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Challenges and opportunities of autonomous
vehicles to urban planning: Investigation into
transit and parking

Final Report

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FINAL REPORT

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Executive Summary

The development of autonomous vehicles (AV) has sparked the interests of scholars and practitioners in the field of planning. This new technology has the potential to bring opportunities as well as challenges. This study addressed the question of how AV may affect public transit and parking systems through two qualitative approaches: literature review and focus group discussions.

We reviewed 30 papers containing keywords related to AV and its impact and identified the general effects brought by AV in three orders. The **first-order impact** is the direct influence of implementing AV, including reducing travel time and increasing safety. The **second-order impact** usually derives from first-order impacts, such as higher vehicle-miles-traveled (VMT) due to the increased demand for AV. Finally, the first- and second-order impacts lead to broader changes in the economy, environment, and social equity, which is the **third-order impact**.

Many studies also shed light on the specific impacts of AV on transit and parking. Some believe AV would decrease ridership and have negative influences on transit. Others also recognize the possible benefits of AV in helping with the first-mile and last-mile problem and increasing transit operation safety. As for parking, most researchers believe that AV can be parked more efficiently, thus freeing up spaces for other purposes. Some further argue that, in the future, shared AV will reduce traffic congestion and increase the occupancy of each vehicle, which further decreases the demand for parking. With less parking demand, current parking facilities could be transferred to buildings for other purposes.

Results of the focus group provide more insights into the analyses of this paper. Almost all the transit focus group participants agreed that this new technology will decrease the cost and increase the efficiency of operating transit, especially in suburban areas. AV can also encourage shared autonomous transit ride and improve the ADA service. But in order to achieve these benefits, issues regarding funding and shared ownership still need more attention. Participants in the parking focus group believed that AV will be able to park themselves without drivers, but they were also concerned with the associated negative effects such as increased VMT and congestion. Unlike the literature review results, opinions of the focus group differ regarding whether the future demand for parking will decrease or increase. Both groups touched on the role of drivers. Despite the technology availability, the perception of safety is also essential. Therefore, many participants were skeptical regarding whether people would be willing to give up control of the vehicle and let it drive itself.

In conclusion, despite some differences in opinions, all the works of literature and participants of the focus groups agreed that the impacts of AV will be significant, but what the actual impacts might look like will depend on how it will be deployed. To minimize the cost and maximize the benefit of AV, collaboration and policy changes will be required.

1. INTRODUCTION

There is a growing interest in autonomous vehicles (AV) among scholars and practitioners. The future deployment of AV could significantly change the current transportation system. AV can largely reduce traffic crashes and improve roadway safety by reducing human errors (Fagnant & Kockelman, 2015). With the use of clean energy, AV can contribute to the decrease in air pollution (Anderson, Nidhi et al., 2014). In the long run, AV can also shape urban land-use patterns (Soteropoulos, Berger et al. 2019). Despite these benefits, AV might also lead to some challenges, including increasing vehicle miles traveled (VMT) and potential urban sprawl (Fagnant & Kockelman, 2015). To maximize the benefits and address the challenges of AV, it is important to examine potential impacts associated with AV and prepare for future policymaking.

The Society of Automotive Engineers (SAE) International classifies vehicle automation into six levels from full human operation to full automation. Vehicles in the first three levels (levels 0 to 2) require drivers to perform primary driving tasks, while the automated driving systems of the latter three levels (levels 3 to 5) can perform primary driving tasks with limited or no driver participation.

- Level 0 – No automation: A vehicle does not have any automation and the driver is responsible to perform all tasks.
- Level 1 – Driver assistance: A vehicle is primarily controlled by the driver with some available automated features such as adaptive cruise.
- Level 2 – Partial automation: Multiple combined automated features are installed in the vehicle, but the driver needs to perform all of the tasks and be observant of the environment.
- Level 3 – Conditional automation: The vehicle can operate with the automated driving system in low-speed dense freeway traffic. The driver does not need to observe the environment but needs to be ready to engage at any time.
- Level 4 – High automation: The vehicle can perform all of the tasks under a certain condition (such as in a geo-fenced location) and the driver does not need to control the vehicle.
- Level 5 – Full automation: The vehicle can perform all of the tasks under any conditions and the driver does not need to control the vehicle.

Automation technologies at different levels can alter the transportation system differently. In this report, we focus on how AV in Levels 4 and 5 could affect transit and parking systems. The report is organized as follows. In Section 2, we present the methods used to conduct the study: literature review and focus groups. In Section 3, we summarize the key results of the literature review. In Section 4, we present the findings based on an analysis of the focus groups. The final section concludes the report.

2. METHODS

In this study, we adopted two approaches to examine the influences of AV on transit and parking systems: literature review and focus group discussions.

2.1 LITERATURE REVIEW

Many studies have examined the potential influences of AV. We looked particularly for the studies examining AV's influences on parking and transit. Our search in Google Scholar includes keywords and titles such as "autonomous vehicle", "self-driving", "transit", "bus", "rail", "parking", and "traffic". We selected only articles written and published in English. Our search generated 90 papers and 30 of them were included in the literature review portion of this report.

2.2 FOCUS GROUP

We completed one 2-hour focus group meetings for each of the two topics: transit and parking, respectively. Outlines of the two focus groups are attached in the Appendix. In each focus group, we started by giving participants a general introduction to the concept of AV. Then, participants were asked to identify current challenges in transit/parking, followed by exploring what and how the AV technology can help address these challenges. Along with the general discussion, we would also discuss what changes AV can make to specific transit/parking services and potential challenges brought by these changes.

To better represent the transportation system in the Twin Cities, we invited eight to nine people from different agencies and different sub-regions to participate in the focus groups. Table 1 presents the affiliations of the participants. In the transit focus group, we invited participants from urban transit agencies, suburban transit agencies, as well as those who work for the entire metro region. In the parking focus group, we invited participants from central cities, suburban cities, specific parking facilities, the airport, and the university. The variety of participants offers views from various perspectives.

Table 1 Affiliations of participants in focus groups

	Transit Group	Parking Group
Participant affiliations	<ul style="list-style-type: none"> • City of St. Paul • City of Minneapolis • Dakota County (former employee) • Southwest Transit • Metro Transit (two representatives from two offices) • Metropolitan Council (two representatives from two offices) 	<ul style="list-style-type: none"> • City of St Louis Park (Suburb) • City of Oakdale (Suburb) • City of Woodbury (Suburb) • City of Minneapolis (Central city) • City of St. Paul (Central city) • 494 Transportation Management Organization • MnDOT (ABC Ramps) • MSP Airport • University of Minnesota

3. LITERATURE REVIEW

3.1 THE GENERAL IMPACTS OF AUTONOMOUS VEHICLE

Based on the work of Milakis, Snelder et al. (2015) and Milakis, van Arem et al. (2017), the impact of AV follows a ripple effect and can be categorized into three orders (Table 2). The **first-order impact** is the direct influence of employing AV. Studies showed that AV reduce travel time, especially when the road is crowded (with a 9% improvement) (Aria, Olstam et al. 2016). The vehicle-to-vehicle communication allows AV to detect the motion of leading vehicles and vehicles in adjacent lanes, producing smoother traffic and reducing travel time (Zhou, Qu et al. 2016). AV could better detect the environment around them without feeling tired or being distracted, and respond to changes almost simultaneously, making them much safer than vehicles operated by human drivers (Levinson 2015). Under the condition with similar speeds and capacities, AV greatly reduce the possibility of human failures (Carbaugh, Godbole et al. 1998). AV generate smoother traffic, thus reducing car crashes and supporting high vehicle throughput (Anderson, Nidhi et al. 2014). More precise operations allow AV to travel with shorter headways and narrower lanes, so AV could increase lane capacity (Chen, Balieu et al. 2016) and roadway capacity in general (Childress, Nichols et al. 2015, Levinson 2015).

Table 2 General impacts of autonomous vehicles in three orders

First-order impacts	<ul style="list-style-type: none"> • Shorter travel time (Aria et al., 2016) • Smoother traffic (Zhou et al., 2017) • Higher safety (Levinson, 2015) • Increased lane capacity (Chen et al., 2016)
Second-order impacts	<ul style="list-style-type: none"> • Higher VMT (Bahamonde Birke et al., 2016) • Lower transit ridership (Begg, 2014) • Lower demand for parking (Alessandrini et al., 2015) • Fewer transportation infrastructures needed (Chapin et al., 2016)
Third-order impacts	<ul style="list-style-type: none"> • Economic growth (Fagnant & Kockelman, 2015) • Environmental benefits (Greenblatt & Saxena, 2015) • Equitable opportunities for elders and people with disabilities (Anderson et al., 2016)

Second-order impacts tend to be derived from the first-order impacts. Assuming that the need for transportation remains constant, the increased demand for AV will reduce the demand for

public transit and non-motorized transportation, which will lead to higher VMT and more traffic (Bahamonde-Birke, Kickhöfer et al. 2018, Kröger, Kuhnimhof et al. 2019, Levin and Boyles 2019). Moreover, AV tend to cause more increase in VMT than in the number of trips, indicating that people prefer to travel longer distances with AV (Kröger, Kuhnimhof et al. 2019). Nevertheless, some argued that VMT increase caused by AV will likely happen in rural areas and urban areas with low population density and poor public transit systems. In larger cities with high population densities, AV will not reverse the trend of sustainable transportation (Begg 2014).

AV save spaces by reducing the need for parking. The parking spots for AV could be smaller and denser (about 2 square meters less per vehicle than conventional spots), freeing up more public spaces (Alessandrini, Campagna et al. 2015, OECD 2015, Nourinejad, Bahrami et al. 2018). With the adoption of shared AV, the need for parking spaces could decrease by about 90% (Zhang, Guhathakurta et al. 2018). With more precise operations, AV require fewer lanes, a narrower lane width, smaller medians, and fewer street signs and signals (Chen, Kockelman et al. 2016; Chapin & Rokyta 2016). The spaces saved could provide more public spaces for pedestrians and bikes (Alessandrini, Campagna et al. 2015). Nevertheless, AV may also produce some barriers to walking and biking. First, AV require fewer traffic signs and signals, which might slow pedestrians and bicyclists since they need to travel in denser traffic without safe intervals between traffic lights. Second, the AV drop-off and pick-up zones might fragment the bike/walk network (Chapin & Rokyta 2016).

Besides the first-order and second-order impacts that mainly occur within the transportation sector, **third-order impacts** are broader and can affect other aspects of the society. If AV reach a 90% market penetration rate, the estimated impact of AV adds up to \$196 billion dollars to the economy (Fagnant & Kockelman, 2015). AV should be able to use clean energy and decrease carbon emissions (Alessandrini et al., 2015). AV could sense and anticipate the braking and acceleration decisions of lead vehicles so that they can have smoother brakes and speed adjustments, reducing fuel consumption (Fagnant & Kockelman, 2015). Compared with current conventional taxis, autonomous taxis could reduce greenhouse gas emissions per mile by 87-94% by the year 2030 (Greenblatt and Saxena 2015). The elderly and people with disabilities or certain medical conditions would be able to “drive” with the AV technology (Alessandrini, Campagna et al. 2015, Harper, Hendrickson et al. 2016). On average, when transit agencies provide services to people with disabilities, 14-18% of their total budgets are spent on paratransit, which could be highly reduced by AV with level 4 or 5 of automation (Anderson et al., 2016).

3.2 TRANSIT

The influences of AV on transit are complicated. AV could have a substantial negative impact on transit (Lutin 2018). Fully automated vehicles are able to operate without a licensed driver, so transit riders who do not have a driver’s license will be able to “drive”. As for choice riders, AV allow them to use travel time more efficiently, thus melting away the benefits of transit, and encourage the use of AV. These mode shifts of both transit-dependent and choice riders will decrease transit ridership.

However, AV may also offer opportunities for transit. AV could help solve the first-mile and last-mile issues, especially for riders with disabilities. Better connectivity with the transit system could attract more riders. Other technologies associated with AV, such as facial recognition and assistive robots, can help with the travel issues of riders with disabilities and improve their travel experiences (U.S. Department of Transportation 2018).

Besides improved mobility, AV technology could also generate benefits in other aspects of transit. One major benefit is improved operational safety. Many expenses are now being devoted to dealing with collisions and casualties related to buses (Lutin 2018). The use of Autonomous Collision Avoidance and Autonomous Emergency Braking systems can largely reduce collisions, improve safety, and save related expenses for other usages (Spears, Lutin et al. 2017). More precise and stable operations also increase the capacity and efficiency of transit services through smoother steering and closer headways. AV technology also increases riding comfort by providing precision docking through the Vehicle Assist and Automation (VAA) system and allow riders to board the bus with a closer gap or even from a level platform (Gregg and Pessaro 2016). Finally, automated BRT or automated feeder service can add more mobility to the transit system.

3.3 PARKING

On average, a vehicle spends 95% of its lifetime on a parking spot (Mitchell 2015). A 2011 study found that there are almost one billion parking spots in the United States, occupying about 6,500 square miles (Thompson 2016). In high-density urban regions, large areas of land used for parking increase both renting and acquisition costs (Nourinejad, Bahrami et al. 2018). Moreover, large amounts of driving time have been spent cruising for parking. Shoup (2006) indicated that each on-street parking space can generate 30 min of cruising time and five vehicular miles per day. Cruising for parking not only occupies road spaces which results in traffic congestion, but also leads to air pollution and energy waste.

Transportation researchers seek ways to help make parking more efficient in urban areas. Many believe that the development of AV will have a tremendous impact on parking demands and design. Some researchers even believe that the biggest impact of AV would be on parking. Nevertheless, there's still discussion regarding what this impact might look like and how these impacts would change transportation and urban environments.

AV can stimulate changes in the design of parking facilities. Amy Korte from Boston.com proposed the future changes of parking garage design. Her research focuses more on designing parking structures that can transform to accommodate the development of AV. Korte's design contains two phases (Sisson 2016). The parking garage in phase one is like conventional garages but has some different features. The phase-one garage would have efficiency rows on the top level for AV and walk-up parking on lower levels for conventional vehicles. The heights of each floor will be increased so that they could be transformed into residential or commercial uses. Then, the garage design enters phase two when more conventional vehicles are replaced by AV. In this phase, AV can be stored more efficiently in a smaller area, and other floors of the garage will be transformed into residential and/or commercial spaces.

Nourinejad, Bahrami et al. (2018) also presented a technical model depicting a new layout of AV parking lots. Because an AV requires less space to park than conventional vehicles, the layout of a parking lot could be changed so that AV are stacked in rows in a solid grid. In this way, each vehicle would occupy a smaller space compared with the design of conventional parking facilities (Figure 1). The problem with this parking design is that some vehicles could be blocked and the blocking vehicles will need to be relocated to release the blocked vehicles. Nourinejad, Bahrami et al. (2018) design a layout for parking to maximize the vehicle-space efficiency and minimize the relocation required. Their estimation shows that the parking lot designed for AV could decrease about 62% needs for parking spaces on average and a maximum of 87% need for parking spaces.

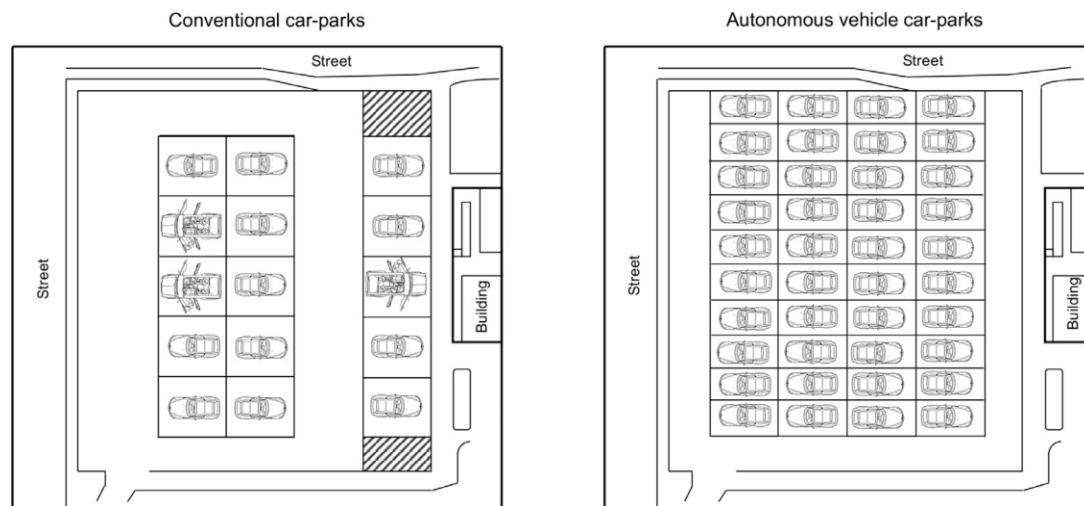


Figure 1 Conventional and AV parking design

Source: (Nourinejad, Bahrami, et al. 2018)

The impact of AV on parking is associated with vehicle ownership. Holmes (2017) divided the ownership of AVs into three scenarios (“private”, “shared ownership or single occupancy”, and “shared use, multiple occupancy”) and predicted the impact of these three ownership scenarios on different aspects of parking, including number of car parks, locations, revenues, facility types, capacity, and so on.

- Numbers of car parks: as more privately-owned vehicle become shared and multiple occupied, the number of cars that requires parking will decrease gradually.
- Locations: when the autonomy can drop off passengers and park elsewhere, parking lots could be in cheaper areas that are relatively farther from destinations.

- Parking revenues: when more vehicles have shared ownership, there will be fewer car parks and the time spent parking cars would decrease. As a result, the revenue generated from parking will decrease.
- Type of facility: parking facilities would become more centralized around service and have waiting areas for users to request and wait for the AV.
- Operational capacity: less parking capacity would be needed.

In general, most researchers believe that AV can be parked efficiently, thus freeing up spaces for other purposes. Some further argue that the ownership of vehicles has significant impacts on parking. They believe that in the future, shared AV will reduce traffic congestion and increase the occupancy of each vehicle, which further decreases the demand for parking. Moreover, some even contend that the future development of shared AV will eliminate the need for parking entirely (Brulte 2017). Instead, there will be pick-up and drop-off zones, which require urban planners and engineers to alter the current built environment and street design accordingly.

4. FOCUS GROUP FINDINGS

4.1 TRANSIT FOCUS GROUP

The transit focus group started by asking participants to indicate what they think would be the most major issues faced by transit in the next five to twenty years, and which might be solved by the introduction of AV. Some keywords that were often mentioned include “funding” and “sharing”. Associated with these keywords, the most pressing transit issues are identified. The first one is the funding structure of transit, especially in the State of Minnesota. As one participant mentioned: *“...identification of stable funding sources is very important especially in Minnesota (where) a lot of our funding is based on motor vehicle sale taxes.”* Currently, 40% of motor vehicle sales taxes are dedicated to transit. If shared AV become prevalent, the number of vehicles sold and sales taxes may decline. The development of transit in the advance of AV would require a more stable and reasonable source of funding. Another major issue is the opportunity to encourage shared mobility, which could help move people with disabilities and workers to exurban destinations. But many challenges will need to be tackled to transfer from the current transit system to the potential sharing mode: *“For our residents it really has to be seamless including the outlining communities and there are so many organizations from city governments county governments federal levels so forth and so on that really all have to involve together in order to make that work.”*

When it comes to the opportunities of using AVs to solve the above-mentioned issues, the discussion focused on the ADA service. The value of AV in solving the first-mile and last-mile problem of the ADA service is acknowledged. But certain roles of ADA drivers cannot be easily replaced by the technology because *“...our ADA service primarily escorts service. And having a driver or not having a driver does not eliminate the need to escort customers door to door.”* According to these practitioners at the focus group, merely having the AV driving technology is far less than enough to provide a proper ADA service due to the lack of human caregiving. Therefore, it is skeptical that AV would provide a better ADA service. Nevertheless, other participants pointed out that AV could free drivers from their current driving tasks and allow them to focus on escorting and caregiving, which might be more beneficial to passengers: *“If you think of metro mobility service that driver now no longer has to play the role of driver they can just play the role of escort. That becomes the role now.”*

Thereafter, the group discussed the specific effects of AV on various aspects of transit. Almost all the participants agreed that this new technology will decrease the cost and increase the efficiency of operating transit, especially in suburban areas. Without drivers, service hours could be largely expanded, which *“opens up a whole bunch of opportunities for serving early/ night shifts, evening and weekends that we currently can’t serve cost-effectively.”* It was also pointed out that automated and connected technology would improve road conditions and free up more spaces for frequent transit services. As one participant mentioned: *“And if other vehicles are automated, that means that their needs from the cycle time are reduced and we can potentially increase our phase at the cycle. All of the things go together and that the urban form conversation.”*

However, there are also aspects of transit that AVs are not capable to solve. First, the introduction of AV in transit wouldn't necessarily lead to higher ridership without changing the current travel pattern. As mentioned in the focus group: *"I don't think autonomous vehicles are going to do anything in terms of increasing passengers per hour as it is right now. Cause trip patterns are trip patterns, the ODs are the ODs."* Furthermore, the perception of safety and sense of community provided by drivers cannot be easily offered by driverless transit. So, a tradeoff needs to be made between reducing numbers of drivers to decrease costs and maintaining the benefits of having human drivers.

4.2 PARKING FOCUS GROUP

Participants in the parking focus group started the discussion by illustrating the current state of parking as well as predicting the future parking scenarios after AV were introduced. Most participants agreed that the future scenario of parking *"totally depends on the model: do we own them or are we subscribing to a service? That's completely different answer(s)."* In other words, if the vehicle is owned, it might be sent home or to a different location by its owner and will come back for pickups when it is needed. If the vehicle is shared, it will circulate among different users and only show up for pickups and drop-offs. The characteristics of the people using the service are also important to consider when exploring the scenarios. As a result, one group participant pointed out the need for a classification system: *"the first thing to do is look at the functional classification system, and who uses it, and what do they need from that. (Be)cause subdivision regulations are designed to meet the needs of those systems."*

Despite the expectation that users will send the AV home after using it and relax the need for parking, many participants in the group were concerned with the negative effects associated with this phenomenon. Having the vehicle drive itself without passengers will double VMT, generating more pollution and congestion. To cope with this potential outcome, two possible solutions were raised. The first one is imposing a congestion pricing scheme that charges people when they send the empty car on the road: *"I can see a situation where cities would start doing a congestion pricing for certain areas, that would be more common to keep people from just sending their vehicles home or have it circulate as much."* The other solution is to build peripheral parking near popular destinations but with lower land prices: *"it's [going to] be somewhat cheaper available land that is close to where people want to be. And would you put the parking in an industrial area for 2 dollars a foot rather than a retail area? Absolutely. And the parking in downtown St. Paul, they don't look so good compare with the industrial area across the river."* Peripheral parking provides cheaper parking while minimizing the VMT created by empty vehicles on the road.

Opinions differ when it comes to whether the future demand for parking will decrease or increase. Some people argued that with more cars on the road, demand for parking will increase. Others believed the need for parking will gradually decline to a much lower point: *"There will be some people that are not going to give control. I don't think it's going to be a switch that flips where all of a sudden no one owns a car and no one drives. It's going to be this gradual decline."* Since the curbside will be used for pick-up and drop-offs, on-street parking will likely go away first. Then, as the parking demand keep declining, some parking ramps and garages

could be torn down or adapted to other usages. Some people even argued that the demand for parking will be tiny in certain scenarios: *“I think if AVs are dominant and shared, demand for parking will drop to eventually nothing. And if they are owned, I think in high land value areas, they would drop to nothing; and it will overall drop and move.”*

Interestingly, similar to the transit group, participants in the parking focus group also touched on the role of drivers in the discussion. One person referred to the airplane to make his point. Even though aircrafts have been automated for a long time, there are still two pilots on board to ensure the actual safety and passengers’ perception of safety. Similarly, due to the lack of safety perception, this participant was very skeptical regarding how many people would be willing to give up control of the vehicle and let it drive itself. As he said in the discussion: *“Maybe there’s a difference between aviation and driving. (But) I just struggle with the overall acceptance of it when we haven’t got (full aviation, not just one pilot but two) even when the tech has been around for a longer time. Are people going to willing to have cars drive themselves?”*

5. CONCLUSION

This study explored the potential effects of autonomous vehicles (AV) on transit and parking. By using a series of qualitative research approaches, including literature review and focus groups, we summarized the major impact of AV on transit and parking in three orders (Table 3). Despite some disagreements regarding degree of the impacts and what the future scenarios would be, all of the literature and focus group participants agreed that AV will have significant impacts. Based on these impacts, we have summarized several key takeaways. First, not all transit and parking problems will be solved by AV technologies. In many circumstances, humans will still be needed as attendants to assist people with disabilities, and at least initially, to provide some feeling of safety for passengers. Moreover, what impact AV have will depend highly on how AV are deployed. Last, but by no means least, the AV technology will not create the change by itself. Policies, such as additional fees for empty miles traveled, will be needed to support the deployment of AV to achieve the greatest benefit.

Due to the scope of this research, we could not support our findings with more results from the practice or link our study to the most cutting-edge technology development in AV. Moreover, our focus groups are composed only of participants working in the Twin Cities metro. Thus, our findings might be more applicable within this region. Nevertheless, our work is valuable because it offers a comprehensive summary of AVs' potential impact on transit and parking and provides perspectives from the practice. More important, this study serves as a foundation for future research in related areas. We encourage researchers to conduct focus groups to explore other aspects that might be affected by AV or replicate groups like those in this study in other metro regions or in smaller geographic areas. In addition, research to develop and test specific policies that could lead to optimal outcomes would be very useful while the technology is still in its infancy.

Table 3 Impacts of AV on Transit and Parking

	<i>Transit</i>	<i>Parking</i>
First order impacts	<ul style="list-style-type: none"> • Higher VMT and lower ridership • Shorter travel time • Less congestion and smoother rides • Lower the opportunity cost and fuel & capital cost of travel • Safer rides 	<ul style="list-style-type: none"> • Gradual declining parking demands • Denser and smaller parking spots;
Second order impacts	<ul style="list-style-type: none"> • More sharing ownership • AV shuttles • Redefinition of transit • Mobility on demand (paratransit, vanpool, ADA) 	<ul style="list-style-type: none"> • Satellite parking • More demand for parking staging and pick-up/drop-off parking spaces • AV delivering • More efficient use of resources • Demand for pricing and other incentives to promote land use efficiencies • Increased commerce

<p>Third order impacts</p>	<ul style="list-style-type: none"> • Transportation infrastructure changes (less signaling, narrower lanes, smaller lots and ramps, current ramps converted to other usages) • Equitable travel opportunities for all population 	<ul style="list-style-type: none"> • Economic growth • Land use changes (curb space needed for pick-up and drop-off); • Suburbanization • Reduce GHG emissions • Promote Equity for people with disability • Less pollution and more environmental benefits
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APPENDIX A: FOCUS GROUP OUTLINES

1. OUTLINE FOR THE TRANSIT FOCUS GROUP

What we expect to get out of this focus group are:

- A better understanding of the impact of autonomous vehicles on various aspects of transit
- More insights regarding how to deal with challenges and opportunities regarding these impacts.

Welcome

Introduce focus group objectives and moderators

Focus group guidelines

- Open discussion
- No right or wrong answers
- 2.5-hour process with a 10-min break [1:30 to 4 pm]
- Confidentiality regarding the tape recording
- Introduce the name and affiliation of each participant

Opening questions/info

- Overview of what we will cover
- What are the challenges of transit in the next 5 to 20 years? (Create a list)

Introductory questions

- To what extent are you familiar with AVs?
- Some background information about AV and its potential impact (a brief and high-level presentation [on transportation]?)

Transition questions

- Can AV be used to address the challenges identified earlier? Which ones? How? (refer to the list before; brief explanations)

Key questions

- What are AV impacts on the following transit services (Peak hour v. non-peak hour)?
 - Suburban local
 - Express
 - Urban local (Frequent v. Infrequent)

- Transitway (BRT vs. LRT)
- Transit link and metro mobility
- How do you think these changes would integrate? How would the AV change the “backbones” of the transit network?
- What are AV impacts on Metro Transit fleet, “Opt-out” fleets, private fleets, and individual car ownership?
- What are possible pathways for transit to adapt to this new technology smoothly? What could be the possible policy and strategy changes in transit in response to the development and potential adoption of AV?

(80 min)

(10-min break)

- AV and transit quality of service
 - How would the potential adoption of AV change passengers’ satisfaction with the service (copy of the Metro Transit Rider Survey)?
 - What would be passengers’ potential concerns with the use of AV technology in transit?
 - How could the potential concerns be addressed?
- What are some of the equity issues associated with AV (challenges v. opportunities)?
 - How can transit benefit from these opportunities?
 - How can transit cope with these challenges?

(60 min)

Ending question

- Out of all the things we discussed today,
 - What is the most important?
 - What is the most urgent?
- Is there anything related to AV and transit that haven’t been discussed, which you feel strongly about?

2. OUTLINE FOR THE PARKING FOCUS GROUP

What we expect to get out of this focus group is:

- A better understanding of the impact of autonomous vehicles on various aspects of parking

- More insights regarding how to deal with challenges and opportunities regarding these impacts.

Welcome

Introduce focus group objectives and the moderator

Focus group guidelines

- Open discussion
- No right or wrong answers
- 2.5-hour process with a 10-min break [8:30 - 11:00 AM]
- Confidentiality regarding the tape recording

Opening question

- What are your name and affiliation? What are the goals your organization aim to achieve from parking (generating revenue, providing service, etc)? What do you think are the major concerns of parking?

Introductory questions

- On a scale of one to five, how familiar are you with the concept of the automated vehicle (AV)?
- Some background information about the AV.

Transition question

- Can AV be used to address the concerns identified earlier? Which ones? How? (refer to the list before; brief explanations)

Key Questions

- Once arriving at destinations, what can people do with their autonomous vehicles (AV)?
- Because these options could generate ghost driving, what policies can be used to minimize it and its associated impacts (VMT, congestion, environment, etc.)?
- Where will peripheral parking facilities be located? Are there any equity concerns?
- 9:35 break
- 9:45
- In general, how would AV impact parking demand (the number of parking stalls) and the space for parking facilities (the space for the same amount of parking stalls) in urban and suburban areas?
- What can road spaces be used for if some on-street parking stalls are removed? Are there any constraints for the width of roads (e.g., emergency vehicle access)?
- What are the equity issues associated with AV impacts on parking?

- Challenges
- Opportunities
- What do these changes mean in terms of
 - Zoning code
 - Revenue from parking meters and parking facilities that charge for parking
 - Parking facilities - both surface and structures
 - Snow clearance
 - Street maintenance
 - ...

Ending question:

- Out of all the things we discussed today,
 - What is the most important?
 - What is the most urgent?
- Is there anything related to AV and parking that haven't been discussed, which you feel strongly about?