Public Perception of UAM: Are we ready for the new mobility that we have dreamed of?

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Urban Air Mobility (UAM) has lately emerged as a time-saving mode of air transportation in congested urban areas. However, several challenges to the commercialization and adoption of UAM vehicles exist, such as licensing and restrictions, security, and construction infrastructure. Besides these, public perception is one of the significant aspects of easing psychological stress and representing users' needs. A survey study was carried out to understand the public perception of UAM and to comprehend how the public perceives and expects UAM aircraft in terms of user requirement analysis as part of human-centered design. To achieve this, a total of 2,847 valid data sets were analyzed. A preliminary data analysis revealed the general level of awareness of UAM machines, expected costs and values for specific scenarios, perceived advantages of UAM vehicles, and overall opinion, along with distinctions based on demographic information such as age groups, residential areas, and income levels. Future research topics might include in-depth data analysis and subsequent user surveys to discover underlying requirements.

INTRODUCTION

A new mode of air transportation is emerging as a result of recent advancements in automation technology, improvements in operation technology, and increased traffic congestion on the ground (Reiche et al., 2018). In the last decade, Urban Air Mobility (UAM) has re-emerged as an alternative transportation in response to this modification (Cohen et al., 2021). The UAM vehicle is an innovative air transportation system that uses a highly automated system to convey people and products in congested urban areas (Park, 2021). This allows people to reduce commuting and transit time in cities by making use of point-to-point flights (Shaheen et al., 2018). While the UAM existed as a concept for a "flying car" in the early twentieth century, it encountered several obstacles such as technological limits, safety concerns, and cost issues (Reiche et al., 2018).

According to a NASA study report (Reiche et al., 2018), three use models for UAM vehicles are expected: last-mile deliveries, air metros, and air taxis. Last-mile deliveries see UAM conveyance as a delivery service after online orders are placed. UAM may also be utilized as an air metro that follows a set route and operates on a predetermined timetable, comparable with current public transit. Another use case is ride-sharing as an air taxi at a local boarding point, allowing customers to call straight to their preferred spot and take off. The upcoming milestones of UAM vehicles are planned in three phases, similar to the sequence of these three use models. In the upcoming years, Vertical Take-Off Landing (VTOL) aircraft-based "air shuttle service" will operate over a defined route. As the infrastructure improves, the "air metro service" will be more accessible, providing multiple flights between various vertiports in urban areas. Eventually, it is intended to arrive at an "air taxi" that provides on-demand and decentralized service (Cohen et al., 2021).

However, there are a number of obstacles that must be addressed for the commercialization of UAM vehicles. NASA revealed that licensing and restrictions, security, air traffic control, building infrastructure, cost, modes of competitiveness, willingness to pay, safety, and environmental concerns are the barriers to the feasibility of UAM vehicles (Reiche et al., 2018).

Additional challenges include operating in harsh weather conditions, aggregate loudness, and public acceptance (Al Haddad et al., 2020; Vascik & Hansman, 2017). As the fast rise of the drone business has created a psychological dread of the unknown (Çetin, 2022), "public perception" is one of the most important criteria in breaking into the transport industry (Park, 2021; Straubinger, 2020). In this regard, a study conducted by Yedavalli and Mooberry (2019) observed that about 44% of people support the UAM initiative. People expect cost reductions for autonomous vehicles, decreased pilot fatigue, and minimal manual error for UAM (Ragbir et al., 2018). Studies find that positive public perceptions of acceptance of autonomous vehicles significantly reduce psychological costs associated with adopting this technology (Penmetsa et al., 2019; Park, 2021). Moreover, understanding public perception and desirability not only impacts whether a new transportation market will be successful but also creates the groundwork for detecting and reflecting users' demands (Park, 2021). Therefore, it is crucial to assess public perception and acceptance of UAM services, as there has been a lack of studies on this issue.

In this regard, in order to develop a more effective and acceptable UAM environment in terms of products, services, infrastructure, regulations, etc., it is necessary to understand how the public recognizes and expects UAM vehicles in terms of user requirements analysis as a part of human-centered design. In the present study, a survey was conducted to identify the profile of public perception of UAM vehicles through various questions, including the level of awareness, alternate methods of public transportation, expected use models, advantages and disadvantages, and willingness to ride. The

differences in response between different user groups also were investigated.

METHOD

Survey Design

An online survey form was developed with 9 sections including the following components: introduction and general description of UAM; general levels of awareness of UAM; personal use of public transportation; expected price and values comparing other public transportation for two different usage scenarios (airport to home and commute); perceived advantages of UAM; perceived disadvantages of UAM; overall opinions on UAM; self-report on technology literacy; and demographic questions. A total of 107 questions were asked, and different formats of measurement scales were used, such as the seven-point Likert scale, rank order, and open questions. Due to the limited space requirement, we report key findings only.

Survey Responses Collection

An online survey was disseminated across the entire U.S. after obtaining IRB exemption from the University of Michigan (HUM00193622). In the survey invitation, it was stated that only adults aged over 18 years old could participate. Respondents were entered into a raffle for a $5 gift card to encourage participation. The average completion time of each survey was approximately an hour. After the survey was completed, 30 respondents received a gift card. Consequently, a total of 3,339 responses have been collected for two months. Among the responses, 2,847 responses were used for analysis as a final dataset, after filtering invalid data such as incomplete responses (less than 50%), reckless responses (e.g., all ratings are the same, all blanks in open questions, etc.).

RESULTS

Respondents' demographics

Table 1 shows the overall summary of basic demographic information of respondents, including age, gender, education level (6 categories), income level (7 categories), place of residence (primarily 3 categories), and marital status. The majority of respondents were in their 20s or 30s (total 86.3%), followed by the 40s (9.4%). The majority of the sample was male (63%). In terms of place of residence, participants lived in urban (68.9%), suburban (25.9%), and rural (5%) areas.

General level of awareness of UAM

We asked questions to measure general awareness of UAM. A stacked bar graph was created based on the seven Likert scale responses. The red and blue bars represent disagreement and agreement, respectively, and the deeper the color, the more extreme the difference. The percentages of agreement and disagreement, excluding neutral, are shown by the numbers to the right and left. The gray circle in the center indicates the mean likert value. The graph description above corresponds to all upcoming seven-likert scale bar graphs. As shown in Figure 1, most people are highly aware of the UAM vehicle, its concept, strengths, weaknesses, and utility. However, it was observed that some different demographic profiles yield different levels of awareness. Analysis of Variance (ANOVA) results revealed that different levels of education ($F(5, 2752)=46.97$, $p<0.001$), income ($F(6, 2747)=35.08$, $p<0.001$), and age ($F(4, 2735)=6.145$, $p<0.001$) are associated with different levels of awareness. That is, in general, respondents at higher income and education levels are more aware of the UAM. Respondents in the age range of the 40s and 50s have more knowledge of UAM than other age groups. The results indicate that more than half of the participants are aware of the UAM, including its concept, strengths, and weaknesses, differences from drones, and as a new transportation method. This might be because the concept and business model of UAM have been exposed in various media. However, it might be interesting to observe the change in the level of awareness after some time has passed in the near future.

Table 1: Summary of respondents' demographic

Variables	Category	Proportion
Age	20-29	46.5%
	30-39	39.5%
	40-49	9.4%
	50-59	3.2%
	over 60	1.4%
Gender	Male	62.3%
	Female	36.8%
	Other	0.9%
Education	Less than high school	5.1%
	High school graduate	21%
	2-year bachelor's degree	24.2%
	4-year bachelor's degree	32.8%
	Master's degree	14%
	Doctorate degree	3%
Income level	Less than $30,000	13%
	$30,000 - $50,000	24.4%
	$50,000 - $75,000	23.3%
	$75,000 - $100,000	18.6%
	$100,000 - $150,000	14.8%
	$150,000 - $200,000	5.3%
	More than $200,000	0.7%
Place of Residence	Urban Area	68.9%
	Suburban Area	25.9%
	Rural Area	5%
	Other	0.2%

Expected Values of UAM in Specific Scenarios

In order to estimate the appropriate fare and expected value of UAM vehicle service as public transportation, two scenarios were presented to the participants: 1) a situation to go to their own house after arriving near the airport after finishing a trip using a flight; and 2) a commute situation taking public transportation. As shown in Table 2, similar alternate transportation modes were presented for comparison. That is, estimated time, fare, place to take, number of passengers, and expected traffic jams using other public transportation were provided for the same route in the survey form.

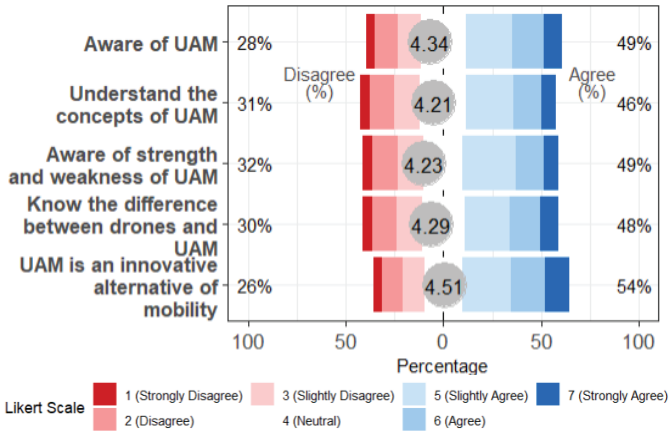

Figure 1. General levels of awareness of UAM

Table 2. Comparisons of public transportation, including UAM, for two situations.

Scenarios	Situations	Taxi / Uber	Bus	Subway /Train	UAM
Airport to home	Distance	30 miles			
	Travel Time	40 min - 50 min	1.5 hours- 2 hours	30 min	15 min
	Fare	$55	$22	$15	**Question**
	Passenger	Solely	Public	Public	Solely
	Traffic	Possible	Possible	No	No
Commute	Distance	7 miles			
	Travel Time	20 min - 40 min	30 min - 1 hour	25 min	10 min
	Fare	$25	$8	$11	**Question**
	Passenger	Solely	Public	Public	Solely
	Traffic	Possible	Possible	No	No

Survey results revealed the average amounts of willingness to pay are $43 (*sd*=30.3) and $21.3 (*sd*=16.4) for the airport to home and commute situations, respectively. Figure 2 shows the willingness to pay for all groups riding the UAM. As shown in Figure 2, the fares that people expect are lower than the cost of a taxi for the same distance. This may imply that, even though the respondents are aware of the UAM vehicle, they would want to pay a compatible fare compared to other public transportation options.

Another question was also asked about the importance of each factor for them to decide to take a UAM, among estimated travel time, fare, traffic, and the number of passengers. ANOVA results revealed that the level of importance for deciding to take the UAM is significantly different for both "airport to home" ($F(3, 11384)= 4.34$, $p=0.005$) and "commute" ($F(4, 14230)=7.35$, $p<0.001$) situations. For the "Airport to home" situation, people responded that relief from traffic jams ($M=4.64$) is the most important reason to take UAM, followed by being able to take it privately (passenger) ($M=4.59$), reasonable fare ($M=4.54$), and travel time ($M=4.50$). For the "commute" situations, the most important factor is a place to take it ($M=4.93$), followed by relief from traffic jams ($M=4.84$), and commute travel time ($M=4.78$), Fare ($M=4.76$), and passenger ($M=4.69$).

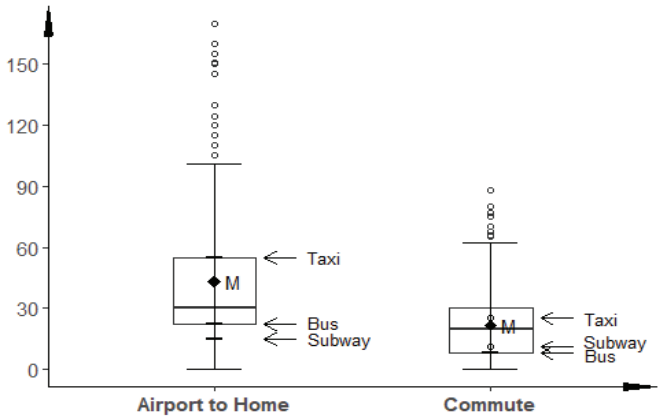

Figure 2. Willingness to pay UAM for the two situations.

However, the effect of residential areas (rural, suburban, and urban) was significant for most of the reasons for taking the UAM vehicle. Respondents living in rural areas tended to rate lower on all factors besides the number of passengers, compared to respondents in suburban and urban areas. Figures 3 and 4 show the results of ratings on the importance of factors by residential areas for "airport to home" and "commute" scenarios, respectively. As shown in the Figures, the general ratings on the importance of riding time to destination, fare, and traffic are not critical for people in rural areas, while ratings on the number of passengers are substantially high. It might be that people in suburban and urban areas have a higher demand for prompt and affordable transportation methods in heavy traffic, compared to those in rural areas.

Perceived Advantages of UAM

Participants were asked to evaluate the expected benefits of making UAM services available in the marketplace. The ANOVA results showed that the mean rating for the six advantages was significant ($F(5, 17076)=26.51$, $p<0.001$). Participants rated the highest advantage of UAM as "time-saving" and the lowest as "safe". Figure 5 shows the average rating for the expected benefits of UAM. Post hoc analysis grouped them into two groups. The highest groups were "time-saving", "eco-friendly", "new experience", and "convenience". And "reasonable price" and "safety" were different groups. It may suggest that the public perceives the advantage of UAM vehicles as a fast means of transportation without traffic jams and that they are environmentally friendly because they use electricity for propulsion. On the other hand, it also implies that there may be concerns about the safety of UAM along with high fares, leading to suggestions that the perception of safety and reasonable price should be improved throughout education or advertisement for the UAM to be realistic in the market.

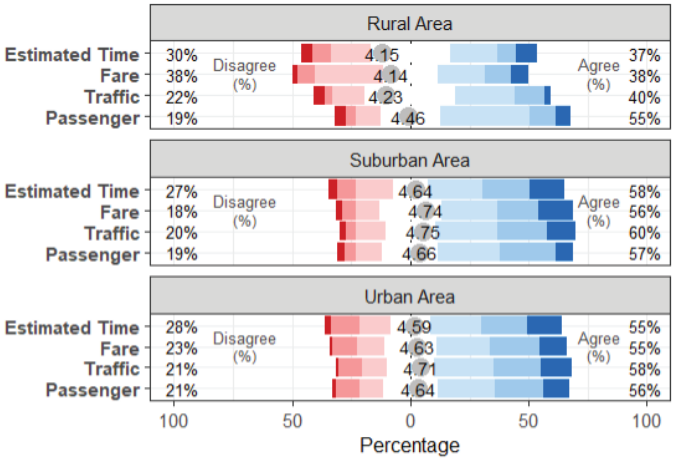

Figure 3. Ratings on factors for the decision to take UAM from Airport to Home

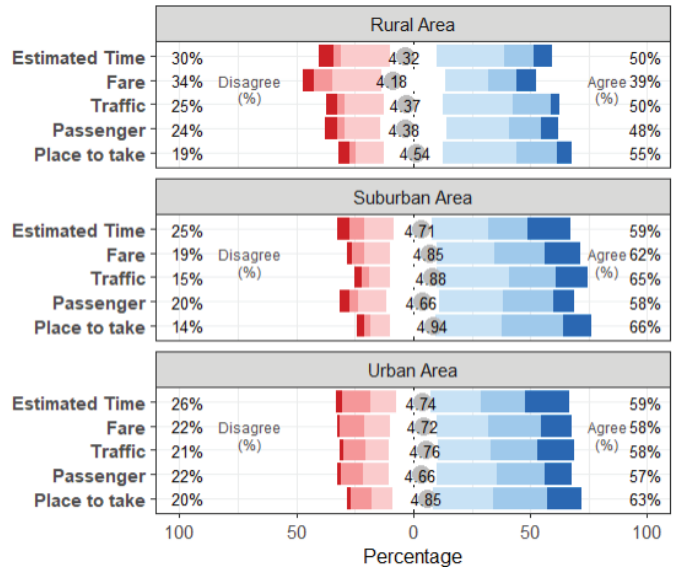

Figure 4. Ratings on factors for the decision to take UAM to commute

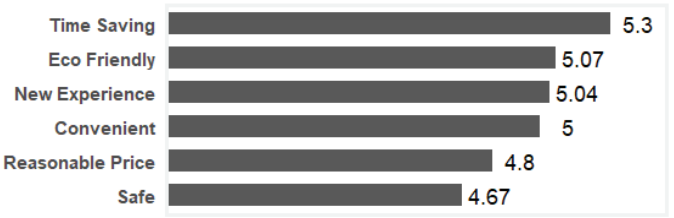

Figure 5. Mean ratings for the expected advantages of UAM

While the general response results were generally positive for most questions, some significant differences were found for various demographic profiles, including the impact of respondents' age and income level. Figure 6 and Figure 7 show the distribution of ratings by age and income level for each question.

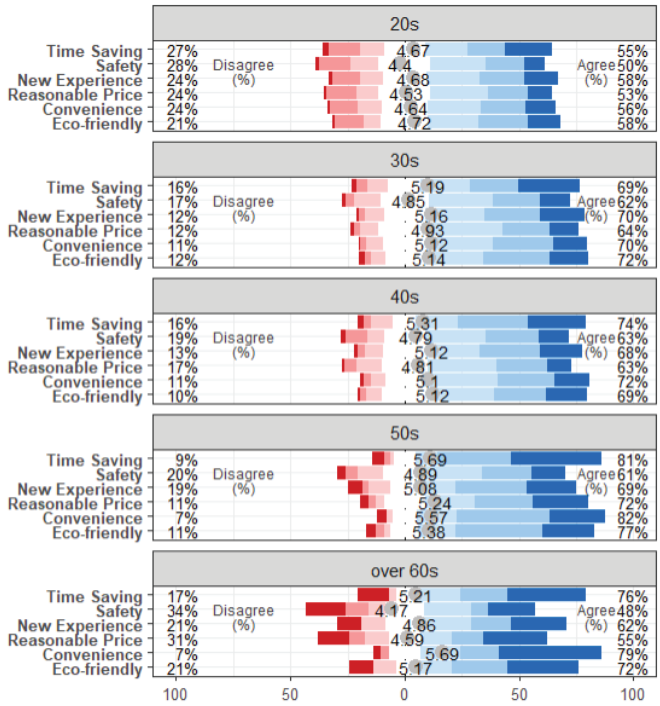

Figure 6. Ratings on anticipating advantages of UAM by age groups

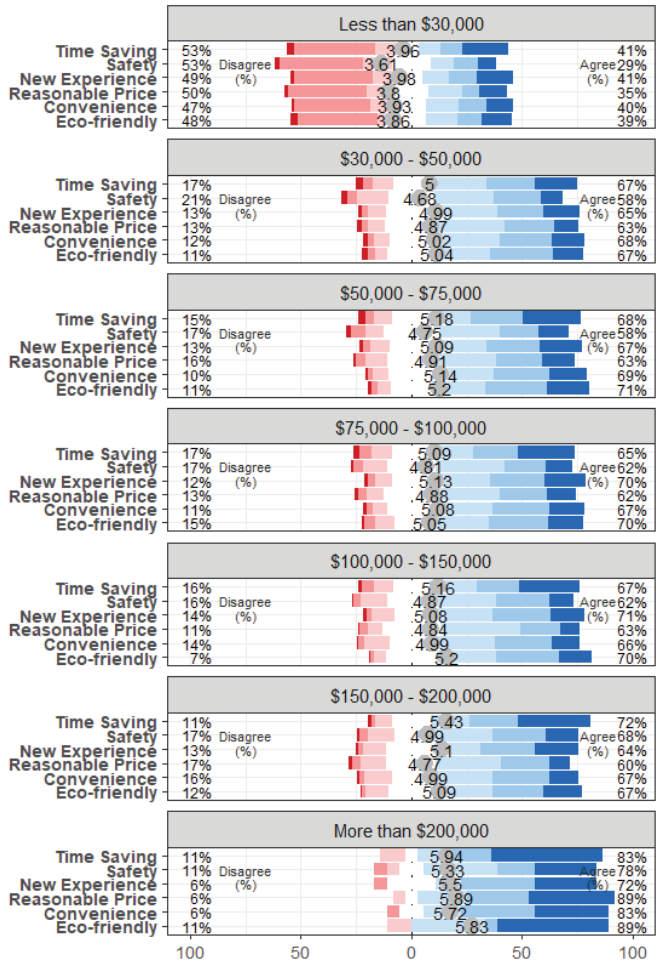

Figure 7. Ratings on anticipating advantages of UAM by income levels

The results may imply several interesting findings, as follows:

- While age groups and income levels are significant in the ratings on most questions, the residential area does not yield significant differences in ratings.
- As shown in Figure 6, senior respondents (aged over 60 years old) expressed concern about "safety" compared to other age groups and other questions. On the other hand, they rated higher on "convenience" than other groups and questions.
- In general, as shown in Figure 7, respondents with higher income levels rated the most advantages of UAM, while respondents with lower income levels rated the lowest. It may mean that even though most people understand the concept and advantages of UAM, they believe the UAM service would be more useful for people with a higher income.

Overall Opinion

In the last part of the survey, we asked a series of questions to understand overall opinions on UAM, including the following components: Whether participants: 1) are willing to share the ride of UAM with other strange passengers, 2) understand that the UAM flies around city and residential areas, 3) perceive UAM is safe and robust transportation methods, 4) perceive UAM has good protection to comfort passengers 5) are willing to take UAM eventually, 6) believe that UAM can be commercialized, and 7) trust the UAM. As shown in Figure 8, respondents evaluated most questions as positive. In particular, about 64% of respondents answered that they trust the UAM and its services. Considering the survey was conducted in 2021, the results indicate that the public perception of UAM has been similar to or improved compared to Yedavalli and Mooberry's (2019) study, which revealed that 44% of people support the concept of UAM. However, it should be noted here that simple questions on trust were asked in this study, and the level of trust might not be comparable to the level of support in Yedavalli and Mooberry's (2019) study. Thus, it might be required to measure the level of trust and support more accurately and independently in future studies.

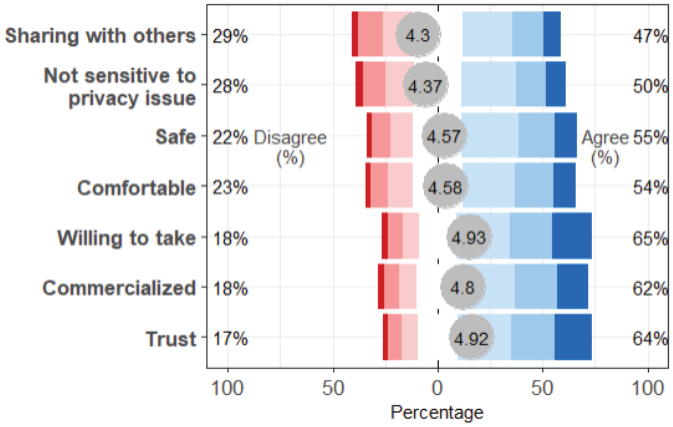

Figure 8. Ratings on questions for overall opinion

CONCLUSION

The survey study was conducted to investigate the public perception of UAM vehicles, including the level of awareness, the expected amount of fare and values, primary reasons for taking UAM, and expected advantages, as well as differences by demographic factors like age, residential area, and income level. It has been discovered that respondents in their 40s and 50s appear to have a high level of understanding of UAM vehicles. Furthermore, those in their 60s and older were most concerned about "safety" for UAM vehicles, although they also expected the most "convenience." General ratings on the importance of riding time to destination, fare, and traffic are not crucial for those living in rural regions. Also, respondents with higher income levels ranked the greatest advantages of UAM highest, while respondents with lower income levels rated it lowest. Even though it is a preliminary analysis, it may provide insights to various stakeholders, such as designers, researchers, businesses, etc.

Future studies can identify underlying requirements to develop and commercialize the UAM by conducting a complete in-depth analysis. Also, successive user studies such as another survey or interview would be required.

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