Revolutionizing Our Roadways
Consumer Acceptance and Travel Behavior Impacts of Automated Vehicles
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Is a self-driving car in your future?

50% YES 50% NO

**YES**
- Safer than human drivers
- Relieve the stress of driving
- Trust the technology
- Expect to be more productive while traveling
- Can support mobility needs for seniors
- Just like public transit

**NO**
- Don’t trust the technology
- Safety concerns
- Affordability concerns
- Prefer to drive and control car
- Insurance/liability concerns
- Don’t know about or see a need for the cars

“No” reasons are drawn from an online survey with a sample size of 556 people in the Austin area.

“Yes” reasons are based on face-to-face interviews with 44 of those respondents who said they were extremely or somewhat likely to use self-driving cars.
Executive Summary

This study provides a glimpse into the not-too-distant future by asking people in the general population how they would respond to the availability of self-driving vehicles, which might be on Texas roadways within a few years. Some elements of the technology are already available in vehicles today. Self-parking, adaptive cruise control, and automated braking are all available currently. In the near future, vehicles might take over driving completely.

Transportation planners, researchers, and policy makers have a keen interest in how the market for such vehicles will develop. The big promise is their ability to reduce traffic accidents. The optimistic view is that such vehicles could also create smoother traffic flow and unlock existing capacity on roadways, meaning less road building. This is because intelligent, self-driving vehicles may drive more safely and efficiently than human drivers. If a fleet of self-driving cars could come to people when needed, it would mean less personal car ownership and fewer parking lots. The safety and productivity gains would bring significant economic benefits, but the potential societal benefits will not be achieved unless these vehicles are accepted and used by a critical mass of drivers. Consumer demand and technological development will determine the pace and scale of market development.

The advent of self-driving vehicles could be truly transformative, but future acceptance and use are highly uncertain. Car ownership could change—people might own more or fewer vehicles. Residential spatial patterns could change—more people might live farther from or closer to downtown. The number of vehicle miles traveled (VMT) could increase or decrease, depending on how, when, and why people use self-driving vehicles. Because self-driving vehicles are not yet present in the traffic streams, with the exception of a few test vehicles, it is difficult to reliably predict future consumer demand. Any purported outcomes are just theoretical at this point. Basic questions exist:

- How likely are people to use self-driving vehicles?
- What are the factors that influence acceptance and intent to use?
- What is the appeal of self-driving vehicles for people?
- In what ways would people change their current travel behavior because of access to self-driving vehicles?
- How might self-driving vehicles on roadways impact traffic and congestion?

Thus far, answers to these questions have come largely in the form of speculative future visions with little or no empirical evidence. This study begins to build an evidence base for transporta-
tion policy making and decision making. The information derives from an online survey and qualitative interviews with Austin metropolitan area residents in May and June 2015. The findings are representative of this sample only, which was a microcosm of Austin area residents.

How Likely Are People to Use Self-Driving Vehicles?

Austin is an auto-centric metropolitan area. Personal vehicle ownership is high, with 95 percent of households owning at least one vehicle (compared to the national average of 91 percent, according to 2013 data from the U.S. Census Bureau’s American Community Survey [ACS]). Public transit usage is low, with 5 percent of people commuting to work by any type of public transport, according to 2012 ACS data. While car-sharing, walking, and biking mode shares are not zero, the vast majority of people in the region use a personal vehicle (either as a driver or passenger) for their daily travel.

People are in a wait-and-see position in terms of acceptance and use of self-driving vehicles. Half are likely to use self-driving vehicles, and half are unlikely to use self-driving vehicles. People with definite views, either embracing or rejecting the technology, represented small slices of the sample. The top reason for being unlikely to use self-driving vehicles was lack of trust in the technology. While the vast majority (80 percent) had heard of self-driving vehicles prior to the survey, answers to interview questions clearly uncovered gaps in knowledge about them. As knowledge increases, acceptance and use should tilt in one direction or the other. If policy makers consider the potential societal benefits to be a policy priority, it would be valuable to educate the public to fill in knowledge gaps regarding the opportunities and challenges these vehicles offer.

What Are the Factors That Influence Acceptance and Intent to Use?

Going against conventional wisdom, neither age nor income was highly relevant in acceptance and intent to use. Psycho-social variables, such as technology adoption, privacy concerns, and perceptions of safety, were more influential. The only demographic variable associated with intent to use was having a physical condition that prohibits driving. While vehicle ownership per se was not a significant factor, currently owning a vehicle with highly automated features, such as adaptive cruise control, automated lane keeping, or automated parking systems, was significant in intent to use a self-driving vehicle.

What Is the Appeal of Self-Driving Vehicles for Consumers?

Why would people be likely to use self-driving vehicles? Perceptions are that such vehicles are safer; less stressful; productivity and mobility enablers, like using transit but better; and the wave of the future. Also, respondents expressed the belief that the vehicles would be adequately tested before being placed on the market—an important point for policy makers. Words used to describe the experience of riding in a self-driving vehicle were carefree, relaxing, and convenient. Only a few mentioned being nervous or having anxiety about the experience. Interestingly, likely users would find the ability to use self-driving vehicles to be a positive change in their traveling experience.
In What Ways Would People Change Their Current Travel Behavior?

In the future, people might access self-driving vehicles in two ways: by owning or by sharing. Private vehicle ownership was preferred over car sharing by a 3 to 1 margin—not surprising given Austin’s auto-centric character. Perhaps as knowledge of how fleets of driverless taxis or driverless jitneys would operate grows, such views might change.

Given the fact that most people would prefer to own a self-driving vehicle, it is also no surprise that there would be almost no change in the number of vehicles owned due to a self-driving vehicle market—at least at this point in time. Most people said they would simply switch out one of their current conventional vehicles for a self-driving one. They did not envision a self-driving vehicle doing double duty within the household, driving itself to and from pick-ups and drop-offs, which could allow a household to divest itself of a vehicle.

Based on survey responses, VMT would stay about the same as well—at least in terms of local travel. Most people did not think their routines, routes, activities, or residential location would change, thereby increasing or decreasing VMT. About half thought their inter-city travel would increase in frequency. With the negatives of driving long distance (e.g., fatigue and stress) disappearing, inter-city travel in a self-driving vehicle was viewed as very desirable, which might have implications for air and any potential rail travel in the state. Congestion on highways and interstates could be impacted as well.

How Might Self-Driving Vehicles on Roadways Impact Traffic and Congestion?

The conventional view of travel is that it is a derived demand—not pursued for its own sake but only as a means of accessing desired activities in other locations; in other words, people want to do activities, and they travel in order to do so. Because automated vehicles appear to mitigate the penalty of travel by making it more enjoyable and productive, there is the likelihood that travel (VMT) will increase in the future. There is also the likelihood that travel in personal vehicles will increase, resulting in a reduction of travel by public transportation.
Defining Automated Vehicles
AVs are defined as vehicles in which at least some aspects of a safety-critical control function (e.g., steering, throttle, or braking) occur without direct driver input. AVs use sensors, cameras, light detection and ranging (LIDAR), global positioning systems, and other onboard technology to operate with reduced, limited, and/or no human interaction. AVs represent a continuum of advanced driver assistance systems (ADASs), whereby more and more of the driving tasks are transferred from a driver to a vehicle for both convenience and safety. AVs can be passenger, public transport, and freight vehicles. AVs are not necessarily autonomous. Autonomous vehicles are responsible for driving solely and independently of other systems. The Google Car is an example prototype autonomous vehicle.

Introduction
Self-driving vehicles have the potential to bring societal benefits, such as fewer traffic accidents, reduced fuel use and emissions, less congestion, and easier parking. The question is not if such vehicles will be on Texas roads but when. It could be as soon as 2016 (1). Several auto manufacturers and Tier 1 suppliers have already accomplished successful precursor tests on public roads.

In 2013, Mercedes’ self-driving car drove 62 miles on German roads. In early 2015, a self-driving Audi A7 traveled 550 miles from San Jose, California, to Las Vegas, Nevada (2). In spring 2015, a self-driving car created by Delphi Automotive completed a 3,400-mile trip from San Francisco, California, to New York City, crossing 15 states (3). Also in summer 2015, Google began testing one of its self-driving vehicles, a retrofitted Lexus sport utility vehicle (SUV), in Austin, Texas. This testing was expanded to include its prototype pod cars in September 2015. Such road tests underscore the great leaps automated vehicle (AV) technology has taken in recent years and why insight into market demand should be important to policy makers now. Public road testing of self-driving vehicles will advance the vehicles to market, but consumer adoption and use patterns will determine the pace and scale of market development. Future adoption and use are highly uncertain.

The National Highway Traffic Safety Administration has helped to clarify policy and technical discussions around AVs by defining levels of automation (see Table 1) (4). The lowest level is no automation, where the driver is in full control of steering, throttle, and braking. Vehicles with Level 2 automation, such as adaptive cruise control and lane centering, are currently in production and marketplace deployment. At Level 3, the driver is able to temporarily turn attention away from the driving task to engage in other activities but needs to be available to retake control within a few seconds’ notice. At Level 4, automated systems replace the driver completely.
An ADAS approach lends itself to evolutionary and iterative progression toward self-driving vehicles. The evolutionary approach is easier for policy making and transportation agency decision making. From a business standpoint, an incremental approach allows automakers to incorporate new features into their vehicles without major disruptions to day-to-day operations. An incremental approach also enables automakers to offer premium technology and safety-oriented car features that do not depend on breakthroughs in technology, regulation, or liability.

In this context, Google’s entry into the AV space is disruptive (i.e., Google’s approach is different from the approach of conventional automakers). Google’s approach is to focus solely on producing a fully self-driving vehicle, thus allowing it to become a leapfrog competitor to the traditional automakers—with significant implications for state and local policy making. The two approaches are often referred to as bottom-up (i.e., incremental) and top-down (i.e., disruptive) (5). The top-down approach will likely result in technology developing faster than policy. Vehicles could be put on the roads prior to the necessary regulatory and policy infrastructure—much like Uber taxis operate in some jurisdictions. Regardless of bottom-up or top-down market entry, consumer demand will determine how the market for these vehicles develops.

**Study Objectives**

Self-driving vehicles could potentially alter travel demand and the transportation system. Will driverless taxis serve many of the trips currently made by privately owned vehicles, reducing vehicle ownership needs? Will more people bike because self-driving vehicles require narrower lanes than conventional vehicles and improved bike lanes can be accommodated? Will the elderly or people with disabilities use self-driving vehicles, thus generating added VMT and perhaps exacerbating congestion?

Because highly automated vehicles are not yet present in the traffic streams, with the exception of a few test vehicles, it is difficult to reliably predict future consumer demand. There might be various responses to the introduction of such vehicles into the market, and so basic questions exist:

- How likely are people to use self-driving vehicles?
- What are the factors that influence acceptance and intent to use?
- What is the appeal of self-driving vehicles for people?
- In what ways would people change their current travel behavior because of access to self-driving vehicles?
- What does this mean for traffic and congestion in the future?

As long as these critical questions go unanswered, states and localities will be hampered in their ability to prepare for the implications of self-driving vehicles. Thus far, answers to these questions have come largely in the form of speculative future visions with little or no empirical evidence. More recently, research has begun trying to answer these questions by collecting data and developing models.

The objective of this study was to gather empirical evidence on consumer acceptance and adoption: the factors associated with intention to use, how that intention might influence mode choice and vehicle ownership decisions, and what all of this could mean for travel demand.

Table 1. Levels of Vehicle Automation.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Driver Only</td>
</tr>
<tr>
<td>1</td>
<td>Specific Function Automation</td>
</tr>
<tr>
<td>2</td>
<td>Combined Function Automation</td>
</tr>
<tr>
<td>3</td>
<td>Limited Self-Driving Automation</td>
</tr>
<tr>
<td>4</td>
<td>Full Self-Driving Automation</td>
</tr>
</tbody>
</table>

Source: (4)

<table>
<thead>
<tr>
<th>0</th>
<th>Driver Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific Function Automation</td>
</tr>
<tr>
<td>2</td>
<td>Combined Function Automation</td>
</tr>
<tr>
<td>3</td>
<td>Limited Self-Driving Automation</td>
</tr>
<tr>
<td>4</td>
<td>Full Self-Driving Automation</td>
</tr>
</tbody>
</table>

Table 1. Levels of Vehicle Automation.
and congestion in the Austin region. The data were gathered through a two-step process:
1. An initial online survey of 556 residents of the Austin metropolitan area.
2. Follow-up, face-to-face interviews with 44 participants.

Given that automation is a new technology, not yet on the market, extreme care was used to design the study language and content. In addition to the questionnaire, the study included a video to portray the self-driving technology in the online survey. The face-to-face interviews were used to gather information on potential travel behavior changes. The qualitative probing on such changes was deemed more reliable than survey data collection.

Intent to Use Self-Driving Vehicles
In the case of self-driving vehicles, potential societal benefits (e.g., enhanced safety, reduced congestion, and improved air quality) will not be achieved unless these vehicles are accepted and used by a critical mass of drivers. Acceptance has been defined as the “degree to which an individual incorporates the system in his/her driving, or, if the system is not available, intends to use it” (6). With self-driving vehicles, the intent to use is an important concept because the technology is not yet on the market. When a product becomes tangible and drivers have an opportunity to experience it “for real,” they can form judgments and provide reliable responses to questions pertaining to actual use. For this reason, this study examined intent to use rather than stated future use.
The data on intent to use self-driving vehicles and its associated factors derive from an online survey of 556 Austin residents. The survey questionnaire contained the following definition of self-driving vehicles:

In our study, we are interested in your opinions about self-driving vehicles. You may be able to buy a self-driving vehicle from major manufacturers or access one through a car-sharing service within the next 5–8 years. A self-driving vehicle is a vehicle that controls all driving functions for an entire trip, including steering, braking, and acceleration. It covers freeway driving, neighborhood driving, and activities like parking. The operator provides destination or navigation input and is in the vehicle to take over control of the vehicle if conditions warrant. The market push for self-driving vehicles is to make driving safer and more efficient.

In addition, a link to a short video on self-driving vehicles was provided after the definition.

**Intent to Use Segmentation**

Austin residents were asked about their intent to use self-driving vehicles: “Imagine that self-driving vehicles were on the market now either for purchase or rental. What is the likelihood that you would ride in a self-driving vehicle for everyday use?” In responding, the sample was evenly split—with 50 percent indicating an intent to use and 50 percent indicating an intent not to use.

Responses to the question were used to segment respondents into four intent-to-use categories (see Figure 2). The smallest segments were those at the intense ends of the spectrum: extremely likely to use (14 percent) and extremely unlikely to use (18 percent). The rest of the people surveyed are in a wait-and-see mode, with most somewhat likely to use (36 percent); only 32 percent were somewhat unlikely to use.

The research team elicited rationales for intent to use through probing in the follow-up face-to-face interviews, which are discussed in detail in the section “Impact on Travel Behavior.” Seven main categories of reasons surfaced in the interviews:

1. Safer than human drivers.
2. Relieves the stress of driving.
3. Mobility enabler for aging seniors.
4. Ability to be productive while traveling in a car.
5. Trust that technology will be adequately tested.
6. Comparability to public transit experience.
7. Attraction of new technology.

Austin is a technology hub, and the intent to use self-driving vehicles might be influenced by its technology focus, although this is not necessarily the case for the current sample. A majority of the sample (66 percent) considered themselves Late Adopters on the technology adoption curve. They wait awhile before adopting new technology and so are not necessarily eager to jump on the self-driving car bandwagon. Early Adopters (e.g., among the first to adopt new technology) comprised 21 percent of the sample, and Laggards (e.g., among the very last) were 13 percent of the sample. Still, technology use among the survey sample was quite strong, which is reflective of Austin’s character (Table 2).

**Factors Associated with Intent to Use**

Demographic variables were not strongly related to intent to use. For example, a respondent’s age was not as predictive of his or her intent to use as one might expect. Table 2 provides the distribution of intent to use self-driving vehicles by age. Younger people (less than 30 years old) were evenly split on intent to use, as were people greater than 65 years old. A slight majority of people 30–45 years old (53 percent) were likely to use, whereas a slight majority of
persons 46–65 years old (55 percent) were unlikely to use. On the other hand, having a physical condition that pre-
vented driving was predictive. All of the small number of 
people (n=11) with a travel-restrictive disability were likely 
to use.

Gender differences were observed. Males, more than females, are likely to use, and 18 percent of males were 
Enthusiasts, compared to 11 percent of females. In terms of household income, most of those with a household in-
come less than $25,000 were unlikely to use (56 percent), while those earning $25,000–$50,000 were more likely to 
use (54 percent). In other income categories, people were equally unlikely and likely to use. Educational attainment 
was not associated with intent to use. However, the pres-
ence of children in the household was associated. House-
holds with children were less likely to indicate intent to 
use than households without children (51 percent and 
45 percent, respectively). However, over one-third of the 
20 households in the sample with three or more children were Enthusiasts.

Half of respondents were unlikely to use. The most fre-
quent reasons cited for being unlikely to ride in self-driv-
ing vehicles for everyday use were:

- Lack of trust in the technology (41 percent).
- Safety (24 percent).
- Cost (22 percent).

These big-picture reasons overshadowed other, more 
individualistic personality traits, such as liking to drive or 
desire for vehicle control (see Table 4).

Data privacy was mentioned by only one individual as a 
reason for being unlikely to ride in a self-driving vehicle, 
but based on other questions, data privacy was found 
to be associated with intent to use self-driving vehicles 
(Table 5). The higher the level of data privacy concerns, the 
less likely a person was to use self-driving vehicles. Among 
total respondents, opinions on data privacy were split:

- Few privacy concerns: Of the total respondents, 
49 percent had concerns about using Internet or 
Internet-enabled technologies in some situations or 
not at all. Of those who expressed concerns in some 
situations, 56 percent were likely to use self-driving 
vehicles. Of those who expressed no data privacy 
concerns, 71 percent were likely to use self-driving 
vehicles. Only 5 percent of the total sample indicated 
that they had no concerns at all.

### Table 2. Frequency of Technology Use (N=556).

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Smartphone</th>
<th>Facebook</th>
<th>Internet Shopping</th>
<th>Emailing</th>
<th>Text Messaging</th>
<th>Transportation Apps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>10%</td>
<td>23%</td>
<td>5%</td>
<td>1%</td>
<td>7%</td>
<td>31%</td>
</tr>
<tr>
<td>Several times/month</td>
<td>3%</td>
<td>10%</td>
<td>58%</td>
<td>5%</td>
<td>7%</td>
<td>32%</td>
</tr>
<tr>
<td>Several times/week</td>
<td>5%</td>
<td>20%</td>
<td>28%</td>
<td>15%</td>
<td>20%</td>
<td>26%</td>
</tr>
<tr>
<td>Several times/day</td>
<td>41%</td>
<td>38%</td>
<td>7%</td>
<td>54%</td>
<td>45%</td>
<td>6%</td>
</tr>
<tr>
<td>Several times/hour</td>
<td>41%</td>
<td>9%</td>
<td>2%</td>
<td>25%</td>
<td>21%</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Table 3. Intent to Use Self-Driving Vehicles by Age.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Less than 30 Years Old (n=132)</th>
<th>30–45 Years Old (n=155)</th>
<th>46–65 Years Old (n=167)</th>
<th>65+ Years Old (n=102)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejecters (extremely unlikely)</td>
<td>24%</td>
<td>14%</td>
<td>22%</td>
<td>15%</td>
</tr>
<tr>
<td>Traditionalists (somewhat unlikely)</td>
<td>26%</td>
<td>33%</td>
<td>33%</td>
<td>35%</td>
</tr>
<tr>
<td>Pragmatists (somewhat likely)</td>
<td>39%</td>
<td>36%</td>
<td>32%</td>
<td>36%</td>
</tr>
<tr>
<td>Enthusiasts (extremely likely)</td>
<td>11%</td>
<td>17%</td>
<td>13%</td>
<td>14%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
· **Many privacy concerns:** Of the total respondents, 51 percent had concerns about using Internet or Internet-enabled technologies in *most or all* situations. Of those who expressed concerns in *most* situations, 57 percent were *unlikely* to use self-driving vehicles. Of those who expressed concerns in *all* situations, 60 percent were *unlikely* to use self-driving vehicles.

Early Adopters of technology (in general) embraced using self-driving vehicles (Table 6). Early Adopters are among the first to adopt new technology, while Late Adopters wait awhile. Laggards are among the last to adopt new technology if at all. Age was related to the adoption curve, with the largest proportion of Early Adopters in the less-than-30 age group and the largest proportion of Laggards in the over-65 age group. Early Adopters skewed heavily toward intent to use (65 percent), whereas Laggards skewed toward not using (62 percent). The few Early Adopters who were Rejecters mainly cited concerns about cost as their main reason for not using. The small number of Laggards who were Enthusiasts tended to be either younger than 30 or older than 65.

**Table 4. Reasons for Not Intending to Use Self-Driving Vehicles.**

<table>
<thead>
<tr>
<th>Reason</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of trust in this technology</td>
<td>117</td>
<td>41%</td>
<td>41%</td>
</tr>
<tr>
<td>Safety concerns</td>
<td>69</td>
<td>24%</td>
<td>65%</td>
</tr>
<tr>
<td>Cost concerns</td>
<td>61</td>
<td>22%</td>
<td>87%</td>
</tr>
<tr>
<td>Like to drive</td>
<td>20</td>
<td>7%</td>
<td>94%</td>
</tr>
<tr>
<td>Desire for control of vehicle</td>
<td>6</td>
<td>2%</td>
<td>96%</td>
</tr>
<tr>
<td>Insurance/liability uncertainties</td>
<td>2</td>
<td>1%</td>
<td>97%</td>
</tr>
<tr>
<td>Anti-technology in general</td>
<td>2</td>
<td>1%</td>
<td>98%</td>
</tr>
<tr>
<td>Lack of information about it</td>
<td>2</td>
<td>1%</td>
<td>99%</td>
</tr>
<tr>
<td>No need for it</td>
<td>2</td>
<td>1%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>282</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5. Intent to Use Self-Driving Vehicles by Level of Data Privacy Concern.**

<table>
<thead>
<tr>
<th>Segment</th>
<th>Not at All Concerned (n=28)</th>
<th>Concerned in Some Situations (n=245)</th>
<th>Concerned in Most Situations (n=208)</th>
<th>Concerned in All Situations (n=75)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejecters (extremely unlikely)</td>
<td>11%</td>
<td>14%</td>
<td>23%</td>
<td>24%</td>
</tr>
<tr>
<td>Traditionalists (somewhat unlikely)</td>
<td>18%</td>
<td>30%</td>
<td>34%</td>
<td>36%</td>
</tr>
<tr>
<td>Pragmatists (somewhat likely)</td>
<td>43%</td>
<td>40%</td>
<td>33%</td>
<td>29%</td>
</tr>
<tr>
<td>Enthusiasts (extremely likely)</td>
<td>28%</td>
<td>16%</td>
<td>10%</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**Table 6. Intent to Use Self-Driving Vehicles by Adoption Curve.**

<table>
<thead>
<tr>
<th>Segment</th>
<th>Early Adopter (n=118)</th>
<th>Late Adopter (n=365)</th>
<th>Laggard (n=73)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejecters (extremely unlikely)</td>
<td>9%</td>
<td>19%</td>
<td>30%</td>
</tr>
<tr>
<td>Traditionalists (somewhat unlikely)</td>
<td>26%</td>
<td>34%</td>
<td>32%</td>
</tr>
<tr>
<td>Pragmatists (somewhat likely)</td>
<td>43%</td>
<td>37%</td>
<td>19%</td>
</tr>
<tr>
<td>Enthusiasts (extremely likely)</td>
<td>22%</td>
<td>10%</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Currently owning or leasing a vehicle had no effect on people’s intent to use. However, currently owning a vehicle with highly automated features did have an effect, and these individuals were more likely to be Enthusiasts (20 percent) than those who did not own a vehicle with highly automated features (12 percent).

Among those currently employed, their commute mode was related to intent to use (Table 7). Commute mode was defined as how people usually got to work last week (i.e., the single mode used for the longest time), and 85 percent of full- or part-time workers indicated they were vehicle drivers. By a slight majority (52 percent), vehicle drivers were unlikely to use self-driving vehicles, whereas the majority of users of all other modes (i.e., vehicle passengers, walkers, or telecommuters) were likely to use self-driving vehicles (57 percent). This was particularly true of vehicle passengers, though they were a very small sample (n=17). The utility of self-driving cars for users of other modes, relative to drivers, might be perceived as providing greater convenience of access and egress or enhanced mobility for those who do not own a car or cannot drive.

Self-reported VMT in 2014 had no correlation with intent to use, but frequency of driving did make a difference. People who drove quite infrequently or almost never expressed a strong intention to use self-driving vehicles (Table 8). These people tended to have a travel-restrictive disability or to be low income (i.e., earning less than $24,999 in 2014), highlighting the accessibility benefits that have been tied to self-driving vehicles.

**Predictors of Intent to Use**

There are transportation decision makers, policy makers, and even researchers with preconceptions about the types of consumers who will adopt and use self-driving vehicles. Many researchers and policy makers feel that it will be Millennials because of their reliance on technology. Others think it will be seniors because the technology will enable mobility well into old age. As the survey results indicate, demographic variables such as age might not be the best predictors of intent to use.

Prior studies present the Car Technology Acceptance Model (CTAM), which the research team used to identify variables that explain new technology adoption and use. These variables are psychological and personality variables that distinguish users who accept or reject technologies. They include such items as attitudes toward using technology, perceived safety while driving, anxiety in the car context, and social influence. In previous technology

### Table 7. Intent to Use Self-Driving Vehicles by Commute Mode.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Vehicle Driver (n=304)</th>
<th>All Other Modes (n=53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejecters (extremely unlikely)</td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td>Traditionalists (somewhat unlikely)</td>
<td>32%</td>
<td>28%</td>
</tr>
<tr>
<td>Pragmatists (somewhat likely)</td>
<td>36%</td>
<td>42%</td>
</tr>
<tr>
<td>Enthusiasts (extremely likely)</td>
<td>12%</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

### Table 8. Intent to Use Self-Driving Vehicles by Frequency of Driving a Motor Vehicle.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Every Day (n=409)</th>
<th>A Few Days Per Week (n=112)</th>
<th>A Few Days Per Month or Almost Never (n=35)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejecters (extremely unlikely)</td>
<td>19%</td>
<td>20%</td>
<td>8%</td>
</tr>
<tr>
<td>Traditionalists (somewhat unlikely)</td>
<td>32%</td>
<td>37%</td>
<td>20%</td>
</tr>
<tr>
<td>Pragmatists (somewhat likely)</td>
<td>36%</td>
<td>31%</td>
<td>49%</td>
</tr>
<tr>
<td>Enthusiasts (extremely likely)</td>
<td>13%</td>
<td>12%</td>
<td>23%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
studies, these psychological or personality variables held more predictive power than demographic variables. In other words, personal beliefs and preferences are often better predictors of technological adoption than basic demographic descriptors like age or gender. The research team conducted higher-level analyses to examine the significance of the different types of variables (e.g., demographic, personality, and behavioral) in the survey. After isolating the significant variables, a regression model was developed to examine determinants of intent to use. The results indicate that individuals who have a higher level of intent to use self-driving vehicles are the ones who:

- Have any physical conditions that prohibit them from driving.
- Think self-driving vehicles would decrease crash risks.
- Use smartphones, text messaging, Facebook, and transportation apps.
- Are not concerned with data privacy when using online technology.
- Think using a self-driving vehicle would be fun.
- Think it would be easy to become skillful at using self-driving vehicles.
- Believe people whose opinions they value would like using self-driving vehicles.

At this early stage in market development for self-driving vehicles, the personality and psychology of the consumers are much more important than their demographic profile.

**Impact on Travel Behavior**

Self-driving vehicles promise to make automobile travel safer and more efficient, and to dramatically change transportation planning and engineering. This is because they offer the potential to free drivers’ attention from the road, to chauffer people who are unable to drive, and ultimately to drive robotically without anyone on board. But how will people’s travel behavior change, if at all, because of these opportunities?

Travel behavior in this study is defined with four key variables:

- The number of vehicles owned.
- The propensity to use shared vehicles versus owning personal vehicles.
- Choices about mode of travel (e.g., vehicle driver, public transit, and walking).
- The amount of VMT.

Information about travel behavior impacts—when projected into the future—provides insight into implications for traffic generation, highway capacity, and congestion over time as self-driving vehicles comprise a greater percentage of the vehicles on the road.
The data on impacts on travel behavior originate from qualitative, face-to-face interviews with 44 people who indicated in the online survey that they would likely use self-driving vehicles and who also agreed to participate in a follow-up interview. The use of qualitative interviews, rather than a survey, enabled the researchers to ask clarifying questions to ensure accurate information was collected. This method also facilitated the capture of opinions, perceptions, and behaviors in people’s own words. Characteristics of these 44 people include:

- 9 percent were less than 30 years old, 50 percent were between 30 and 45 years old, 23 percent were between 46 and 65 years old, and 18 percent were 66 years old or older.
- Most (75 percent) prefer to be the driver rather than passenger when traveling in a conventional car in an urban area, but a slight majority (55 percent) prefer to be the passenger for long-distance trips.
- The majority (71 percent) are not at all or only somewhat concerned that their data are not kept private when using Internet-enabled technologies. More (82 percent) are not at all or only somewhat concerned that their data would not be kept private when using self-driving cars.
- Most (69 percent) feel moderately or extremely safe in vehicles today when driving.
- Virtually all would feel safer (46 percent) or about the same as now (48 percent) in a self-driving vehicle.

### Rationale for Intent to Use

It is important to find out why individuals decide to use self-driving vehicles because intention to use could provide insights into the potential impacts on travel behavior. The first question these individuals were asked was: “You indicated in the prior online survey that you would likely ride in a self-driving vehicle for everyday use. Can you tell me your reasons for that answer?” Seven main categories of reasons surfaced in the interviews:

1. Safer than human drivers.
2. Relieves stress of driving.
3. Trust that technology will be adequately tested.
4. Comparability to public transit experience.
5. Attraction of new technology.
6. Mobility enabler for aging seniors.
7. Ability to be productive while traveling in a car.

The first five reasons (safety, relief from stress, trust, like public transit, and new) spanned different age groups. For example, regardless of age, respondents felt AVs would be better drivers than humans (see Table 9).

Also regardless of age, respondents thought traveling would be less stressful in self-driving vehicles, especially in Austin traffic, which they pointed out as being currently bad. In addition, several respondents described the activity of driving as “a chore.” Some people equated the experience of using a self-driving vehicle to using public transit. The implication was that a self-driving vehicle would be more convenient than traditional public transit and, therefore, desirable. One thing that might have made these respondents more comfortable about using self-driving technology was their trust that the vehicles would not be allowed on the roads until proven safe. One major rationale category had to do with the attraction of new technology. Several respondents said they would likely ride in a self-driving vehicle simply because it was new.

There were also age-specific rationales, such as facilitating mobility as one grows older (see Table 10). Those individuals older than 65 years recognized that, as they were aging, such vehicles would be useful. Even a couple of the people aged 46–65 pointed out the benefits as they age. The ability to be more productive while traveling in a car was also a frequently cited rationale, especially among people between the ages of 30 and 45 years.

### Perceptions of the Self-Driving Experience

Respondents were asked to do the following: “Imagine that you are riding by yourself in a self-driving vehicle on a trip to the grocery store. Describe what you think the experience would be like.” Words the respondents used to describe the self-driving experience included nervous, carefree, convenient, relaxing, and independent.

Several respondents said that they would be nervous at first because it is something new. They described themselves as being hyperaware of how the car is reacting and trying to figure out how it knew to do certain things:
“What is the car going to do in X situation?” Others mentioned that they might not be able to relax at first. They would feel a need to “over-correct or override the system.” Some also said:

- “I would probably have my hands on the steering wheel (if there was one).”
- “Once I knew [the car was able to handle all situations,] I would probably do other things.”

Respondents that were apprehensive were a minority. The majority of respondents ticked off the things that they would be doing on the trip such as reviewing a

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Table 9. Reasons for Intent to Use.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Some Direct Quotes from Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safer than human drivers</td>
<td>If everybody is in an automated car, it would be safer (less than 30 years old). I feel as more and more people obtain such vehicles, it will increase safety and decrease human errors (30–45 years old). I get nervous driving; other drivers tend to drive carelessly. I would like this idea (46–65 years old). I like the ability to avoid other cars and traffic (65+ years old).</td>
</tr>
<tr>
<td>Relieves stress of driving</td>
<td>With Austin traffic, it would be convenient not to have to worry about the drive to work (46–65 years old). Mostly for lack of stress caused when driving to and from work; traffic-related concerns and having to pay attention (30–45 years old). Driving is something you have to do to get from point A to point B…if there was technology to do it, I would definitely be willing not to have to drive (less than 30 years old). I do not like to drive, especially in Austin (46–65 years old).</td>
</tr>
<tr>
<td>Trust that technology will be adequately tested</td>
<td>By the time they allow it on the road, it will be safer than my driving (65+ years old). Before something like this comes to market, it would be tested a lot (30–45 years old). By the time it gets to market, it will be so mistake proof, it would be safer, without human errors (46–65 years old).</td>
</tr>
<tr>
<td>Comparability to public transit experience</td>
<td>I used public transit often when I lived overseas, and I enjoyed the ride with no responsibilities (less than 30 years old). I look at it like when I could take mass transit; I did not have to focus on driving (30–45 years old). I would be interested in using it somewhat the way you would use public transportation…read something (46–65 years old).</td>
</tr>
<tr>
<td>Attraction of new technology</td>
<td>The first reason at this point is it is something very new and different. I like technology (46–65 years old). I already have a car that has steering assist. It reads the stop signs and signals (65+ years old). New technology, and I want to be a part of it (46–65 years old). It is the wave of the future (30–45 years old).</td>
</tr>
</tbody>
</table>

Table 10. Age-Specific Reasons for Intent to Use.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Some Direct Quotes from Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility enabler for aging seniors</td>
<td>By the time they allow it on the road, it will be safer than my driving. As I get older, I would find this technology more and more appealing. Riding in a self-driving vehicle would be easier as I get older. I get distracted, and my reflexes are not as good as they used to be. Becoming disabled soon, I will not be able to drive myself. Also entering my older years, it will benefit me.</td>
</tr>
<tr>
<td>Ability to be productive while traveling in a car</td>
<td>I could do something productive on my trip. We waste a lot of time behind the wheel. To be able to be productive like on a plane or rail. It would let me do other tasks, such as eating, watch a movie, be on a cell phone while you are on your trip. It would be easier to conduct business or for personal time. I spend a lot of time driving; it would be nice to be able to do other things. My commute is short, but it would allow me to do other things. It would reduce the stress of living in a big city. Get in a vehicle and work on other things. Make it a more productive trip.</td>
</tr>
</tbody>
</table>
grocery list, using a cell phone, flipping through radio stations, taking care of personal matters, talking to children in the car, or doing work or homework. Others talked about doing nothing:

- “Get in the car and tell it where to go. It takes me there.”
- “I could relax; my mind would be free.”

When asked “Where would you sit?” most people answered the driver’s seat—at least at first. They said:

- “Driver’s seat; habits die hard.”
- “Driver’s seat in case I would have to switch it to manual.”
- “Driver’s seat. I would want to still see the controls.”
- “Still sit in the driver’s seat at least at first. Just because I am used to sitting in the driver’s seat.”

After getting comfortable with the self-driving vehicle, they would then sit in the passenger seat or the back seat, whichever would be more comfortable.

A few said that they would sit on the passenger side immediately:

- “Passenger side and probably focus on my computer surfing the web.”
- “Passenger side because there is more room and focus on whatever task I had at hand and wanted to get done.”

Potential Concerns with Using Self-Driving Vehicles

Respondents were asked, “Can you think of any potential problems or concerns you might have in using a self-driving vehicle?” The most frequently cited concerns related to system failure or malfunctions in the technology:

- “Failure of the car…is there sufficient redundancy?”
- “If you’re in a car that is connected, what happens when you lose connection?”
- “What if you get struck by lightning?”
- “You’d want to know that the car wouldn’t glitch out—leave you stranded.”
- “What if it malfunctions and causes an accident?”
- “With new technology, when it first comes out, generally there are bugs.”

Other items mentioned by a few people included “someone hacking in,” “an environment where not everyone is driving a self-driving vehicle,” and the “vehicle’s handling of unforeseen events.” The concerns about hacking were not just about hacking when the vehicle was operating, but respondents also worried about identity theft: “How does the vehicle know it is me getting into the car and not someone trying to steal my vehicle?” Cost was only mentioned by two people. Two people also mentioned losing the capability or the fun of driving.

Even though nearly 8 out of 10 survey respondents had heard of self-driving vehicles before participating in this study, most of the issues raised were actually questions about technology:

- How fast can it stop if a kid steps in front? Is the reaction time faster than a human’s?
- How do I program it? Do I have to use MapQuest?
- Does it see potholes and speed bumps?
- Does it only go the exact speed limit?
- Does it know what to do at a flooding location?
- Does it even know that an area has the potential for flooding?
- Do I need to give it specific commands?
- Would they be rentals?
- Is it voice activated?
Interest in Owning Self-Driving Vehicles

There is much uncertainty surrounding the question of whether the self-driving vehicle market will develop as a privately owned vehicle market or a shared-vehicle market. Respondents were asked to assume that self-driving vehicles were available for use today, and were asked, “Would you be more interested in owning one or just using one, like a Car2go or Uber taxi?”

Most (59 percent) indicated they would be more interested in owning a self-driving vehicle than in using one, like a Car2Go or Uber taxi (see Figure 3).

There has been much speculation that with self-driving vehicles, there would be a lot of occupant-free cars on the road because usage would be as shared vehicles—in fleets or within households. But at this early stage in market development, such concepts are not top of mind. The majority of respondents who were interested in owning a self-driving vehicle indicated they would use their self-driving vehicle in the same way as a conventional vehicle—to travel to and from work, errands, and shopping, and to visit family and friends. Only a few people mentioned anything out of the norm. They did not fully grasp the new opportunities that might unfold with ownership of a self-driving vehicle. One individual assumed that an insurance discount would be given because of its enhanced safety functionality, and so he would have his teenage son take the self-driving vehicle. Another said, “I’m the less confident driver, so I would use it.” A couple mentioned that their young children could use it to go to school.

Factors Influencing Intention to Own

An important factor in people’s intention to own a self-driving vehicle was convenience:
• “Convenient to have it when I needed one.”
• “For having it there when I needed it and not having to call someone.”
• “[There are the] same negatives associated with shared vehicles as with public transit like convenience of access and egress.”
• “More freedom to do other things while on my trips.”
• “Would not be interested in using it just here and there. Would want it as my vehicle to use whenever I need it.”
• “If it got to the point where the great majority of the cars on the road were self-driving cars (like Ubers or car shares), then maybe car share but for now it seems inconvenient.”

Also mentioned as a factor in whether people would own or car share was price. While most people thought car sharing would be less expensive (see the subsection “Interest in Shared Self-Driving Vehicles”), a few thought it would be less expensive to own:
• “The cost—would like a discount for new users.”
• “If there were a sharing option, I think it would be more expensive. They take their cost plus a profit.”

Only one or two people mentioned liability, legislation, vehicle size, brand, or rules of the road. On the latter, law enforcement rules were mentioned: “Can I drink and have the vehicle drive me home?”

**Willingness to Pay for Vehicle**

In answer to the question, how much extra would you be willing to pay to own a self-driving vehicle above the average price of a new vehicle—which was about $32,000 in 2014—by far the most frequent response was “a slight amount” as compared to “zero” or a “great amount.” Categorical response options were used for the question rather than monetary units because the technology is so new that answers with exact monetary figures would not be reliable. The information gathered in this question provides insight into the intensity of desire to own and the value placed on self-driving vehicles. That few would be willing to pay a great amount suggests that consumer demand for self-driving vehicles may be soft at present.

Respondents gave varying reasons to support their willingness to pay just a slight amount above the average price for a new vehicle. Some people recognized that the technology “has to cost something.” They said:
• “I’ve generally been willing to pay a small premium for some technologies.”
• “I look at this as an option on the vehicle.”

A few recognized that this specific technology was of value to them:
• “Because not having to drive myself is worth something to me.”
• “I think it would be worth it. I’m getting older. I cannot get out on the road as I used to.”

There were those who could see the value, so they did not say zero, but cost was a factor:
• “Budget constraints. Same reason I don’t own a hybrid car.”
• “Retired; do not think I could afford an expensive car.”

Others did not want to pay for something that was like a novelty to them:
• “Do not have a great need for it; it would be more like a toy. With that, I would not want to pay a whole lot more.”
• “I don’t know if the convenience would justify a big increase in cost.”

Two people said that they would pay a great amount more. Their reasons were tied to perceptions that the technology does not come cheap. One said, “I would expect a 30 to 50 percent increase.” Two people said that they would pay zero. One focused on how quickly autos depreciate in value: “It goes down in value very fast. Just not worth the extra money.” The other factored in the related expenses of upkeep and maintenance.

**Interest in Shared Self-Driving Vehicles**

Many people have speculated that car sharing will be the primary business model for self-driving vehicles. However, among the Austin respondents, fewer were interested in using a shared self-driving vehicle—like Zipcar,
Car2go, or Uber taxi—than in owning one (41 percent and 59 percent, respectively). There were no age or income effects that were associated with interest in car sharing. Two categories of reasons underpinned this choice: gaining experience and cost.

**Gaining Experience and Cost**

By far, most people said that they would want to “try it out to see if I like it.” They would not want to invest in one before experiencing it:

- “To start with, I would do the car share just so I could get experience and gain trust in the vehicle.”
- “Would first want to see how they work and if I liked them.”
- “I already have a vehicle, but it would be nice to have the option of not having to drive myself on long trips.”

Others were budget conscious:

- “The tradeoff of sharing compared to owning a car would be cheaper.”
- “Would rather pay for a vehicle when I need it than have to worry about all the upkeep.”
- “It would be costly to own one, and it would take years to get an older model.”
- “More practical method. If you are not going to control the vehicle, why not use as a mass usage.”

**Willingness to Pay for Shared Vehicles**

In answer to the question, “How much extra would you be willing to pay to access a self-driving car-share vehicle above the average rate of $10 per hour?” by far the most frequent response was “a slight amount” as compared to “zero” or a “great amount.” The main rationale was that they understood that, as a new technology, the cost of accessing a self-driving car share would go up, but they felt there would be cost savings from the economies of scale associated with car sharing and being driverless. One person said, “You are replacing human labor with a computer, so it should not go up too much. When things first come out, they are usually more.”

Three people said they would pay a great amount more. For example, one said, “I would pay double. I would not use it all day since it is by the hour. Would make it worth it.”

Two people said they would pay zero, basically because “I am cheap.”

Regardless of their willingness to pay, many people assumed that, with time, “the price would go down.”

**Impact on Number of Vehicles Owned**

One theory concerning self-driving vehicles is that households will reduce the number of vehicles owned because of the capability to share cars within the household: a self-driving vehicle, for example, could take one worker in the household to work, return to take the second worker, and then ferry children to school. The auto would not be sitting idle during the day in a workplace garage. Interview respondents were asked, “You currently own X number of cars. How would that change if self-driving vehicles were available today?”

In terms of vehicle ownership, three of five respondents (61 percent) indicated that being able to own or access a self-driving vehicle would cause no change in their current vehicle ownership, whereas 23 percent indicated they would reduce the number of vehicles owned. A smaller percentage (16 percent) said they would increase the number of household vehicles (see Table 11).

**Table 11. Change in Number of Vehicles Owned (N=44).**

<table>
<thead>
<tr>
<th>Change</th>
<th>Zero Vehicles</th>
<th>One Vehicle</th>
<th>Two Vehicles</th>
<th>Three or More Vehicles</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No change</td>
<td>1</td>
<td>9</td>
<td>14</td>
<td>3</td>
<td>27 (61%)</td>
</tr>
<tr>
<td>Reduce</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>10 (23%)</td>
</tr>
<tr>
<td>Increase</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>7 (16%)</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>15</td>
<td>19</td>
<td>8</td>
<td>44 (100%)</td>
</tr>
</tbody>
</table>
Respondents who answered “no change” tended to report that they would switch out a conventional vehicle for a self-driving vehicle. Most did not conceive of being able to share the same self-driving vehicle with other household members:

- “We each need to have our own cars because our schedules are different.”
- “[We] need both cars. I work, and my wife takes kids around.”
- “She needs a car, and I need a car.”
- “[We] would get rid of our oldest vehicle and have the self-driving for a back-up if we needed to do two different things at the same time.”

• “[I] would keep my car now and get the self-driving vehicle. It would be less wear on the vehicle and [I would] use the older one when I have time.”

**Impact on VMT**

It is very uncertain if self-driving vehicles would increase or reduce VMT. Some speculate that people would live farther away from work or school because they could do other activities while on their commutes, which would increase VMT per capita. Others believe that self-driving vehicles will be making lots of zero-occupant trips because owners would not want the vehicles to sit idle, which would add to overall VMT. The assumption also exists that the mobility challenged (e.g., elderly or impaired) would travel more often and that this too would increase VMT. On the opposite end of the spectrum, some believe that self-driving car-sharing programs will decrease VMT per capita, as has been found with conventional car-sharing programs (8).

In the online survey, 16 percent of respondents indicated that they drove less than 5,000 miles in 2014, 35 percent reported driving 5,000 to 10,000 miles, 35 percent reported driving 10,000 to 15,000 miles, and 15 percent reported driving more than 15,000 miles in 2014.

In the follow-up, interview respondents were asked, “You now drive X miles in an average week. How would that change if self-driving vehicles were available today?” Most (66 percent) said their annual VMT would stay the same; 25 percent indicated it would increase (see Table 12). Respondents were mostly vehicle drivers. There was only one person who took public transit. None of these individuals had any disability preventing them from driving or were currently non-drivers. Researchers

Table 12. Change in VMT (N=44).

<table>
<thead>
<tr>
<th>Change</th>
<th>Less than 5,000</th>
<th>5,000 to 10,000</th>
<th>10,000 to 15,000</th>
<th>More than 15,000</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay the same</td>
<td>3</td>
<td>4</td>
<td>10</td>
<td>12</td>
<td>29 (66%)</td>
</tr>
<tr>
<td>Increase</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>11 (25%)</td>
</tr>
<tr>
<td>Decrease</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4 (9%)</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>44 (100%)</td>
</tr>
</tbody>
</table>
did not find an age effect in terms of a reported increase in VMT. Those people age 66 and older were no more likely to increase their VMT than other age groups.

People who believe their VMT would “stay the same” do not believe that self-driving vehicles will change their routines, their routes, or their activities:
- “Daily routine would not change.”
- “I do not see doing anything different than I normally do.”
- “[I] will not change my habits just because I have a car that takes me places.”

On the other hand, the people who answered “increase” did think that having a self-driving vehicle would induce travel. Some of this travel would be long-distance or leisure travel, but local travel might increase as well:
- “I would go on more trips since I would not have to drive.”
- “We might take longer day trips. The car could take us there and back.”
- “[Automated vehicles would] give us flexibility to visit friends and family out of town. [We] could go downtown more.”
- “[I] turn down a lot of things because I do not want to drive.”
- “[I] might go out more. [I] could nap on the way there.”

The primary reasons that a few people said they would drive less are they would use car sharing or their travel would probably go from point A to B more efficiently.

Impact on Residential Location
Much speculation surrounds whether people with access to self-driving vehicles would relocate to residences farther from where they work. Most of the sample (80 percent) said they would not change where in the Austin region they live today. People choose where they live for a variety of reasons: price, schools, neighborhood amenities, public services, etc. Access to a self-driving vehicle, at least under their current knowledge of the travel opportunities such a vehicle would bring, would not change their location choice: “I would not move for a car.”

Nine people said they would change where they live. Of these, most would move farther out:
- “[I] might move farther out to get more house for the money and be productive and less stressed on the way to work.”
- “[I] would be able to live farther out but with the convenience of a self-driving car.”

Two people indicated that they would move closer to downtown Austin:
- “I would want to live in the city closer to public services as I get older. I do not like driving in the city now.”
- “Car-share services would more likely be in Austin, so I would need to be closer.”

When asked if the mode of travel for inter-city trips would change if self-driving vehicles were available today, 45 percent said they would change.

Impact on Long-Distance Travel
Of the 44 respondents, 57 percent said they occasionally make inter-city trips in Texas, and 43 percent said they frequently make them. When asked if the mode of travel for inter-city trips would change if self-driving vehicles were available today, 45 percent said they would change. But while the mode would not change, trip frequency would:
- “I might travel more frequently and to different destinations.”
- “I would be willing to make more trips.”
- “I would probably be going on more trips since I wouldn’t have to be the driver.”

Most of the respondents’ travel is in vehicles as a driver or passenger. Only three people said they mostly use air, and of these, two would not change their behavior if self-driving vehicles were available.

These people were also asked if their mode of travel would change for trips outside of Texas. Most people (76 percent) currently travel outside of Texas by air. Forty-two percent
said they would change their mode of travel. Most people said they would probably take the self-driving vehicle more for these trips (rather than air) if the car was fuel efficient and they had the time for the drive:

- “I would probably travel in self-driving vehicles. I could see more, and it may be cheaper than flying.”
- “If it were close enough where the fuel expense was less than a plane, I would take the vehicle.”

Of the people who would not change from air travel to the self-driving vehicle, the main reasons were time and distance:

- “I don’t have the time to drive—[it takes a] full day to drive somewhere and to drive back.”
- “Because of the distances involved.”
- “Time factor; time issues.”

Modeling AV Impact on Travel Demand

Because of the transformative nature of AV technology, this study attempted to quantitatively model the impact on traffic and congestion in the Austin region by answering these questions:

- How might self-driving vehicles on roadways impact traffic and congestion?
- Will people drive more if their vehicle is automated?
- How will people value their travel time if they have AVs?
- Will the travel time be less onerous with the introduction of automation?

Answering such questions is challenging for a number of reasons. As an emerging mode of transportation and a brand-new technology, AVs bring a high level of uncertainty to the field of travel-demand modeling.

Travel-Demand Forecasting Models

Travel-demand forecasting models attempt to replicate the real travel environment, and are used to estimate travel behavior and resulting demand for a specific time in the future. These models help answer the chal-
lenging “what if” policy questions, such as “How might addition of a new transit line impact traffic congestion on a specific route?” Travel forecasting models are computer models—they are complex, based on various assumptions, and built through mathematical formulas. These models are often in need of large amounts of data, and the process of model development starts with the collection of observed data. Given that AVs are not yet part of the transportation system, no observed data are yet available to build (or validate) such forecasting models.

Researchers and agencies have thus been challenged with the question of how to incorporate this new mode of travel into the transportation models to accurately estimate the traffic-related impacts. A recent study by Guerra (9) revealed that only two of the 25 largest metropolitan planning organizations (MPOs) in the United States mentioned automated or connected vehicles in their long-range transportation plans. The study results reveal that MPOs are not yet sure how to plan for and model this future. Apparently, neither the models nor the data yet exist to answer the various questions being raised, but researchers are eager to produce some answers to kick-start future scenarios. The last several years have witnessed attempts to adopt or advance the currently used methodologies to test different automation scenarios. More frequently, these studies applied simpler techniques to offer rough estimations of AV impacts.

**Future Projections of Impact on Travel Demand: A Test Case Using CAMPO Model**

Keeping in mind all the complexities and uncertainties but using the insights obtained from the survey results, a similar approach was undertaken using the Capital Area Metropolitan Planning Organization (CAMPO) 2010 travel-demand forecasting model developed for the Austin region.

The CAMPO travel-demand model is founded on a trip-based approach, which uses individual trips as the unit of analysis. The trip-based approach uses a traditional four-step process:
1. Trip generation—estimates the number of trips that will be made.
2. Trip distribution—estimates where the trips will likely go.
3. Mode choice—estimates how the trips will be divided among the available modes of travel.
4. Trip assignment—estimates the routes that the trips will likely go.

Among these four components, the question of interest (i.e., how the emerging mode of self-driving vehicles will influence travel) can be evaluated within the mode choice step of a trip-based model. This step uses mathematical expressions to allocate trips to the mode people will likely use to travel between their origins and destinations and, by extension, how those choices affect the overall travel in the region. When people are making decisions on which travel mode to use, their decisions are influenced by several factors, such as travel alternatives (e.g., travel time, travel cost, walk access distance, transfers required, or transit fare) or individual and household characteristics (e.g., income, age, number of vehicles owned, or number of children in the traveler’s household).

Researchers and agencies have thus been challenged with the question of how to incorporate this new mode of travel into the transportation models to accurately estimate the traffic-related impacts.

While individuals might place different importance on such variables, travel time has always been identified as one of the most important factors adversely influencing their choice of travel mode. The longer the travel time, the less likely an individual will choose the corresponding mode of travel. This provides a key measure in evaluating the impact of AV technology.

As discussed in the previous sections, people responding to the survey generally indicated positive attitudes toward AVs. While the reasons varied, one of the potentially applicable results was related to the more relaxing and carefree environment that they envision while traveling without the need to drive. Respondents also indicated
that time spent in the car could be more productive. The perceived benefits of the more relaxed, more productive travel options offered by AVs could lead to a decrease in the perceived travel time penalty, particularly for drivers. Thus, the long travel times spent in cars might not be that much of a concern with self-driving vehicles.

Assuming that the travel time will be less onerous with the introduction of automation, different scenarios were tested in the CAMPO model by reducing the sensitivity of travelers to the time they spend inside the vehicle. While results varied by the levels of sensitivity that were tested under different scenarios, the results suggest three main findings. As the sensitivity of individuals to the time spent inside the vehicle is reduced, the model results suggest the following:

- Total daily VMT shows a slightly increasing trend.
- Individuals drive more—the total number of auto trips shows an increasing trend across all categories of auto trips but especially for trips made for home-based work and home-based education purposes.
- Individuals use less transit—the total number of transit trips shows a decreasing trend especially for reliance on the local bus.

Many urban regions suffer from continuing increases in traffic congestion and more time spent traveling. Longer travel times increase traveler frustration, which could lead to changes in individuals’ behaviors, such as shifting to other modes of travel. However, if travel time is less burdensome and more enjoyable, individuals might care less about the time they spend inside the vehicle. Based on the survey results, this can be achieved by self-driving vehicles given the more relaxing and productive travel time the survey respondents assumed would be the case. Based on the model results, such a positive view toward travel time might also indicate a willingness to travel more miles or shift from reliance on transit to a personal auto. An individual might be more willing to tolerate longer travel time if there is congestion since they can use that time more productively and might find the other alternatives, such as taking a local bus, less attractive. This might consequently increase traffic and congestion in the region.

The model results presented here should be evaluated with caution. Besides the data limitations that might prevent obtaining accurate representation of the changes under AV scenarios, the trip-based models (as in the case of the CAMPO model) fall short in responding to policy-sensitive questions that require more behavioral realism, such as how new technology will impact travel behavior. The need for realistic representations of behavior (instead of statistical aggregation of trips) has precipitated a shift in the planning profession from trip-based approaches to more behavioral approaches in travel-demand modeling. Behavioral models might be especially helpful in responding to the shorter-term congestion management policies or in understanding transformations in an environment with new travel options.

Estimating congestion impacts of AVs in the Austin region requires a complex set of structural changes in the CAMPO model. However, the main limitation in confidence of the model results is the lack of observed data for this emerging AV technology, regardless of the modeling approach. The results provided here are intended to serve as a starting point for discussion regarding the broader impacts of implementing AV technology in Austin.
Conclusions

How Likely Are People to Use Automated Vehicles?

The sample was evenly split on intent to use self-driving vehicles, with half likely and half unlikely to use them. This is indicative of the early stages of research into the topic and the fact that the public is aware of but not very knowledgeable about self-driving vehicles. As knowledge increases, it is reasonable to expect the results to tilt in one direction or the other. Many transportation experts expect that the public will tilt toward acceptance and use of self-driving vehicles.

In the survey sample, nearly 7 out of 10 people were in a wait-and-see position, with 36 percent “somewhat likely” to use and 32 percent “somewhat unlikely” to use. Narrow slices of the sample had definite views, with 18 percent being “extremely unlikely” to use and 14 percent being “extremely likely” to use. A segmentation scheme was developed to portray the differences in acceptance and intent to use: Rejecters (extremely unlikely), Traditionalists (somewhat unlikely), Pragmatists (somewhat likely), and Enthusiasts (extremely likely).

The top reason someone was unlikely to use was lack of trust in the technology, and this factor has also been observed in previous research although stated in other ways.

What Are the Factors That Influence Acceptance and Intent to Use?

Further analysis showed that intent to use was higher in some population segments. Interestingly, age was not a significant factor in intent to use, nor was household income. While vehicle ownership per se was not a significant factor, currently owning a vehicle with highly automated features was significant in intent to use. Because people have gained trust in the automated features performing appropriately on the vehicles they own now, they may be predisposed to believe that the self-driving vehicle will perform as required.

Psycho-social variables were important to acceptance and intent to use. A person’s position on the adoption curve was highly correlated with intent to use: Early Adopters were likely Enthusiasts or Pragmatists, and Laggards were likely Rejecters or Traditionalists. Variables such as perceived safety benefits and data privacy were significant in adoption, and the research supports these findings. The more concerned a person was about data privacy issues, the lower his or her intent to use self-driving vehicles. However, desire to feel in control was not associated with intent to use.

A regression model was used to identify the significant predictors of intent to use from among the various demographic, behavioral, and psycho-social variables.
in the study. The model results indicate the only demographic variable associated with intent to use was having physical conditions that prohibit driving. Other variables were psycho-social, such as thinking that using self-driving vehicles would be fun, that there would be a decreased accident risk, and that it would be easy to become skillful at using self-driving vehicles. Unsurprisingly, such findings suggest likely users focus on personal benefits rather than societal benefits. There is also an underlying social aspect to intent to use. Use of social media technology (i.e., text messaging and Facebook) was a stronger predictor than the use of conventional technology, such as emailing and online searching. Social influence was also a strong determinant. This may stem from the car often being regarded as a status symbol, which highlights the connection between intent to use and the social environment.

The model results indicate the only demographic variable associated with intent to use was having physical conditions that prohibit driving.

What Is the Appeal of Self-Driving Vehicles for Consumers?

Those who were likely to use self-driving vehicles were asked, “Why?” While the reasons varied from person to person, the most frequent answers were that the vehicles would:

- Be safer than human drivers.
- Relieve the stress of driving.
- Allow people to be productive while traveling in a car.
- Be like using public transit but better.
- Be the wave of the future.
- Be a mobility enabler for aging seniors.
- Be adequately tested before being placed on the market.

In the same vein, words that likely users used to describe the experience were carefree, relaxing, and convenient; only a few said they would be nervous. Generally, people who currently think they would be likely to use these vehicles view the experience as a positive change. Their biggest worries relate to self-driving system malfunctions or glitches. The questions they had about the technology emphasized that people may be aware of the new technology but not very knowledgeable about it.

In What Ways Would People Change Their Current Travel Behavior?

People can access self-driving vehicles in two ways: personal vehicle ownership or use as a shared vehicle, like an Uber taxi or Car2go. Private ownership was preferred over car sharing by a 3 to 1 margin. For this Austin sample, the shared mobility market was not the desired choice, even though it may be how some self-driving vehicle providers see the market developing.

This research did not reveal the dramatic impacts on travel behavior about which people have speculated, at least not at this point in time when knowledge and experience with the technology are so limited. Most respondents said they would not change their vehicle ownership, VMT, or residence location. Anticipating that people would have a difficult time conceiving of possible changes for a technology they have not experienced, qualitative interviews were conducted, enabling interviewers to clarify and probe respondents’ answers.

In terms of vehicle ownership, in 2012, there were two vehicles per household (median) in Austin. There would be almost no change in the number of vehicles owned due to self-driving vehicles because, at this point in time, most people said that they would switch out one of the conventional vehicles they own for a self-driving one. These people did not conceive of the self-driving vehicle as being able to do double duty within a household. Currently, only about 5 percent of households in Austin have zero vehicles. These survey data do not indicate that this number will grow.

Average annual VMT would stay about the same as well, which was about 25 miles per day per capita. People did

1Double duty in this context means serving the mobility needs of multiple persons in the household because the vehicle could drive itself to and from pick-up and drop-off locations.
not think their routines, their routes, or their activities would change because of the availability of self-driving vehicles. About one in four persons thought their VMT would increase due to induced travel, much of it long-distance or leisure travel. Few if any could conceive of reducing their VMT; those who did cited car sharing as the reason. Few people would change their residential location because of access to a self-driving vehicle; only a small share of respondents would move farther out to get more house for the money. Some would move closer to downtown to access self-driving car-sharing services, which they believe will be more prevalent in the central city.

Many respondents felt they would increase the frequency of their long-distance (inter-city) trips.

Most people could envision large changes in their long-distance travel behaviors when they gain access to a self-driving vehicle. Many respondents felt they would increase the frequency of their long-distance (inter-city) trips. In a future world of self-driving vehicles, one could conceive of more long-distance travel by vehicle beginning and ending in Austin—both of which would impact current conditions.

**How Might Self-Driving Vehicles on Roadways Impact Traffic and Congestion?**

Despite the model’s coarseness at modeling traffic and congestion impacts from AVs, it did show that the new vehicle technologies will likely increase VMT and decrease transit use.

The conventional view of transportation planners and modelers is that travel is a derived demand—not pursued for its own sake but mainly as a means of accessing desired activities in other locations. In other words, people want to do activities and must travel to reach these activities, but they try to minimize the travel while reaching the desired destination.

Because AVs appear to mitigate the penalty of travel, there is the likelihood that travel (VMT) will increase in the future. Additionally, travel in personal vehicles will likely increase, resulting in a reduction of travel by public transportation.
Summary

These results provide some of the first data on the types of people likely to use self-driving vehicles and their rationale. Since self-driving vehicles are not currently commercially available, it is impossible to verify that intention to use will correlate with actual usage. The correlation across a variety of studies in different fields indicates that the CTAM model, used in this study, is capable of predicting actual use and lends credibility to the research approach and findings.

This study began by laying out basic questions about future demand for self-driving vehicles and its impact on travel behavior. These vehicles are not yet on roadways, so it was challenging to capture reliable and accurate information about people’s intent to use and their behavioral responses to its use. Nonetheless, planning for publicly provided goods and services demands collecting such information to develop an evidence base on likely impacts. That said, while respondents were aware of the concept of self-driving vehicles, they were not very knowledgeable about them. Researchers and policy makers are looking for specific impacts on travel behavior, but it is difficult for early research to identify them because the general public is not yet familiar with the new opportunities (or challenges) self-driving vehicles may bring, such as intra-household car sharing, new types of car-sharing fleets, or the challenges of mixed fleets on the road.

This methodology was designed to account for the fact that large portions of the general public are uninformed about self-driving vehicles, and this research points out the lack of public education and outreach on the topic. Realizing that public opinion polls are not substitutes for thought, this study used a two-phased approach of online survey and face-to-face interviews, which was effective. By having people answering questions in a qualitative manner, researchers were able to learn about the respondents’ misconceptions or uncertainties with the technology. This information will be useful for future studies that could replicate this survey within a larger population, such as that of Texas or the nation, to determine whether the findings will remain consistent with a diverse population. The Austin metropolitan statistical area may not be representative of all potential users of self-driving vehicles. Also, future research needs to assess how the determinants perform over time. Acceptance and adoption may be conceived as an experiential factor, and as the vehicles become available, the determinants may change.
References


