AIAA AVIATION Forum
17-21 June 2019, Dallas, Texas
AIAA Aviation 2019 Forum

10.2514/6.2019-2871

A Survey to Model Demand for eVTOL Urban Air Trips and Competition with Autonomous Ground Vehicles

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In this paper, we present details of a survey we designed to model competition among an electric air taxi service, autonomous ground vehicles, and traditional ground vehicles for an urban commuting context in the United States. The survey was administered from March 26 to May 10, 2019 and responses were obtained from 1,405 full-time workers with annual household incomes of at least $75K who reside and work in the Atlanta, Boston, Dallas-Ft. Worth, San Francisco Bay Area, or Los Angeles combined statistical areas (CSAs). The survey targeted individuals with average one-way commutes of 30 minutes or more and quotas were used to ensure a minimum number of responses were collected for different age groups and household income groups.

I. Introduction

Many companies are developing prototypes for electric vertical take-off-and-landing (eVTOL) aircraft to serve as air taxis in cities. At the time of this writing, the Vertical Flight Society, which tracks progress in eVTOL aircraft, had catalogued over 150 eVTOL aircraft in development by different organizations worldwide [1]. Companies are making investments based on the hypothesis that there will be strong consumer demand. However, to date very little work has been published about the potential demand for eVTOL air taxi services. As noted in Garrow et al., "demand estimation is challenging because, as an entirely new transportation mode, there is no past market data that would facilitate estimates" [2]. In these cases, it is common to design stated preference surveys and ask consumers what mode they would take under hypothetical situations. In 2018, we conducted a stated preference survey that was focused on understanding market size and willingness to pay for an on-demand commuting air taxi service for high-income individuals in five U.S cities under a near-term scenario representing the insertion of eVTOL into *current* market conditions, i.e., an electric air taxi service and traditional ground vehicles. In this paper, we describe a second survey that is an extension representing a longer-term scenario of *future* market conditions, i.e., competition among electric air taxis, autonomous ground vehicles, and traditional ground vehicles. We published the details of our first survey in the 2018 AIAA conference proceedings [3]. The 2018 and 2019 surveys overlap in several ways, e.g., they sample individuals from the same U.S. cities and have numerous questions in common. For these reasons, we draw text directly from our 2018 paper to provide the reader with a self-contained description of our 2019 survey.

II. Sampling Plan

We used a commercial opinion panel to survey commuters in five metropolitan areas in the U.S. Specifically, we included individuals who had a home and work zip code within the Census-defined Combined Statistical Areas (CSAs) for Atlanta, Boston, Dallas/Ft. Worth, the San Francisco Bay Area, and Los Angeles, shown in Figure 1. (See [4-12] for the TIGER/line® road, county, and CSA shapefiles we used to generate Figures 1-6). We surveyed 1,405 individuals with household before-tax annual incomes of at least $75,000 and average one-way commute times of at

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least 30 minutes. We applied minimum quotas on household incomes and age as shown in Tables 1 and 2. Note that the household income quotas are specific to each CSA whereas the age quotas are applied across the entire sample. In general, we met the majority of our target quotas, with some minor under-sampling in Dallas and among those ages 18-24 as shown shaded in the tables. Also, given the 2018 and 2019 surveys focused on different times in the future (with the 2018 survey focused on near- to mid-term adoption and the 2019 survey focused on longer-term adoption), we intentionally included a wider range of household incomes in the 2019 survey. The total cost of the survey was $24,050 (excluding overhead and survey programming costs).

Figure 1. Survey Cities

Table 1. Household Income Quotas (Actual Obtained) by CSA

	$75-$99K	$100-$149K	$150-$199K	$200K or more	TOTAL
Atlanta	65 (74)	65 (66)	65 (64)	65 (65)	260 (269)
Boston	65 (71)	65 (84)	65 (68)	65 (77)	260 (300)
Dallas-Ft. Worth	65 (63)	65 (67)	65 (63)	65 (56)	260 (249)
Los Angeles	65 (67)	65 (78)	65 (82)	65 (77)	260 (304)
San Francisco	65 (71)	65 (67)	65 (76)	65 (69)	260 (283)
TOTAL	325 (346)	325 (362)	325 (353)	325 (344)	1300 (1405)

Table 2. Age Quotas Applied Across the Sample

18-24	25-34	35-44	45-54	55+	TOTAL
100 (97)	300 (296)	300 (381)	300 (316)	300 (315)	1250 (1405)

Our motivations for selecting the five CSAs (which are identical to those included in the 2018 survey) are described below.

Figure 2. Atlanta CSA

Atlanta is a land-locked city in the Southeast that has no geographic features that help prevent outward growth expansion in the region. The sprawling region provides a spoke interstate system to different areas of the region and has many large employment centers along the Interstate 285 perimeter that surrounds Atlanta. The automobile-dominant mode share of the region, combined with the lack of natural boundaries that limit outward expansion and the spoke interstate feature, set the region apart from the other survey cities.

Boston is a city on the East Coast that is part of the Northeast Corridor. The Boston CSA has geographic features and transportation alternatives that influence commute patterns. The Boston CSA borders the Atlantic Ocean and includes parts of Connecticut, New Hampshire, Massachusetts, and Rhode Island. The City of Providence, Rhode Island lies within the Boston CSA. The Boston Harbor, Cape Cod Bay, and Charles River are all geographic features that affect commute patterns and commute times. The transit mode share is higher in the Boston region than for any other CSAs in our survey.

Figure 3. Boston CSA

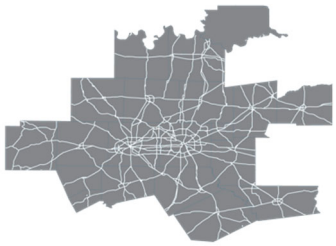


Figure 4. Dallas-Ft. Worth CSA

Dallas-Ft. Worth is similar to Atlanta in that it lacks geographic features that limit sprawl and influence development patterns. Distinct from Atlanta, the interstate network was constructed in a grid-pattern between Dallas and Ft. Worth with many large business-attracting areas between the cities near the City of Arlington and along the perimeter of the cities. Dallas is one of two cities in the U.S. that Uber selected for testing eVTOL flights [13].

Los Angeles is the second city in the U.S. that Uber selected for testing eVTOL flights [13], and is one of two West Coast cities included in our study. The region is infamous for long commute times and for having one of the most congested interstate systems in the nation [14]. Los Angeles has geographic features that act as barriers to development in particular areas of the region, e.g., the CSA borders the Pacific Ocean and has terrain features (such as mountains) that impact where development occurs and where the transportation network can be located. Los Angeles is unique among the other cities in that from the 1970s until 2014, it had regulations requiring buildings above a certain height to have a heliport on their roof to assist in evacuations [15]. This sets Los Angeles apart from other cities in that it already has an existing infrastructure in a downtown area that could potentially be converted to vertiports.

Figure 5. Los Angeles CSA

Figure 6. San Francisco CSA

Finally, the San Francisco CSA was chosen because of its unique geographic features and reputation as an incubator of new technologies [16]. The Bay Area has three major cities (Oakland, San Francisco, and San Jose) within the San Francisco CSA. The San Francisco Bay only has four existing bridge crossings from the East Bay to areas in San Francisco and the cities of Silicon Valley. This physical barrier makes for challenging commutes and could be an ideal pattern for future eVTOL air-taxi service. There are also key geographic features in the terrain that impact the location of existing transportation connections along the interstates, highways, and transit.

III. Survey Instrument

The survey instrument contained nine parts. It included approximately 100 questions in all, but some questions were not shown to all respondents, e.g., respondents were only asked if they made a transfer on their commute to work if they indicated that they typically commute to work using a transit mode. Appendix 1 provides complete details of the survey instrument and associated programming logic described in this section.

A. Institutional Review Board Consent

The first section contains the required Institutional Review Board (IRB) statement, provides compensation information, and asks respondents whether they agree to participate in the study. We stated that as a participant, "You will be asked to complete a survey that asks you about your attitudes and current travel patterns." We did not explicitly refer to an air taxi service in the introduction, to minimize biasing recruitment (people may have been less inclined to respond if they had no interest in the service) and results (those who did respond may have been more likely to answer favorably toward questions involving air travel service if they knew that was our primary interest in conducting the survey).

B. Screening Questions

The second section contains screening questions. Only those individuals who were full-time workers, traveled to a work location outside the home at least two days per week, had a minimum one-way commute time of 30 minutes, and had an annual household income of at least $75K were eligible to participate in the study. Individuals employed by an airline were excluded on the assumption that the travel benefits they may receive would bias our assessment of current travel patterns. We used the home and work zip codes to ensure that the respondent lived and worked within one of the five CSAs included in the study.

C. Opinions about Travel

The third section of the survey asked participants about their views on a variety of issues directly or indirectly related to travel. We use the questions in this section (as well as those collected later in the survey) to conduct factor and cluster analyses, which will provide insights into the types of consumers for which air taxi service is most attractive. (See Garrow, Mokhtarian, German and Glodek [2] for the market segmentation we conducted on our first survey).

To conduct a factor analysis, we first identify constructs that we hypothesize will influence demand for air taxi services. We include ten constructs in this section, shown in Table 3. Twenty questions were asked, to obtain measurements associated with these constructs. For each question, respondents reported how much they agree or disagree with the statement using a Likert-type scale with five categories: strongly disagree, disagree, neutral, agree, and strongly agree. The questions in this section are identical to those we asked on the 2018 survey, with the exception that we added two questions related to commute benefit (shaded on the table) as we hypothesize that the trade-offs between self-driving cars and an air taxi service may be related to perceived levels of productivity while commuting. We also modified the motion sickness question to be more general versus specific to traveling in an aircraft.

In factor analysis, it is common to ask at least two questions associated with each construct, and preferable to vary the directionality of the questions to be (collectively) both "positively" and "negatively" associated with a given construct. Stated another way, the wording of the two questions associated with the construct is designed so that an individual who selected "agree" or "strongly agree" on one question would tend to select "disagree" or "strongly disagree" on the other question. The questions were ordered differently in the survey than in Table 3, to minimize the consistency bias associated with having the items pertaining to the same construct adjacent to each other, to counteract respondents' tendencies to fall into an automatic response pattern (e.g. a predictable alternation of positively and negatively oriented questions), and to reduce any unintended carryover effects from one question to the next.

Finally, we included a "trap question" in this section, in which we asked participants to select "disagree" to confirm they were reading the questions. We terminated the survey for those who did not select the correct response, given it is more likely these individuals were not paying attention to the survey questions (and would potentially obscure the true relationship if they completed the entire survey).

Table 3. Constructs and Survey Questions Related to Opinions about Travel

Survey Question	Construct	Direction
I am fine with not owning a car, as long as I can use/rent one any time I need it	Car-oriented	-
I need a car while I am at work	Car-oriented	+
Whenever practical I prefer to walk rather than drive	Mode preference	+/-
Whenever practical I would prefer to take transit rather than drive	Mode preference	+/-
I would take transit more often if I had a guaranteed ride home when I had to leave work late	Mode preference	+/-
I like traveling by airplane	Mode preference	+
Traveling by air makes me nervous	Mode preference	-
My trips to and from work are generally pleasant	Commute benefit	+
My trips to and from work are stressful	Commute benefit	-
I wish I could instantly be at work – the trip itself is a waste of time	Commute benefit / productivity	-
My commute is a useful transition between home and work	Commute benefit	+
I would tend to feel sick if I tried to read while on a vehicle	Motion sickness	+
I rarely consider the impact of the environment in my daily choices	Pro-environment	-
I limit my driving to help improve air quality	Pro-environment	+
Traveling by car is safer overall than taking transit	Driving/car safety	+
Using a ride-sharing service, such as Lyft or Uber, is safer overall than driving	Driving/car safety	-
Using a ride-sharing service, such as Lyft or Uber, is more convenient overall than driving	Ridesharing convenience	+
If I were to use a ride-sharing service, such as Lyft or Uber, I would have to wait too long to be picked up	Ridesharing convenience	-
I would usually rather have someone else who is trustworthy do the driving	Control	-
Being in a car makes me nervous if someone else is driving	Control	+

Note: Shaded lines are new items we added on the 2019 survey compared to the 2018 survey.

D. Current Commute and Air Travel

The fourth section of the survey asked questions about the individual's current commute and current air travel including:

- The typical travel mode taken to work
- The typical departure times at which the individual left home for work and left work for home
- Whether the individual typically made stops on the way to and/or from work
- Whether the individual had taken a ride-sharing service and if so, how the individual typically used these services
- Congestion levels near the individual's home and work locations during the two commuting periods
- How many annual air trips the individual typically makes

Based on insights gained from focus groups, we found that individuals who owned battery-operated automobiles were warier of battery-operated aircraft [17]; thus, we included questions about whether the individual owned or leased a battery-powered vehicle and if so, whether it was used in a high-occupancy vehicle lane to reduce commute time.

E. Introduction to Self-Driving Cars

The fifth part of the survey introduced the concept of self-driving cars and showed participants three images based on designs reported in the press that showed individuals sleeping, reading or working on a tablet, and interacting with a large screen. See [18-20] for these images, which are not included in this paper due to copyright restrictions. We

edited these images for the survey, e.g., we removed a steering wheel to better reflect a fully-autonomous vehicle. We used a bullet-pointed list to describe the self-driving cars. The description included the following:

- Driverless cars would be at least as safe as today's cars are, and would be generally affordable.
- The car could be equipped with services such as an office, a television, or a small fridge for snacks.
- The car could be equipped with power outlets to keep your laptop and phone fully charged.
- You could send an empty self-driving car somewhere to pick up children or groceries, or to park after dropping you off at work or other locations.
- You could let a self-driving car take you places while you are sleeping.

Based on this initial description, we asked individuals how appealing self-driving cars were to them, how likely they would be to *use* a self-driving car, and how likely they would be to *own* a self-driving car. We asked two questions related to productivity on individuals' current commute. We then presented respondents with potential features of the self-driving cars and asked them if they would be more or less likely to use it with these characteristics. The tested features focused on privacy and productivity dimensions and included the following:

- You own the self-driving car
- You arrange for a pick-up from a rideshare company (such as Lyft or Uber) and travel alone
- You arrange for a pick-up from a rideshare company and share with people you know
- You arrange for a pick-up from a rideshare company and share with strangers
- You could use your phone to talk, text, and access the internet
- You could do work on your laptop
- You could sleep
- The ride quality (such as noise, potholes, and stops) is similar to that of your current commute

Finally, we asked whether self-driving cars would influence any mid- to long-term decisions, such as where to live or how many ground vehicles to own or lease.

F. Introduction to Air Taxi Service

The sixth part of the survey introduced the concept of eVTOL aircraft for air taxi service. This section was designed to be very similar to the structure used to introduce self-driving cars, to help minimize bias the respondent may perceive towards one of these new modes. We showed participants four images based on designs reported in the press (see [21-24] for these images, which are not included in this paper due to copyright restrictions). We used a bullet-pointed list to describe the aircraft and included information about the design, operation, and safety features based on questions participants in our prior focus groups asked [17]. The description included the following:

- Are battery powered
- Carry two to four passengers
- Travel within a city at cruise speeds of 150 mph
- Could be used for getting to and from work faster
- Have efficient security checks with no lines
- Take off and land vertically like a helicopter
- Take off and land at locations in a city such as tops of buildings and parking decks
- Have a ride quality and cabin noise level similar to large aircraft
- Are much quieter than helicopters, both for the community and for the occupants of the aircraft
- Travel at about the altitude where traffic helicopters fly
- Are flown by certified pilots
- Do not fly in hazardous weather conditions (such as thunderstorms)
- Meet stringent safety requirements mandated by the U.S. Federal Aviation Administration

Based on this initial description, we asked individuals how appealing the design was to them and how likely they would be to use it. We then presented respondents with potential features of the eVTOL aircraft and asked them if they would be more or less likely to use it with these characteristics. The tested features included fuel/battery combinations, a parachute for the aircraft, multiple propellers for redundancy, noise levels, and ride quality. Also,

given that pilots of small aircraft need to pay attention to the total weight they are carrying, we asked if respondents would be more or less likely to take an eVTOL aircraft if they had to be weighed on a scale or if they had to verbally state their weight to an agent. We further asked whether their decision to take an eVTOL aircraft for commuting would be influenced by the availability of the air taxi service (which would not be able to operate in bad weather) and the availability of a ride guarantee in the event the eVTOL could not operate. We asked whether this air taxi service would influence any mid- to long-term decisions, such as where to live or how many vehicles to own or lease. We conclude by asking six questions related to eVTOL perceptions (reaction to battery technologies, pros/cons of proximity, and overall impressions, shown in Table 4.

Table 4. Constructs and Survey Questions Related to Perceptions about eVTOL Aircraft

Survey Question	Construct	Direction
I like that these aircraft can take off and land close to my home and work locations	Proximity	+
I would be concerned to fly in an aircraft that takes off and lands vertically within a city with tall buildings	Proximity	-
I like the idea of battery-powered aircraft for helping the environment	Battery technology	+
I would be concerned to travel in a battery-operated aircraft	Battery technology	-
I would find it exciting to travel in one of these eVTOL aircraft	Overall impression	+
These aircraft would cause more problems than they would solve	Overall impression	-

G. Trade-off Questions

The seventh part of the survey contained nine questions as shown in Figures 7 and 8 (these images, and others included in the survey, are reprinted here from the Creative Commons Attribution license [25-28]). Each question presented two hypothetical options for commuting and asked which one the respondent would choose. The first option had features similar to the respondent's current trip, the second option was a trip via a self-driving car, and the third option was a trip on a new eVTOL aircraft.

In designing these trade-off questions, there are several decisions the researcher needs to make: how many options should be included in each question? What attributes should be included with each option? For each attribute, what range of values (referred to as levels) should we include? And, how many trade-off questions should we ask respondents?

Given the length of our survey, we decided to keep these trade-off questions as "simple" as possible. We customized the trade-off questions to be representative of the individual's current typical commute.

Figure 7. Transit, Self-Driving Car, Piloted Air Taxi

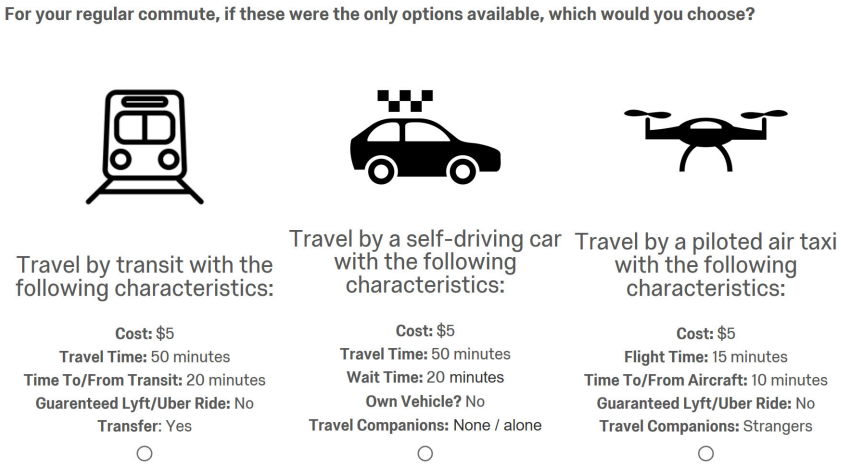
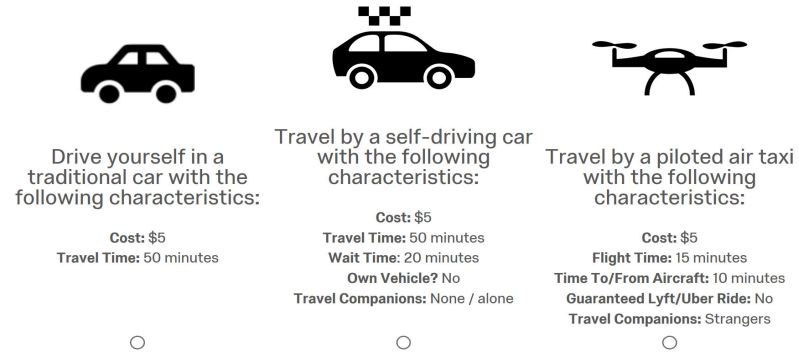


Figure 8. Traditional Car, Self-Driving Car, Piloted Air Taxi



We included multiple factors in our model. Given our primary objective is to estimate commuters' willingness to pay, we wanted to ensure: (1) the travel times for the non-eVTOL modes were comparable to those currently experienced by the respondent; (2) the travel times for the eVTOL flights spanned the range of values researchers anticipate will be needed for profitability and are typically (but not always) lower than those for the non-eVTOL modes;[5] and, (3) the costs for the non-eVTOL modes are typically (but not always) lower than those for the eVTOL mode and are bounded by the cost of a transit fare across the study areas. To achieve these goals, we customized time and cost for each of the modes based on distance bands. In particular, we used the reported home and work zip codes to place the individual into one of four distance categories (using the centroids of the zip codes and a straight-line distance calculation): 0-24 miles, 25-39 miles, 40-54 miles and 55 or more miles. We set the minimum travel time at 30 minutes and the maximum travel time at two hours for the non-eVTOL modes. Given statements by Uber that they are targeting 150 mph for initial air taxi service and up to 200 mph in the longer term as batteries improve, we used design speed of approximately 150 – 175 knots (corresponding to about 170 – 200 mph) for estimating eVTOL flight times [29].Table 5 summarizes the travel times used in the survey. Note we used the same travel times for the transit and rideshare modes.

Table 5. Travel Times Used in Survey

Distance (miles)	Level 1				Level 2				Level 3				Level 4			
	AIR	CAR	TR	AV	AIR	CAR	TR	AV	AIR	CAR	TR	AV	AIR	CAR	TR	AV
0 – 24	0:15	0:30	0:30	0:30	0:25	0:40	0:40	0:40	0:30	0:50	0:50	0:50	0:40	1:00	1:00	1:00
25 – 39	0:15	0:30	0:30	0:30	0:25	0:45	0:45	0:45	0:30	1:00	1:00	1:00	0:40	1:15	1:15	1:15
40 – 54	0:20	1:00	1:00	1:00	0:30	1:15	1:15	1:15	0:40	1:30	1:30	1:30	0:45	1:45	1:45	1:45
55+	0:25	1:00	1:00	1:00	0:45	1:30	1:30	1:30	0:45	1:45	1:45	1:45	1:00	2:00	2:00	2:00

Note: AIR=eVTOL, CAR=traditional (non-autonomous) car; AV=self-driving car, TR=transit.

Deciding on the range of cost values to be tested was the most challenging part of the survey design. Costs – as well as travel times – vary by multiple factors. For example, the costs of a transit ride for the T in Boston or MARTA in Atlanta are $3.00 and $2.50, respectively, and do not vary with distance. In reality, the cost of travel by auto varies within the study areas. According to Gas Buddy, on May 1, 2018 the national gas price average was $2.82 per gallon; within our study areas it was $2.66 in Dallas, $2.76 in Atlanta, $2.83 in Boston, $3.66 in Los Angeles, and $3.72 in San Francisco [30]. The fuel efficiency of the individual's auto will also impact commuting costs. To accommodate the large variation in costs, we set the costs associated with a one-way commute within a lower bound equal to that of a transit pass in Atlanta ($2.50) and an upper bound of $20.

We set the range of prices of the eVTOL ride based on estimates reported in conferences. Most recently, Uber shared that they were targeting eVTOL prices of $5.73 per passenger mile at launch, $1.84 per passenger mile in the near term, and $0.44 per passenger mile in the long term [31]. To put this in context the average operating cost of helicopters is $8.93 per passenger mile and the average cost per mile of auto ownership in 2017 was $0.592 [31, 32]. We recognize that the costs we used in the survey are higher than those used in other studies (e.g., see [33]) and that

[5] We allow for the possibility in the survey design that the door-to-door travel time on eVTOL is higher than the door-to-door travel time on non-eVTOL modes.

it is unrealistic to expect a large number of individuals to pay $90 per day for a round-trip commute (of more than 55 miles one-way). However, given that our goal is to determine if there is a viable market for launching air taxi service before the long-term costs per passenger mile are realized, we set the prices in a range we believe would be realistic in the mid-term and targeted our sampling plan to higher-income individuals with long commutes – i.e. those with both the motivation and the means to pay a premium for a shorter commute. Table 6 summarizes the costs used in the survey. Note we used the same costs for the transit and rideshare modes.

Table 6. Costs (in USD) Used in Survey

Distance (miles)	Level 1				Level 2				Level 3				Level 4			
	AIR	CAR	TR	AV	AIR	CAR	TR	AV	AIR	CAR	TR	AV	AIR	CAR	TR	AV
0 – 24	5	2.50	2.50	2.50	5	2.50	2.50	2.50	10	5	5	5	10	5	5	5
25 – 39	5	2.50	2.50	2.50	10	3	3	3	15	4	4	4	20	5	5	5
40 – 54	10	4	4	4	20	6	6	6	30	8	8	8	40	10	10	10
55+	20	5	5	5	25	10	10	10	35	15	15	15	45	20	20	20

Note: AIR=eVTOL, CAR=traditional (non-autonomous) car; AV=self-driving car, TR=transit.

In addition to travel time and cost, we included access/egress times, wait times, guaranteed ride availability, and transfers. Table 7 summarizes these factors and how they relate to the underlying survey design, i.e., the "other travel time component" is referred to as "time to/from eVTOL," "time to/from transit," and "wait time" for the eVTOL, transit, and self-driving car modes, respectively. We assumed that the traditional auto alternative did not include access and egress times.

Given the number of attributes in our trade-off questions, combined with the number of levels that we wanted to test, we would have had to ask each individual respondent 32 trade-off questions, which clearly is not realistic. In these cases, it is common to create blocks of questions so that each respondent sees no more than eight tradeoff questions. Respondents are then randomly assigned to one block (which contains eight questions). We created a total of 128 trade-off questions, representing a total of 4 distance ranges × 4 blocks × 8 questions per block. Table 7 summarizes the attributes and levels used in the survey. Appendix 2 shows which levels correspond to each of the 128 trade-off questions. Because we did not vary time or cost across the transit and self-driving auto modes, we used the same 128 trade-off questions for the blocks that asked respondents to make trade-offs among *traditional auto*, self-driving cars, and eVTOL and for the blocks that asked respondents to make trade-offs among *transit*, self-driving cars, and eVTOL. That is, the factors and levels we used are identical; we only changed the image shown, the labeling of the "other" travel time components, and which attributes were shown (based on which attributes were relevant to the transit versus self-driving modes).

Table 7. Other Attributes and Their Levels Used in the Survey

Additional Features	L1				L2				L3
	AIR	CAR	TR	AV	AIR	CAR	TR	AV	AV
Other travel time component labeled as (in min):		N/A				N/A			
Time to/from aircraft	10				20				
Time to/from transit			10				20		
Wait time				10				20	N/A
Ride guarantee	Yes	N/A	Yes	N/A	No	N/A	No	N/A	N/A
Transfer	N/A	N/A	Yes	N/A	N/A	N/A	No	N/A	N/A
Own vehicle?	N/A	N/A	N/A	Yes	N/A	N/A	N/A	No	N/A
Travel companions	Strangers	N/A	N/A	Strangers	People you know	N/A	N/A	People you know	Alone

Note: AIR=eVTOL, CAR=traditional (non-autonomous) car; AV=self-driving car, TR=transit. Note: Travel companions and wait times for AV are shown only if "Own vehicle?" is Yes.

Finally, as part of this section we kept track of the number of times the respondent selected the eVTOL option and asked if there was anything that would have changed the respondent's mind or any circumstances under which the respondent would have selected an eVTOL option more often.

H. Personality and Lifestyle Questions

The eighth part of the survey asked questions focused on personality and lifestyle characteristics, similar to those described in Section C. We included ten constructs, shown in Table 8, that we hypothesize will help predict individuals' willingness to take an air taxi service and a self-driving car. We drew some of the constructs from a recent study of self-driving cars [34] and another study on the sharing economy [56]. In contrast to our 2018 survey, we included several new constructs specific to work privacy concerns, technology concerns, personal safety concerns, time pressure, wait tolerance, and travel sociability (represented by the grey rows on Table 8) that we hypothesize will differ across individuals and influence their mode choice. We only included one question associated with the subjective well-being construct. This section also included a trap question. We did not terminate the survey if the respondent answered the trap question incorrectly, but will use it to identify potential respondent fatigue. As in Part C and for the same reasons, the questions were ordered differently in the survey than in Table 8.

Table 8. Constructs and Survey Questions Related to Personality and Lifestyle

Survey Question	Construct	Direction
I like the idea of living somewhere with large yards and lots of space between homes	Pro-high density	-
I like the idea of living in a neighborhood where I can walk to shops	Pro-high density	+
My phone is so important to me, it's almost a part of my body	Technology dependence	+
I often introduce new trends to my friends or family	Technology/early adopter	+
I like to wait a while rather than being the first to buy new products	Technology/early adopter	-
I am generally satisfied with my life	Subjective well being	+
I am concerned that my personal or work information may be seen by others if I use a public internet connection	Privacy concern (work)	+
Generally, I feel comfortable talking about work when I'm near other people in a public place	Privacy concern (work)	-
I like it that companies can tailor products to my preferences, even though it requires me to provide personal information	Technology concern	-
I'm worried that technology invades my privacy too much	Technology concern	+
I would generally be concerned about my personal safety if sharing a ride with people I don't know	Personal safety concern	+
I am comfortable that I could handle unwanted physical contact that might arise from other people in a shared vehicle	Personal safety concern	-
I feel like I need to make the most of every minute	Time pressure	+
I never get very far behind on the things I'm trying to get done	Time pressure	-
Having to wait can be a useful pause in a busy day	Wait tolerance	+
Having to wait is an annoying waste of time	Wait tolerance	-
I like meeting new people through ridesharing	Travel sociability	+
I'm uncomfortable traveling in the same car with strangers	Travel sociability/Personal safety	-/+

Note: Shaded lines are new items we added on the 2019 survey compared to the 2018 survey. Constructs related to a leisure-oriented lifestyle and trust were removed as they did not load on the 2018 survey.

I. Additional Socio-economic Information

We conclude the survey by asking for socio-demographic and socio-economic information that we did not obtain in the earlier parts of the survey we used to screen individuals or customize survey questions. These questions included gender, education level, number of adults, and number of children ages 17 and younger living in the household.

IV. Next Steps/Conclusion

This paper described the sampling plan and survey instrument we will use to forecast commuting demand for eVTOL flights. The inclusion of perceptual and attitudinal constructs and socio-demographic characteristics will enable us to understand how individuals' perceptions and attitudes influence demand for commuting air taxi service and how these perceptions and attitudes are correlated with socio-demographic characteristics.

Appendices

Appendix 1 contains the survey instrument and Appendix 2 contains the values of time and cost we used in the trade-off questions.

Acknowledgments

This work was supported in part by National Institute of Aerospace task order 601047. The authors are grateful to Sung Hoo Kim, who provided the edited images for the self-driving cars and Wenhui Yang who prepared the guaranteed ride images.

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Appendix 1: Survey Instrument

PART A: IRB CONSENT FORM

The Institutional Review Board (IRB) consent form is shown to participants and they can agree/disagree to participate in the study.

[Programming note: If individual does not agree to participate in survey, then terminate]

PART B: SCREENING QUESTIONS

1. What is your five-digit home zip code?

[Programming note: If home zip code does not belong to the study area, then terminate]

2. What is your five-digit work zip code? If you have multiple work locations, please enter the zip code of the primary location.

[Programming note: If work zip code does not belong to the study area, then terminate; both home and work zip codes have to be in the same CSA]skx

3. How many minutes did it usually take you to get from ***home to work*** last week (or the most recent week you worked)?

- ○ 1 - 15 minutes
- ○ 16 - 29 minutes
- ○ 30 - 44 minutes
- ○ 45 - 59 minutes
- ○ 60 or more minutes

[Programming note: If less than 30 minutes, then terminate]

4. How many minutes did it usually take you to get from ***work to home*** last week (or the most recent week you worked)?

- ○ 1 - 15 minutes
- ○ 16 - 29 minutes
- ○ 30 - 44 minutes
- ○ 45 - 59 minutes
- ○ 60 or more minutes

5. What was your total HOUSEHOLD income during the PAST 12 MONTHS? (This is the income earned before taxes and deductions.)

- ☐ $0 - $74,999
- ☐ $75,000 - $99,999
- ☐ $100,000 - $149,999
- ☐ $150,000 - $199,999
- ☐ $200,000 or more

[Programming note: If less than $75,000, then terminate]

6. What is your age in years?

- ☐ 17 and younger
- ☐ 18 - 24 years
- ☐ 25 - 34 years
- ☐ 35 - 44 years
- ☐ 45 - 54 years
- ☐ 55 - 64 years
- ☐ 65 and older

[Programming note: If less than 18, then terminate]

7. What is your current employment situation? Please check ***ALL*** that apply.

- ☐ I work full-time for pay
- ☐ I work part-time for pay
- ☐ I am a homemaker / caregiver
- ☐ I am retired
- ☐ I do not work
- ☐ Other

[Programming note: If work full-time is not selected, then terminate]

8. How many days per week do you typically go to a workplace outside your home?

- ○ None
- ○ One
- ○ Two
- ○ Three
- ○ Four
- ○ Five
- ○ Six
- ○ Seven

[Programming note: If individual selects none or one, then terminate]

9. Are you an airline employee?

- ○ Yes
- ○ No

[Programming note: If individual selects yes, then terminate]

PART C: YOUR OPINIONS ABOUT TRAVEL

In this section, we ask about your views on a variety of issues directly or indirectly related to travel. For each of the following statements, please check the response that best expresses your opinion.

[Programming note: Questions 10-30 are shown as individual questions but were displayed to respondents in a matrix format; the matrix was split so that no more than six questions were displayed in the same matrix to help ensure that the response labels could be seen at all times.]

10. My trips to and from work are generally pleasant

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

11. Using a ride-sharing service, such as Lyft or Uber, is more convenient overall than driving

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

12. I need a car while I am at work

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

13. I would usually rather have someone else who is trustworthy do the driving

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

14. I rarely consider the impact on the environment in my daily choices

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

15. I like traveling by airplane

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

16. I wish I could instantly be at work - the trip itself is a waste of time

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

17. Whenever practical, I would prefer to take transit rather than drive

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

18. If I were to use a ride-share service, such as Lyft or Uber, I would have to wait too long to be picked up

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

19. Whenever practical, I prefer to walk rather than drive

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

20. My commute is a useful transition between home and work

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

21. Traveling by car is safer overall than taking transit

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

22. I would take transit more often if I had a guaranteed ride home when I had to leave work late

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

23. Traveling by air makes me nervous

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

24. I limit my driving to help improve air quality

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

25. Being in a car makes me nervous if someone else is driving

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

26. I would tend to feel sick if I tried to read while in a moving vehicle

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

27. My trips to and from work are stressful

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

28. To confirm you are really reading this, please select "Disagree"

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

[Programming note: If individual does not select disagree, then terminate survey]

29. I am fine with not owning a car, as long as I can use/rent one any time I need it

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

30. Using a ride-sharing service, such as Lyft or Uber, is safer overall than driving

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

PART D: YOUR CURRENT COMMUTE AND AIR TRAVEL

The questions in this section relate to various aspects of your current trips to and from work and your current air travel.

31. How did you usually get to work *LAST WEEK*? *If you usually used more than one method of transportation during the trip, choose the one used for most of the distance.*

- ☐ Car, truck, or van, (EXCEPT taxi, Lyft/Uber, or similar)
- ☐ Taxicab
- ☐ Rideshare (Lyft/Uber)
- ☐ Bus or trolley bus
- ☐ Streetcar or trolley car
- ☐ Subway or elevated train
- ☐ Railroad
- ☐ Ferryboat
- ☐ Motorcycle
- ☐ Bicycle
- ☐ Walking
- ☐ Worked at home
- ☐ Other method (specify) [ ]

[Programming note:
If individual selects bus or trolley bus, streetcar or trolley car, subway or elevated train, railroad, or ferryboat then go to Question 32
Else go to Question 33]

32. Did you make any transfers?

- ☐ Yes
- ☐ No

33. What time did you usually ***leave home*** to go to work *LAST WEEK (or the most recent week you worked)*?

Departure Time [▼]

[Programming note: dropdown options include 12:00-5:59 AM; 6:00-6:29 AM; 6:30-6:59 AM; 7:00-7:29 AM; 7:30-7:59 AM; 8:00-8:29 AM; 8:30-8:59 AM; 9:00 AM-2:59 PM; 3:00-5:59 PM; 6:00-8:59 PM; 9:00-11:59 PM]

34. What time did you usually ***leave work*** *LAST WEEK (or the most recent week you worked)*?

Departure Time

[Programming note: dropdown options include 12:00-5:59 AM; 6:00-8:29 AM; 9:00 AM-2:59 PM; 3:00-3:29 PM; 3:30-3:59 PM; 4:00-4:29 PM; 4:30-4:59 PM; 5:00-5:29 PM; 5:30-5:59 PM; 6:00-6:29 PM; 6:3-6:59 PM; 7:00-7:29 PM; 7:30-7:59 PM; 8:00-8:29 PM; 8:30-8:59 PM; 9:00-11:59 PM]

35. For each of the following segments of your ***usual*** trip to or from work, please select the option that most closely describes the conditions you experience

	Little to no congestion	Minor congestion	Moderate congestion	Heavy congestion
Near your home when you ***leave*** for work?	☐	☐	☐	☐
Near your work when you ***arrive*** for work?	☐	☐	☐	☐
Near your work when you ***leave*** for home?	☐	☐	☐	☐
Near your home when you ***arrive*** home?	☐	☐	☐	☐

36. Do you regularly make stops on the way to and/or from work?

- ☐ Yes
- ☐ No

37. How often do you use ride-sharing services (in any city), such as Lyft or Uber?

- ☐ I have never used a ride-sharing service
- ☐ Once a week or more often
- ☐ Two or three times a month
- ☐ About once a month (12 times a year or so)
- ☐ About four to eleven times a year
- ☐ About two or three times a year
- ☐ About once a year
- ☐ Less than once a year

[Programming note: If response not equal to Never, go to Question 38, otherwise go to Question 39]

38. Which of the following explains how you use ride-sharing services? (choose all that apply)

- ☐ To get to/from the airport
- ☐ To get to/from work on a regular basis
- ☐ To get to/from work occasionally (e.g., when my car is in the shop)
- ☐ To get home after a night out
- ☐ For socialization and nightlife
- ☐ Other (specify) _____

39. How many vehicles does your household own or lease?

- ☐ None
- ☐ One
- ☐ Two
- ☐ Three or more

40. Do you own or lease a hybrid or battery-powered vehicle?

- ☐ Yes
- ☐ No

[Programming note: If response = yes then go to Question 41, otherwise go to Question 42]

41. Do you drive your hybrid or battery-powered vehicle in a high-occupancy vehicle (HOV) lane to reduce your time to get to and from work?

- ☐ Yes
- ☐ No

42. Approximately how often do you make air trips (for any purpose)?

- ☐ One round trip per **week** or more
- ☐ 1 - 3 round trips per **month**
- ☐ 7 - 11 round trips per **year**
- ☐ 1 - 6 round trips per **year**
- ☐ Fewer than one round trip per **year**

PART E: INTRO TO SELF-DRIVING CARS

In this section, we'd like to know your opinions on self-driving (or driverless) cars. Such vehicles drive themselves and control all operating and safety functions, and are even able to travel without a human inside. For our purposes, we want you to imagine a future where both conventional cars and self-driving cars (that do not need humans driving them) are available.

Specifically, please assume that ...

- Driverless cars would be at least as safe as today's cars are, and would be generally affordable.
- The car could be equipped with services such as an office, a television, or a small fridge for snacks.
- The car could be equipped with power outlets to keep your laptop and phone fully charged.
- You could send an empty self-driving car somewhere to pick up children or groceries, or to park after dropping you off at work or other locations.
- You could let a self-driving car take you places while you are sleeping.

These figures below may help you imagine the possibilities:
[Programming note: Three pictures of self-driving cars are shown but are suppressed here due to copyright restrictions. See [18-20] for representative images.]

43. Based on the description provided so far, how appealing do you find self-driving cars?
    - ○ Very unappealing
    - ○ Somewhat unappealing
    - ○ Neutral
    - ○ Somewhat appealing
    - ○ Very appealing

44. Carefully considering your circumstances, how likely would you be to ***use*** a self-driving car for your own local travel?
    - ○ Very unlikely
    - ○ Somewhat unlikely
    - ○ Neutral
    - ○ Somewhat likely
    - ○ Very likely

45. Carefully considering your circumstances, how likely would you be to ***own*** a self-driving car for your own local travel?

- ☐ Very unlikely
- ☐ Somewhat unlikely
- ☐ Neutral
- ☐ Somewhat likely
- ☐ Very likely

46. Some people may want to use their travel time productively (e.g., make phone calls, work on a laptop), while others may just want to relax (e.g., nap or listen to music). How much do conditions during your trip to work allow you to do the things you might want to do while traveling?

[Programming note: A sliding horizontal scale is shown with values between 1 and 5 where 1 is associated with "hardly at all" and 5 with "almost completely."]

47. In terms of its value to you, how would you rate the time you now spend on your typical trip to work?

- ☐ Mostly wasted time
- ☐ Somewhat wasted time
- ☐ Neutral
- ☐ Somewhat useful time
- ☐ Mostly useful time

48. In the following questions, we will present you with potential features of self-driving cars. For each feature, we are interested in knowing how much more or less likely you would be to travel in a self-driving car, compared to a traditional car.

[Programming note: The matrix shown below was split into two matrices, each with four statements, to help ensure the response labels were always visible to respondents.]

	Much less likely to take self-driving car	Less likely to take self-driving car	Would not affect my decision	More likely to take self-driving car	Much more likely to take self-driving car
You ***own*** the self-driving car	○	○	○	○	○
You arrange for a pick-up from a rideshare company (such as Lyft or Uber) and ***travel alone***	○	○	○	○	○
You arrange for a pick-up from a rideshare company and share with ***people you know***	○	○	○	○	○
You arrange for a pick-up from a rideshare company and share with ***strangers***	○	○	○	○	○
You could use your phone to talk, text, and access the internet	○	○	○	○	○
You could do work on your laptop	○	○	○	○	○
You could sleep	○	○	○	○	○

	Much less likely to take self-driving car	Less likely to take self-driving car	Would not affect my decision	More likely to take self-driving car	Much more likely to take self-driving car
The ride quality (such as noise, potholes, and stops) is similar to your current commute	☐	☐	☐	☐	☐

49. Would you move to a different residential location if you could regularly take a self-driving car to and from work?
    - ☐ I would move further from work (e.g., to a more attractive or more spacious location)
    - ☐ I would move closer to work
    - ☐ I would not move

50. Would you change the number of vehicles your household owns or leases if you could regularly take a self-driving car to and from work?
    - ☐ Very likely to own fewer
    - ☐ Somewhat likely to own fewer
    - ☐ Most likely to own the same
    - ☐ Somewhat likely to own more
    - ☐ Very likely to own more

PART F: INTRO TO AIR TAXI SERVICE

NASA and many companies are spearheading research to develop an air taxi service for cities. The aircraft

- Are battery powered
- Carry two to four passengers
- Travel within a city at cruise speeds of 150 mph
- Could be used for getting to and from work faster
- Have efficient security checks with no lines
- Take off and land vertically like a helicopter
- Take off and land at locations in a city such as tops of buildings and parking decks
- Have a ride quality and cabin noise level similar to large aircraft
- Are much quieter than helicopters, both for the community and for the occupants of the aircraft
- Travel at about the altitude where traffic helicopters fly
- Are flown by certified pilots
- Do not fly in hazardous weather conditions (such as thunderstorms)
- Meet stringent safety requirements mandated by the U.S. Federal Aviation Administration

In this section, we ask you to imagine that you are flying in one of the new electric vertical take off and landing (or eVTOL) aircraft shown below.

[Programming note: Three pictures of eVTOL aircraft are shown but are suppressed here due to copyright restrictions. See [21-24] for representative images].

51. Based on the description of the new aircraft provided so far, how appealing do you find this idea?
    - ○ Very unappealing
    - ○ Somewhat unappealing
    - ○ Neutral
    - ○ Somewhat appealing
    - ○ Very appealing
52. Carefully considering your circumstances, how likely would you be to use such a service for your own local travel?
    - ○ Very unlikely
    - ○ Somewhat unlikely
    - ○ Neutral
    - ○ Somewhat likely
    - ○ Very likely

53. In the following questions, we will present you with features that the eVTOL aircraft could have. We are interested in knowing how much more or less likely you would be to fly in an eVTOL aircraft if each feature were present.

	Much less likely	Less likely	Would not affect my decision	More likely	Much more likely
Uses both fuel and batteries	☐	☐	☐	☐	☐
Uses only fuel	☐	☐	☐	☐	☐
Uses only batteries	☐	☐	☐	☐	☐
Has a large parachute for the entire aircraft, so that you and the aircraft could descend safely to the ground if there were an emergency	☐	☐	☐	☐	☐
Has multiple propellers for redundancy in case of failures	☐	☐	☐	☐	☐
Requires you to wear noise-cancelling headphones	☐	☐	☐	☐	☐
The ride quality (smoothness/ bumpiness) of the flight is similar to that of a small airplane or helicopter today	☐	☐	☐	☐	☐

54. Small aircraft need to pay attention to how much total weight they are carrying. Compared to your original response, how likely would you be to take one of these aircraft if you...

	Much less likely	Less likely	Would not affect my decision	More likely	Much more likely
Had to verbally state your weight to the agent in order to board?	☐	☐	☐	☐	☐
Had to be weighed on a scale?	☐	☐	☐	☐	☐

55. eVTOL aircraft will likely not be able to fly in bad weather. Compared to your original response, how likely would you be to take one of these aircraft if...

	Much less likely	Less likely	Would not affect my decision	More likely	Much more likely
The aircraft could not fly 5% of the time (or one trip out of 20)	☐	☐	☐	☐	☐
The aircraft could not fly 5% of the time (or one trip out of 20) but you had a guaranteed ride to and/or from work in bad weather (e.g., via a free or reduced-price Lyft or Uber ride)	☐	☐	☐	☐	☐

56. Would you move to a different location if you could regularly take an eVTOL aircraft to and from work and the service were reliable and affordable?

- ☐ I would move further from work (e.g., to a more attractive or more spacious location)
- ☐ I would move closer to work
- ☐ I would not move

57. Would you change the number of vehicles your household owns or leases if you could regularly take an eVTOL aircraft to work and the service were reliable and affordable?

- ☐ Very likely to own fewer
- ☐ Somewhat likely to own fewer
- ☐ Most likely to own the same number
- ☐ Somewhat likely to own more
- ☐ Very likely to own more

58. For each of the following statements, please check the response that best expresses your opinion.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I would be concerned to fly in an aircraft that takes off and lands vertically within a city with tall buildings	☐	☐	☐	☐	☐
I would find it exciting to travel in one of these eVTOL aircraft	☐	☐	☐	☐	☐
I would be concerned to travel in a battery-operated aircraft	☐	☐	☐	☐	☐
I like that these aircraft can take off and land close to my home and work locations	☐	☐	☐	☐	☐
These aircraft would cause more problems than they would solve	☐	☐	☐	☐	☐
I like the idea of battery-powered aircraft for helping the environment	☐	☐	☐	☐	☐

PART G: TRAVEL TRADE-OFFS

[*Programming note: This section contains eight trade-off questions. These questions were customized based on how the respondent answered Questions 1, 2, and 31. In particular, we used the reported home and work zip codes from Questions 1 to 2 to place the individual into one of four distance categories (using the centroids of the zip codes and a straight-line distance calculation): 0-24 miles, 25-39 miles, 40-54 miles and 55 or more miles. We then used the response to Question 31 to place the individual into one of two "typical" modes: traditional auto or transit. Those who answered (1) car, truck or van (EXCEPT taxi, Lyft/Uber, or similar); (2) motorcycle; or (3) other were assigned to the "auto" mode. Those who answered: (1) bus or trolley car; (2) streetcar or trolley car; (3) subway or elevated train; (4) ferryboat; or (5) railroad were put into the "transit" mode. Those individuals who selected (1) rideshare (Lyft/Uber) or (2) taxi were randomly assigned to either the "auto" or "transit" mode. Note that individuals who selected (1) biking or (2) walking were screened from the survey. For each trade-off question, the eVTOL option, self-driving car, and "typical" mode were shown to respondents. The levels associated with each factor varied as a function of distance and each mode (as described in the main text). Within each distance range and typical mode, respondents were randomly assigned to one of four blocks (defined as a set of eight trade-off questions). In Question 59, we show one representative*

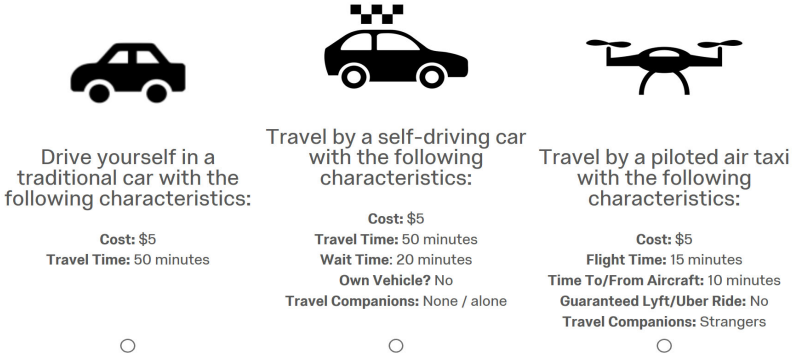
question for the traditional car vs. self-driving car vs. air modes and one representative question for the transit vs. self-driving car vs. air modes. Note that a total of 4 distance ranges × 4 blocks × 8 questions per block or 128 questions were programmed for each set of trade-offs as part of this section; each respondent was shown 8 questions. See Appendix 2 for the trade-off questions (and associated levels) corresponding to these 128 questions. See references 11-14 for sources we used for the images.]

In the next series of questions, we would like for you to compare three hypothetical options for traveling to and from work. The first option is a mode that is currently available. The second option is a trip on a self-driving car. The third option is an electric vertical take-off and landing (eVTOL) aircraft.

The eVTOL aircraft will operate as an air taxi service that you could request from your phone – similar to what you would do now to request an Lyft or Uber. This idea is shown in the image on the left. The air taxi service may come with a ride guarantee. In the event that the eVTOL option is not available (for example due to bad weather) a ride guarantee makes sure you receive priority for taking a Lyft or Uber car. To compensate you for the inconvenience, the rideshare option would be discounted and you would pay less than what the cost of an eVTOL flight would have been. This idea is shown in the image on the right. For the questions that follow, some options include this ride guarantee and some options do not include this ride guarantee.

[*Programming note: we show two images based on the Lyft application but have suppressed them here due to copyright restrictions]*

59. *For your regular commute, if these were the only options available, which would you choose?*



Travel by transit with the following characteristics:	Travel by a self-driving car with the following characteristics:	Travel by a piloted air taxi with the following characteristics:
Cost: $5 **Travel Time:** 50 minutes **Time To/From Transit:** 20 minutes **Guarenteed Lyft/Uber Ride:** No **Transfer**: Yes	**Cost:** $5 **Travel Time:** 50 minutes **Wait Time:** 20 minutes **Own Vehicle?** No **Travel Companions:** None / alone	**Cost:** $5 **Flight Time:** 15 minutes **Time To/From Aircraft:** 10 minutes **Guaranteed Lyft/Uber Ride:** No **Travel Companions:** Strangers
○	○	○

[Programming note: If the respondent never selected the eVTOL option (out of the 8 trade-off questions shown) go to Question 60; if the respondent selected the eVTOL option one or two times, go to Question 61, otherwise go to Question 62.]

60. You never selected the eVTOL aircraft option. Is there anything that would change your mind/any circumstances under which you would take an eVTOL aircraft?
    - ☐ Yes (Please describe these circumstances) _____
    - ☐ No

61. You selected the eVTOL aircraft a few times. Are there any circumstances under which you would take an eVTOL aircraft more often?
    - ☐ Yes (Please describe these circumstances) _____
    - ☐ No

PART H: YOUR PERSONALITY AND LIFESTYLE

The questions in this section relate to various aspects of your personality and lifestyle. There are no right or wrong answers**.**

[Programming note: The matrix shown below was split into several matrices, each with five statements, to help ensure the response labels were always visible to respondents.]

62. For each of the following statements, please check the response that best expresses your opinion.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
My phone is so important to me, it's almost a part of my body	☐	☐	☐	☐	☐
I feel like I need to make the most of every minute	☐	☐	☐	☐	☐
Generally, I feel comfortable talking about work when I'm near other people in a public place	☐	☐	☐	☐	☐
I like the idea of living somewhere with large yards and lots of space between homes	☐	☐	☐	☐	☐
I like it that companies can tailor products to my preferences, even though it requires me to provide personal information	☐	☐	☐	☐	☐
I would generally be concerned about my personal safety if sharing a ride with people I don't know	☐	☐	☐	☐	☐
I like to wait a while rather than being the first to buy new products	☐	☐	☐	☐	☐
I am comfortable that I could handle unwanted physical contact that might arise from other people in a shared vehicle	☐	☐	☐	☐	☐
I never get very far behind on the things I'm trying to get done	☐	☐	☐	☐	☐
I'm worried that technology invades my privacy too much	☐	☐	☐	☐	☐

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I like the idea of living in a neighborhood where I can walk to shops	☐	☐	☐	☐	☐
To confirm you are really reading this, select “Agree”	☐	☐	☐	☐	☐
Having to wait is an annoying waste of time	☐	☐	☐	☐	☐
I am concerned that my personal or work information may be seen by others if I use a public internet connection	☐	☐	☐	☐	☐
I like meeting new people through ridesharing	☐	☐	☐	☐	☐
I often introduce new trends to my friends or family	☐	☐	☐	☐	☐
I’m uncomfortable traveling in the same car with strangers	☐	☐	☐	☐	☐
Having to wait can be a useful pause in a busy day	☐	☐	☐	☐	☐
I am generally satisfied with my life	☐	☐	☐	☐	☐

PART I: SOME INFORMATION ABOUT YOURSELF

Your responses in this section enable us to project results from this small sample to the population as a whole. By **household members**, we mean people who live together, and share at least some activities and some financial resources. Ordinary roommates would not usually be considered household members.

63. What is your gender?

☐ Male

☐ Female

64. What is the highest degree or level of school you have *COMPLETED?*

- ○ Less than high school
- ○ Regular high school diploma
- ○ GED or alternative credential
- ○ Some college credit, but less than 1 year of college credit
- ○ 1 or more years of college credit, no degree
- ○ Associate's degree (for example: AA, AS)
- ○ Bachelor's degree (for example: BA, BS)
- ○ Master's degree (for example: MA, MS, MEng, MEd, MSW, MBA)
- ○ Professional degree beyond bachelor's degree (for example: MD, DDS, DVM, LLB, JD)
- ○ Doctoral degree (for example: PhD, EdD)

65. How many adults *(ages 18 and older)*, including yourself, live in your household?

- ○ 1 adult
- ○ 2 adults
- ○ 3 adults
- ○ 4 adults
- ○ 5 or more adults

66. How many children *(under the age of 18)* live in your household?

- ○ No children
- ○ 1 child
- ○ 2 children
- ○ 3 children
- ○ 4 children
- ○ 5 or more children

Appendix 2: Levels Used in Survey

This appendix includes the levels we used for the 128 trade-off questions in the survey. Note that we used the same levels for the choice sets that used traditional auto as the reference mode and the choice sets that used transit as the reference mode. We only changed the image shown, the labeling of the "other" travel time components, and which attributes were shown (based on which attributes were relevant to the non-eVTOL mode). The "other travel time component" is referred to as "time to/from eVTOL," "time to/from transit," and "wait time" for the eVTOL, transit, and self-driving auto (which applies when the individual does not own the auto), respectively. The last column was only used for the transit mode. The trade-off questions that correspond to Block 1 in Table A2.1 are presented in Figures A2.1 – A2.3, showing how the levels in the table translate to the trade-off questions shown to respondent.

Figure A2.1. Question 1 of Block 1 for Distance Range of 0-24 miles for Traditional Auto as Reference

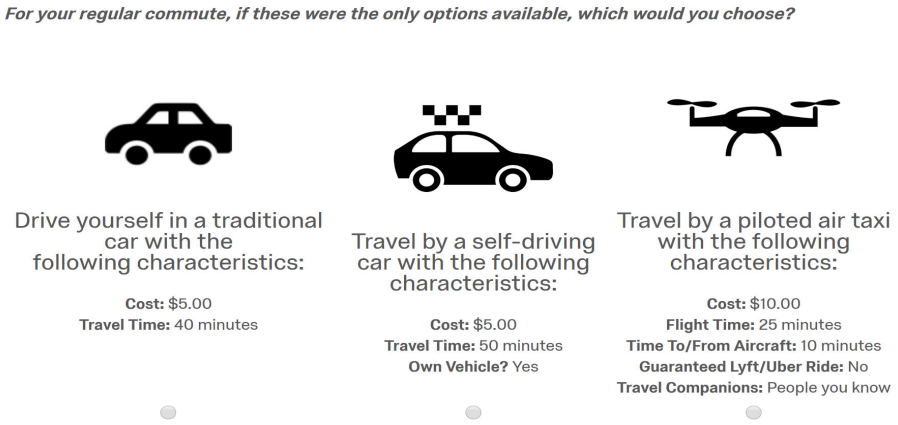


Figure A2.2. Question 1 of Block 1 for Distance Range of 0-24 miles for Transit as Reference

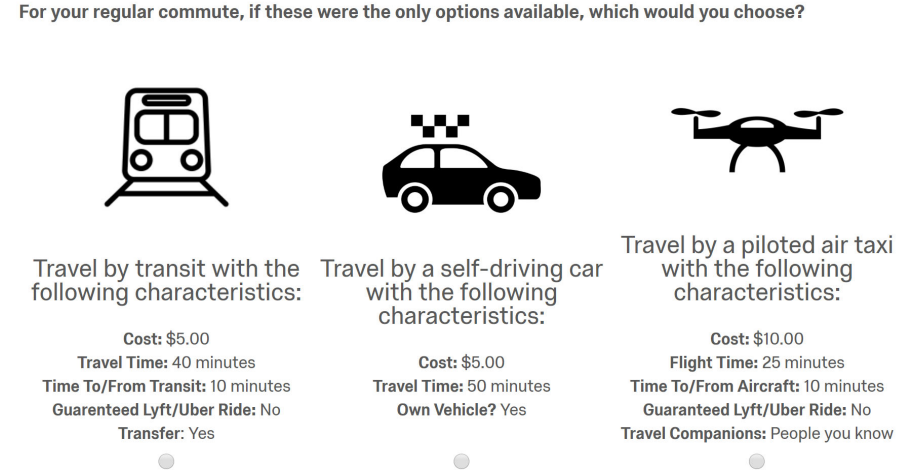


Table A2.1 Levels for Distances between 0-24 Miles

Block	Ques	Cost TR or Car	TT TR or Car	Other TT TR	Ride G. TR	Transfer TR	Cost AV	TT AV	Other TT AV	Own AV	Companions AV	Cost Air	TT Air	Other TT Air	Ride G. Air	Companions Air
1	1	5	50	20	No	Yes	5	50	20	No	Alone	5	15	10	No	Strangers
	2	5	1:00	10	No	Yes	5	1:00	10	No	Strangers	5	40	10	Yes	Strangers
	3	5	40	20	Yes	No	5	1:00	N/A	Yes	N/A	5	25	20	No	Known
	4	2.5	1:00	20	Yes	Yes	2.5	50	N/A	Yes	N/A	10	40	10	Yes	Known
	5	2.5	30	20	No	No	2.5	30	N/A	Yes	N/A	5	25	10	No	Strangers
	6	2.5	50	10	Yes	No	2.5	30	20	No	Known	5	40	20	Yes	Known
	7	5	30	10	Yes	Yes	5	40	20	No	Alone	10	25	10	No	Known
	8	2.5	40	10	No	No	2.5	40	N/A	Yes	N/A	5	30	10	Yes	Strangers
2	1	5	50	20	No	Yes	5	40	N/A	Yes	N/A	10	40	20	Yes	Strangers
	2	2.5	40	20	No	Yes	5	40	10	No	Known	5	15	10	Yes	Known
	3	5	30	20	Yes	Yes	2.5	50	20	No	Strangers	5	15	20	Yes	Strangers
	4	2.5	50	20	Yes	Yes	5	1:00	20	No	Alone	10	30	10	No	Strangers
	5	2.5	40	10	No	No	2.5	50	10	No	Alone	10	25	20	No	Strangers
	6	5	40	10	Yes	No	2.5	30	N/A	Yes	N/A	10	15	10	Yes	Strangers
	7	5	50	10	No	No	2.5	50	N/A	Yes	N/A	5	30	10	No	Known
	8	2.5	1:00	10	Yes	No	5	40	N/A	Yes	N/A	5	30	20	No	Strangers
3	1	5	1:00	10	No	Yes	5	30	N/A	Yes	N/A	10	15	20	No	Strangers
	2	5	1:00	20	Yes	No	2.5	1:00	N/A	Yes	N/A	5	25	10	Yes	Known
	3	2.5	30	20	Yes	Yes	2.5	1:00	20	No	Known	10	30	20	Yes	Strangers
	4	2.5	30	10	No	Yes	5	30	20	No	Alone	5	40	10	No	Known
	5	5	40	20	No	No	5	30	10	No	Strangers	10	30	10	Yes	Known
	6	2.5	1:00	20	Yes	No	2.5	40	10	No	Alone	5	15	20	No	Known
	7	5	30	10	Yes	Yes	5	50	N/A	Yes	N/A	5	30	20	Yes	Known
	8	2.5	50	10	Yes	No	2.5	1:00	N/A	Yes	N/A	10	15	10	No	Known

Notes: TR=Transit, Car=traditional (non-autonomous) car; AV=self-driving car; Air=eVTOL; TT=travel time; Ride G. =ride guarantee, Own=do you own your self-driving car? Comp=travel companions.

Table A2.1 (Continued) Levels for Distances between 0-24 Miles

Block	Ques	Cost TR or Car	TT TR or Car	Other TT TR	Ride G. TR	Transfer TR	Cost AV	TT AV	Other TT AV	Own AV	Companions AV	Cost Air	TT Air	Other TT Air	Ride G. Air	Companions Air
4	1	2.5	50	20	No	No	5	30	N/A	Yes	N/A	5	25	20	Yes	Strangers
	2	5	1:00	20	Yes	Yes	2.5	30	10	No	Alone	10	30	20	No	Known
	3	2.5	40	20	No	No	5	50	N/A	Yes	N/A	10	40	20	No	Known
	4	5	40	10	Yes	Yes	2.5	1:00	10	No	Alone	5	40	20	No	Strangers
	5	2.5	1:00	10	No	Yes	5	50	10	No	Known	10	25	10	Yes	Strangers
	6	2.5	30	10	No	No	5	1:00	N/A	Yes	N/A	10	15	20	Yes	Known
	7	5	50	10	Yes	Yes	2.5	40	20	No	Strangers	10	25	20	Yes	Known
	8	5	30	20	No	No	2.5	40	N/A	Yes	N/A	10	40	10	No	Strangers

Notes: TR=Transit, Car=traditional (non-autonomous) car; AV=self-driving car; Air=eVTOL; TT=travel time; Ride G. =ride guarantee, Own=does individual own self-driving car? Comp=travel companions.

Table A2.2 Levels for Distances between 25-39 Miles

Block	Ques	Cost TR or Car	TT TR or Car	Other TT TR	Ride G. TR	Transfer TR	Cost AV	TT AV	Other TT AV	Own AV	Companions AV	Cost Air	TT Air	Other TT Air	Ride G. Air	Companions Air
1	1	5	1:00	20	No	Yes	5	1:00	20	No	Alone	10	15	10	No	Strangers
	2	5	1:15	10	No	Yes	4	1:15	10	No	Strangers	5	40	10	Yes	Strangers
	3	5	45	20	Yes	No	5	1:15	N/A	Yes	N/A	5	25	20	No	Known
	4	2.5	1:15	20	Yes	Yes	2.5	1:00	N/A	Yes	N/A	20	40	10	Yes	Known
	5	3	30	20	No	No	2.5	30	N/A	Yes	N/A	10	25	10	No	Strangers
	6	3	1:00	10	Yes	No	3	30	20	No	Known	10	40	20	Yes	Known
	7	4	30	10	Yes	Yes	4	45	20	No	Alone	15	25	10	No	Known
	8	3	45	10	No	No	3	45	N/A	Yes	N/A	5	30	10	Yes	Strangers
2	1	4	1:00	20	No	Yes	5	45	N/A	Yes	N/A	15	40	20	Yes	Strangers
	2	2.5	45	20	No	Yes	4	45	10	No	Known	10	15	10	Yes	Known
	3	4	30	20	Yes	Yes	3	1:00	20	No	Strangers	5	15	20	Yes	Strangers
	4	3	1:00	20	Yes	Yes	4	1:15	20	No	Alone	20	30	10	No	Strangers
	5	2.5	45	10	No	No	3	1:00	10	No	Alone	20	25	20	No	Strangers
	6	5	45	10	Yes	No	2.5	30	N/A	Yes	N/A	15	15	10	Yes	Strangers
	7	4	1:00	10	No	No	2.5	1:00	N/A	Yes	N/A	5	30	10	No	Known
	8	2.5	1:15	10	Yes	No	5	45	N/A	Yes	N/A	10	30	20	No	Strangers
3	1	4	1:15	10	No	Yes	4	30	N/A	Yes	N/A	20	15	20	No	Strangers
	2	4	1:15	20	Yes	No	3	1:15	N/A	Yes	N/A	10	25	10	Yes	Known
	3	2.5	30	20	Yes	Yes	2.5	1:15	20	No	Known	15	30	20	Yes	Strangers
	4	2.5	30	10	No	Yes	5	30	20	No	Alone	5	40	10	No	Known
	5	4	45	20	No	No	5	30	10	No	Strangers	20	30	10	Yes	Known
	6	3	1:15	20	Yes	No	2.5	45	10	No	Alone	5	15	20	No	Known
	7	5	30	10	Yes	Yes	4	1:00	N/A	Yes	N/A	10	30	20	Yes	Known
	8	2.5	1:00	10	Yes	No	3	1:15	N/A	Yes	N/A	15	15	10	No	Known

Notes: TR=Transit, Car=traditional (non-autonomous) car; AV=self-driving car; Air=eVTOL; TT=travel time; Ride G. =ride guarantee, Own=do you own your self-driving car? Comp=travel companions.

Table A2.2 (Continued) Levels for Distances between 25-39 Miles

Block	Ques	Cost TR or Car	TT TR or Car	Other TT TR	Ride G. TR	Transfer TR	Cost AV	TT AV	Other TT AV	Own AV	Companions AV	Cost Air	TT Air	Other TT Air	Ride G. Air	Companions Air
4	1	2.5	1:00	20	No	No	4	30	N/A	Yes	N/A	5	25	20	Yes	Strangers
	2	5	1:15	20	Yes	Yes	3	30	10	No	Alone	15	30	20	No	Known
	3	3	45	20	No	No	4	1:00	N/A	Yes	N/A	15	40	20	No	Known
	4	4	45	10	Yes	Yes	2.5	1:15	10	No	Alone	10	40	20	No	Strangers
	5	3	1:15	10	No	Yes	5	1:00	10	No	Known	15	25	10	Yes	Strangers
	6	3	30	10	No	No	5	1:15	N/A	Yes	N/A	20	15	20	Yes	Known
	7	5	1:00	10	Yes	Yes	2.5	45	20	No	Strangers	20	25	20	Yes	Known
	8	5	30	20	No	No	3	45	N/A	Yes	N/A	20	40	10	No	Strangers

Notes: TR=Transit, Car=traditional (non-autonomous) car; AV=self-driving car; Air=eVTOL; TT=travel time; Ride G. =ride guarantee, Own=does individual own self-driving car? Comp=travel companions.

Table A2.3 Levels for Distances between 40-54 Miles

Block	Ques	Cost TR or Car	TT TR or Car	Other TT TR	Ride G. TR	Transfer TR	Cost AV	TT AV	Other TT AV	Own AV	Companions AV	Cost Air	TT Air	Other TT Air	Ride G. Air	Companions Air
1	1	10	1:30	20	No	Yes	10	1:30	20	No	Alone	20	20	10	No	Strangers
	2	10	1:45	10	No	Yes	8	1:45	10	No	Strangers	10	45	10	Yes	Strangers
	3	10	1:15	20	Yes	No	10	1:45	N/A	Yes	N/A	10	30	20	No	Known
	4	4	1:45	20	Yes	Yes	4	1:30	N/A	Yes	N/A	40	45	10	Yes	Known
	5	6	1:00	20	No	No	4	1:00	N/A	Yes	N/A	20	30	10	No	Strangers
	6	6	1:30	10	Yes	No	6	1:00	20	No	Known	20	45	20	Yes	Known
	7	8	1:00	10	Yes	Yes	8	1:15	20	No	Alone	30	30	10	No	Known
	8	6	1:15	10	No	No	6	1:15	N/A	Yes	N/A	10	40	10	Yes	Strangers
2	1	8	1:30	20	No	Yes	10	1:15	N/A	Yes	N/A	30	45	20	Yes	Strangers
	2	4	1:15	20	No	Yes	8	1:15	10	No	Known	20	20	10	Yes	Known
	3	8	1:00	20	Yes	Yes	6	1:30	20	No	Strangers	10	20	20	Yes	Strangers
	4	6	1:30	20	Yes	Yes	8	1:45	20	No	Alone	40	40	10	No	Strangers
	5	4	1:15	10	No	No	6	1:30	10	No	Alone	40	30	20	No	Strangers
	6	10	1:15	10	Yes	No	4	1:00	N/A	Yes	N/A	30	20	10	Yes	Strangers
	7	8	1:30	10	No	No	4	1:30	N/A	Yes	N/A	10	40	10	No	Known
	8	4	1:45	10	Yes	No	10	1:15	N/A	Yes	N/A	20	40	20	No	Strangers
3	1	8	1:45	10	No	Yes	8	1:00	N/A	Yes	N/A	40	20	20	No	Strangers
	2	8	1:45	20	Yes	No	6	1:45	N/A	Yes	N/A	20	30	10	Yes	Known
	3	4	1:00	20	Yes	Yes	4	1:45	20	No	Known	30	40	20	Yes	Strangers
	4	4	1:00	10	No	Yes	10	1:00	20	No	Alone	10	45	10	No	Known
	5	8	1:15	20	No	No	10	1:00	10	No	Strangers	40	40	10	Yes	Known
	6	6	1:45	20	Yes	No	4	1:15	10	No	Alone	10	20	20	No	Known
	7	10	1:00	10	Yes	Yes	8	1:30	N/A	Yes	N/A	20	40	20	Yes	Known
	8	4	1:30	10	Yes	No	6	1:45	N/A	Yes	N/A	30	20	10	No	Known

Notes: TR=Transit, Car=traditional (non-autonomous) car; AV=self-driving car; Air=eVTOL; TT=travel time; Ride G. =ride guarantee, Own=do you own your self-driving car? Comp=travel companions.

Table A2.3 (Continued) Levels for Distances between 40-54 Miles

Block	Ques	Cost TR or Car	TT TR or Car	Other TT TR	Ride G. TR	Transfer TR	Cost AV	TT AV	Other TT AV	Own AV	Companions AV	Cost Air	TT Air	Other TT Air	Ride G. Air	Companions Air
4	1	4	1:30	20	No	No	8	1:00	N/A	Yes	N/A	10	30	20	Yes	Strangers
	2	10	1:45	20	Yes	Yes	6	1:00	10	No	Alone	30	40	20	No	Known
	3	6	1:15	20	No	No	8	1:30	N/A	Yes	N/A	30	45	20	No	Known
	4	8	1:15	10	Yes	Yes	4	1:45	10	No	Alone	20	45	20	No	Strangers
	5	6	1:45	10	No	Yes	10	1:30	10	No	Known	30	30	10	Yes	Strangers
	6	6	1:00	10	No	No	10	1:45	N/A	Yes	N/A	40	20	20	Yes	Known
	7	10	1:30	10	Yes	Yes	4	1:15	20	No	Strangers	40	30	20	Yes	Known
	8	10	1:00	20	No	No	6	1:15	N/A	Yes	N/A	40	45	10	No	Strangers

Notes: TR=Transit, Car=traditional (non-autonomous) car; AV=self-driving car; Air=eVTOL; TT=travel time; Ride G. =ride guarantee, Own=does individual own self-driving car? Comp=travel companions.

Table A2.4 Levels for Distances of 55 Miles or More

Block	Ques	Cost TR or Car	TT TR or Car	Other TT TR	Ride G. TR	Transfer TR	Cost AV	TT AV	Other TT AV	Own AV	Companions AV	Cost Air	TT Air	Other TT Air	Ride G. Air	Companions Air
1	1	20	1:45	20	No	Yes	20	1:45	20	No	Alone	25	25	10	No	Strangers
	2	20	2:00	10	No	Yes	15	2:00	10	No	Strangers	20	1:00	10	Yes	Strangers
	3	20	1:30	20	Yes	No	20	2:00	N/A	Yes	N/A	20	45	20	No	Known
	4	5	2:00	20	Yes	Yes	5	1:45	N/A	Yes	N/A	45	1:00	10	Yes	Known
	5	10	1:00	20	No	No	5	1:00	N/A	Yes	N/A	25	45	10	No	Strangers
	6	10	1:45	10	Yes	No	10	1:00	20	No	Known	25	1:00	20	Yes	Known
	7	15	1:00	10	Yes	Yes	15	1:30	20	No	Alone	35	45	10	No	Known
	8	10	1:30	10	No	No	10	1:30	N/A	Yes	N/A	20	45	10	Yes	Strangers
2	1	15	1:45	20	No	Yes	20	1:30	N/A	Yes	N/A	35	1:00	20	Yes	Strangers
	2	5	1:30	20	No	Yes	15	1:30	10	No	Known	25	25	10	Yes	Known
	3	15	1:00	20	Yes	Yes	10	1:45	20	No	Strangers	20	25	20	Yes	Strangers
	4	10	1:45	20	Yes	Yes	15	2:00	20	No	Alone	45	45	10	No	Strangers
	5	5	1:30	10	No	No	10	1:45	10	No	Alone	45	45	20	No	Strangers
	6	20	1:30	10	Yes	No	5	1:00	N/A	Yes	N/A	35	25	10	Yes	Strangers
	7	15	1:45	10	No	No	5	1:45	N/A	Yes	N/A	20	45	10	No	Known
	8	5	2:00	10	Yes	No	20	1:30	N/A	Yes	N/A	25	45	20	No	Strangers
3	1	15	2:00	10	No	Yes	15	1:00	N/A	Yes	N/A	45	25	20	No	Strangers
	2	15	2:00	20	Yes	No	10	2:00	N/A	Yes	N/A	25	45	10	Yes	Known
	3	5	1:00	20	Yes	Yes	5	2:00	20	No	Known	35	45	20	Yes	Strangers
	4	5	1:00	10	No	Yes	20	1:00	20	No	Alone	20	1:00	10	No	Known
	5	15	1:30	20	No	No	20	1:00	10	No	Strangers	45	45	10	Yes	Known
	6	10	2:00	20	Yes	No	5	1:30	10	No	Alone	20	25	20	No	Known
	7	20	1:00	10	Yes	Yes	15	1:45	N/A	Yes	N/A	25	45	20	Yes	Known
	8	5	1:45	10	Yes	No	10	2:00	N/A	Yes	N/A	35	25	10	No	Known

Notes: TR=Transit, Car=traditional (non-autonomous) car; AV=self-driving car; Air=eVTOL; TT=travel time; Ride G. =ride guarantee, Own=do you own your self-driving car? Comp=travel companions.

Table A2.4 (Continued) Levels for Distances of 55 Miles or More

Block	Ques	Cost TR or Car	TT TR or Car	Other TT TR	Ride G. TR	Transfer TR	Cost AV	TT AV	Other TT AV	Own AV	Companions AV	Cost Air	TT Air	Other TT Air	Ride G. Air	Companions Air
4	1	5	1:45	20	No	No	15	1:00	N/A	Yes	N/A	20	45	20	Yes	Strangers
	2	20	2:00	20	Yes	Yes	10	1:00	10	No	Alone	35	45	20	No	Known
	3	10	1:30	20	No	No	15	1:45	N/A	Yes	N/A	35	1:00	20	No	Known
	4	15	1:30	10	Yes	Yes	5	2:00	10	No	Alone	25	1:00	20	No	Strangers
	5	10	2:00	10	No	Yes	20	1:45	10	No	Known	35	45	10	Yes	Strangers
	6	10	1:00	10	No	No	20	2:00	N/A	Yes	N/A	45	25	20	Yes	Known
	7	20	1:45	10	Yes	Yes	5	1:30	20	No	Strangers	45	45	20	Yes	Known
	8	20	1:00	20	No	No	10	1:30	N/A	Yes	N/A	45	1:00	10	No	Strangers

Notes: TR=Transit, Car=traditional (non-autonomous) car; AV=self-driving car; Air=eVTOL; TT=travel time; Ride G. =ride guarantee, Own=does individual own self-driving car? Comp=travel companions.