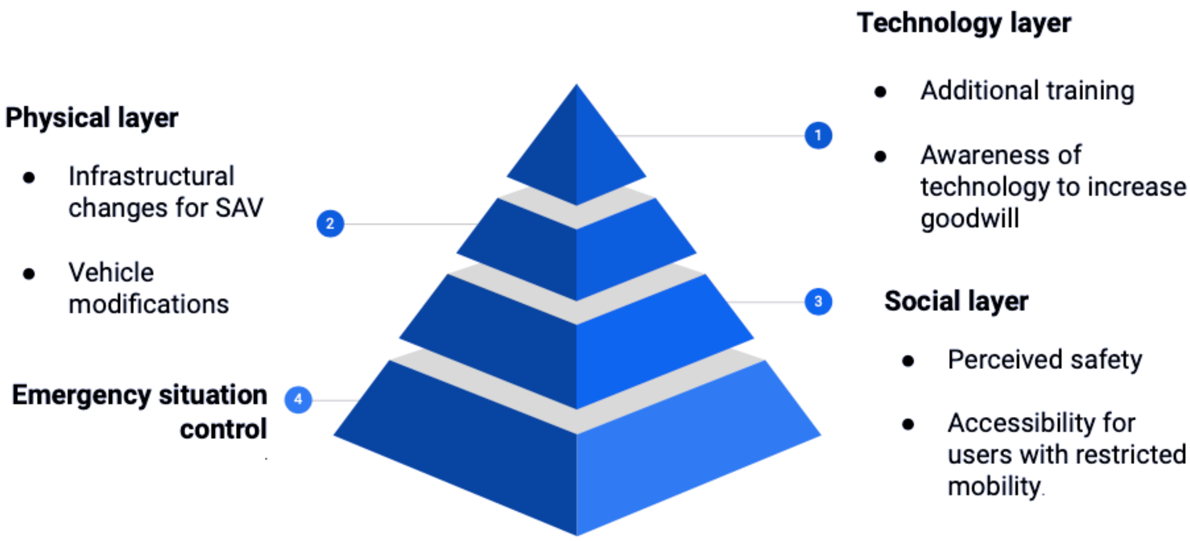

Figure 2: Layers for the identified factors for analysis

1: Technology Layer

- Additional training: The need of extra training for the supervisor to manage the vehicle physically or remotely

- Awareness of technology to increase goodwill: The need to make people aware of SAVs. This depends on how much the SAV interacts with or comes in contact in each scenario

2: Physical layer

- Infrastructural changes for SAV: The modifications or adaptations required in the road infrastructure to incorporate the SAV. This can include road studs, road markings, signages, stops, crossings and so on.

- Vehicle modifications: This includes the added features or components required in the SAV for each scenario.

3: Social layer

- Perceived safety: The safety of the SAV as perceived by the passengers

- Accessibility for users with restricted mobility: Accessibility for users with restricted mobility (like elder citizens) in terms of how easily they can access the service and travel without difficulties.

4: Emergency control: The means by which the emergency situations are handled

The scenarios are then defined in detail using this four-level metrics. This would then make the analysis easier because each point of focus in the analysis part would be addressed.

(i) Scenario 1

The SAVs will be running on public roads/cycling lanes with shared infrastructure where the vehicle is expected to interact with other road users like pedestrians, cyclists, passenger cars etc. It will have a fixed schedule similar to a public transport system and will have a steward on board. Since it is running mixed with other vehicles, there will be a restriction in the maximum speed compared to the vehicle running on dedicated lanes. A lower operational speed can also be a possibility to increase the capacity and allow standing inside the SAV. However, due to the 1.5 m norm as a COVID-19 precautionary, it would not be so feasible. Additionally, fixed schedule system has a disadvantage of running empty trips. It is expected to be more effective in urban areas where there's more population. As it has a fixed schedule, timetabling and scheduling with other public transport services will be easier; a seamless integration into the existing public transport network. Pilots like Appelscha, Drimmelen, Oslo, Digibus was/is operating in these conditions.

Emergency control:

In case of an emergency, the steward will take over. This can save a lot of time for the passengers as the steward will be prepared with strategies to ensure that the passengers reach their destination and that the SAV does not disrupt the traffic flow much. The steward can either manually take over or guide the passengers outside the vehicle and make sure there is minimum delay. The steward will keep the passengers calm and transport them using the next shuttle in the schedule. However, one possible disadvantage is that due to the SAV sharing the infrastructure with other road users, it can affect the overall traffic and can lead to added travel time and waiting time for the other users due to the SAV emergency.

Social layer:

The presence of the steward increases the perceived safety (especially at times of emergencies) and their roles can extend to being a host where they can help people with mobility challenges/restrictions. Fixed schedule should have a higher perceived safety compared to on-demand service because passengers know in advance which stops, where and when the shuttle will have. Moreover, with fixed operations, it is possible to train the vehicle to follow always the same route, so that obstacle detection and road mapping are optimized for the particular route.

Physical layer:

As the SAV will be sharing the infrastructure with other road users, there can be a possible effect on speed of the other users due to the limited operational speed of the SAV. Added signage, road markings etc. would be needed to ensure that the users are aware of the SAV sharing the infrastructure. As it will be a fixed schedule system, there will be additional costs for setting up stops as well.

Technology layer:

As the SAV is expected to run on public roads, other road users must be aware of the technology and that they will interact with such SAV. So, awareness campaigns must be done to increase goodwill. Additionally, the SAV are still at the nascent stage and because each company keeps data to themselves due to the competition in the market, data is scattered across many pilots. Therefore, there should be sufficient investment on the stewards present on board to train them and equip them well enough to handle the emergencies; the main purpose they are present in the SAV for.

(ii) Scenario 2

The SAVs will be running on public roads/cycling lanes with shared infrastructure where the vehicle is expected to interact with other road users like pedestrians, cyclists, passenger cars etc. It will have a fixed schedule similar to a public transport system and will not have a steward on board. The only difference between scenario-1 is the presence of steward, and therefore all restrictions and limitations in terms of speed, capacity and empty trips applies to this scenario as well. It is expected to be more effective in urban areas where there's more population. As it has a fixed schedule, timetabling and scheduling with other public transport services will be easier and it can seamlessly integrate into the existing public transport network.

Emergency control:

As there is not steward in the vehicle, the SAV will be remotely supervised by personnel from the operator control room. In case of an emergency, the emergency brakes will be deployed and the remote supervisor will have to move the vehicle out of the public road and transport the passengers to their destination as well. This process, however, will be time consuming as the control center need not be close by to the location where the emergency occurred. The remote supervisor must either send a new vehicle to pick up the passengers or co-ordinate with the SAV running next in schedule to accommodate these passengers. Additionally, he/she has to provide the instructions via the intercom, ensuring that the passengers do not panic. This emergency situation can hinder the other traffic movement and can cause loss of time both for the passengers in the SAV and for the complete traffic system.

Social layer:

Due to the absence of the steward, the perceived safety will be less and the welcoming function of the steward as a host is also removed. This can have an effect on the societal benefit in terms of helping passengers with mobility restrictions. This will have a higher perceived safety compared to running on-demand because of better optimization in terms of obstacle detection and road mapping for the particular route. Unlike running on-demand, there won't be many variations or complexities involved. As mentioned earlier, it is possible that the perceived safety for the SAV will reduce if the emergency situation in this scenario is not handled very well. Therefore, it can reduce the overall attractiveness of the SAV itself.

Physical layer:

Similar to scenario 1, the other road users can also be affected by the restricted speed of the SAV because the SAV will be sharing the infrastructure with other road users. Additional road signage and road markings is needed and will add up to the total cost for the operation. There will be an intercom system inside the vehicle for communication with the passengers. If required, the remote supervisor can even function as a remote host by using a live video stream to increase perceived safety of the passengers. Finally, like scenario 1, there will be added costs for setting up stops as well.

Technology layer:

As there is no steward physically present in the SAV, it will be hard to assess the situation at intersections and provide the go-no-go initiation required from the steward. Moreover, the absence of steward itself needs to be well communicated to the public, with awareness drives and pilot runs to demonstrate that the SAV is safe to run on public roads. As remote supervision is still very new, proper training must be provided to the supervisors, which will be an additional cost in the business model.

(iii) Scenario 3

The SAVs will be running on public roads/cycling lanes with shared infrastructure where the vehicle is expected to interact with other road users like pedestrians, cyclists, passenger cars etc. It will run on-demand similar to a ridesharing service and will have a steward on board. The vehicle can be requested via an app where it will arrive in front of your house or street as requested, similar to a typical ridesharing/carpooling service. This can serve better as a feeder system for rural areas to connect with the hubs. Since it is on-demand, it has an added benefit in terms of lower congestion and need of parking spaces. However, having such an on-demand SAV system will have many complexities involved. Additionally, the 1.5 m norm due to COVID-19 can work very efficiently.

Emergency control:

In case of an emergency, the steward will take over. The steward is responsible to move the passengers to the nearest public transport systems or call taxis or another SAV itself to their destinations. This saves a lot of time for the passengers as the steward will be prepared with strategies to ensure that the passengers reach their destination and that the SAV minimizes the disruption to the traffic flow.

Social layer:

The presence of the steward increases the perceived safety (especially at times of emergencies) and their roles can extend to being a host where they can help people with mobility challenges/restrictions. Since the system involves a lot of complexities, the perceived safety will be lesser compared to running on a dedicated lane.

Physical layer:

As the SAV will be sharing the infrastructure with other road users, there can be a possible effect on speed of the other users due to the limited operational speed of the SAV. Hence, added signage and road markings would be needed to ensure that the users are aware of the SAV sharing the infrastructure and the speed restriction. Since the SAV could ideally be requested from anywhere, the road infrastructure and the vehicle features should be able to facilitate all the movements.

Technology layer:

As the SAV is expected to run on public roads, other road users must be aware of the technology and that they will interact with such SAV. Road signages and marking can only raise awareness to an extent. So, awareness campaigns must be done to increase goodwill. Additionally, with the amount of uncertainties and complexities involved in this scenario, there should be sufficient investment on the stewards present on board to train them and equip them well enough to handle the emergencies; the main purpose they are present in the SAV for.

(iv) Scenario 4

Similar to scenario 3, the SAVs will be running on public roads/cycling lanes with shared infrastructure where the vehicle is expected to interact with other road users like pedestrians, cyclists, passenger cars etc. It will run on-demand to a ridesharing service, but will not have a steward on board. It will be similar to a carsharing service, but fully automated. The vehicle can be requested via an app and it can serve as a feeder system for rural areas to connect with the hubs. The added benefits like lower congestion, reduced need of parking spaces, 1.5 m norm due to COVID-19 still applies in this scenario. However, having such an on-demand SAV system will have many complexities involved, and as there is no steward, it will be much harder to deal with them.

Emergency control:

Emergency situations has to be handled remotely and hence it will take some time to handle the situation. Emergency brakes will be deployed in case of an emergency or if someone presses the emergency button, and then the supervisor has to remotely handle the situation. The remote supervisor must either send a new vehicle to pick up the passengers or send taxis to pick them up. Schemes like refunding their travel expense due to the emergency can also be an option, however that can reduce the attractiveness of the mode, reliability and perceived safety.

Additionally, he/she has to provide the instructions via the intercom, ensuring that the passengers do not panic. Once the passengers exit the vehicle, it'll be hard to still communicate with them unless an actual person is sent to the location. Again, the problem of the control room being far away and leading to a loss of time will arise. This emergency situation can hinder the other traffic movement and can cause loss of time both for the passengers in the SAV and for the complete traffic system.

Social layer:

The absence of steward in the vehicle decreases the perceived safety (especially at times of emergencies). Hence, effectiveness of measures like live video of what the SAV actual sees, two-way intercom system with video to increase the perceived safety can be checked. As there won't be an actual person to greet people, handle emergencies and help elder citizens if they have difficulties, the attractiveness of the mode would be questionable. Since the system involves a lot of complexities, the perceived safety will be lesser compared to running on a dedicated lane.

Physical layer:

As the SAV will be sharing the infrastructure with other road users, there can be a possible effect on speed of the other users due to the limited operational speed of the SAV. Added signage, road markings etc. would be needed to ensure that the users are aware of the SAV sharing the infrastructure. Features like intercom system with video, live tracking of SAV movement with video like in flights can be added to compliment the social layer. Since the SAV could ideally be requested from anywhere, the road infrastructure and the vehicle features should be able to facilitate all the movements.

Technology layer:

As the SAV is expected to run on public roads, other road users must be aware of the technology and that they will interact with such SAV. Road signages and marking can only raise awareness to an extent. So, awareness campaigns must be done to increase goodwill. Additionally, with the amount on uncertainties and complexities involved in this scenario, the supervisors remotely handing the SAV must be sufficiently trained and equipped to handle any kind of emergencies effectively. This would then be an additional cost in the business model.

(v) Scenario 5

The SAVs will be running on dedicated lanes where the vehicle will have restricted or zero interactions with other road users like pedestrians, cyclists, passenger cars etc. There will be crossings at potential points of conflicts, like how bikes have a dedicated infrastructure. It will run on-demand similar to a ridesharing service and will have a steward on board. Dedicated lanes cannot be built in front of every single street so that it can work like a normal carsharing service. Therefore, there will be a button at designated stops where the user can press to call the vehicle and go anywhere within the route planned. This can serve better as a feeder system for rural areas to connect with the hubs. Since it is on-demand, it has an added benefit in terms of lower congestion. Additionally, the 1.5 m norm due to COVID-19 can work very efficiently. As there is restricted interaction with other users, it ensures safety compared to operating in mixed traffic. Since it has a dedicated lane, it can go at higher speed, but on the other hand, it may not be supportive of people standing and hence can have limited capacity.

Emergency control:

In case of an emergency, the steward will take over. The steward is responsible to make sure the passengers reach their destinations by calling taxis or calling another SAV. This saves a lot of time for the passengers as the steward will be prepared and will be physically present to cater to the passenger's needs. As it is running on a dedicated lane, the emergency will not affect the other traffic users.

Social layer:

The presence of the steward increases the perceived safety (especially at times of emergencies) and their roles can extend to being a host where they can help people with mobility challenges/restrictions, deal with any queries or discomfort. As it is dedicated lane with minimum interactions, users are expected to feel safer.

Physical layer:

As the SAV will run on its own infrastructure, it will require dedicated signal control devices, crossings, guidance system (magnets). The stops and the buttons to call the SAV would also add to the cost.

Technology layer:

As the SAV is expected to run on dedicated lanes roads, not much extra awareness is required for other road users. However, general public must be aware on how to interact with it while using it or interacting with it at crossings. Furthermore, awareness campaigns must be done to increase goodwill and to increase attractiveness. The stewards present on board must be trained and equipped well enough to handle any emergencies.

(vi) Scenario 6

The SAVs will be running on dedicated lanes where the vehicle will have restricted or zero interactions with other road users like pedestrians, cyclists, passenger cars etc. It is exactly similar to scenario 5, except that there is no steward on board. Dedicated lanes cannot be built in front of every single street so that it can work like a normal carsharing service. The benefits of being a feeder system, lower congestion, effective for COVID-19 precautions and safety due to restricted interaction still holds. Since it has a dedicated lane, it can go at higher speed, but on the other hand, it may not be supportive of people standing and hence can have limited capacity. All functions that an actual steward does must be done remotely, although it won't be exactly the same. Rivium Parkshuttle

Emergency control:

In case of an emergency, the remote supervisor will handle it. As it is not running on a fixed schedule and is not sharing the infrastructure with any other vehicles, the remote supervisor can send a new vehicle to the location of emergency quickly. Compared to the scenario with a steward on board, it can be a little time consuming due to the absence of physical presence of the steward. Passenger's needs can then be handles only via the intercom system and reassure that the situation is under control. However, the communication channel would be difficult once the passengers clear out of the SAV. As it is running on a dedicated lane, the emergency will not affect the other traffic users.

Social layer:

The absence of the steward decreases the perceived safety (especially at times of emergencies). Features like live video streaming of vehicle's path, live video communication with remote supervisor can play a role in making the passengers feel safer. However, it won't be the same as an actual person inside the SAV who can help out elder citizens. This would then be a factor that can lead the users to question the safety and reliability of the SAV. Since it is dedicated lane with minimum interactions, users are expected to feel safer than operating in mixed environment.

Physical layer:

As the SAV will run on its own infrastructure, it will require dedicated signal control devices, crossings, guidance system (magnets). The stops and the buttons to call the SAV, features like intercom system with video, live tracking of SAV movement with video like in flights to compliment the social layer, will also add to the cost.

Technology layer:

As the SAV is expected to run on dedicated lanes, not much extra awareness is required for other road users. However, as there is no steward on board, general public must be aware on how to interact with it while using it or interacting with it at crossings. Furthermore, awareness campaigns must be done to increase goodwill and to increase attractiveness to make users trust the remote supervision sufficiently to use the service. The supervisors remotely handing the SAV must be trained and equipped well to handle any kind of emergencies effectively. This would then be an additional cost in the business model.

(vii) Scenario 7

The SAVs will be running on dedicated lanes where the vehicle will have restricted or zero interactions with other road users like pedestrians, cyclists, passenger cars etc. There will be crossings at potential points of conflicts, like how bikes have a dedicated infrastructure. It will have a fixed and will have a steward on board. There will be designated stops like a normal bus service. The dedicated infrastructure would enable the SAV to operate at higher speeds compared to operating in mixed traffic. Additionally, as there is restricted interaction with other users, it ensures safety relative to running in mixed traffic. The higher operational speed, however, may not be supportive of people standing and hence can have limited capacity. Also, fixed schedule system has a disadvantage of running empty trips. It is expected to be more effective in urban areas where there's more population. As it has a fixed schedule, timetabling and scheduling with other public transport services will be easier, leading to a seamless integration into the existing public transport network.

Emergency control:

In case of an emergency, the steward will take over. The steward is responsible to make sure the passengers reach their destinations by calling taxis or waiting for the next SAV. The steward can either manually take over or guide the passengers outside the vehicle and make sure there is minimum delay. This saves a lot of time for the passengers as the steward will be prepared and will be physically present to cater to the passenger's needs. The steward will keep the passengers calm and transport them using the next shuttle in the schedule. As it is running on a dedicated lane, the emergency will not affect the other traffic users.

Social layer:

The presence of the steward increases the perceived safety (especially at times of emergencies) and their roles can extend to being a host where they can help people with mobility challenges/restrictions. As it is dedicated lane with minimum interactions, users are expected to feel safer. Fixed schedule should have a higher perceived safety compared to on-demand service because passengers know in advance which stops, where and when the shuttle will have. Moreover, with fixed operations, it is possible to train the vehicle to follow always the same route, so that obstacle detection and road mapping are optimized for the particular route.

Physical layer:

The SAV will run on its own infrastructure and hence it will require dedicated signal control devices, crossings, guidance system (magnets). As it will be a fixed schedule system, there will be additional costs for setting up stops as well.

Technology layer:

As the SAV is expected to run on dedicated lanes, not much extra awareness is required for other road users. However, general public must be aware on how to interact with it while using it or interacting with it at crossings. Furthermore, awareness campaigns must be done to increase goodwill and to increase attractiveness. The stewards present on board must be trained and equipped well enough to handle any emergencies.

(viii) Scenario 8

The SAVs will be running on dedicated lanes where the vehicle will have restricted or zero interactions with other road users like pedestrians, cyclists, passenger cars etc. It is exactly similar to scenario 7, except that there is no steward on board. The dedicated infrastructure would enable the SAV to operate at higher speeds compared to operating in mixed traffic. Additionally, as there is restricted interaction with other users, it ensures safety relative to running in mixed traffic. All the other factors (advantages and disadvantages) defined in scenario 7 is still applicable here. All functions that an actual steward does must be done remotely, although it won't be exactly the same.

Emergency control:

In case of an emergency, the remote supervisor will handle it. As it is running on a fixed schedule and is not sharing the infrastructure with any other vehicles, the remote supervisor can send a new vehicle to the location of emergency quickly or communicate to the passengers to wait for the next SAV in the schedule. Since the steward is not physically present inside the SAV, the communication to guide the passengers and prevent them from panicking need not be as effective as the same scenario with a steward on board. Additionally, it would be difficult to pass on instructions to the passengers once they clear out of the SAV. As it is running on a dedicated lane, the emergency will not affect the other traffic users.

Social layer:

As it is a dedicated lane with limited interactions with other users, passengers are expected to have higher perceived safety. However, this could be cancelled out due to the absence of the steward, especially at times of emergencies. Additionally, if emergencies aren't handled well, the attractiveness of SAV will drop. Moreover, fixed schedule will have higher perceived safety than on-demand service. Features like live video streaming of vehicle's path, live video communication with remote supervisor can play a role in making the passengers feel safer. However, it won't be the same as an actual person inside the SAV who can help out elder citizens. This would then be a factor that can lead the users to question the safety and reliability of the SAV.

Physical layer:

As the SAV will run on its own infrastructure, it will require dedicated signal control devices, crossings, guidance system (magnets). The physical stops (similar to bus stops) of the SAV, features like intercom system with video, live tracking of SAV movement with video like in flights to compliment the social layer, will also add to the cost.

Technology layer:

As the SAV is expected to run on dedicated lanes, not much extra awareness is required for other road users. However, as there is no steward on board, general public must be aware on how to interact with it while using it or interacting with it at crossings. Furthermore, awareness campaigns must be done to increase goodwill and to increase attractiveness to make users trust the remote supervision sufficiently to use the service. The supervisors remotely handing the SAV must be trained and equipped well to handle any kind of emergencies effectively. This would then be an additional cost in the business model.

An overview of all the scenarios is shown in Table 2.

Table 2: Overview of scenarios

Scenario	Infrastructure		Schedule		Steward	
	Dedicated lanes	Mixed roads	Fixed	On-demand	Yes	No
1		★	★		★	
2		★	★			★
3		★		★	★	
4		★		★		★
5	★			★	★	
6	★			★		★
7	★		★		★	
8	★		★			★

4.4 Scenario analysis

The 8 scenarios defined in the previous section are analyzed using a multi-actor multi-criteria (MAMCA) analysis. The parameters defined in the four layers defined earlier is used as the attributes to assess the scenarios. As the attributes cannot be quantified properly, cost-benefit analysis method cannot be used. Moreover, a stakeholder analysis is lacking to clearly understand the objectives and goals of the key stakeholders. Therefore, two actors, namely the road authority (which is a governmental body) and the public transport operator are chosen. Then the layers are given an order or weight from 1 to 4 in a logical manner; 4 meaning highest weight and 1meaning lowest weight. The order does not imply that any of the factor is not relevant; some factors are assumed to have higher importance over others and hence a weight accordingly is assigned.

The scenarios are given values on a scale of 1 to 8 for each attribute, where no two scenarios can have the same value for a specific attribute. A higher value for the emergency control attribute implies the scenario is better at handling emergency situations with minimum disruptions to the traffic users and minimum delay for the passengers. A higher value in social layer in indicative of higher perceived safety and better accessibility for passengers with mobility challenges. A higher value in the physical layer means that the scenario does not require much infrastructural modifications or added features in the SAV. Similarly, a higher value in the technology layer signifies that the scenario requires minimum additional training and awareness. The values assigned to each scenario for each attribute is shown in Table 3. The order of preference assumed in the layers for both the actors and the justification is given in Table 4-a and Table 4-b respectively.

Table 3: Values assigned to scenarios

#	Attributes						
	Technology layer		Physical layer		Social layer		Emergency control layer
	Additional training	Technology awareness	Road Infra	Vehicle features	Perceived safety	Accessibility for elderly	
1	6	6	7	7	6	4	6
2	2	2	6	3	2	1	3
3	5	5	8	5	5	8	5
4	1	1	5	1	1	7	1
5	7	7	2	6	7	6	7
6	3	3	1	2	3	3	2
7	8	8	4	8	8	5	8
8	4	4	3	4	4	2	4

Table 4-a: Weights assigned to the layers for the road authority

Weight	Road authority (govt.)	
4	Social layer	If the users don't perceive the SAV safe enough to use or if the elderly isn't able to use it, then it won't be profitable to invest; also, social welfare is one of the goals of government.
3	Physical layer	Focus on infrastructure as that's the major concern of the road authority
2	Emergency control	To prove that it is safe as any accidents or emergencies if not handled well, road authority will also be responsible
1	Technology layer	To prevent emergencies, and also that all road users are aware of the changes to adapt

Table 4-b: Weights assigned to the layers for the public transport operator

Weight	Public transport operator	
4	Emergency control	Emergency control needs to be addressed as if not done well, attractiveness will reduce and number of users will reduce, essentially resulting in lower revenue
3	Social layer	Increase attractiveness so that more users will use; more revenue
2	Technology layer	To increase attractivenes and increase modal split, users must have increased awareness; also additional training for emergency control
1	Physical layer	Road and vehicle features are relatively less important factors to increase attractiveness

The weight of a layer is multiplied with the value assigned to the scenario under that specific attribute. Then the total sum of each scenario is calculated, as shown in Table 5. A heat map is applied to it, where it varies from dark red (minimum) to dark green (maximum).

Table 5: MAMCA scores for the scenarios

Scenario	Road authority	Public transport operator
1	106	92
2	49	38
3	111	92
4	54	38
5	104	103
6	43	41
7	120	115
8	61	57

5. Results

Both the sub-research questions can be answered from the questionnaire study and the scenario analysis done. The results of these two are explained in this section.

5.1 Result from questionnaire

Six respondents filled in the questionnaire that were sent out. The number of responses isn't sufficient to perform a statistical analysis to uncover patterns or trends. However, the stewards who responded has been a part of multiple pilots like Wepod, Appelscha, HaGashuttle, ESA-ESTEC shuttle, Rivium Generation-2 project, I-AT project and Drimmelen shuttle. The responses are discussed elaborately in this section.

All the stewards had undergone steward/supervisor training. Five out of six respondent felt the training was sufficient for them to handle emergency situations. One of them responded that the training was insufficient and that they weren't confident enough to drive alone in the first few weeks. The training was felt insufficient because the training was done only last minute in that specific case. The training comprised of how to handle emergency stops due to internal or external factors, keeping an eye on fellow road users and obstacles, checking for any strange behaviour from the vehicle, and ensuring the passengers wear their seatbelts. Additionally, the instruction manual was also reported to be outdated as many new issues weren't addressed in it.

All the stewards agree that the SAVs are doing well and is very effective, but still has a long way to go. One of the respondents felt that it was a bit awkward to control the vehicle manually using the joystick controller. Most of them functioned not just as a steward, but as a host, supervisor or manager. On a scale of 0 to 10, four out of six of them responded with a score of 8 or more. The other two relatively lower responses can be because they hardly came across any emergency situation that required their attention. One peculiar situation that was in the response was the cars being parked incorrectly on the road. This problem can be solved by what was done by the CityMobil2 project where on-street parking was removed. However, it is a trade-off on which must be given more priority. Additionally, it was reported that passenger cars stopped to watch the SAV out of curiosity.

Three of the six stewards responded that the frequency of emergency situation in the SAV is high, almost every trip or regularly. Out of the remaining three, two responded that they had zero emergencies and the third one said it happens twice a year. In case of an emergency situation, they responded that they are expected to push the button, check surrounding, do a diagnosis of the incident and resume manual operation if deemed necessary. One respondent said that they are responsible to respond the incident in detail and provide an incident report. Finally, another respondent said that they have to explain to the passengers what is going on in case of an emergency and prevent them from panicking. All six respondents feel that the SAV cannot manage these emergency situations on its own without manual intervention.

Four out of the six stewards responded that their functions can be performed remotely with enough added features, but they foresee that happening slowly in a few years. The presence of steward in an SAV is necessary because the law still mandates it for safety purposes. They think that when the technology matures enough, it is quite possible that SAVs can function without a steward. The other two stewards feel their physical presence is required in the SAV.

They feel that physical presence is mandatory in the SAV for the safety of the passengers and also because public traffic is so complex that a steward is indispensable.

5.2 Result from analysis

It can be seen from Table 5 that the scenarios with a steward on board have a better score than the scenarios without steward on board, which is expected. For both the chosen stakeholders, scenario 7, where the SAV runs on dedicated infrastructure and on a fixed schedule and a steward on board has the highest score. It is interesting to see that scenario 3 that comes second from the road authority perspective scores the least in the scenarios with stewards from the public transport operator perspective. This can be because for scenario 3, where the SAV runs on mixed roads and on-demand with a steward doesn't require much infrastructural modifications, whereas it involves the most complexities because it must ideally be prepared for any emergency situation. This would then give a lower score for the emergency control layer for the public transport operator perspective, which has the highest weight. Scenario 5, where the SAV runs on-demand on dedicated infrastructure with steward on board scores the least out of all scenarios with a steward on board from the road operator perspective. This can be because the SAV being on demand is still not accessible enough for the elderly. The social layer and physical layer are the top two in terms of weight for road authority. The elder citizens prefer using a public transport mode if it is closer to their houses [22][23], which can be the reason by scenario 3 (on demand on mixed roads with stewards) has a better score. Moreover, the additional cost due to the dedicated infrastructure can also be the reason. Similarly, for the public transport operator, scenarios 5 and 7 (dedicated infrastructure) has better score because the physical layer has the least weight. Scenarios 1 and 3 (mixed roads) has a comparatively lower score because they run on mixed infrastructure and as it has more interactions than dedicated lanes, the perceived sense of safety and emergency control would have lower scores, which have higher weight for the actor.

As the technology is expected to mature in the future where SAVs can function without stewards on board, then the question would be which scenario is the best for without stewards on-board. Comparing the scores of the scenarios without a steward on board can give some insight about this from both the chosen actors' point of views. For both the actors, the scenario with the highest score is scenario 8 (dedicated lane and fixed schedule). This is already being implemented in the Rivium Parkshuttle. In terms of safety, serving as a first and last mile mode of transport, integrating into the existing public transport network and higher operational speed without an effect on other road users, makes it the best scenario for both the actors. For the public transport operator, the remaining scenarios have scored very less compared to scenario 8. As for the road authority, the scenario that scored the second-best score is scenario 4 (on demand in mixed traffic conditions) which is already being implemented in the U. S. by vehicle manufacturing companies like Waymo or Cruise. Scenario 4 has a better score than scenario 6 because of the additional cost of dedicated infrastructure and due to accessibility, as those two are the layers with the top weights. Although scenario 8 also has additional infrastructure costs, it balances out by doing well in the other layers and hence obtained a better overall score.

6. Discussion

The questionnaire responses and the scenario analysis gave good insights into the effect of the steward in an SAV. However, there are some uncertainties and drawbacks involved in this study and are explained in this section.

The number of responses received from the questionnaire is very less and insufficient to do a statistical analysis. Therefore, more data can help confirm the conclusions drawn from the questionnaire responses and will me much helpful to find a pattern or trend between the stewards.

Conducting a stakeholder analysis would be really beneficial to identify the key stakeholders in the project and to assess the goals or objectives of the stakeholders. Such an analysis would give more solid base to the scenario analysis than the assumed weight and focus provided to the layers from the actors' perspectives. There is no monetary cost involved in the analysis because some factors cannot be quantified. However, the additional infrastructure and vehicle features can be better represented in terms of actual cost. So, finding an effective method for quantifying the qualitative factors using a key performance indicator (KPI) can be investigated further. Finally, a sensitivity analysis can be done to find the actual impact of attributes in the overall system, but due to time constraint it was not done.

The trade-off between the cost savings by removing steward from the SAV and the additional costs incurred for training and added features must be investigated in detail. It seems a bit unfair to all the scenarios without stewards on board as evidently for all the attributes except physical layer, the scenarios with stewards obtains a better score than stewards without a steward on board. Therefore, more factors can be included in the scenario analysis.

The presence of emergency button inside the SAV is one of the emergency control methods. However, the accountability of users pressing the button unnecessarily must be addressed. It was reported in the questionnaire and in the studies done about pilots that other road users slowed down or stopped to watch the SAV. A study even showed that autonomous vehicles being recognizable leads to an added risk-taking tendency due to too much trust in the technology. This can be investigated in detail. The third generation of Rivium parkshuttle will be running on mixed traffic. Once there is enough data, it can provide good insights and can be used to verify the results of this study.

The idea of having a robot presence in an AV was welcomed by 19 out of 26 people in a survey [24]. Some respondents also indicated that they prefer a virtual character on the screen, while others said that they would like just an audio presence. Such presence can be very beneficial to offer guidance, help elder citizens, explain the functionalities of the SAV and during emergency situations.

These points can be used as points for further research or to extend this study. This research in influenced partially by the effect of Covid-19. In the future, it need not be under this influence. Hence, the study can be repeated to check whether similar results are obtained. There are studies being conducted to obtain better insights for SAVs by many companies all over the world. But due to non-disclosure agreements, the data and results are restricted within themselves to spearhead the company into the frontline of the competition. For the era of self-driving vehicles to take a phenomenal leap, companies must come together and share data to get a more comprehensive idea about the system, investigate deeper into the failures and can come up with better solutions. From capitalist perspective, it is understandable why this isn’t viable, but from a technology perspective, designing the perfect self-driving vehicle will give birth to more technological leaps in the field of transportation.

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8. Appendices

8.1 Appendix 1 - Questionnaires

8.1.1 Appendix 1A – Questionnaire (English)

1. Which SAV pilot were you a part of?

2. Where and when did you attend the steward/supervisor training?

3. What is your opinion about the SAV used in the pilot in terms of the functionality and the use of the vehicle?

4. What was your function within the SAV (steward/host/supervisor/combination of all the three) and what tasks did this role involve?

5. How important do you think is your role in the smooth functioning of the SAV? (Scale of 1-10; 1 = no or very small role, 10 = essential role)

6. What kind of SAV emergency situations are you prepared for during the training?

7. Were there any 'emergency' situations, i.e. situations that required your intervention? If yes, what were they and what actions did you take?

8. How frequently did these emergency situations occur where your intervention was required?

9. Was the training/preparation provided for you enough to handle these situations? If so, please explain the situation and your involvement.

10. What do you do/what is your role in case of an emergency situation?

11. Can the SAV manage on its own in these emergencies without your intervention?

12. In your opinion, do you think your physical presence is required inside the SAV or can you perform all the necessary functions remotely?

13. What is your opinion about SAVs without stewards on-board? Why do you think it is mandatory now to have a steward on board?

8.1.2 Appendix 1B – Questionnaire (Dutch)

1. Aan welke SAV pilot heeft u deelgenomen?

2. Waar en wanneer heeft u de steward of supervisor training gevolgd?

3. Wat is uw mening over de in de pilot gebruikte SAV, met betrekking tot de functionaliteit en het gebruik van het voertuig?

4. Welke functie vervulde u in de SAV (steward, supervisor, host, etc.) en welke taken omvatte deze functie?

5. Hoe belangrijk is volgens u uw rol bij het soepel functioneren van de SAV? (Schaal van 1-10 misschien?) 1=geen of zeer kleine rol"- "10=onmisbare rol

6. Op wat voor noodsituaties in de SUV bent u tijdens uw training voorbereid?

7. Zijn er 'noodsituaties' (situaties waarbij uw ingrijpen noodzakelijk was) voorgekomen? Zo ja, wat waren deze, en welke actie heeft u ondernomen?

8. Hoe vaak kwamen deze noodsituaties voor waarbij uw tussenkomst vereist was?

9. Was de training/ voorbereiding voldoende om deze situaties aan te pakken?

10. Wat doet u / wat is uw rol bij een noodsituatie?

11. Kan de SAV zich zelfstandig uit deze noodsituaties redden, zonder uw ingrijpen?

12. Volgens u, denkt u dat uw fysieke aanwezigheid in de SAV onontkoombaar is of zou u alle benodigde functies op afstand kunnen uitvoeren?

13. Wat is uw mening over SAV's zonder stewards aan boord? Waarom denkt u dat het nu verplicht is om een steward aan boord te hebben?

8.2 Appendix 2 – Relevant factors

Factor	Level of uncertainty	Development direction	Relevant for study
Interaction allowed	High	No interaction at all or interaction allowed	Yes
Effect on other road users	High	Negligible effect or significant effect	Yes
Infrastructure used	High	Dedicated infrastructure or mixed infrastructure	Yes
Emergency Situation control	High	Different scenarios and situations require different control strategies	Yes
Policy and regulations	Low	Towards a more sustainable future	No
Battery capacity	Low	Progress in technology will only increase the battery capacity	No
Operational speed of SAV	Low	High speed or low speed as travel time is important, lower speed won't be the case	Yes
Awareness of technology	Low	Aware or not aware; technological progress can only lead to people becoming more aware	Yes
Appearance or recognizability	High	Can be recognizable or not; if recognizable as an AV, a higher risk-taking tendency can be a problem	No
Range of the vehicle	Low	Technological development is expected to only increase the range of the SAV	No
Accessibility for users with restricted mobility	High	High or low	Yes
Presence of steward	High	Steward present or absent	Yes
Presence of emergency button	Low	Already SAVs has an emergency button on-board	No
Additional training for operator personnel	High	Required or not required	Yes
Schedule of SAV	High	Fixed schedule or on-demand	Yes
Work from home trend	High	The work from home trend either stays or not	No
Capacity of SAV	Low	High capacity or low capacity	Yes
Infrastructural changes	High	Required or not required	Yes
Type of city	High	Rural or urban; despite rapid urbanization, uncertain where it's more effective	Yes
Presence of camera inside vehicle	High	Present or not; as it is dependent on future privacy regulations	No
Public acceptance or perceived safety	High	High acceptance or low acceptance	Yes
Social distancing	High	Social distancing norm present or absent	Yes