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User Acceptance and Public Policy Implications for Deployment of Automated Driving Systems

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User Acceptance and Public Policy Implications for Deployment of Automated Driving Systems

A Research Report from the University of California Institute of Transportation Studies

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16. Abstract

The objective of this project is to understand public perception of Automated Driving Systems (ADS) and to develop acceptance models that can help understand users' intentions to use fully ADS, including both personally owned fully ADS and shared-use fully ADS. This project consisted of three phases, including (1) in-depth interviews with end-users of partially ADS, (2) interviews with experts in the transportation domain regarding policy gaps for deployment of ADS, and (3) focus group and online surveys to understand public perception and acceptance model of fully ADS. Findings from this study show that safety, vehicle control and compatibility, and trust are the three most critical factors that have influence on users' acceptance of the fully automated driving systems.

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DISCLAIMER

User Acceptance and Public Policy Implications for Deployment of Automated Driving Systems

UNIVERSITY OF CALIFORNIA INSTITUTE OF TRANSPORTATION STUDIES

August 2018

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Executive Summary

The objective of this project is to understand public perception of Automated Driving Systems (ADS) (SAE International, 2014) and to develop acceptance models that can help understand users' intentions to use fully ADS, including both personally owned fully ADS and shared-use fully ADS. This project consisted of three phases, including (1) in-depth interviews with end-users of partially ADS, (2) interviews with experts in the transportation domain regarding policy gaps for deployment of ADS, and (3) focus group and online surveys to understand public perception and user acceptance model of fully ADS.

In Phase 1, we interviewed 20 end-users of Tesla Autopilots, whom mostly consider themselves early adopters of the automated driving system. It was found that the primary motivations of purchasing Autopilot were convenience (32%) and less stress while driving (27%). Regarding learning of Autopilot, 42% of the participants learned how to use Autopilot by trial-and-error. The other 29% learned from dealership. The majority of the participants mentioned that they used Autopilot more than 70% of the time while they were driving on highways.

In Phase 2, we interviewed four experts with two from academia, one from industry, and one expert from governmental agency. Through the expert interview, we explored various aspects of policy gaps for the seven domains: (1) education and training, (2) financial incentives, (4) shared-use fully ADS, (5) mobility needs and services for elderly users, (6) data privacy and ownership, and (7) liability and insurance.

In the third phase of the study, we conducted 7 focus group studies with 59 participants. Through the focus group, we attempted to understand end-user's perspectives regarding the following six aspects of fully ADS: (1) factors that influence user acceptance; (2) education and training; (3) incentives; (4) liability and insurance; (5) data privacy and ownership; and (6) shared-use fully ADS. After the focus group, we carried out two online questionnaire surveys. One survey was about the user acceptance model for personally owned fully ADS. The other survey was about the user acceptance model for shared-use fully ADS. In total, we had 329 respondents for the owned concept and 270 respondents for the shared concept. As a result, factors of (1) safety, (2) trust, (3) compatibility, (4) perceived ease of use, (5) perceived usefulness, and (6) intention to use were included in both models. It was found that there were noticeably different patterns between the models for the two concepts

Introduction

While road transportation is an essential service in society, the burden of traffic accidents and traffic congestion is immense. The USDOT National Highway Traffic Safety Administration (NHTSA) reported that 37,461 people lost their lives in traffic accidents on the US roadways in the year of 2016. The data show two consecutive years of growth in highway fatalities. According to NHTSA (2013) human error accounted for 93% of traffic accidents. At the same time traffic congestion nationally reached a new peak in 2016, according to INRIX 2016 Global Traffic Scorecard (http://www.inrix.com/). On average Americans spent one hour a week stuck in traffic on their commutes in 2016. In many cities in California, the situation is much worse. Researchers argue that automated driving systems (ADSs) have the potential to resolve some of current transportation challenges and improve road safety and efficiency (Bengler et al., 2014; Anderson et al., 2014; Litman, 2018).

The extent of these improvements will directly depend on public perception and widespread adoption. Moreover, Howard and Dai (2014) identified many challenges of fully ADSs that are yet to be addressed, including public perception, liability issues, security, and control of the systems. Public perception and potential adoption issues of ADSs can potentially be observed in the usage of level-2 ADS that have been introduced to the market. For example, the ADS platform that was chosen to be a target system in this study is Autopilot system offered by Tesla, which is the prevalent type of partially ADS available in the market at this time. In 2016, a Tesla fatal accident which happened in Florida was strongly associated with the misuse of Autopilot (NHTSA, 2017), and several non-fatal crashes were linked to delayed reaction or misuse of Autopilot (Tesla Motors Club, 2016).

In addition to public perception, legislation and policy gaps are also complicating issues that will affect widespread adoption. Questions regarding liability, privacy, licensing, security, and insurance regulation remain mostly unanswered (Fagnant & Kockelman, 2015). Although individual U.S. states have been advancing ADS legislation (Center for Information and Society, 2012), federal regulations have not yet been put in place for fully ADSs beyond testing purposes on public roads. Nevertheless, auto manufacturers are continuing their effort and investment in development of ADSs. Several auto manufacturers have introduced into the market level-2 and plus automation, including Tesla's Autopilot, Audi's AI traffic jam pilot, General Motors' super cruise and Mercedes Benzes' Drive Pilot. In addition, tech companies like Google and Uber are developing fully ADSs and experimenting with their vehicles on the public roads. In light of these advancements in ADS development, there is a strong need for policymakers to plan and to address policy gaps and facilitate the adoption of these emerging technologies to benefit the public.

The objective of this project is to understand public perception of ADSs, to develop a user acceptance model that can help understand user intentions to accept and use ADSs, and to identify the policy gaps that can align legislative processes with technological trends to bring out the greatest benefit for the society as a whole. In this project, two forms of fully ADSs were studied, including personally owned fully ADSs and shared-use fully ADSs. Specifically, this project set out to investigate the following three research questions.

- What are users' perceptions regarding automated driving systems?
- What are the important factors for users' acceptance regarding both personally owned fully ADSs or shared-use fully ADSs and how does each factor contribute?
- Finally, what policy gaps regarding fully ADSs should be addressed to enable these technologies to serve the public in a significant manner?

This study used an approach consisting of three phases which included: (1) in-depth interviews with end users; (2) semi-structured interview with experts from academia, public agencies and industry; and (3) focus group discussions and online questionnaires with the public. This study adopts an innovative and integrated framework to investigate users' intentions to use and adopt fully ADSs. Findings of this study offer guidelines that can help public agencies to better address the alignment and synergy of public policies with the trend of ADS to benefit road users as well as the general public. Relevant policy domains that are considered in this study include: (1) education and training; (2) consumer incentives; (3) shared-use fully ADSs; (4) mobility needs and services for elderly drivers; (5) data privacy and ownership, and (6) liability and insurance.

Methodology

Phase One: In-depth Interview with End-User

A 47-item questionnaire was developed for the end-user interview, which included two sections. The first section was about partially automated driving systems (partially ADSs such as Tesla Autopilot), which the participants have been using. The second section was about fully automated driving systems (fully ADSs), which are yet to be broadly commercialized in the future.

Questions in the first section addressed three aspects of participants' experience associated with the partially ADSs that they own and use: (1) expectations and concerns prior to the purchase; (2) experience during the learning process; and (3) experience during the use. Questions in the second section addressed: (1) factors that would impact participants' acceptance of both partially ADSs and fully ADSs, (2) interests in and expectations of using fully ADSs, and (3) participants' opinion regarding shared-use fully ADS. The questionnaire was built by considering insights gained from and recommendations by recent and relevant research of technology acceptance (Kyriakidis et al., 2017; Howard, D., & Dai, D. 2014; Payre et al., 2014).

The study was originally planned to recruit end-users of different kinds of partially ADSs, currently available on the market such as Tesla Autopilot, GM Super Cruise, and Audi Traffic Jam Pilot. The recruiting process includes several efforts: (1) posting flyers online, (2) distributing flyers in dealerships, and (3) reaching out to personal contacts. It turned out that there were few responses from owners and users of the GM Super Cruise and Audi Traffic Jam, since both were relatively new to the market in 2017 and the available pool of users is small. We decided to select a group of Tesla Autopilot users, with twenty participants recruited. Participants' demographic information such as years of driving and experience of using Tesla Autopilot were collected through a self-administered questionnaire prior to the interview. The interviews with individual participants, each for 45-60 minutes, were then carried out in the months of February to May 2018. The interviews were audio recorded, so that researchers could re-visit the recording as needed in order to further understand participants' ratings and narratives.

Phase Two: Expert Interview

Semi-structured interviews were conducted to obtain experts' knowledge regarding governmental policy from both the federal and California state viewpoints. Four experts were interviewed with two experts from academia, one from industry, and one from governmental agency. All four of the experts have worked in the transportation sector for more than two decades.

Researchers created guidelines for interviews that included seven policy domains. These domains were (1) education and training, (2) consumer incentives, (3) shared-use fully ADS, (4) mobility needs and services for elderly users, (5) data privacy and ownership, and (6) liability. For each policy domain, several questions were posed to cover the main aspects of that domain. For instance, two questions were asked about the first domain (Education and Training): (1) What are the policy gaps that you see concerning consumers' training and licensing in respect to AVs, and (2) How are these policy gaps going to affect consumers' adoption?

The four experts were interviewed individually. At the beginning of each interview, the interviewer introduced an overview of the project and the purpose of the interview. Each interviewee was asked questions in 3-4 policy domains according to their expertise. The interviews, each with a duration of 60-90 minutes, were carried out in the month of April 2018. The interviews were audio-recorded and were transcribed after the interview for further analysis.

Phase Three: Focus Group and Online Questionnaires

Focus Group

Focus groups are typically used as part of a large research program, as they provide data to be integrated with data from experiments, surveys, and individual interviews. In the focus group study, the overall objective was to understand each participant's perception and expectation of suggested policy aspects identified in Phase Two from an end-user's viewpoint. Specifically, the goals of this focus group study were to understand the following six aspects of ADS from end-user's perspectives: (1) factors that influence user acceptance; (2) education and training; (3) incentives; (4) liability and insurance; (5) data privacy and data ownership; and (6) shared-use fully ADS.

Seven focus groups were conducted. Each group consisted of 6 to 12 participants. The total number of participants in all seven groups is 59. Each participant received a minimum compensation of twenty dollars.

The background of participants in each group varies. The goal was to recruit participants that offer a broad range of potential end-users of fully ADS. These groups differ in terms of transportation needs, household income and existing knowledge of ADS. Some characteristics of the groups are highlighted below.

(1) The first group consisted of elderly drivers, at an age of 65 or older.
(2) The second group represented researchers who work in the transportation and/or automated vehicle area.
(3) The third group comprised transportation professionals from a government agency, who work on various transportation problems on the daily basis.
(4) The fourth group included college students.
(5) The fifth group represented Silicon Valley professionals.

(6) The sixth and seventh groups included insurance professionals from one major insurance company in the US.

The seven groups of participants were recruited through different approaches. The elderly-driver participants were recruited through the weekly publication of a senior community in the city of Walnut Creek, California. The researcher and student participants were recruited through campus channels at UC Berkeley. The governmental transportation professional participants were recruited by reaching out to contacts in a transportation agency. Similarly, the insurance professional participants were recruited through contacts in the insurance company. Silicon-Valley professional participants were recruited through personal contacts of the research team.

Focus group procedures

Each focus group took place at a location that was convenient for participants. For the elderly driver group, the focus group was conducted in a conference room of the city library near the senior community. For the researcher group and student group, the focus group was held in a conference room on UC Berkeley campus. For the Silicon Valley group, the focus group was conducted at the home of one of the participants. For the transportation professional and the insurance professional groups, the focus group meetings were conducted in a conference room at each of their own facilities.

At the beginning, participants were given a brief introduction of the study, including the purpose and the procedure of the study. After the introduction, participants were asked to read and sign an informed consent form. Then participants were asked to fill out a demographic information form, including questions such as age, gender, education level, driving experience, income, level of education, and ADS experience. After completion of the demographic information form, participants were shown a 5-minute long presentation introducing different levels of automation, definition of fully ADS and exemplar prototypes of both personally owned and shared-use fully ADS. Afterwards, the moderator posed questions regarding fully ADS, one topic after another, and led the group in discussions to share their opinions, interact with other participants and build upon the ideas of one another. The discussion duration of each topic was controlled to be within 10 minutes. Audio recording was made throughout the discussion. In addition to the lead moderator, two other moderators participated in the focus group study; controlling the presentation of slides, pace of discussions, and making notes of the discussion. For each group, four to six topics were covered within one and a half hours approximately.

Online Questionnaires

The overall objective of online questionnaires was to develop a user acceptance model that can help understand user intentions to accept and use both personally owned fully ADSs and shared-use fully ADSs. Specifically, the goals of online questionnaires were to identify the significant factors which would impact intention to use fully ADS and the relationships among the factors.

Data collection and procedure for online questionnaire

The data were collected from two separate online questionnaires for personally owned fully ADS model and shared-use fully ADS model. The questionnaires were filled out by respondents who live in the State of California. For the personally owned fully ADS questionnaire, respondents first provided their demographic and background information. Then they were required to watch a two-minute video. The video had three main objectives: (1) introduce the different levels of ADS (SAE International, 2014); (2) define level 5 automation (fully ADS) and its capabilities; and (3) show a prototype of personally owned fully ADS introduced by Volvo car corporation (2018). After watching the video, respondents rated 34 items regarding acceptance of personally owned fully ADS. For the shared-use fully ADS questionnaire, after answering the demographic and background questions, the respondents were required to watch a 3-minute video. The video included information regarding (1) level 5 automation (fully ADS) and its capabilities, (2) shared-use fully ADS and its capabilities, and (3) two prototypes introduced by Waymo (2015) and Group Renault, EZ-Go, (2018). Then respondents rated 33 items regarding acceptance of shared-use fully ADS.

The data were collected from 329 respondents for the personally owned fully ADS questionnaire. We eliminated the respondents who had missing data in any question or rated all items the same. As a result, 19 respondents were excluded. Among remaining respondents, 47.4% were male and 52.6% were female. Approximately 21.6% of respondents were younger than 30 years of age, 27.1% were between 30 and 44, 28.7% were between 45 and 60, and 22.6% were older than 60.

For the shared-use fully ADS questionnaire, data were collected from 270 respondents. Twenty (20) respondents were eliminated due to missing data or rating all the items similarly. Among remaining respondents, 47.4% of respondents were male and 52.6% were female. About 24.4% of users were younger than 30 years of age, 30.8% were between 30 and 44, 26.4% were between 45 and 60, and 18.4% were older than 60.

Hypotheses and Research Model

To assess user acceptance of personally owned fully ADSs and shared-use fully ADSs, an extended Technology Acceptance Model (TAM) was developed in this study. TAM is frequently used to predict individual adoption and use of new information technologies. Considering TAM, which takes into account perceived usefulness and perceived ease of use as the core of the proposed model, six constructs are hypothesized to impact the core based on related studies (Davis, 1989; Venkatesh et al. 2003; Choi & Ji, 2015; Osswald et al., 2012; Ghazizadeh et al. 2012; May et al. 2017) and findings from multiple phases on this study. The proposed constructs are (1) safety (SA), (2) trust (TR), (3) compatibility (CO), (4) willingness to pay (WoP), (5) traffic environment (TE), and (6) social influence (SI). The definitions of the mentioned constructs are shown in Table 1.

Table 1 Definitions of Model Elements and Proposed Constructs

ID	Constructs	Definition
1	Behavioral Intention to Use (BIU)	The degree to which an individual believes that he/she is ready to use ADSs.
2	Perceived Usefulness (PU)	The degree to which an individual believes that using the ADSs will enhance his/her mobility performance.
3	Perceived Ease of Use (PEoU)	The degree to which an individual believes that using the ADSs will be free of effort.
4	Safety (SA)	The degree to which an individual believes that using ADSs will affect his/her well-being.
5	Trust (TR)	The degree to which an individual believes using ADSs will help achieve his/her mobility goals even in a situation characterized by uncertainty and vulnerability.
6	Compatibility (CO)	The degree to which an individual believes driving/riding with ADSs is perceived as being consistent with existing experience.
7	Willingness to Pay (WoP)	The degree to which an individual is willing to pay to purchase and maintain ADSs.
8	Traffic Environment (TE)	The degree to which an individual believes that traffic environment of ADSs such as other road user behavior, road condition, and weather condition will affect his/her well-being.
9	Social Influence (SI)	The degree to which an individual believes that people who are important to him/her think that he/she should use ADSs.

With TAM model as a core, TR, SA, and CO are proposed to affect PU, together with PEoU, influence BIU. SA, WoP, TE, and SI were proposed to affect BIU directly. Fifteen proposed hypotheses are listed in Table 2. The strength of the hypothesized relationships in the model and the robustness of the model in predicting behavioral intention to use of personally owned fully ADSs and shared-use fully ADSs were tested.

Table 2 Hypotheses of the Research Model

ID	Hypotheses
H1	PU of ADSs positively affects BIU.
H2	PEoU of ADSs positively affects BIU.
H3	PEoU of ADSs positively affects PU.
H4	SA of ADSs positively affects BIU.
H5	SA of ADSs positively affects PU.
H6	SA of ADSs positively affects PEoU.
H7	TR of ADSs positively affects PU.
H8	TR of ADSs positively affects PEoU.
H9	TR of ADSs positively affects SA.
H10	CO of ADSs positively affects PU.
H11	CO of ADSs positively affects PEoU.
H12	CO of ADSs positively affects SA.
H13	WoP of ADSs positively affects BIU.
H14	TE of ADSs positively affects BIU.
H15	SI of ADSs positively affects BIU.

Develop instrument measures

The proposed constructs were measured with multiple items which were adapted from existing studies (Davis, 1989; Venkatesh et al. 2003; Choi & Ji, 2015; Osswald et al., 2012; Ghazizadeh et al. 2012; May et al. 2017; Zmud et al. 2017) and were developed based on the findings from previous phases of this study including the end-user interview, the expert interview, and the focus group studies. The items were modified to increase internal consistency and to allow the comprehension of the effect of personally owned fully ADSs and shared-use fully ADSs. Through two online questionnaires, all of the items with a 7-point Likert scale from 1 (extremely disagree) to 7 (extremely agree) were measured for personally owned fully ADS and shared-use fully ADS models (see Table 3 and Table 4, respectively).

Table 3 Items Used in Personally Owned Fully ADS User Acceptance Model

Constructs	Items	
Behavioral Intention to Use (BIU)	BUI1	Assuming I have access to a personally owned fully Automated Driving System, I intend to use it.
	BUI2	I expect that I will use a personally owned fully Automated Driving System in the future.
	BUI3	If a personally owned fully Automated Driving System is available, I plan to use it in future.
Perceived Ease of Use (PUoE)	PUoE1	Learning to use a personally owned fully Automated Driving System would be easy for me.

Constructs	Items	
	PUoE2	I would easily understand how to interact with a personally owned fully Automated Driving system.
	PUoE3	I would be able to quickly interact with a personally owned fully Automated Driving System.
	PUoE4	I would easily become skillful at using a personally owned fully Automated Driving System.
Perceived Usefulness (PU)	PU1	Using a personally owned fully Automated Driving System would allow me to reach my destinations more quickly.
	PU2	A personally owned fully Automated Driving System would perform some driving tasks better than I can.
	PU3	A personally owned fully Automated Driving System would increase my productivity (e.g., have time to do some work) during my travel.
	PU4	A personally owned fully Automated Driving System would make my trip less stressful.
	PU5	A personally owned fully automated vehicle would reduce my fuel consumption.
	PU6	I would like to use a personally owned fully Automated Driving System because it's cutting-edge technology.
Trust (TR)	TR1	A personally owned fully Automated Driving System would provide adequate, effective, and responsive help.
	TR2	A personally owned fully Automated Driving System would handle driving tasks without any human intervention.
	TR3	A personally owned fully Automated Driving System would be free of errors or accidents.
	TR4	A personally owned fully Automated Driving System would be predictable and reliable.
Compatibility (CO)	CO1	I expect that a personally owned fully Automated Driving System will drive the same way as I do.
	CO2	A personally owned fully Automated Driving System would be able to select a route in the same way that I do.
	CO3	A f personally owned fully Automated Driving System would drive in the way that I would expect as a passenger.
Safety (SA)	SA1	A personally owned fully Automated Driving System would decrease the risk of an accident.
	SA2	A personally owned fully Automated Driving System would make proper decisions and take actions faster than some drivers.
	SA3	I would feel safer if I could take over control of a personally owned fully Automated Driving System when it is necessary.
	SA4	In emergency situations, a personally owned fully Automated Driving System would protect passengers' lives and safety.

Constructs	Items	
Traffic Environment (TE)	TE1	I expect that a personally owned fully Automated Driving System would be able to handle aggressive drivers when encountered in real-world traffic.
	TE2	I expect that a personally owned fully Automated Driving System would be able to handle driving in unusual situations such as construction or accident zones.
	TE3	I expect that a personally owned fully Automated Driving System would be able to handle driving in all weather conditions.
	TE4	I expect that a personally owned fully Automated Driving System would be able to handle driving on improperly maintained roads, for example where lane markings are not clear.
Willingness to Pay (WoP)	WoP1	Assume buying a personally owned fully Automated Driving System would add $10,000 to the cost of a vehicle. In general, I would be willing to buy a fully automated driving system even if it has a significant price premium.
	WoP2	Assume buying a personally owned fully Automated Driving System (ADS) would add $10,000 to the cost of a vehicle. It would be worth paying more for a fully Automated Driving System in comparison with non-ADS vehicles.
	WoP3	Assume buying a personally owned fully Automated Driving System would add $10,000 to the cost of a vehicle. I would be willing to pay the extra money to use a personally owned fully Automated Driving System because it is such a cutting-edge technology.
Social Influence (SI)	SI1	My friends/family who have experience with personally owned Automated Driving Systems would encourage me to use it.
	SI2	My friends/family who are tech-savvy would recommend that I use a personally owned fully Automated Driving System.
	SI3	I would have more prestige if I used a personally owned fully Automated Driving System, a cutting-edge technology.

Table 4 Items Used in Shared-Use Fully ADS User Acceptance Model

Constructs	Items	
Behavioral Intention to Use (BIU)	BUI1	Assuming I have access to a shared-use fully Automated Driving System, I intend to use it.
	BUI2	I expect that I will use a shared-use fully Automated Driving System in the future.
	BUI3	If a shared-use fully Automated Driving System is available, I plan to use it in future.

Constructs	Items	
Perceived Ease of Use (PUoE)	PUoE1	Learning to use a fully Automated Driving System would be easy for me.
	PUoE2	I would easily understand how to interact with a shared-use fully Automated Driving system.
	PUoE3	I would be able to quickly interact with a shared-use fully Automated Driving System.
	PUoE4	I would easily become skillful at using a shared-use fully Automated Driving System.
Perceived Usefulness (PU)	PU1	A shared-use fully Automated Driving System would be useful for the areas that I usually travel to, such as urban areas with limited parking.
	PU2	A shared-use fully Automated Driving System would increase my productivity (e.g., have time to do some work) during my traveling time.
	PU3	A shared-use fully Automated Driving System would reduce my travel expenses.
	PU4	A shared-use fully Automated Driving System would minimize my responsibility regarding vehicle maintenance and liability.
	PU5	I think a shared-use fully Automated Driving System would be available anytime that I need it.
Trust (TR)	TR1	A shared-use fully Automated Driving System would be free of errors or accidents.
	TR2	A shared-use fully Automated Driving System would handle driving tasks without any human intervention.
	TR3	A shared-use fully Automated Driving System would be predictable and reliable.
	TR4	A shared-use fully Automated Driving System would provide adequate, effective, and responsive help.
Compatibility (CO)	CO1	A shared-use fully Automated Driving System would fit well with my preferred mode of transportation.
	CO2	A shared-use fully Automated Driving System would be as clean as my personal car.
	CO3	A shared-use fully Automated Driving System would drive in the way that I would expect as a passenger.
Safety (S)	SA1	I would feel safe if I use a shared-use fully Automated Driving System service.
	SA2	In highly hazardous situations, a shared-use fully Automated Driving System would protect passengers’ lives and safety.
	SA3	A shared-use fully Automated Driving System would make proper decisions and take actions faster than drivers.
	SA4	I would not feel safe using a shared-use fully Automated Driving System in a dangerous neighborhood.

Constructs	Items	
Traffic Environment (TE)	TE1	I expect that a shared-use fully Automated Driving System would be able to handle aggressive drivers when encountered in real-world traffic.
	TE2	I expect that a shared-use fully Automated Driving System would be able to handle driving in unusual situations such as construction or accident zones.
	TE3	I expect that a shared-use fully Automated Driving System would be able to handle driving in all weather conditions.
	TE4	I expect that a shared-use fully Automated Driving System would be able to handle driving on improperly maintained roads, for example where lane markings are not clear.
Willingness to Pay (WoP)	WoP1	In general, I would be willing to pay for a shared-use fully automated driving system.
	WoP2	I would be willing to pay more for a shared-use fully Automated Driving System, compared with currently shared rides (e.g., Uber and Lyft).
	WoP3	I would be willing to pay to use a shared-use fully Automated Driving System because it is such a cutting-edge technology.
Social Influence (SI)	SI1	My friends/family who have experience with a shared-use fully Automated Driving System would encourage me to use it.
	SI2	I would be proud of being a user of a shared-use fully Automated Driving System.
	SI3	I would gain prestige if I used a shared-use fully Automated Driving System.

Results

Phase One: In-depth Interview with End-Users

Participants' Demographic Information

All of the Tesla end-users have a college degree, and most of them (90%) think of themselves as early technology adapters. They all live in the San Francisco Bay area, California. Driving is the regular commute mode of all the end-users. They all have extensive driving experience. Their experience with the use of Autopilot has a mean of 19.54 months but varies significantly with a standard deviation of 16.94 months. Table 5 and Table 6 provide more demographic information for those interviewed.

Table 5 Demographic Information of the Participated End-Users: Part 1

Item	**Number**	**Percentage**
Gender		
Male	13	65%
Female	7	35%
Education Level		
Bachelors	7	35%
Masters	11	55%
Ph.D.	2	10%
Income Range		
<150K	3	15%
150K-250K	6	30%
250K-350K	1	5%
>350K	3	15%
Not revealed	7	35%
Autopilot Usage Hardware		
Hardware Generation 1	10	50%
Hardware Generation 2	10	50%
Number of Cars in the household		
1-2	11	55%
3-4	6	30%
5-8	3	15%
Technology Adoption		
Early	18	90%
Late	2	10%
Laggard	0	0
Commute mode		
Driving	20	100%
Walking	0	0

Item	Number	Percentage
Public Transportation	0	0

Table 6 Demographic Information of the Participated End-Users: Part 2

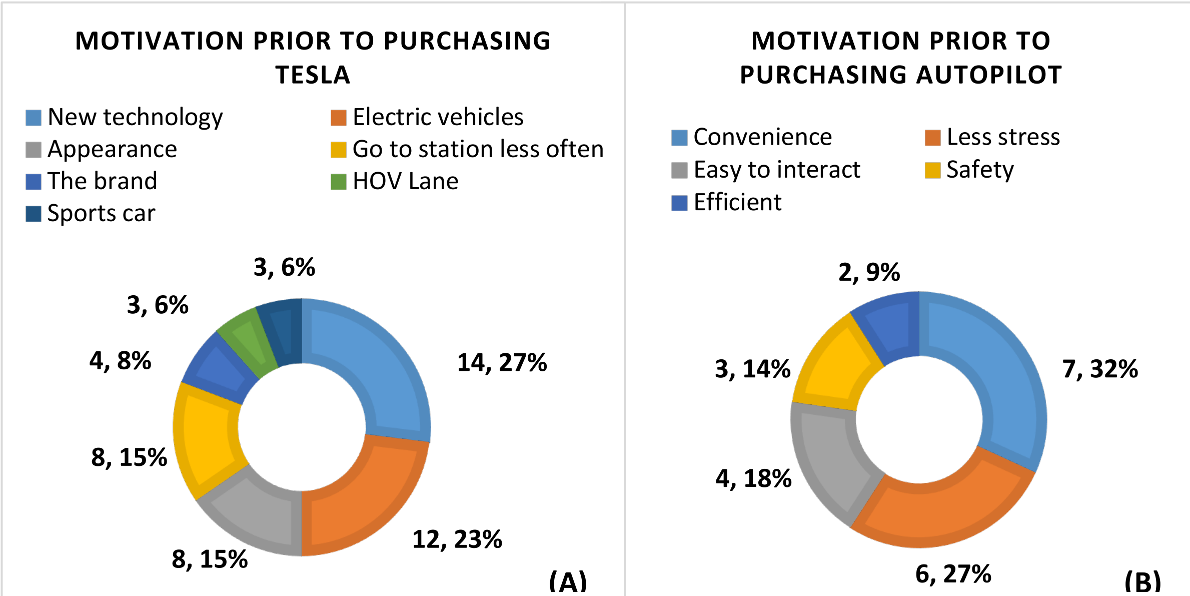
Item	Mean	Standard deviation
Age (years)	42.26	10.47
Driving Experience (years)	24.00	10.55
Autopilot Experience (months)	19.54	16.94
Daily Driving Time in Traffic (hours)	1.16	0.84

Questionnaires Section I: Partially Automated Driving Systems (ADSs)

Section I.1 prior to purchase

The objective of this section is to understand motivations for purchasing Tesla and using Autopilot. Through the interview, the end-users were asked to share their reasons for purchase. According to the interview results, the significant factors of end-users for purchasing a Tesla vehicle were: (1) using the new technology (e.g., Autopilot), (27%), (2) owning an electric car that is considered a green vehicle (23%), (3) enjoying the appearance of a Tesla (15%), and (4) not going or going less often to gas or electric stations (15%). Additionally, the end-users mentioned that enjoying the brand (8%), having the ability to use a high occupancy vehicle lane (6%), and driving a sporty car (6%) as other factors (see Figure 1-A). The numbers in the Figure 1-A include the numbers of users followed by the percentage representation. It should be noted that the number counts and percentages are according to the number of times that the factors were mentioned by participants in their response to the questionnaire. Each participant may mention more than one factors.

Figure 1 Summary of Motivations Prior to Tesla and Autopilot Purchase



As for the Autopilot function, the primary motivations prior to the purchasing Autopilot were reported to be (1) its convenience (32%), (2) experiencing less stress while driving (27%), (3) being able to easily interact (18%), and (4) feeling safe (14%). One other mentioned factor prior to purchasing Autopilot was efficiency (9%). The end-users also mentioned that, since they usually experienced a long commute, traffic jams and a 'stop and go' pattern, Autopilot could be helpful for them and reduce their stress. Figure 1-B illustrates the detailed information regarding motivations for purchasing a Tesla to use Autopilot. Table 7 provides some verbatim responses from the interviews for these reasons. It should be noted that the reported percentages are according to the number of times that the motivations were mentioned by participants. Each participant may mention more than one factor.

Table 7 Evidence for Main Motivations Prior to Tesla and Autopilot Purchase

	Main motivations	Number of end-users (out of 20)	Percentage	Verbatim
Tesla	New Technology	14	27%	"I like to live in the future."
	Electric Vehicles	12	23%	"My company has several electric stations and a lot of my colleagues drive electric cars, and I want to see what's going on! I want to go green!"
	Appearance	8	15%	"It's an electric car, and it does not look creepy. It looks like a normal sedan."
	Go to station less often	8	15%	"It has a big battery. You do not need to charge it frequently! Also, you can charge it at home, too."
Autopilot	Convenience	7	32%	"I have a long commute, and I expected that highway driving becomes perfect."
	Less stress	6	27%	"Stop and Go traffic is very stressful. Computers do a better job in stressful time. They won't be tired and distracted as humans."
	Easy to interact	4	18%	"It's very easy to use! It's just two taps, and then your hands will be set free!"

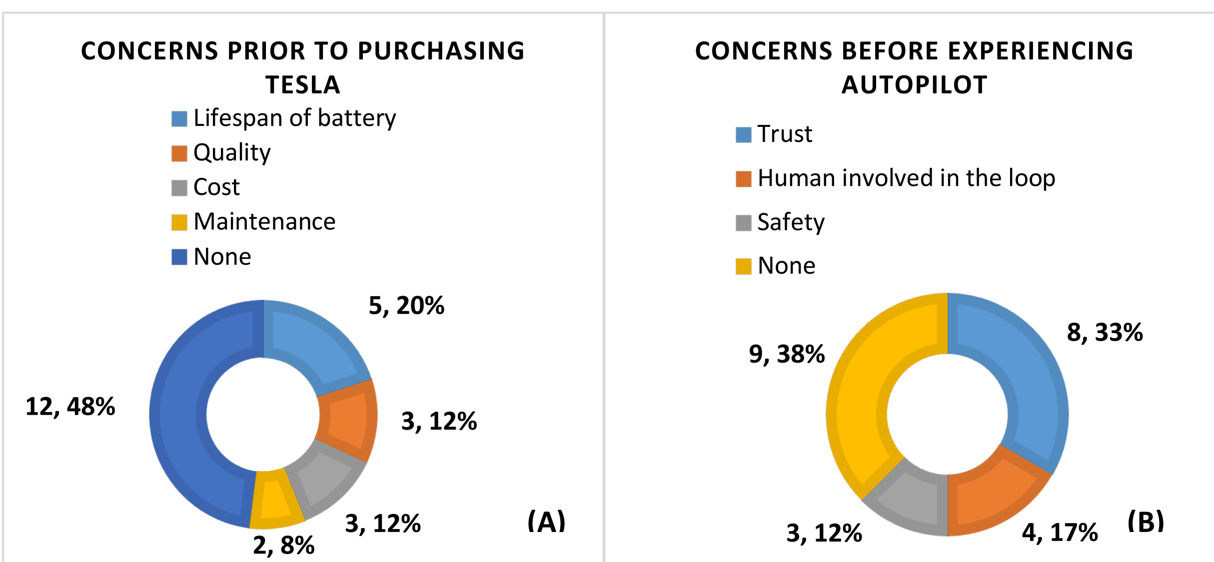
In the interviews, about half of the end-users (48% for owning and driving a Tesla car) mentioned that they had no concern about Tesla prior to purchase. However, the lifespan of Tesla's battery (20%), product's quality (12%), cost of Tesla (12%) and its maintenance (8%) were reported as concerns prior to purchase of a Tesla. One end-user complained that: "*I want to go green, but it is hard to manage the battery range and estimate mileage use.*"

As for the use of Autopilot function, 38% of end-users indicated no concern prior to using it. Some of them did mention trust (33%), keeping the human involved in the driving tasks (17%), and safety (12%) as their concerns prior to the purchasing the car and experiencing Autopilot (verbatim provided in Table 8). The detailed information of the concerns prior to purchasing process of Tesla (Figure 2-A) and Autopilot (Figure 2-B) are shown in Figure 2. It should be noted that the reported percentages are according to the number of times that the concerns were mentioned by participants. Each participant may mention more than one factor.

Table 8 Evidence for Main Concerns Prior to Tesla and Autopilot Purchase

	Main concerns	Number of end-users (out of 20)	Percentage	Verbatim
Tesla	Lifespan of battery	5	20%	"I was really terrified if I ran out of the battery."
	Quality	3	12%	"Tesla is not traditional car maker; I concerned about their quality."
	Cost	3	12%	"Cost vs Quality! At time that I was thinking buying Autopilot, no one knows what Autopilot does! So why should pay for that? It was pricey!"
	Maintenance	2	8%	"It's a new technology. What if it breaks down, what will be happened after 5 years."
Autopilot	Trust	8	33%	"It's a big change. You have to let the control of the car to go. Can this car really drive, for example in stop and go traffic?"
	Human involved in the loop	4	17%	"My awareness would be decreased by using this technology! It's better to do all job by itself."

Figure 2 Concerns Prior to Purchasing Tesla and Autopilot



Section I.2 during the learning process

The end-users were interviewed about Autopilot and their learning process. Almost half of the end-users (42%) indicated that they learned how to use Autopilot by trial-and-error. Beside the trial-and-error method, dealership guidance (29%) through a test drive was a primary resource for the end-users to learn how to use Autopilot. Thirteen percent (13%) of end-users had sought help from other people who had experience with Autopilot and ten percent (10%) of them searched online to learn how to use Autopilot. More importantly, only 6% of the end-users had read the manual (see Figure 3). It should be noted that the reported percentages are according to the number of times that the participants mentioned the sources of learning. Each participant may mention more than one answer to the question.

As expected from this multiple-source learning process, 75% of the end-users had failed to fully learn all of the features of Autopilot. Among Autopilot's features, all of the end-users had learned how to use the following features: (1) Adaptive Cruise Control (ACC) which matches speed to traffic conditions, (2) Lane Keeping, which keeps Tesla within a lane, and (3) Automatic Lane Change, which automatically changes lanes without requiring driver to steer.

All of the end-users mentioned they had used Autopilot to match speed to traffic conditions (ACC) and to keep within a lane (Lane Keeping). However, 15% of the end-users indicated that they did not use Autopilot to change the lane automatically (Automatic Lane Change), because the system is not compatible with their style of changing lane and the system does not disengage automatically.

Eighty-five percent (85%) of the end-users reported that they had learned how to use Auto Park. However, majority of the participants (70%) had failed to learn how to use the Summon feature. Regarding the Auto Park feature, although 85% of the end-users learned how to use it, they did not actually use it. The Summon feature was not popular among the end-users. There was only one end-user who stated that she frequently used it. Table 9 includes some verbatim descriptions of the reasons for not using different features. For this part of questionnaire in this interview, the end-users selected the easiest and hardest features of Autopilot to learn. ACC was chosen as the easiest feature to learn (65%) while Auto Park was chosen as the hardest one (55%).

Figure 3 Learning Resources for the End-users

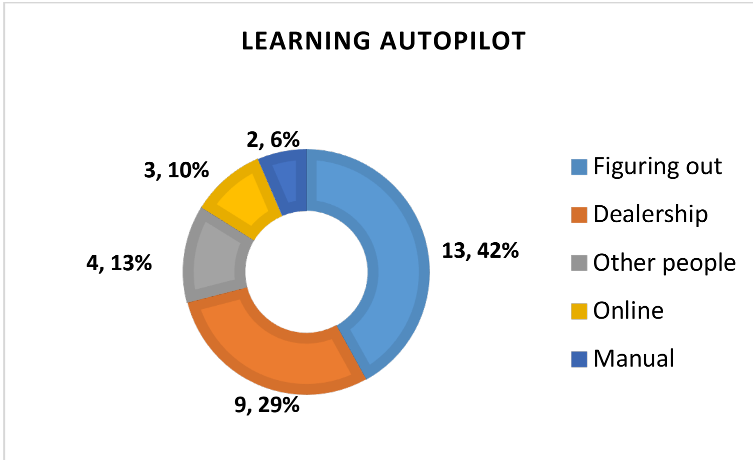


Table 9 Reasons for Not Using Autopilot Features

Features	Reasons
Automatic Lane Changing	1. It is not compatible with drivers' styles (too slow or too aggressive). 2. It does not disengage automatically and give drivers the feeling that it will continue changing lane.
Self-park	1. It is too slow and unreliable for detecting a parking spot. 2. It works in very specific cases. 3. It parks too close to the other cars.
Summon	1. The end-users do not know the use cases. 2. The end-users do not want to allow the car to be unoccupied.

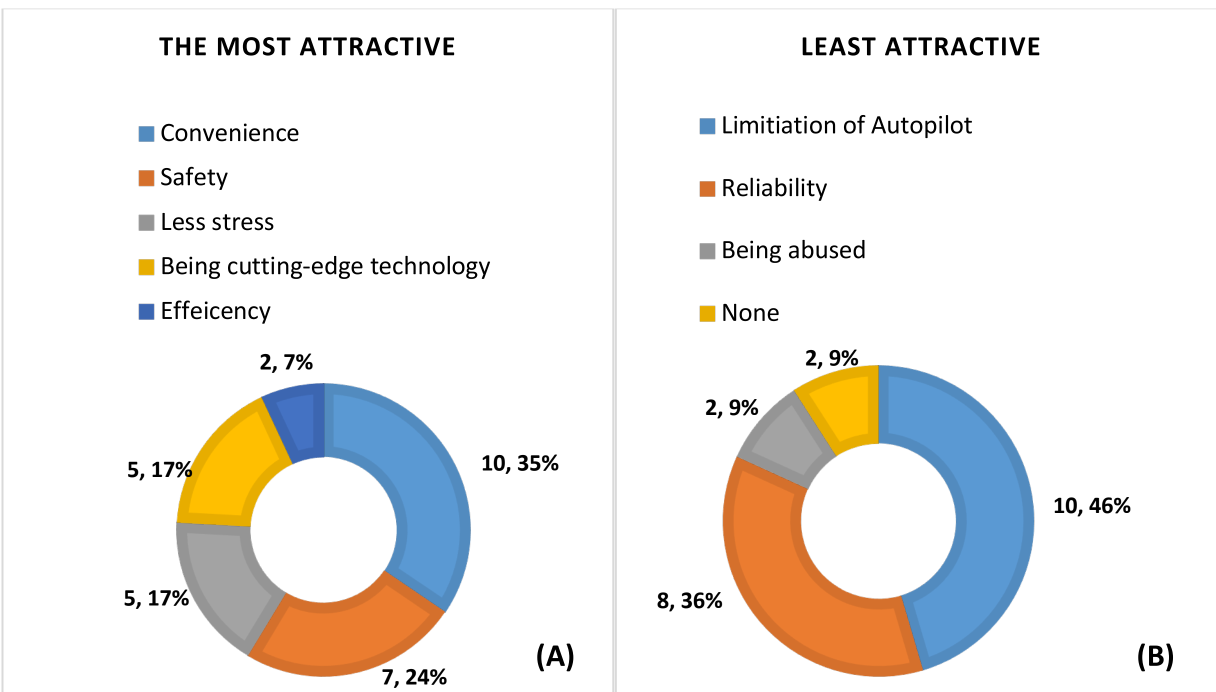
Section I.3 Driving experience (post learning experience)

In general, the end-users had a positive attitude toward Autopilot. The majority of them (80%) mentioned that they had used Autopilot more than 70% of the time that they were driving on highways. Two end-users reported that they had even used Autopilot on other roads (local roads). There were only two end-users who mentioned that they did not use Autopilot frequently. One of them mentioned driving enjoyment as the reason for not using Autopilot frequently. The other one reported her obsession with exerting control over the vehicle as the reason.

The end-users who had relatively extensive experience with Autopilot explained what were the most and the least attractive aspects of using Autopilot. Convenience (35%), safety (24%), experiencing less stress (17%), using cutting-edge technology (17%) and efficiency (7%) were mentioned as the most attractive aspects of Autopilot. However, the limitations of Autopilot (the level-2 automation in general), such as being unable to detect road signs and headlights (46%), the lack of reliability and occasional malfunctions of the Autopilot system (36%) and being abused by some other road users (9%) were reported as the least attractive aspects of Autopilot. Two end-users did not indicate any least attractive aspect of Autopilot. Figure 4 illustrates the detailed information regarding the most and the least attractive aspects of using Autopilot. It should be noted that the reported percentages are according to the number of times that the least and most attractive aspects were mentioned by participants. Each participant may mention more than one answer to the question.

The end-users also shared their bad experiences with Autopilot. According to the interview results, the reported bad experiences were: (1) speed adjustment during transition from one highway to another or at exits of a highway, (2) operating on inclined, declined and sloped roads, (3) detecting road marking when roads were poorly maintained, and when they merged or split, (4) detecting reflective pavement markers, (5) lane positioning, which is not always in the middle of the lane, and (6) accelerating aggressively in small gaps in traffic.

Figure 4 During Driving Experience: The Most and Least Attractive Aspects of Using Autopilot



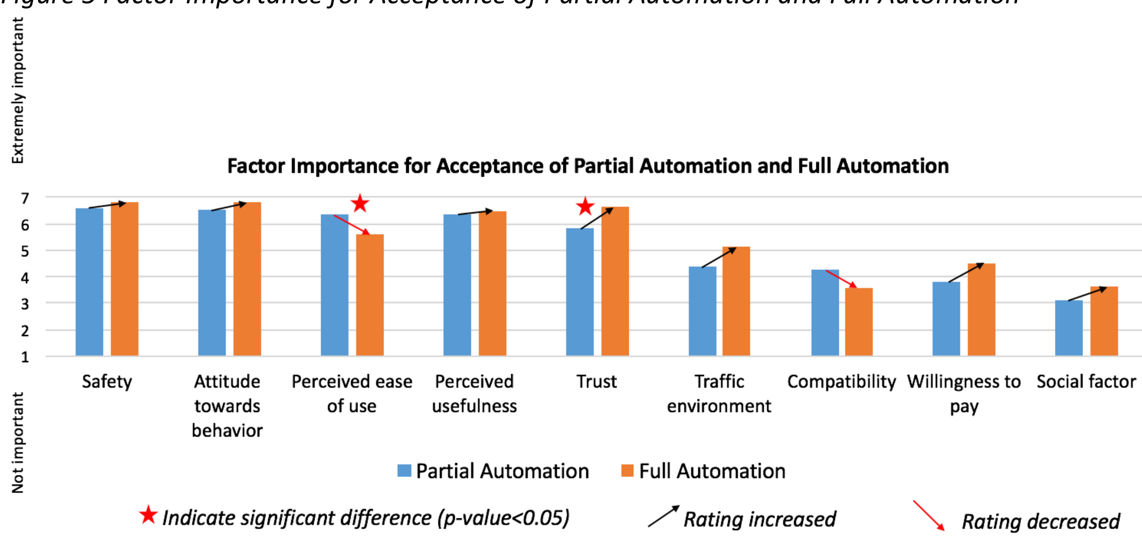
Questionnaire Section II: Factor Importance and Fully Automated Driving Systems (ADSs)

Section II.1 Factor importance for acceptance of partial automation and full automation

In this part of the interviews, the user acceptance model was investigated to gain a better understanding of the factors that impact user acceptance of both partially ADSs (i.e., Autopilot) and fully ADSs. A proposed model with multiple factors was suggested to the end-users to rate the following factors, including safety, attitude towards vehicle behavior, perceived ease of use, perceived usefulness, trust, compatibility, willingness to pay, and social factors. During the interview, the traffic environment factor, which was originally missing in the proposed model was identified and later considered in rating.

The findings revealed that most of the factors for the user acceptance model of fully ADSs were rated relatively higher than factors for partially ADSs (i.e. the users believed the factors were more important in their considerations of using and accepting fully automated systems). One factor, trust, was rated significantly higher in the user acceptance model of fully ADSs compared with partially ADSs. On the other hand, perceived ease of use and compatibility were rated lower in the user acceptance model of fully ADSs compared with partially ADSs. Out of the two factors rated lower, Perceived ease of use was rated significantly lower. Figure 5 depicts the rating for each factor in both models.

Figure 5 Factor Importance for Acceptance of Partial Automation and Full Automation



Section II.2 Fully automated driving systems (ADSs)

Regarding fully ADSs, the end-users shared their expected benefits and concerns. The most important expected benefits were enhanced convenience (25%), increased efficiency (25%), reduced stress (17%), and enhanced safety (15%). The most significant concerns were trust (36%), safety issues (28%) and doubting the capability of the technology to handle challenging traffic environments (19%), such as construction zones, poorly maintained roads and weather conditions. Figure 6 illustrates the detailed information regarding the expected benefits (Part A) and concerns (Part B) about fully ADSs. Table 10 and Table 11 provide some verbatim for these expected benefits and concerns of fully ADSs.

The end-users were asked how frequently they would like to take control over fully ADSs and drive by themselves. Most of the users (70%) answered that they were would never or rarely be interested in taking control over fully ADSs. One end-user wanted to keep his hands on the steering wheel all the time. Table 12 provides detailed information and verbatim regarding the end-user's response to this question. It should be noted that the reported percentages are according to the number of times that the benefits and concerns were mentioned by participants. Each participant may mention more than one answer to the question.

Figure 6 Expected Benefits of and Concerns about Fully ADS

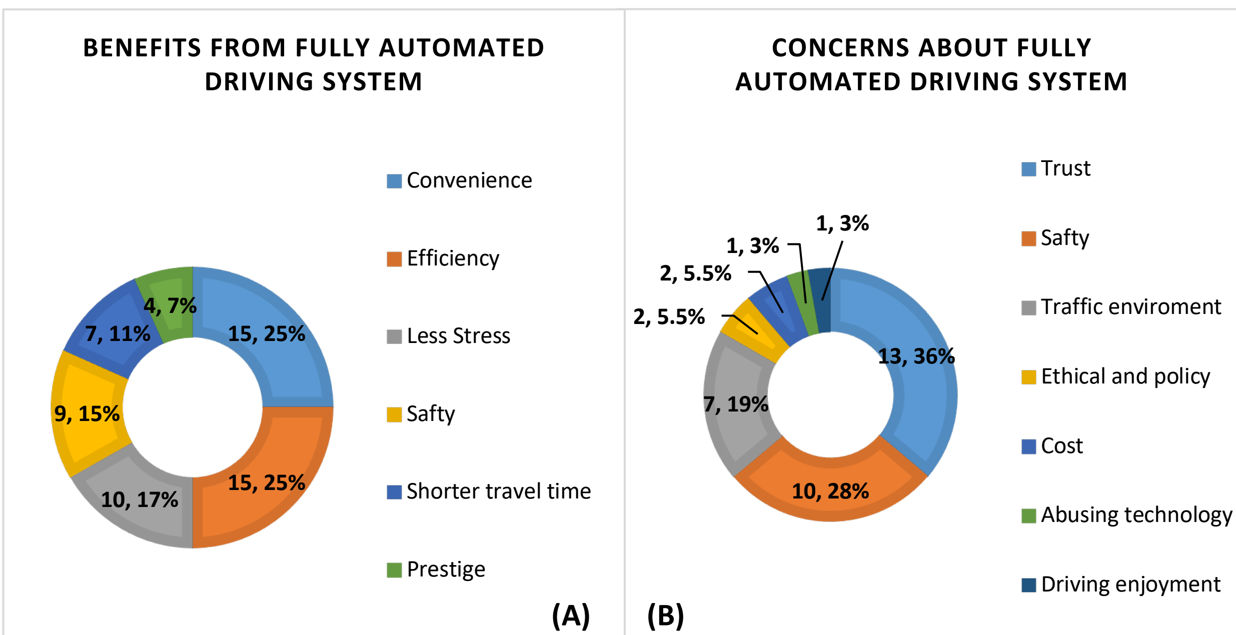


Table 10 Expected Benefits of Fully ADS

Expected benefits	Number of end-users (out of 20)	Percentage	Verbatim
Convenience	15	25%	"Commute driving is huge pain; if I can sleep when going to work, it would be very nice."

Expected benefits	Number of end-users (out of 20)	Percentage	Verbatim
Efficiency	15	25%	"I can save my time and work during my commute."
Less stress	10	17%	"I can sit back, relax, and enjoy my ride."
Safety	9	15%	"It will be a better and safer driver than me. I am so distracted while I am driving."
Shorter travel time	7	11%	"It can improve traffic. I will have a shorter commute time."
Prestige	4	7%	"It will be very luxury for me. I can show it to my friends."

Table 11 Expected Concerns About Fully ADS

Expected concerns	Number of end-users (out of 20)	Percentage	Verbatim
Trust	13	36%	"I am afraid if somebody hacks my fully ADS. I will need the steering wheel to fight back."
Safety	10	28%	"How fully ADS will work it out with pedestrians?"
Traffic environment	7	19%	"I am worried about how my fully ADS will handle bad drivers or weather conditions."
Ethical and policy	2	5.5%	"Regulations and policy fall behind and do not keep up with marketing and technology."
Cost	2	5.5%	"It will be very expensive and not everyone can buy it."
Abusing technology	1	3%	"What would happen if other people abuse the technology?"
Driving enjoyment	1	3%	"I will lose the fun of driving."

Table 12 Interest Level of End-users Regarding Taking Control of Fully ADS

Interest level for taking control	Number of end-users (out of 20)	Percentage	Verbatim
Never	6	30%	"As long as it can handle the driving task, I won't bother to drive."
Rarely	8	40%	"I am interested only when I don't trust the fully ADS."
Occasionally	3	15%	"I love the option to drive, to control, to feel alive."
Sometimes	2	10%	"I like driving; it's fun to drive especially a car like Tesla."
Frequently	0	0%	None
Usually	0	0%	None
Every time	1	5%	"I will still keep my hands on the wheel all the time."

Section II.3 End-users' opinions about shared-use fully ADS

During the interview, the end-users were asked about their interest regarding the sharing concept. Specifically, the question was about whether they would be open to use shared fully ADS with others. There were only four end-users who indicated that they were open to do so. The reasons for being reluctant to share included: (1) availability (39%), (2) the privilege of keeping personal items in the car (26%), (3) cleanliness (17.5%), and (4) not feeling safe when sharing rides with others (17.5%). Table 13 provides some verbatim for these reasons. It should be noted that the reported percentages are according to the number of times that were mentioned by the participants as the reasons for being reluctant to share. Each participant may mention more than one answer to the question.

Table 13 Reasons for not Sharing Fully ADS

Reasons for not sharing	Number of end-users (out of 20)	Percentage	Verbatim
Availability	9	39%	"I won't want to wait more than 5 minutes."
Personal items in the car	6	26%	"I won't share my car with others. I want to customize it for kids."

Reasons for not sharing	Number of end-users (out of 20)	Percentage	Verbatim
Cleanliness	4	17.5%	"I am so sensitive to smell and cleanliness!"
Safety	4	17.5%	"I do not want to be locked up with strangers in a small place like fully ADS. You do not know what will happen."

The end-users were asked if they would prefer shared-use fully ADSs or conventional shared services with a driver (i.e., ride-hailing services). Approximately half of the end-users (39%) preferred shared-use fully ADSs, since they would not need to deal with drivers. Some of them were also concerned about the driving capability of drivers (17.5%). One of the end-users stated that "*after 8 hours driving, a driver, as a human, will be exhausted. However, a computer will accurately work*." Safety concerns (17.5%) was another reason for preferring shared-use fully ADS; as one of the end-users mentioned that "*using the shared-use fully ADS will be more trustworthy especially at midnight.*" Having privacy (17.5%) and using a new technology (8.5%) were two other reported reasons. The detailed information and verbatim responses regarding these reasons are listed in Table 14. It should be noted that the reported percentage is according to the number of times were mentioned by participants. Each participant may mention more than one answer to the question.

Table 14 Reasons for Preferring the Shared-Use Fully ADS over Conventional Shared Services

Reasons for preferring shared-use fully ADS	Number of end-users (out of 20)	Percentage	Verbatim
No interaction with driver	9	39%	"You don't know what kind of driver you get. I would rather be there by myself"
Driving capability	4	17.5%	"I trust computer more than a taxi driver."
Safety	4	17.5%	"I prefer shared-use fully ADS. It will be safe for a female."
Privacy	4	17.5%	"I do not want to be with a stranger."
Using a new technology	2	8.5%	"I am open to new technologies. I want to see new things."

Phase Two: Expert Interview

Domain 1: Education and Training

One of the most critical policy gaps investigated is user education and training. Through the expert interviews, three education and training policy aspects are investigated: (1) education and training of drivers regarding safety of ADS; (2) educational communication between state DOTs and original equipment manufacturers (OEMs); and (3) use of terminology among the key stakeholders (i.e., industry, public sector and academia).

Driver education can change expectations of how and when the technology works, as well as a driver's ability to understand the system's directions and warnings. The expectation and knowledge about the technology affect the effectiveness of the technology and, more importantly, users' safety. Traditionally, in the absence of ADSs, driving tasks were mostly mechanical, with the use of the steering wheel and pedals to control a vehicle. ADSs are changing traditional mechanical driving tasks and require the drivers to interact with the new technologies, particularly with additional driver-vehicle interface. There is an increasing need for drivers to learn how and when the new technologies work.

According to the feedback of interviewees, driving education and training system should be updated to educate drivers about ADSs' capabilities and limitations.

- One expert interviewee stated: "*Right now there is a lot of misperception about what the ADSs can do. There is an educational gap in what level of safety can be provided by using the technologies*." He talked about Autopilot as an example. "*According to Tesla, drivers still need to pay attention, monitor the traffic conditions and be ready to take over the control. However, the critical safety concern is about the action of taking over when driver has been out of the loop*." Having less than few seconds to take over and control the vehicle is not safe, especially for an inattentive driver who usually relies on ADSs and might be distracted. At present, there is no clear policy at the national level about how ADSs should safely transfer the control to the driver and how the driver needs to be trained.

- Another expert mentioned an initiative called "My car does what?" started by the National Highway Traffic Safety Administration (NHTSA). In this program, drivers are being educated about the complicated features of their vehicles. He suggested: "*The same approach should be done for ADSs, which are now available in the market such as "Autopilot" and other future ADSs. To prevent misusing systems, people should be educated to not accidentally engage a system without knowing its capability and limitations.*" The interviewee cited some of the recent accidents as examples of what would happen when people are misusing ADSs.

Another aspect of the education-related policy gap that was identified was the lack of clear educational communication between state departments of transportation (DOTs) and OEMs. This lack of engagement and communication has created two concerns regarding: (1) a guideline for testing polices and (2) having plans in place for addressing ADS infrastructure needs.

Several states, including California, have regulations that allow ADSs testing. However, the conditions and regulations regarding these tests are not transparent to the general public or the OEMs. Two of the interviewees pointed out the lack of proper communication between OEMs and DOTs as a reason for the aspect of the education and training policy gap.

- One of the experts stated that lawmakers need to be well educated by manufactures before signing documents that allow public road tests. Manufacturers should provide the lawmakers with a precise explanation of the reasons and desired outcomes of the tests as well as the vehicles' capabilities.

- One of the interviewees stated: "*At both the national level and state level, there is a lack of guidance about experimentation and testing. The government agencies, as well as the industry and the research community, need to work together to develop and identify proper guidance that support the future of ADSs while turning to a policy[making a policy for ADSs]*."

Moreover, this lack of engagement and communication through the development process of ADSs may cause serious concerns regarding road environment challenges.

- "*DOTs may need to engage constantly about what the design criteria and the capability of ADS is*." A connected vehicle, a vehicle that needs to interact with the infrastructure to provide messaging to enable communication with a driver, was mentioned as an example. "*Both partners should understand that roads and ADSs are parts of a system which need to interact with each other*." To implement ADSs and overcome the environmental challenges, OEMs who design and manufacture ADSs and DOTs who build and maintain the roads need to interact with one another.

- Additionally, the expert from the governmental sector mentions that they typically repair and maintain some of roads every 20 years and they need to know in advance what the ADS infrastructure needs. He also mentioned that Tesla once shared one of their road environment challenges with California Department of Transportation (Caltrans): "*Tesla was doing testing in Southern California. The machine vision system had an issue detecting the lane markings. So, the division of traffic operations changed their lane marking policy to accommodate Tesla's system need*." Fifty-four companies now have permits to test ADSs in California. These companies need to have constant communication with Caltrans about the road environment challenges that their systems may have. Currently, there is no policy on how these two parties should interact regarding ADSs implementation and its environmental challenges.

Another aspect that creates an education policy gap is terminology. Terminology used to describe

ADSs and their functionality can greatly affect the drivers' perception of the vehicles' capabilities.

- One of the interviewees mentioned that "*after the Tesla and Uber crashes in March 2018, a lot of different terminologies were used throughout the internet. Besides the general public, industry and researcher communities should know that each terminology carries a different implication about what the vehicle and technology can do*."

- Two of the interviewees mentioned "Autopilot" as an example. They believed that calling the level-2 ADS, "Autopilot" could cause the misperception that the vehicle is completely automatic and does not need any intervention by the drivers under any circumstances. In fact, they advocated that not only should a common understanding of terminology be established by manufacturers, researchers and the general public, but also appropriate language and wording should be used to minimize the risk of misperceptions.

Domain 2: Consumer Incentives

Although some of the benefits of ADS adoption are directly related to the owner or driver, many of the benefits will be shared with others. For example, if ADSs result in the reduction of congestion, this will help everyone on the road, whether or not they have adopted ADSs. This suggests that some incentive policies may be sensible or justified. In the expert interviews, the following incentive policies for consumers were suggested: (1) provide access to High Occupancy Vehicle (HOV) lanes, (2) offer insurance policies which protect consumers' benefits and decrease their cost, (3) provide financial incentives, and (4) scale up the infrastructure (e. g., charging station for electric ADSs).

According to one interviewee, HOV lane accessibility is a powerful incentive. Citing the congestion of the Bay Area, he stated: "*The big motivation for adopting ADSs is to address the congestion problem*." He continued: "*Since simulation studies have proved that equipped vehicles can push more vehicles through an existing lane compared with manually driven cars; it is reasonable to give HOV lane accessibility to an equipped vehicle.*" Moreover, another interviewee mentioned that "*from the safety perspective, since public does not know the reliability of ADSs yet, it would be appropriate to make separated lanes available for ADSs*."

Another aspect of the incentive policy gaps investigated was insurance policies which could protect consumers' benefits and decrease their cost. All of the interviewees believed that by purchasing ADSs, consumers would improve their driving safety. As one of the interviewees stated: "*There should not be an opportunity for insurance companies to take advantage of the consumer who is investing in buying an equipped vehicle.*" Therefore, there should be facilitative policies for insurance of vehicles with ADSs to motivate and help consumers to adopt ADSs.

If ADSs were combined with electric vehicles, then financial incentives and infrastructure readiness should be considered jointly in the incentive policies. Electric vehicles (EVs) enhance the ability to manage transportation to produce fewer emissions. Since the State of California has a goal of producing less emission by managing traffic, adoption of ADSs combined with EVs should be eligible for financial incentives. Besides financial incentives, policies should be adopted to map out the infrastructure needs of this type of vehicle, since there is potential growth in adoption of EVs.

Domain 3: Shared-Use Fully ADSs

By implementing shared-use fully ADSs, consumers would save some fixed costs associated with vehicle ownership, such as capital depreciation, finance charges, vehicle registration fees and insurance. Besides these personal benefits, reduced emission and congestion would be counted as social benefits of shared-use fully ADSs. However, there is no widespread policy agreement about encouraging Level 5 ADSs to be deployed as part of shared-use fleets. Moreover, even for ADSs each state is following a range of different trajectories. Therefore, there is a need for policy adjustments and accommodation when it comes to localities where shared-use fully ADSs will be used.

The aspects of the shared-use fully ADSs' policy gaps identified by interviewees were curb space and rights-of-way, dedicated pick-up and drop-off locations, dedicated lanes, and public safety, as well as cyber security and cyber terrorism and discriminatory practices. Moreover, two candidate policies to promote shared automated EVs were identified: (1) applying additional credits to operators who place an electric vehicle in a shared context, and (2) limiting access of single and zero occupant vehicles in specific locations.

- One expert talked about low-speed shuttles as a case study and stated: "*There are many policy gaps to be addressed here: Who will get the priority access to the rights-of-way at the curb, ADSs or manually driven cars? Will higher occupancy vehicles (shared vehicles) have dedicated pick-up and drop-off locations to assure timeliness? Do they give high occupancy vehicles dedicated lanes to ensure better travel times?*"

The other aspects regarding policy gaps of shared-use fully ADSs' that were identified included concerned public safety, discriminatory practices, and cyber security.

- Safety of passengers in the absence of human drivers on board has to be ensured. One expert illustrated the point by an example of women's safety and continued: *"What if a woman shared a ride with other passengers at midnight in a shared-use fully ADS?"* Besides public safety, the interviewee noted the possibility of discriminatory practices that could arise from artificial intelligence (AI) or machine learning.

- An interviewee stated: *"There is a possibility that machine learning could develop* *discriminatory practices about whom to pick up and where not to pick up passengers. For example, female and male passengers or individuals who have African sounding names may be treated differently. How can public policy ensure equitable access to vehicles?*" The policies against discriminatory practices should not only assure equitable access of different race and gender but also should assure equitable access of disabled people, which was addressed in the next section.

- Another aspect of shared-use fully ADSs' policy gap mentioned by experts was cyber security and cyber terrorism. One expert mentioned: "*How could policy help with the safety of people in these vehicles? Because shared-use fully ADSs could become a target as a form of public transport*."

Two policy gaps in promoting placement of EVs in shared context were discussed. One expert believed that traveling in the EV placed in shared-use fully ADS fleets could expose people to the concept of electrification and increase their familiarity and comfort with EVs. The experts commented that "*by giving people the opportunity to experience electric vehicles in the context of shared-use fully ADSs, they could be motivated to buy an electric vehicle. That experience may address some barriers to electrification such as better understanding EVs and range considerations.*" This suggested that policies should consider promoting the placement of an EV in the shared ADS context.

One possible policy gap of high priority is in the application of additional credits to the placement of electric vehicle in shared context. "*Policymakers (e.g., California Air Resources Board) could consider providing additional credits for automakers and fleet operators, if they place/sell electric vehicles in a shared mobility context and/or deploy the shared-use automated electric vehicles as a first-mile-last-mile service. This approach was applied through the [Zero-Emission Vehicle] ZEV mandate through "transportation system credits"; however, these credits sunset in 2018,*" one expert said. Another suggested approach to promoting shared-use automated EVs is to limit access of single and zero occupant vehicles in specific locations. According to one expert's opinion, passengers will be motivated to ride in shared vehicles to access restricted locations and operators to provide services there. This can lead to more shared mobility services and reduced emissions in sensitive areas (e.g., urban core). Such incentives can encourage operators to deploy electric vehicles in shared vehicle fleets. Examples of increased costs faced by shared mobility operators in deploying EVs (without incentives) include infrastructure costs for installing EV chargers and costs from users running out of battery power and requiring service and/or a tow.

Domain 4: Mobility Needs and Services for Elderly Users

ADSs have the potential to transform personal mobility and open doors for aging and disabled communities who currently have very limited or impractical mobility options. As one of the expert mentioned *"elderly persons should also be considered with respect to policy".* Two different opinions were expressed in the expert interviews regarding the timeliness of addressing their needs. One expert from the governmental sector believed that accessibility for the aged population should be considered from the beginning. He further referred to the California DMV public hearings: "*The aged communities view ADSs as the ticket to the independence and freedom. They have made it clear that accessibility for the aged population should be thought on the front end, not as an afterthought*." However, he was concerned about the manufacturers' motivations to build a vehicle that would be accessible to the general public, even though there would only be a small percentage of people that need to use those accessibility features.

Another expert also agreed that increasing mobility of disadvantaged groups such as elderly or disabled people could be one of the critical benefits of ADSs. However, he opined that many hurdles needed to be overcome. He highlighted that: "*We are designing vehicles for different types of users who may just learn how to drive versus who has been driving for 30 years, also people who had a special need*." He stated that the starting point for designing such a system should be based on the general public and their needs. If the design would work well for the general public, then the design could be translated to help those with a special need. The reported special needs were vehicle wheelchair accessibility and equivalent accessibility of disabled individuals to point-to-point mobility.

Domain 5: Data Privacy and Ownership

Consumers have deep concerns about how their data ownership and privacy would be managed. According to a Pew Research Center study (http://www.pewinternet.org), Americans are not confident about the privacy of their personal data and how their data is distributed without their knowledge. In the ADSs context, a policy should address the consumers' concerns and make companies legally obligated to protect consumers' privacy and the security of their ADS-related data. In interviews, one expert offered the perspective of the infrastructure owner operator. He explained that government needed processed and aggregated information to manage the transportation system. He added more details saying that: "*DOTs are not interested in data; they are interested in information. Information is not the speed of a vehicle at a point. Information is an average speed of a hundred vehicles of lasts 15 seconds at that point*." He specified that the data privacy and ownership needed to be directed by third parties. However, currently there is no clear policy regarding data ownership and privacy of ADSs' consumers.

Domain 6: Liability and Insurance

One of the most serious and complicated policy challenges is the ADS liability. Liability policy will have a significant effect on both consumer acceptances of ADSs and their rate of deployment. Two interviewees mentioned that the consumer should have less liability, especially for Level 4 and Level 5 ADSs. One of the interviewees believed that if insurance companies finds that ADSs will improve safety, consumer's liability insurance should be reduced. Another interviewee stated that: "*The automakers should hold the responsibility*." He continued: "*At Level 4 and Level 5 automation, manufacturers should be liable for whatever their system does*," and "*At Level 3 automation, it is difficult to separate the drivers' responsibility from that of the manufacturers.*" Thus, he suggested that policy should make it clear in what circumstances drivers or the manufacturer would be liable.

Phase Three: Focus Group and Online Questionnaire

Focus Group

Participants' demographic information

The mean age of the entire set of participants is 45.29 (SD=16.35). Participants' demographic information is shown in Table 15.

Table 15 Participants' Demographic Information

	Categories	Number	Percentage
Gender	Female	21	35.59%
	Male	38	64.41%
Age	Below 35	21	35.59%
	35 to 49	15	25.42%
	50 to 64	15	25.42%
	65 and above	8	13.56%
Education	Undergraduate	21	35.59%
	Master	21	35.59%
	Ph.D. and postdoctoral	12	20.34%
	Others	5	8.47%
ADS Experience	Yes	35	59.32%
	No	24	40.68%
Technology Adoption	Early	25	42.37%
	Late	25	42.37%
	Laggard	7	11.86%
	Not specified	2	3.39%

Data analysis

After each focus group, the research team held a debriefing session to reflect upon all the specifics of the discussion. The audio records were transcribed using an online transcription tool. Categories for coding of the participants' statements were aligned with the factors in the proposed technology user acceptance model.

For the purpose of easier presentation, we divide the six topics into two parts. In the first part, it includes three topics: (1) factors influencing technology acceptance, (2) education and training, and (3) consumer incentives. The second part includes the other three topics: (1) liability and insurance, (2) data privacy and ownership, and (3) shared-use fully ADS.

Table *16* shows the coding scheme and percentage of occurrence of feedbacks in each topic. The counts and percentages of various feedbacks in each topic are provided for descriptive purposes.

Table 16 Coding Scheme and Percentage of Feedbacks: Part 1

Technology acceptance		**Education and training**		**Incentives**	
Safety	19 (35.85%)	*Whether need training for using fully ADS?*		Need incentives	16 (50.00%)
Benefits	11 (20.75%)	• Need training	34 (68%)	Not need incentives	7 (21.88%)
Vehicle Control and Compatibility	7 (13.21%)	• Not need training	16 (32%)	Built-in incentives	5 (15.63%)
Trust	6 (11.32%)	*Whether training should be mandatory or optional?*		Depends…	4 (12.50%)
Ease of use	4 (7.55%)	• Mandatory	5 (35.71%)		
Cost	3 (5.66%)	• Optional	9 (64.29%)		
Convenience	2 (3.77%)				
Share with others	1 (1.89%)				

Part I.1: Technology acceptance

The following question was asked: "What are the factors that will have influence on your acceptance of the fully automated driving system?" This topic was discussed within 4 groups: the elder-driver group, the researcher group, the Silicon Valley group and one of the insurance professional groups. In total, there were 53 statements about factors that influence technology acceptance. Each factor and statements are summarized as follows:

- Safety: The most mentioned factor that influences participants' acceptance of the fully ADS was safety at 19 (35.85%). Participants elaborated on safety as (1) "*being safer than me as a driver", (2) "not hurting other road-users", (3) "not involving in fatal crashes", (4) "being able to deal with emergency situations", and (5) "being able to function on improperly maintained roads"*. Participants thought that the fully ADS should be well-tested and examined by a third-party rather than by the manufacturer. Some participants also commented on safety design of the prototype vehicles presented during the introduction section. For example, *"The shared-use fully ADS should also have safety seatbelt."*

- Benefits: There were 11 (20.75%) statements about benefits, which participants expected from the fully ADS. Those benefits could be further divided into three categories: (1) saving time and effort for something else instead of fighting in the traffic, (2) being comfortable, and (3) presenting a good social image of the owner.

- Option of vehicle control and compatibility: There were 7 (13.21%) statements about having the option of exercising vehicle control when needed or to be compatible with driver's driving style. About having the option of vehicle control, participants wanted to occasionally have control of the vehicle and enjoy driving themselves. Participants also deemed it necessary to take over vehicle control at certain conditions. As for shared-use fully ADS, participants expected the driving style to be compatible with a manually driven vehicle. It is expected to not take longer time to arrive a destination just because the driving style of the fully ADS is too conservative. Participants also expressed that with shared-use fully ADS, they won't be able to keep the personal belongings inside of the vehicle, which would be inconvenient for families with kids.

- Trust: There were 6 (11.32%) statements about trust of fully ADS. The most salient reason that participants don't trust fully ADS is cyber security and computer glitches. Participants had the concern that computer wouldn't be able to always function as it is supposed to. In case of the computer malfunction, the consequence would be much more severe for fully ADS. Some participants mentioned that they would build the trust of fully ADS step by step by starting with using ADAS (Advanced driver assistance system). Some participants also mentioned that they would like to build their trust over the system based on other people's experience with fully ADS.

- Other factors: ease of use, cost, convenience, and option of sharing with others. There were 4 (7.55%) statements about ease of use, 3 (5.66%) statements about cost, 2 (3.77%) statements about convenience and 1 (1.89%) statement about not sharing with others. Participants expected the fully ADS to be as easy as a regular vehicle, easy and intuitive to communicate with, responsive in emergency situations. Participants expressed the concern of how much the fully ADS would cost. Affordability is an important factor that will influence user acceptance. Regarding shared-use fully ADS, participants expressed the concern of convenience and reluctance of sharing with others. One example is *“(I am) not comfortable to share with other people at the same time. Don't want to be distracted while doing some work.”*

Part I.2: Education and training

For this topic, several questions were asked, including “Do you think training for using fully ADS is needed?” “What kind of training is preferred?” “What would you like to learn?” For elderly driver group, it was also asked “Do you think special training is needed for elderly drivers?” This topic was discussed in all seven groups.

- <u>Do you think training for using fully ADS is needed</u>? There were 50 feedback statements to this question. Thirty-four (68.00%) of the statements were positive about having training. For those participants, they need training of how to start and stop fully ADS, and how to tell fully ADS where to go. They also need training on how to deal with emergency situations, and how to take over the vehicle control if this option is available. Sixteen (32.00%) statements were negative about having training. For those participants, they believe that a well-designed system doesn’t need training, which should be intuitive and easy to use. They also assumed that there is no interaction between fully ADS and driver/passenger and there is no transition of vehicle control from vehicle to human. Hence no training is needed. In some groups, it was further asked “Whether training should be mandatory or optional?” There were 14 feedback statements to this question. Five of them (35.71%) were about making the training mandatory, as it was considered a responsibility to ensure safety of other road-users. The other 9 (64.29%) statements were about making training optional. The reason was that *“If making the training mandatory some people will not be able to make it. Then they will be excluded from the basic (transportation) need.”*

- <u>What kind of training is preferred</u>? There were 11 feedback statements to this question. The most mentioned feedback was to have multiple training approaches. The reasons were “*Different people need different approaches.*” “*Manufacturer should design proper training programs and make them available to customers.*” “*It's something that you can just read in the pamphlet. Then maybe you can just pull it off your phone. This extensive hands-on is better as you don't want a 200-page manual obviously.”* The other approaches such as (1) safety card similar as the one on the airplane, (2) driving simulator, and (3) on-road training were also mentioned.

- <u>What would you like to learn</u>? There were 9 feedback statements to this question. Three (33.33%) of the statements were suggesting training of what to do when emergency happens. The other 6 (66.67%) statements were suggesting having basic safety training, as well as having basic safety test.

- <u>Do you think special training is needed for elderly drivers</u>? This question was only asked in the elderly driver group. Only one participant gave feedback, which applied not only to elderly drivers but also to all driver groups. He thought that training was definitely needed, because *"…… this is not a computer simulation or this is not a PowerPoint. This has high consequences to it…." "It is really a trial-and-error thing. I think that they (the manufacturers) are not going to be able to anticipate everything which are going to go wrong and they're going to adjust it*."

Overall, training is considered needed but optional as commented by most of the participants. Multiple approaches of training material should be available, to accommodate people's preference and needs in different situations. Training of safety precautions and instructions of what to do during emergency situations were deemed as critical.

Part I.3: Incentives

For incentive, the question was asked "Do you think incentive is needed for people who buy a personally owned fully ADS and for people who use shared fully ADS?" This topic was discussed in all seven groups. There were in total 32 feedback statements to this question.

- Overall, 16 (50.00%) statements said that incentive should be provided. Among the 16 statements, 4 of them suggested giving incentive to shared-use fully ADS. Another 4 statements suggested giving the incentive of dedicated lane and providing more charging station for electrical vehicles with fully ADS. Four statements suggested incentives of lower price, less payment for parking and built-in insurance for personally owned fully ADS. Another four statements explained that giving incentive would increase the penetration of fully ADSs and would lead to less accidents and higher highway throughput.

- Seven (21.88%) statements advocated for no incentive. The reasons were "*It should be market driven.*" "*Incentive should be provided for shared one and green one, but not for (personally owned fully) ADS.*" "*If everyone is using it, why do I need incentive?*"

- Five (15.63%) statements said that incentive was already built in for personally owned fully ADS, such as saving time for entertainment and saving money for parking.

- Another four (12.50%) statements said whether having incentive for personally owned fully ADS should depend on (1) market penetration and (2) public vote.

In summary, most participants agreed on providing incentive to shared-use fully ADS as it would help to reduce the number of vehicles on the road and make traffic flow faster. Format of incentive for shared-use fully ADS could be dedicated lane or lower price. Whether giving incentive to personally owned fully ADS should (1) depend on the benefits that it contributes to the society and (2) be market driven.

The second part of the results are descripted in the following paragraphs. Three topics are covered in this part: (1) liability and insurance; (2) data privacy and ownership; and (3) shared-use fully ADS. Table 17 shows the coding scheme and percentage of feedbacks for each of the three topics.

Table 17 Coding Scheme and Percentage of Feedbacks: Part 2

Liability and insurance		**Data privacy and ownership**		**Shared-use fully ADS**	
Is insurance needed?		*Overall perception of data privacy issue*		*Expected experience*	
• Need insurance	24 (72.73%)	• Issue exists in various domains		• Clean and comfortable	
• Not need insurance	5 (15.15%)	• Data for product support		• Fast response from the dispatch center	
• Built-in insurance	4 (12.12%)	• Personal data		• Designated route or door-to-door services	
Who is responsible for an accident?		• Don't know value of the data		• Option of not sharing with others	
• OEM	8 (50.00%)	*Data ownership and other rights*		• Emergency response	
• Owner	6 (37.50%)	• To share	14 (50.00%)	• ADA Compliance	
• Both	1 (6.25%)	• To own	9 (32.14%)	*Likes and dislikes*	
• Programmer	1 (6.25%)	• No personal data	4 (14.29%)	• Likes	13 (46.43%)
How to define the responsibility in case of accidents?		• Only to know	1 (3.57%)	• Dislikes	15 (53.57%)
		Usage of data and privacy concerns		*Approaches to enhance safety*	
• Technology to detect pedestrian	4 (36.36%)	• No commercial use	10 (55.56%)	• Cameras	11 (40.74%)
• New law system	4 (36.36%)	• To improve technology	7 (38.89%)	• Identification	8 (29.63%)
• Use data	3 (27.27%)	• Don't care	1 (5.56%)	• Options	5 (18.52%)
				• Others	3 (11.11%)

Part II.1: Liability and insurance

For liability and insurance, participants were asked two questions: (1) "Do you think insurance is needed for fully ADS?" and (2) "Who should be responsible in case of accident?" For the 2nd question, participants further commented on how to define the responsibility of an accident. This topic was discussed in all seven groups. The comments were coded along three dimensions of (1) whether insurance is needed, (2) who should be responsible for an accident, and (3) how to define the responsibility.

- Whether insurance is needed? There were in total 33 statements for this question. Among the 33 statements, 24 (72.73%) argued for the necessity of insurance. The main reasons include "*nothing is perfect", "malfunction will be more serious for ADS", "because you (the owner) may misuse it", "because of maintenance" and "because tree may fall on your car*". Even for shared-use fully ADS, participants suggested having individual insurance, as "*The company (operator) will buy insurance for the car (shared-use fully ADS). But you have to buy individual insurance for yourself."* Only 5 (15.15%) statements said that no insurance would be needed. Exemplar reasons are "*Manufacturers produce the vehicle 100% confident. Don't need insurance (for the personally owned fully ADS)."* There were another 4 (12.12%) statements saying that insurance should be built-in on top of the vehicle price. One example is "*Who should pay for insurance? Do I need to pay for something I don't have control over? Make it built in.*"

- Who is responsible for an accident? In total, there were 16 statements for this question. Among the 16 statements, 8 (50.00%) of them pointed at the manufacturer. One example is "*Manufacturer is responsible and need to recall.*" Six (37.50%) statements pointed at the owner/driver of the fully ADS. Examples include "*Consumer choose to put it on street." and "……maintenance and update. It is your responsibility to change the tire.*" One (6.25%) statement said that both the owner and manufacturer should be responsible. Interestingly, there was also one (6.25%) statement saying that the software programmer should be responsible.

- How to define the responsibility? Participants further commented on approaches of defining responsibility of an accident. They assumed that in the era of fully ADS, behavior of other road-users would change. It could become more cautious or be more careless, for example, "*Pedestrian (may) show(s) up suddenly on purpose.*" There might be other malicious intentions directed at fully ADS. Technology itself should be able to detect the hazards in those situations, as indicated in 4 (36.36%) statements. Another solution would be to learn from the aviation industry, by retrieving data from the black-box in order to clearly define responsibility. This type of solution was mentioned 3 times (27.27%). Another 4 (36.36%) statements said that the state and court would need to adopt new laws in order to define responsibility for accidents involving fully ADS.

Generally speaking, most participants thought that insurance would still be needed for personally owned fully ADS in order to protect themselves as the vehicle owner. In case an accident happens to the fully ADS, most participants thought that the manufacturer should take more responsibility than the owner. However, the vehicle owners are responsible for maintaining the vehicle at the proper working condition. In order to avoid malicious intentions at fully ADS, there should be techniques such as a black-box or cameras to record the operational data in order to clearly define the responsibility of accidents.

Part II.2: Data privacy and ownership

For this topic, participants were asked "Who should own the data of fully ADS, the vehicle manufacturer or the owner?" This topic was discussed in all seven groups. Each comment on this topic was coded along three dimensions: (1) participants' overall perception of data privacy issue, (2) ownership, right to share, right to access and right to know, and (3) usage of data and privacy concerns.

- <u>Overall perception of data privacy issue</u>: Firstly, participants were aware that data privacy is an unclear issue not only in the automotive domain but also on other personal devices like cellphone. A lot of personal data had been collected in different domains. Secondly, participants understood that some data were collected for the purpose of product support, like notification of tire pressure, investigation of product defect. Thirdly, participants had concerns with personal data like GPS location being collected. One example was "*They track your movement, same as what they do with phone GPS.*" Lastly, individuals didn't have the knowledge to understand the value of their personal data and didn't know how to protect their data privacy.

- <u>Data ownership and other rights</u>. There were 28 statements about the ownership and other rights (e.g., to access, to alter, to know). Fourteen (50.00%) statements said that both the owner/driver and the manufacturer of the fully ADS should have access to vehicle data. Participants would like to share the data with the manufacturer on the condition that somehow, they would have the say-so for the data. Examples include "*Consumer should own and access all the data all the time. OEM could access the data to enhance the technology.*" "*Both parties have access. Cooperate to decide how to use it.*" Or "*Privacy data is very important and I would like manufacturer to get my consent before sharing it with anyone.*" Nine (32.14%) statements said that owners of the fully ADS should have the absolute ownership of the data, such as "……*It is non-negotiable.*" "*If they want, they could pay for my data.*" There were 4 (14.29%) statements saying that no personal data or GPS data should even be collected no matter what the purposes might be. Only one (3.57%) statement from one participant said that he would only need the right to know what data would be captured.

- Usage of data and privacy concerns in different usage: In total, 18 statements were coded as data usage. There were 10 (55.56%) statements saying that no commercial use, no advertisement, no use against the owner/driver, and no selling of data to others. One example was "*The problem is not they know the privacy. The problem is they may use it (the data) against you.*" There were 7 (38.89%) statements saying that participants would agree to share the data if it would be for the purpose of safety or improving the technology. For example, "*If you really want to prioritize safety, you would be okay with sharing data because it makes it safer when they have more view.*" Only one (5.56%) statement from one participant said that she didn't care about the data as long as the vehicle is safe.

To summarize, participants had privacy concern if persona data were collected in fully ADS. However, they didn't necessarily have the knowledge to protect their data privacy. Most participants wanted ownership of the data. At the same time, they were willing to share the data with the manufacturer for the purpose of improving safety of the technology. Most participants didn't like their data to be used for other commercial purposes.

Part II.3: Shared-use fully ADS

For shared-use fully ADS, three questions were asked (1) "*What experience do you expect while riding in shared-use fully ADS?*" (2) "*What aspects do you like and dislike about shared-use fully ADS?*" and (3) "*What approaches could make you feel safe to ride in shared-use fully ADS?*" This topic was discussed in six groups except for one of the two insurance professional groups. The comments were coded along the three dimensions. Each dimension corresponds to one of the three questions.

- Expected experience: There were 21 statements. Participants expected to have cleanness and comfort, fast response from the dispatch center, designated route and door-to-door services, the option of not sharing with others, emergency response in case of accidents, as well as ADA Compliance.

- Likes and dislikes: Participants had 28 statements about potential advantage and disadvantage of shared-use fully ADS. There were 13 (46.43%) statements about the advantages, including higher right of way, lower cost for riding and parking and no cost for maintenance. Examples include "*If I have the priority on the road, I have a higher right of way if I ride this kind of car.*" "*You don't have to do parking in the city.*" There were 15 (53.57%) statements about the disadvantages, including concerns of safety, concerns of sanitation, availability, potential increase of traveling time, as well as privacy concerns. Examples include "*A little bit downside is that the service is not that standardized. The sanitation situation inside the car, some is very clean (and) some is disgusting.*" "*The concern is still safety. Won't do sharing if it's too late.*"

- Approaches to make it safe. There were 27 statements about how to make shared-use fully ADS safe. Among the 27 statements, 11 (40.74%) statements suggested using cameras, remote monitoring system, security robot, etc. for maintaining personal security inside of the shared-use fully ADS. There were 8 (29.63%) statements about using background check or other qualifications in order to screen the passengers. Another 5 (18.52%) statements suggested having different options, such as not sharing with others, only sharing with co-workers or not sharing on certain neighborhoods. One example was "*Should have options to do pool or ride alone*." Another 3 (11.11%) statements suggested other approaches such as using different safety protocol in different time of the day and for different user groups (e.g., grown-ups vs. kids).

As a summary, participants expected the shared-use fully ADS service to be clean, comfortable and responsive. They understood the potential advantages of using shared fully ADS, but they also had various concerns regarding safety, sanitation, efficiency and privacy. Participants proposed different approaches in order to make it safe while riding in shared-use fully ADS with other passengers. However, each aforementioned approach needs to be further investigated in order to make them really work.

Online Questionnaires

In this section, we discuss the validation of the proposed models for both personally owned fully ADS and shared-use fully ADS, via responses from online surveys. We take the following four steps: (1) analyzing respondents' demographic and background information, (2) analyzing reliability of the models, (3) analyzing fitness of the measured models and convergent validity by performing Confirmatory Factor Analysis (CFA), and (4) analyzing structural relationships by performing Structural Equation Modeling (SEM).

Demographic and background information

For the personally owned fully ADS questionnaire, approximately 67% of the respondents have a college degree, 64.2% have ADS experience and 46.8% think of themselves as late technology adapters. The majority of them earn more than 50K per year (62.9%). Driving is the most common mode of their commute (87.7%). They have environmental concerns (67.7%). They all have extensive driving experience. Respondents were asked about their ADS experience. In the questionnaires the following systems were mentioned as examples of ADS: Blind Spot Warning System, Cruise Control, Adaptive Cruise Control, Forward Collusion Warning System, Lane Departure Warning System, Autopilot, Traffic Jam Assist, Super Cruise, and Driver Pilot. They were allowed to mention any other ADS experience. Their ADS experience has a mean of 5.23 years but varies significantly with a standard deviation of 8.65 years.

For the shared-use fully ADS questionnaire, 60.4% of the respondents of the shared-use fully ADS questionnaire report that they have a college degree and 75.6% have ADS experience. Almost half of them think of themselves as late technology adapters (48.0%). Driving is their regular commute mode (86.8%). More than half of them earn more than 50K per year (58%). They are all experienced drivers and have some ADS experience with a mean of 6.72 years and a standard deviation of 10.49 years. Sixty percent of the respondents have environmental concerns. The detailed information regarding the demographic and background of participants of both questionnaires are reported in Table 18 and Table 19.

Table 18 Demographic Information of Respondents: Part 1

Item	Personally-owned fully ADS		Shared-use fully ADS	
	Number (Out of 310)	Percentage	Number (Out of 250)	Percentage
Age				
18-29	67	21.6%	61	24.4%
30-44	84	27.1%	77	30.8%
45-60	89	28.7%	66	26.4%
>60	70	22.6%	46	18.4%
Gender				
Male	147	47.4%	101	40.4%
Female	163	52.6%	149	59.6%
Education Level				
High School	100	32.3%	76	30.4%
Bachelors	138	44.5%	90	36.0%
Masters	55	17.7%	45	18.0%
Ph.D.	5	1.6%	7	2.8%
Postdoctoral	10	3.2%	9	3.6%
Others	2	0.7%	23	9.2%
Income Range				
<24.9K	52	16.8%	38	15.2%
25.0K-49.9K	63	20.3%	67	26.8%
50.0K-74.9K	58	18.7%	61	24.4%
75.0K-99.9K	69	22.3%	39	15.6%
100K-124.9	30	9.6%	17	6.8%
>125K	38	12.3%	28	11.2%
Driving Enjoyment Level				
Not Enjoying	32	10.3%	24	9.6%
Neutral	144	45.8%	111	45.2%
Enjoying	136	43.9%	115	46%
Number of Cars in the Household				
0	22	7.1%	14	5.6%

Item	Personally-owned fully ADS		Shared-use fully ADS	
	Number (Out of 310)	Percentage	Number (Out of 250)	Percentage
1	115	37.1%	113	45.2%
2	122	39.4%	92	36.8%
>=3	51	16.4%	31	12.4%
Number of EV in the Household				
0	258	83.2%	193	77.2%
1	41	13.2%	44	17.6%
2	8	2.6%	9	3.6%
>=3	3	1%	4	1.6%
Having ADS Experience				
Yes	199	64.2%	189	75.6%
No	111	35.8%	61	24.4%
Technology Adoption				
Early	123	39.7%	113	45.2%
Late	145	46.8%	120	48.0%
Laggard	42	13.5%	17	6.8%
Driving Commute Mode				
Yes	272	87.7%	217	86.8%
No	38	12.3%	33	13.2%
Type of Road Experience				
Highway	189	37.8%	151	36.8%
Metropolitan	124	24.8%	91	22.2%
Suburban	142	28.4%	129	31.5%
Rural	45	9%	39	9.5%
Environmental Concern				
Do not Concern	22	7.1%	26	10.4%
Neutral	78	25.2%	72	28.8%
Concern	210	67.7%	152	60.8%

Table 19 Demographic Information of Respondents: Part 2

Item	Personally-owned Fully ADS		Shared-use fully ADS	
	Mean	Standard deviation	Mean	Standard deviation
Driving Experience (years)	26.94	17.25	23.62	17.02
ADS Experience (years)	5.23	8.65	6.72	10.49
Commute time (hours)	1.73	1.57	2.25	2.15
Daily Driving Time in Traffic (hours)	0.88	1.10	1.18	1.37

Reliability of constructs

Coefficient alpha was used to validate the internal consistency (0.7 or higher is recommended) (Harlow, 2014). Coefficient alpha was calculated for all constructs in both personally owned fully ADS model and shared-use fully ADS model. As shown in Table 20, coefficient alpha for constructs in the personally owned fully ADS model is between 0.83 and 0.95. For Safety items (Cronbach's alpha= 0.83), a more detailed analysis shows that dropping Item SA3 increases the reliability (Cronbach's alpha= 0.90). Item S3 states that "I would feel safer if I could take over control of the fully Automated Driving System when it is necessary".

Table 20 Internal Reliabilities: Instruments of the Personally Owned Fully ADS Model

Constructs	**Coefficient alpha**
Behavioral Intention to Use (BIU)	0.95
Perceived Ease of Use (PUoE)	0.92
Perceived Usefulness (PU)	0.90
Trust (TR)	0.91
Compatibility (CO)	0.84
Safety (SA)	0.83
Traffic Environment (TE)	0.93
Willingness to Pay (WoP)	0.95
Social Influence (SI)	0.84

Table 21 depicts coefficient alpha for constructs in the shared-use fully ADS model. The coefficient alpha for all constructs exceeds 0.75 except for Safety (Cronbach's alpha= 0.59). By dropping one of the Safety items (Item SA4: "I would not feel safe using a shared-use fully Automated Driving System in a dangerous neighborhood"), the coefficient alpha increases to 0.85.

Table 21 Internal Reliabilities: Instruments of the Shared-Use Fully ADS Model

Constructs	**Coefficient alpha**
Behavioral Intention to Use (BIU)	0.91
Perceived Ease of Use (PUoE)	0.89
Perceived Usefulness (PU)	0.82
Trust (TR)	0.84
Compatibility (CO)	0.75
Safety (SA)	0.59
Traffic Environment (TE)	0.91
Willingness to Pay (WoP)	0.85
Social Influence (SI)	0.82

Fitness of the measured models and convergent validity

For reducing complexity, the constructs were gradually added into the model in four steps. The first model included BIU, PEoU, PU, TR, CO, and SA. This model was considered as the main model since the relationship between the constructs were proved empirically in recent studies (Choi & Ji, 2015; May et al 2017). Moreover, the interviews in phase I and focus group discussions in phase III of this study showed importance of the constructs to the end-users. In the second model, Willingness to Pay was added. The third model combined the second model with Traffic Environment. Finally, in the fourth model, Social Influence was added. Thus, four models were developed and compared for both personally owned and shared-use fully ADS.

Confirmatory factor analysis (CFA) was performed using Lavaan package in R studio (version 0.99.879). According to Harlow (2014), not significant χ^2 is preferred; however, with a big sample size, usually χ^2 is significant (χ^2/df should be less than 3). Comparative fit index rages from 0 and 1 where 0.95 or higher is preferred. Hu and Bentler (1999) suggested that values around 0.9 were acceptable. Moreover, regarding root means square error of approximation (RMSEA), Harlow (2014) mentioned that values of 0.05, 0.08, 0.1 could be considered as indication of good, fair and acceptable fit, respectively.

The fitness scores of models for personally owned fully ADS and shared-use fully ADS are reported in Table 22 and Table 23, respectively. All personally owned fully ADS models show a good fit. Regarding shared-use fully ADS, based on guidelines from Hu and Bentler (1999), the models are acceptable.

Table 22 Fitness Score of Models for Personally Owned Fully ADS

Model	**χ^2/df**	**P-value**	**RMSEA**	**CFI**
Model 1	2.40	<0.001	0.067	0.958
Model 2	2.20	<0.001	0.062	0.961
Model 3	2.02	<0.001	0.058	0.961
Model 4	2.05	<0.001	0.058	0.953

Table 23 Fitness Score of Models for Shared-Use Fully ADS

Model	**χ^2/df**	**P-value**	**RMSEA**	**CFI**
Model 1	2.85	<0.001	0.080	0.910
Model 2	2.57	<0.001	0.079	0.908
Model 3	2.24	<0.001	0.071	0.925
Model 4	2.06	<0.001	0.058	0.953

After checking the model fitness, convergent validity was examined by a standard criterion recommended by Harlow (2014). All factor loadings should be significant. Values of 0.5, 0.3, and 0.1, can be considered as indication of good, fair and acceptable loadings. As shown in Table 24 and Table 25, all factor loadings are above 0.50 which can be indicated as good.

Table 24 Factor Loadings for Different Models of Personally Owned Fully ADS

Constructs	Items	FL Model 1	FL Model 2	FL Model 3	FL Model 4
Behavioral Intention to Use (BIU)	BUI1	0.926	0.925	0.925	0.926
	BUI2	0.922	0.923	0.923	0.923
	BUI3	0.963	0.963	0.963	0.962
Perceived Ease of Use (PUoE)	PUoE1	0.882	0.883	0.883	0.883
	PUoE2	0.853	0.852	0.853	0.852
	PUoE3	0.828	0.827	0.826	0.828
	PUoE4	0.917	0.918	0.918	0.917
Perceived Usefulness (PU)	PU1	0.736	0.741	0.742	0.743
	PU2	0.770	0.764	0.763	0.762
	PU3	0.784	0.781	0.782	0.782
	PU4	0.852	0.851	0.851	0.851
	PU5	0.663	0.660	0.660	0.659
	PU6	0.842	0.848	0.848	0.848
Trust (TR)	T1	0.926	0.927	0.924	0.924
	T2	0.788	0.785	0.788	0.788
	T3	0.800	0.802	0.804	0.805
	T4	0.893	0.892	0.893	0.892
Compatibility (CO)	C1	0.753	0.751	0.753	0.754
	C2	0.733	0.732	0.728	0.727
	C3	0.889	0.891	0.892	0.892
Safety (SA)	S1	0.841	0.840	0.838	0.838
	S2	0.860	0.860	0.859	0.866
	S4	0.889	0.889	0.891	0.888
Willingness to Pay (WoP)	WoP1		0.931	0.931	0.838
	WoP 2		0.934	0.935	0.930
	WoP 3		0.937	0.936	0.934
Traffic Environment (TE)	TE1			0.887	0.887
	TE2			0.897	0.897
	TE3			0.879	0.879

Constructs	Items	FL Model 1	FL Model 2	FL Model 3	FL Model 4
	TE4			0.862	0.861
Social Influence (SI)	SI1				0.880
	SI2				0.889
	SI3				0.780

Table 25 Factor Loadings for Different Models of Shared-Use Fully ADS

Constructs	Items	FL Model 1	FL Model 2	FL Model 3	FL Model 4
Behavioral Intention to Use (BIU)	BUI1	0.875	0.868	0.867	0.869
	BUI2	0.813	0.819	0.821	0.817
	BUI3	0.917	0.918	0.917	0.918
Perceived Ease of Use (PUoE)	PUoE1	0.718	0.719	0.718	0.718
	PUoE2	0.856	0.855	0.856	0.857
	PUoE3	0.879	0.881	0.882	0.880
	PUoE4	0.774	0.772	0.770	0.771
Perceived Usefulness (PU)	PU1	0.791	0.792	0.790	0.778
	PU2	0.762	0.765	0.767	0.769
	PU3	0.661	0.662	0.660	0.653
	PU4	0.550	0.545	0.544	0.547
	PU5	0.634	0.632	0.634	0.649
Trust (TR)	T1	0.722	0.721	0.722	0.717
	T2	0.702	0.701	0.697	0.696
	T3	0.820	0.819	0.818	0.815
	T4	0.801	0.803	0.805	0.811
Compatibility (CO)	C1	0.730	0.749	0.747	0.761
	C2	0.596	0.594	0.597	0.594
	C3	0.777	0.755	0.756	0.741
Safety (SA)	S1	0.777	0.785	0.777	0.792
	S2	0.807	0.807	0.809	0.814
	S3	0.799	0.792	0.798	0.780
Willingness to Pay (WoP)	WoP1		0.879	0.881	0.874
	WoP2		0.760	0.759	0.767
	WoP3		0.870	0.870	0.872
Traffic Environment (TE)	TE1			0.822	0.821
	TE2			0.886	0.888
	TE3			0.831	0.830

Constructs	Items	FL Model 1	FL Model 2	FL Model 3	FL Model 4
	TE4			0.862	0.862
	SI1				0.750
Social Influence (SI)	SI2				0.821
	SI3				0.731

The fitness of the structural model

Macro-level Interpretation

We followed Harlow's (2014) recommendation regarding the macro-level interpretation and micro-level interpretation for Structural Equation Modeling (SEM). At the macro-level, the recommendations are: (1) Chi-square/degree of freedom (χ^2/df), wherein the value of χ^2/df should be below the cut-off: 3.0, (2) RMSEA, wherein the RMSEA values of 0.05, 0.08, 0.1 can be considered as indication good, fair, and acceptable fit, (3) R^2 which is suggested as a good effect size (ES) wherein the values of 0.26, 0.13, 0.02, can be considered as indication large, medium, and small, and (4) Comparative Fit Index (CFI) 0.95 or higher is preferred. It is worth noting that Hu and Bentler (1999) suggested that values around 0.9 were acceptable.

As shown in Table 26, among the four models of personally owned fully ADS, only Model 1 shows a good fit (χ^2/df=2.27, RMSEA=0.067, R^2=0.911, CFI=0.952) based on the mentioned guidelines. Therefore, Model 1 is chosen as the structure of the proposed model, which efficiently characterizes the relationships between the constructs.

Table 26 Fitness Score of the Structural Models for Personally Owned Fully ADS

Model	χ^2/df	P-value	RMSEA	R^2	CFI
Model 1	2.27	<0.001	0.067	0.911	0.952
Model 2	2.91	<0.001	0.083	0.868	0.915
Model 3	3.26	<0.001	0.085	0.864	0.888
Model 4	3.60	<0.001	0.094	0.837	0.854

Table 27 reports the macro-level indices of shared-use fully ADS. Model 1 shows an acceptable fit. The output results are as follows: χ^2/df =2.80, RMSEA=0.079, R^2=0.770, and CFI =0.911. Although CFI is less than 0.95, Hu and Bentler (1999) suggested that values around 0.9 were acceptable. Therefore, the results of Model 1 indicate that this structure of proposed model efficiently characterizes the relationships between the constructs.

Table 27 Fitness Score of the Structural Models for Shared-Use Fully ADS

Model	χ^2/df	P-value	RMSEA	R^2	CFI
Model 1	2.80	<0.001	0.079	0.770	0.911

Model	χ^2/df	P-value	RMSEA	R^2	CFI
Model 2	2.63	<0.001	0.081	0.813	0.911
Model 3	2.93	<0.001	0.083	0.825	0.917
Model 4	2.38	<0.001	0.084	0.830	0.906

Micro-level Interpretation

Following Harlow's (2014) recommendation regarding the micro-level interpretation, two values: (1) z-value for constructs, and (2) the standardized loadings (ß) should be calculated. With the z-values, statistical conclusion is assessed by testing the null hypothesis for each path coefficient. It is recommended to take note of the significance of z-value for constructs. Regarding the standardized loadings, which gauge the magnitude of a relationship between variables, the recommendation is that loadings with values of 0.5, 0.2, and 0.1 should be considered as large, medium and small loadings.

In Model One for personally owned fully ADS, six path coefficients (z-values) are significant. The results are reported in Table 28.

(1) PU has a significant positive impact on BIU (z = 4.669, p < 0.001, β = 0.965).
(2) Although PEoU does not have a significant impact on BIU (z = 0.552, p = 0.581, β = 0.028,), PEoU significantly affects PU (z = 2.546, p = 0.011, β = 0.114).
(3) SA significantly impacts BIU (z = 2.177, p = 0.029, β = 0.267).
(4) SA significantly impacts PU as well (z = 2.032, p = 0.042, β = 0.193). This finding implies that while participants might have a strong intention to use which is influenced by PU, they may still want to ensure that ADS is safe to use.
(5) TR significantly influences on SA (z = 2.940, p = 0.003, β = 0.915).
(6) CO heavily impacts TR (z = 2.946, p = 0.003, β = 0.982).

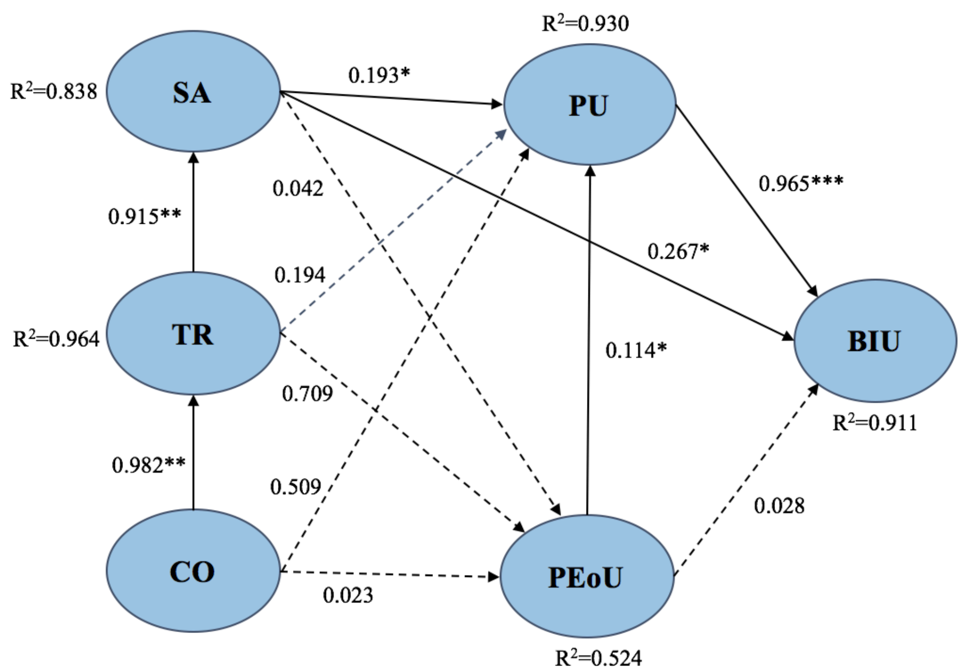
Table 28 Z-values and Standardized Path Coefficients (β) for Personally Owned Fully ADS Model

Hypothesis	z-value	Path coefficient β	Support
H1: PU➔BIU	4.669	0.965***	Yes
H2: PEoU➔BIU	0.552	0.028	No
H3: PEoU➔PU	2.546	0.114*	Yes
H4: SA➔BIU	2.177	0.267*	Yes
H5: SA➔PU	2.032	0.193*	Yes
H6:SA➔PEoU	0.269	0.042	No
H7:TR➔PU	0.445	0.194	No
H8:TR➔PEoU	1.031	0.709	No
H9:TR➔SA	2.940	0.915**	Yes
H10:CO➔PU	1.236	0.509	No
H11:CO➔PEoU	0.037	0.023	No
H12:CO➔TR	2.946	0.982**	Yes

(Note: * $p < 0.05$, ** $p < 0.01$, ***$p < 0.001$)

In summary, the finding reveals that personally owned fully ADS users' intention to use is influenced by two constructs: PU and SA. Moreover, this finding confirms their intention to use is not affected by PEoU, which means they might know that the system is not easy to handle but they may still have high intention to use it. Interestingly, the other constructs such as SA, TR, and CO also have insignificant relationships with PEoU. However, two constructs, PEoU and SA are significantly influenced by PU. These findings show the strong PU effect on BIU and weak PEoU effect on BIU. SA is strongly influenced by TR, which is impacted by CO. Figure 7 illustrates the assessment of the structural model for personally owned fully ADSs along with standardized path coefficient and R^2 value for constructs.

Figure 7 Assessment of the Structure Model for Personally Owned Fully ADSs



(Note: *p<0.05, ** p<0.01, ***p<0.001)

We did similar analyses for shared-use fully ADS. The results are reported in Table 29. Six path coefficients (z-values) are significant as follows:

(1) PU significantly impacts by BIU (z = 2.643, p = 0.008, β = 0.690).
(2) PEoU does not have a significant impact on BIU (z = 0.923, p = 0.356, β = 0.098). However, PEoU significantly affects PU (β = 0.380, z = 2.598, p = 0.009). This finding implies that while users might know that the system is not easy to use, due to usefulness and safety of the system, they still have the intention to use it.
(3) SA significantly impacts BIU (z = 2.326, p = 0.027, β = 0.290).
(4) SA significantly impacts PU (z = 2.105, p = 0.035, β = 0.468).
(5) SA is heavily influenced by TR (z = 2.049, p = 0.040, β = 0.906). This large coefficient implies

the important effect of TR on SA.

(6) CO heavily impacts TR (z = 2.056, p = 0.040, β = 0.976).

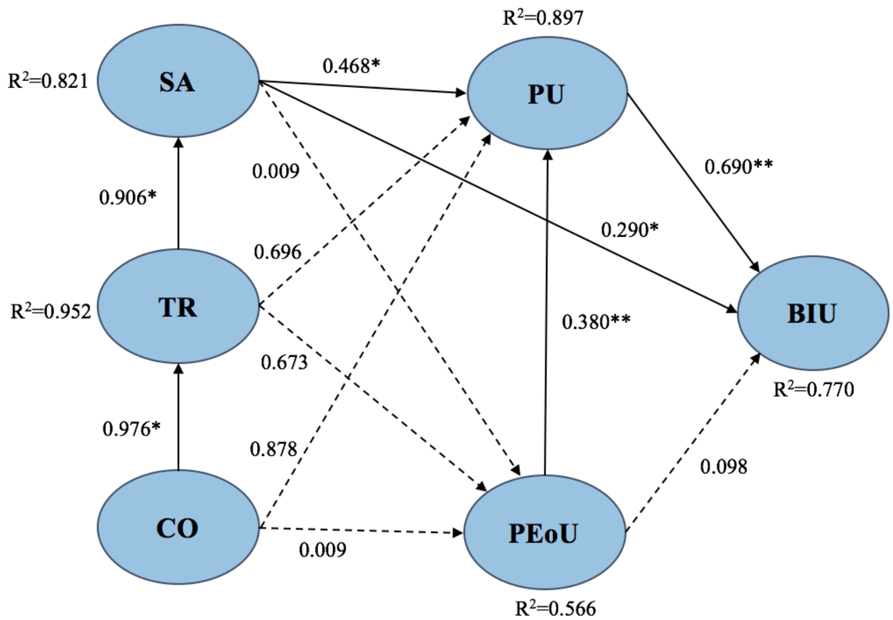
Table 29 Z-statistics and Standardized Path Coefficients for Shared-Use Fully ADS Model

Hypothesis	**z-value**	**Path coefficient β**	**Support**
H1: PU→BIU	2.643	0.690**	Yes
H2: PEoU→BIU	0.238	0.098	No
H3: PEoU→PU	2.598	0.380**	Yes
H4: SA→BIU	2.326	0.290*	Yes
H5: SA→PU	2.105	0.468*	Yes
H6:SA→PEoU	0.048	0.009	No
H7:TR→PU	0.818	0.696	No
H8:TR→PEoU	0.810	0.673	No
H9:TR→SA	2.049	0.906*	Yes
H10:CO→PU	0.839	0.878	No
H11:CO→PEoU	0.048	0.009	No
H12:CO→TR	2.056	0.976*	Yes

(Note: * $p < 0.05$; ** $p < 0.01$, ***$p < 0.001$)

In summary, almost the same results as personally owned fully ADSs are obtained. The shared-use fully ADS users' intention to use relies on how useful and safe the system is, rather than how easy it is to use. None of the constructs such as SA, TR, and CO have an effect on PEoU. However, the results show the significant effects of PEoU and SA on PU. TR strongly influences SA while it is strongly impacted by CO. Figure 7 depicts the proposed structural model for shared-use fully ADS along with significant path coefficient and R^2 values.

Figure 8 Assessment of the Structure Model for Shared-Use Fully ADSs



(Note: *p<0.05, ** p<0.01, ***p<0.001)

Comparing personally owned and shared-use fully ADS results

The findings in both the personally owned and shared-use fully ADS models show significant and similar results. Six path coefficients are significant with sufficient z-values. There are noticeable different patterns between the models. For example, PU shows high significant effect on BIU in the personally owned fully ADS model (***p < 0.001), whereas it shows moderate significance effect on BIU in the shared-use fully ADS model (**p < 0.01). Similarly, while in the personally owned fully ADS model, TR and CO show a moderate significance effect on SA and TR respectively (**p < 0.01), which show a lower significant effect in the shared-use fully ADS model (*p < 0.05). However, PEoU in the shared-use fully ADS model impacts on PU more significantly than the personally owned fully ADS model. It can be inferred that the factors have different levels of importance in these two models. PU, TR, and CO may be more important in the personally owned fully ADS model compared with the shared-use fully ADS model while PEoU is more significant in the shared-use fully ADS model compared with the personally owned fully ADS model.

Discussion

The objective of this section is to report the key findings of this study. First, the key findings regarding the Tesla Autopilot end-user's perception are discussed. Next, the implications of personally owned fully ADS and shared-use fully ADS user acceptance models are explained. Finally, policy gaps and their significant impact on the deployment of fully ADSs are identified.

User Perception

This section discusses the key findings of end-user's expectation prior to and post learning experience, their learning process, and importance of factors in their adoption. It is worth noting that these findings are based on the interview results with the end-users of level-2 ADS, Autopilot. Since they are users of the latest version of ADS most representative of products in the market, it is meaningful and crucial to consider these key findings.

End-User Expectation Prior to and Post Learning Experience: Benefits and Concerns

The results indicated that prior to learning experience, the end-users were motivated to purchase and use Autopilot because of four main perceived benefits: (1) convenience of not driving, (2) experiencing less stress while driving, (3) ease of use, and (4) feeling safe. The interviewees mentioned the same benefits after learning and experiencing the technology. This consistency in expected benefits and received benefits from Autopilot implied that the end-users had a good understanding regarding the benefits of the Autopilot prior to purchase.

However, almost half of the end-users indicated no concerns prior to purchase, but some concerns arose post learning process. This indicated that the learning experience had opened the end-user's eyes to the limitations of Autopilot. They mentioned not being able to detect road signs and headlights (level 2 automation limitations) and the lack of reliability and occasional malfunctions as the least attractive aspects of Autopilot. The significant difference between the pattern of concerns prior to and post learning process revealed that the end-users did not have enough knowledge regarding the limitations of the technology prior to their purchases. In other words, they had unrealistic expectations regarding the Autopilot's functionality. After experiencing the technology, they gradually noticed its limitations and developed more realistic expectations of its functionalities. During the learning process, this difference between expectation and reality could increase the risk of an accident.

Manufacturers should create a realistic expectation for consumers regarding the benefits prior to purchase. They are also able to help drivers to understand the limitations of the technology. Moreover, some researchers argue that not only are the manufacturers capable of increasing drivers' understanding of Autopilot limitations, but also this is their responsibility (Lin et al., 2018).

End-Users' Learning Process

Another key finding is regarding the learning process. The dealership, experiences from friends or family, online materials, and the owner's manual were reported by the end-users as resources to learn how to use Autopilot. However, the primary method for learning the technology was trial-and-error, which was mentioned by almost half of the end users. By using this method as the main resource of learning to use Autopilot, the users failed to learn many features of Autopilot thoroughly. The trial-and-error method has been found to be an insufficient practice for learning ADS such as ACC (Beggiato and Krems, 2013). Even experienced users often fail to fully understand the technology by this method (Bianchi Piccinini et al., 2015). The learning process shapes users' understanding of what the systems' capabilities are. Thus, this process should be effectively designed and should be able to convey knowledge to users accurately. In addition to designing effective training, providing users with supplementary materials and online materials developed by the manufacturers could be helpful to the end-users, since experienced people and online materials were reported as the most popular resources. Providing these materials directly from the manufacturers can ensure that users receive manufacturers' information, rather than third-party information, which may be inaccurate (Abraham et al., 2017).

Important Factors for End-User Acceptance

The final key finding from the end-user interview is about the importance of certain factors for user acceptance model. Safety, attitude towards behavior, perceived usefulness, perceived ease of use, and trust were rated in average higher than 5 (=somewhat important). This result is in line with previous studies (Ghazizadeh et al., 2012; Choi & Ji, 2015; May et al., 2017; Zmud et al., 2017). Moreover, the findings revealed that these factors were rated to be more important in user acceptance model for the fully ADS compared with the model for partially ADS. One of the end-users explained that users needed to rely on fully ADSs to perform driving. Therefore, they think most of the factors would be more important for fully ADSs compared with partially ADSs.

On the other hand, there were two factors which were found to be less important for fully ADS compared with partially ADS: (1) perceived ease of use and (2) compatibility. Perceived ease of use was rated significantly lower. One of the end users mentioned that he would be willing to overcome some complication if the benefits of fully ADSs' became a reality. This finding implies that the ease of use is no longer a critical factor and that this factor should be redefined. As Shin et al. (2014) pointed out, PEoU may also refer to convenience of use, and thus there may be benefits of using such technologies. The importance of compatibility decreased in the fully ADS user acceptance model, compared with that for the partially ADS user acceptance model. Although the decrease was not statistically significant, the background of the end-users might explain this finding. Almost all of the end-users considered themselves as early adopters. Being early adopters makes such users more flexible regarding technology acceptance. Hence, compatibility may not be an important factor for them.

User acceptance model Implications

In this study, new constructs that impact both personally owned fully ADS and shared-use fully ADS user acceptance models were developed and tested through the online survey. The findings of this study are largely supported by the previous research models (Gazizadeh, 2012; Choi & Ji, 2015; May et al., 2017; Zmud et al., 2017).

Impact of Perceived Ease of Use (PEoU)

The first key finding is regarding PEoU. All four path coefficients relating to PEoU in both models were statistically insignificant. This finding is different with the previous TAM studies which have consistently shown the significant impact of PEoU. In this study, the role of PEoU was relatively weak compared with PU. In addition, the R^2 of PEoU (=0.524) was the lowest compared with all the other constructs (>0.838). This result can be explained by considering that respondents are already familiar with driving a vehicle or using shared vehicles. Therefore, they assumed that it would not be too hard for them to use fully ADSs or shared-use fully ADSs. Moreover, the ease of use in ADSs impacts the usefulness of the system; there is a significant path coefficient of PEoU to PU in both models. Therefore, it is suggested that PEoU should be redefined to convenience of use and benefits of using such technologies, following Shin et al. (2014).

Impacts of Safety (SA), Trust (TR) and Compatibility (CO)

SA was found as the significant predictor of BIU, which is in line with previous studies (Osswald et al., 2012, Zmud et al., 2017). This result highlights the significant influence of safety on users' intention to use personally owned fully ADSs or shared-use fully ADSs. On the other hand, the significant predictor of SA is TR (ß>0.90), in both models. This finding demonstrates that user needs to trust the personally owned fully ADSs and shared-use fully ADSs to perceive them as safe. The effect of TR on SA was found in the previous study (Choi & Ji, 2015). The other strong relationship exists between TR and CO. Previous studies (Ghazizade et al., 2012; May et al., 2017) also identified this relationship. This study supports their findings (ß>0.97) in both models. This finding is particularly important for car manufacturers and emphasizes the importance of designing compatible ADS features to help users build trust and feel safe which lead users to have intention to use ADSs.

In summary, users' intention to use depends perceived usefulness and safety. While users' perceived usefulness is impacted by safety and perceived ease of use, safety is influenced by trust and indirectly by compatibility. Although both personally owned and shared-use fully ADSs depict similar results, there are some differences in the importance of the constructs. For personally owned fully ADSs, perceived usefulness, trust and compatibility play more significant roles in users' intention to use and perceived ease of use shows a less significant role in users' intention to use, compared with shared-use fully ADSs.

Policy Gaps and Implications

Education and Training

__Safety Training:__ One of the most important policy gaps is in terms of user education and training regarding safety. As the experts highlighted in the interview, there is no policy about how users of ADSs should be trained for safety purposes. Safety was also found as the most important factor in the end-user interviews. Additionally, it was one of the significant factors which impacted intention to use in the user acceptance models for both personally owned fully ADS and shared-use ADS. This finding is also in line with the focus group results, which demonstrates the need for training, especially on safety and how to deal with an emergency situation. Although designing a universal and efficient training for all drivers is a challenging task (Abraham et. al, 2017), it is necessary to have a policy which leads manufacturers to provide various training methods. This is particularly important since consumers may have different needs due to their age, physical capabilities and interests. The effectiveness of training can be maximized based on these needs.

Educational Communication Between State DOTs and OEMs: The other key finding regarding the gap in education policy is lack of educational communication between OEMS and DOTs which engage DOTs constantly about the design and the capability of ADSs. As it was found in the expert interview, State DOTs and OEMs should have clearer and more educational communication to: (1) create a guideline for testing policies and (2) develop a better arrangement for addressing ADS infrastructure needs. Regarding testing, policymakers should be provided with the capabilities of the targeted vehicle, objectives of the tests, and results of the tests. Regarding infrastructure, manufacturers should educate State DOTs regarding the infrastructure requirements for ADSs. Since DOTs typically have long time intervals between each road maintenance program (such as every 20 years), receiving information from manufacturers will enable them to make a more precise plan to address infrastructure needs of ADSs. Moreover, Caltrans will be able to resolve some of the manufactures' road environment challenges, which could potentially expedite the ADSs' development process. Engaging policymakers at the early stage of the technology development will enable policymakers to contribute more to the process of technology deployment.

Consumer Incentives

One of the key policy gaps is in the area of consumer incentives. Fully ADSs will have built-in incentives for potential consumers. However, many of the benefits will be shared with other road users. Substantial effect on safety, congestion and energy use are examples of their potential benefits which help everyone on the road (Anderson et al., 2014). Some suggestions were obtained through the expert interviews and focus group studies regarding this policy gap, including : (1) access to HOV lanes (or dedicated lanes), (2) facilitative insurance policies, (3) financial incentives, and (4) infrastructure scale up (e. g., charging station for electric ADSs).

HOV Lane (or Dedicated Lane) Accessibility: This was found as one of the consumer incentives through multiple phases of this study and is supported by recent studies (Anderson et al., 2014; Litman, 2018). This incentive is particularly valuable for the Bay Area residents who encounter the traffic congestion on the daily basis. Additionally, in the initial stage of ADS deployment, an accessibility lane policy which separates manual driven vehicles from fully ADSs will improve users' safety.

Facilitative Insurance: Researchers have estimated that fully ADSs will increase occupants' safety (Litman, 2018). Therefore, the insurance cost should be reduced for adopters. Facilitative insurance policies for consumers will motivate more users to adopt the technology and will increase safety in general. In the focus group study, it was suggested that built-in insurance for consumers could be offered by manufacturers.

Financial Incentives: Another incentive policy gap was identified to be the provision of financial incentives for consumers. Experts suggested that adoption of ADSs, which could potentially be combined with adoption of EVs, should be eligible for a financial incentive. Moreover, during the focus group, participants suggested that there should be lower parking rates for adopters. They also mentioned financial incentives for shared-use fully ADSs users. These findings are in line with the literature (Anderson et al., 2014), where it is argued that reduction in cost would increase adoption of technology and have the potential to improve social welfare.

Infrastructure Scale up: Policies are needed to address the readiness of the infrastructure for adoption of ADSs. If ADSs are deployed in EVs, there will be a demand for more charging stations. Policies should be developed to map out the infrastructure (e.g. charging station) requirements to promote ADS adoption by consumers.

Shared-Use Fully ADS

There are some policy gaps regarding implementation of shared-use fully ADSs including: (1) curb space and rights-of-way, (2) dedicated pick-up and drop-off locations, (3) dedicated lanes, (4) public safety, (5) sanitation concerns (6) cyber security and cyber terrorism and (7) discriminatory practices. These policies will help to address core concerns of consumers related to efficiency, safety, sanitation, privacy, and discrimination. Moreover, two policy gaps regarding incentives for adoption of shared automated EVs: (1) applying additional credits to operators who place an electric vehicle in a shared context, and (2) limiting access to specific locations by single occupant vehicles.

Mobility Needs and Services for Elderly Users

Two aspects of this policy gap were addressed in this study: (1) timeliness of addressing aged users' needs and (2) specific training needs for this group. Regarding the timeliness, the experts had different points of view. One of the experts believed that aged users' needs should be addressed from the beginning of ADSs development. However, the other expert stated that designing a system should be primarily based on the general public's needs initially. Afterward, it could be modified for special group of users as needed.

The training needs of aged users were discussed in one of the focus groups. The participants, who were all older than 65 years old, highlighted the fact that the need for training was not specific to aged users and was more of a general need for all users. Providing a variety of training methods for consumers with different needs due to their age, physical capabilities, and interests was suggested.

Data Privacy and Ownership

Data privacy and ownership was found as a critical policy gap. This concern is not limited to personally owned fully ADSs and shared-use fully ADSs. Cellphones, GPS and social media data were also reported as consumers' privacy and ownership concerns. Based on the results, it appears that although participants understand the benefits of sharing ADS data with manufacturers, they still have privacy concerns. Policymakers should address such concerns and make companies legally obligated to protect consumers' privacy. One of the suggested solutions is to require manufacturers to obtain consent from owners of fully ADSs or riders of shared-use fully ADSs for using data from ADS vehicles and/or rider information for non-safety purposes.

Liability and Insurance

One of the most important policy gaps was found to be the issue of ADSs' liability and insurance. Regarding this policy gap, experts suggested that manufacturers should be responsible for any malfunctioning of fully ADSs. Based on the focus group study results, it was believed that owners would still need insurance to protect themselves from unexpected circumstances. They would also remain responsible for maintaining the vehicle in proper working condition. However, the focus group participants believed that most of the responsibilities for accidents would rest on the manufacturers. Thus, policymakers have a critical role in making it clear that in what circumstances owners or the manufacturer should be liable. From another aspect, approaches such as the black-box recorder used in the aviation industry or data recording via vehicle' sensors and cameras should be developed and used as evidence to define responsibility in case of accidents.

Conclusion

Our findings show that safety, vehicle control and compatibility, and trust are the three most critical factors that have influence on users' acceptance of the fully automated driving systems. For deployment of fully ADS, public agencies should develop policy to support consumer education and training, policy to direct companies to protect consumer data privacy, policy to define the liability between the manufacturer and the users, and policy for consumer incentives to promote adoption of the technology. From manufacturers' perceptive, firstly they should make every effort to ensure that the fully ADS are safe and robust in all road conditions. Secondly, they should design different training programs for consumers to learn how to use fully ADS. Thirdly, they should develop new approaches to define responsibilities in the cases of accidents. Last but not least, they should give access to the consumers of their own data and not use it for other commercial purposes. There are considerable safety concerns related to shared-use fully ADS, which should be well investigated and resolved before the deployment.

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