7 (3): 353-364 (2023)

Journal of Aviation

https://dergipark.org.tr/en/pub/jav

e-ISSN 2587-1676

A Comprehensive Analysis of Society's Perspective on Urban Air Mobility

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Article Info

Received: 10 July 2023
Revised: 24August 2023
Accepted: 26 August 2023
Published Online: 06 October 2023

Keywords:
Urban Air Mobility
Advanced Air Mobility
Unmanned Aerial Vehicles
Society's Perspective
Transportation

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RESEARCH ARTICLE

https://doi.org/10.30518/jav.1324997

Abstract

Urban Air Mobility (UAM) is an innovative concept that offers a distinct solution for dense urban transportation through the use of electric vertical take-off and landing (eVTOL) aircraft and unmanned aerial vehicles (UAVs), despite not being the first technological development in transportation. This study aims to understand society's perspective on this innovative concept by analysing its benefits and challenges. A total of 518 individuals living in Ankara and Istanbul, which are the provinces with the highest population density in Türkiye, were surveyed online as part of this research. The analysis results indicate that the system is perceived as beneficial by the public, particularly in emergency situations, where its usage receives general acceptance. However, significant challenges are observed in terms of integrating UAM into the existing airspace. Moreover, variations in the level of benefit based on gender and frequency of public transportation usage, as well as differences in the level of challenge based on age, have been identified. Furthermore, it is evident that there are differences in society regarding knowledge level, attitude, and willingness to use UAM.

1. Introduction

As cities continue to experience growth and population increases, there is an increasing need for innovative transportation solutions to move people efficiently. Urban Air Mobility (UAM) is being considered as one of the promising solutions to this challenge. UAM has the potential to revolutionize urban transportation by reducing traffic congestion, improving air quality, and making it easier for people to get around (Garrow et al., 2021). However, as with any emerging transportation technology, UAM presents both benefits and challenges. UAM encompasses a wide range of vehicles, including helicopters, tiltrotors, electric vertical take-off and landing (eVTOL) aircraft, and unmanned aerial vehicles (UAVs). Nevertheless, recent advancements in UAVs have led to an increasing association of UAM (Luque-Vega et al., 2022). UAV market has experienced significant developments, resulting in a surge of research on autonomous vehicles for UAM. In recent years, several companies and organizations have been exploring the potential of UAM, including Uber, Airbus, and NASA (Chakraborty et al., 2020). For example, Uber has been working on its Elevate program, which aims to launch aerial ride-sharing services using eVTOL aircraft in several cities around the world by 2023 (Nikitas et al., 2021). Additionally, Airbus has also been working on its CityAirbus program, which involves the development of a four-seat eVTOL aircraft for UAM (Saeed et al., 2021). Furthermore, Boeing is actively engaged in the development of autonomous aerial vehicles and air taxi systems through its "Boeing NeXt" program (Boeing NeXt, 2019). Volocopter specializes in manufacturing eVTOL aircraft and offers solutions for commercial air transportation (Helihub, 2021). Kitty Hawk aims to make air mobility more accessible by developing personal air vehicles (eVTOL News, 2023). Amazon plans to utilize UAVs for enhancing its air cargo delivery service called "Prime Air" (Amazon, 2023). Alphabet, the parent company of Google, is leading the "Wing" initiative, which focuses on air cargo and delivery services (Retail Dive, 2023).

UAM is a concept that has been around for decades, but it is only recently that technology has caught up with the idea. UAM is an emerging transportation mode that leverages advanced technologies to provide safe, efficient, and eco-friendly air transportation for people and goods in urban areas (Koumoutsidi et al., 2022). The history of UAM can be traced back to the early 20th century when airplanes were first used for commercial transportation. However, it wasn't until the 1960s that the concept of vertical takeoff and landing (VTOL) aircraft was first introduced (Nguyen, 2020). In the 1970s, the US military began using VTOL aircraft for battlefield transportation (Hu & Yang, 2022). In the 1980s and 1990s, several companies began developing small VTOL aircraft for civilian use, but these efforts were mostly unsuccessful due to technical limitations and high costs. Today, the UAM market is growing rapidly, with several companies developing and testing UAM systems around the World (Donateo & Çinar, 2022). Advances in UAV technology, such as electric propulsion systems, advanced battery technology, and autonomous navigation systems, have made UAM systems more efficient, safe, and affordable. In addition, new regulatory frameworks are being developed to accommodate UAM systems, including air traffic management and certification standards. The future of UAM is exciting, with the potential to revolutionize urban transportation. By providing fast, efficient, and eco-friendly air transportation, UAM systems could reduce traffic congestion, improve accessibility, and reduce greenhouse gas emissions. Some experts predict that UAM systems could be fully operational by the mid-2020s, with commercial services available in several cities around the World (Cohen et al., 2021). The future of UAM is promising, and it is likely that we will see UAM systems become an integral part of urban transportation in the coming years. However, while UAVs offer many benefits, such as reduced travel time, greater flexibility, reduced infrastructure costs, and improved emergency response, environmental and economic, for UAM and other applications in urban environments, several challenges must be addressed before they can be widely deployed. The challenges, such as safety, security, noise, privacy, integration, airspace management, and infrastructure, must be overcome. Regulatory frameworks must be established to ensure the safe and efficient operation of UAM systems. Both commercial mobility-on-demand operators and government-sponsored research institutes such as NASA are exploring various approaches to allow UAVs to travel safely and efficiently through cities (Cetin et al., 2020).

Advancements in the field of UAM have been observed globally. For instance, China has successfully completed the certification of the EH216-S, the first unmanned passenger-carrying aircraft (Aviation Week, 2023). Spain has also achieved a significant milestone by conducting the inaugural public flight of the EH216-S, making it the first European Union nation to operate an eVTOL for public safety purposes (AAM International, 2022). In France, which is planning air taxi operations during the 2024 Paris Olympic Games, four locations have been identified for takeoff and landing purposes (Future Flight, 2023). Japan, on the other hand, is planning to facilitate approximately 30,000 eVTOL air taxi flights during the World Expo 2025 to accommodate the influx of international tourists (eVTOL Insights, 2022). In the United States, specifically in the City of Los Angeles (LA), efforts are being made to establish LA as a role model for other communities in providing safe, efficient, and sustainable transportation and comprehensive UAM (used as Advanced Air Mobility in the USA) public services during the 2028 Olympic Games (Urban Movement Labs, 2022). According to studies, the estimated global market for UAM is projected to range between $74 to $641 billion US in 2035, with the wide variation being attributed to the scope of the projections. The $74 billion US estimate only considers eVTOL vehicles and excludes military applications. In addition, the projected market for goods delivery is estimated to range between $3.1 to $8 billion US in 2030, while the projected market for passenger mobility is estimated to range between $2.8 to $4 billion US in 2030 (Cohen et al., 2021).

2. Benefits and Challenges of UAM in The Literature

The use of UAVs in UAM offers several benefits over traditional ground-based transportation systems. Firstly, UAVs can travel directly to their destination without being impeded by traffic congestion, which can significantly reduce travel times (Straubinger et al.,2020; Li et al., 2022; Jiang et al., 2023). UAM systems can improve accessibility for people with mobility impairments, providing a new mode of transportation that may be more accessible than traditional ground-based transportation systems. This could lead to faster and more efficient transportation for passengers. Secondly, UAM can provide greater flexibility in terms of routing, allowing for more efficient transportation of people and goods (Poudel & Moh, 2020). It can allow for improved delivery times and increased productivity. Thirdly, UAVs can be used to transport emergency supplies and medical equipment to hard-to-reach locations, potentially saving lives (Grzegorz et al., 2021; Flores-Caballero et al., 2020). The emergency response times in densely populated urban areas can be improved using urban mobility. Fourthly, UAM systems can reduce the need for costly ground-based infrastructure, such as highways and bridges (Liang et al., 2021). This would result in significant cost savings for the government and taxpayers. Furthermore, UAM systems could create new jobs and economic opportunities in areas such as manufacturing, maintenance, and logistics. Lastly, the use of UAVs for UAM can help reduce ground-level traffic congestion and air pollution by reducing the number of cars on the road (Marzouk, 2022; Yu et al., 2022). UAM systems have the potential to reduce greenhouse gas emissions by reducing the number of cars on the road (Jiang et al., 2023). In addition to all, UAVs are also useful for various purposes in urban environments such as traffic monitoring cities (Lee et al., 2019), mapping (Yuan et al., 2022), photography, management of disasters (Gupta et al., 2020), and weather forecasting (Böhler et al., 2018). Overall, the deployment of UAVs for UAM has great potential to transform urban transportation and contribute to building smart cities in the future.

Despite their many benefits, the use of UAVs for UAM also poses several challenges. One of the main challenges is safety (Sun et al., 2021). UAVs are still new and untested, so there is a risk of accidents. UAVs operating in urban areas need to be able to detect and avoid obstacles, including other aircraft, buildings, and people. UAVs need to be able to operate safely in adverse weather conditions, such as strong winds or heavy rain (Hann et al., 2021; Mohan et al., 2021). Due to their inherent mobility and the potential for collision among UAVs in complex flight conditions, it is critical to provide a collision avoidance protocol for safe flights (Huang et al., 2020). Another challenge is developing an effective air-traffic control system for managing UAVs in urban environments and integrating them into existing airspace systems (Xu et al., 2020). The management of UAV traffic in urban areas requires a unique approach that takes into account factors such as air space clearance, flight patterns, and safety requirements (Ecke et al., 2022). Additionally, UAM systems will need to be integrated with existing transit hubs, such as train stations and bus terminals, to provide seamless transportation options for passengers. Information security in UAV wireless communications is also a challenge that needs to be addressed (Mahmoud et al., 2015). UAVs used for UAM may be vulnerable to cyberattacks or physical attacks, posing a security risk to passengers and the public (Xia & He, 2022). Another one is the privacy of urban life when flying in the city (Li et al., 2020). The issue of noise pollution is a significant challenge that must be addressed (Rodríguez et al., 2021). UAVs can generate significant amounts of noise, which can be disruptive to people living in urban areas. Lastly, a major challenge is public acceptance (Tuncal & Uslu, 2021; Wu & Zhang, 2021). The public may be hesitant to embrace UAM due to concerns over safety, privacy, and noise pollution. To overcome these challenges and fully realize the potential of UAV technology for UAM and other applications in urban environments will require ongoing research and development to improve safety, reliability, and security in UAV communications and navigation systems. Furthermore, there is a need to develop effective policies and regulations related to the use of UAVs in urban environments.

UAM represents the future trajectory of aviation and the success of endeavors in this domain has the potential to bring about significant transformations in cities worldwide. Consequently, the attitudes exhibited by individuals towards UAM services will play a pivotal role in shaping future planning and policy decisions. Therefore, it is of paramount importance to comprehensively understand people's perceptions and concerns regarding UAM, as this understanding will inform decision-making processes and contribute to fostering greater acceptance of UAM services in the future. To this end, our objective is to conduct a study that delves into people's perspectives and apprehensions concerning UAM services, leveraging existing scholarly research. The outcomes derived from comprehensive analysis of society's perspective on UAM will serve to enhance the future acceptance of UAM services and aid in making informed and judicious choices in this field.

3. Literature Review

The conducted literature review reveals a significant increase in research efforts focusing on the concept of UAM in recent years. Donateo et al. (2022) found that UAM could have lower environmental impacts than traditional road transportation, whereas Cohen et al. (2021) highlighted several barriers to growth and mainstreaming, including regulatory environment, public acceptance, safety concerns, noise, social equity, and environmental impacts. Rothfeld et al. (2018) identified factors of passenger acceptance and potential passengers' value of time, demonstrated first UAM modeling approaches, and presented potential spatial and welfare effects of UAM implementations. Koumoutsidi et al. (2022) found that the utilization of UAM, specifically for the purposes of cargo transportation and air ambulance services, is anticipated to represent the most advanced and fully developed business models during the upcoming decade. Rowedder (2019) provided an overview of the development status of UAM and its challenges, including licensing through the responsible authorities. Scheff et al. (2020) discussed the human factors challenges associated with safely operating UAM platforms in airspace, including workload factors and machine vs. human automation needs. Vascik et al. (2018) assessed how the introduction of UAM services and UAV systems may challenge Air Traffic Control (ATC) in the United States and what opportunities exist to support these forthcoming operations. Cokorilo (2020) provided an overall analysis of creating dominant safety management principles in the aviation industry and considers aircraft accidents caused by flight crew errors as the main problem in UAM safety issues. Reiche et al. (2021) discussed the potential weather and public acceptance challenges for UAM operations in adverse conditions. Straubinger et al. (2020) provided an overview of different research areas in the emerging topic of UAM, including vehicle-related aspects, certification and policy, traffic management, ground infrastructure requirements, operational concepts, market structures, and public acceptance. Mavraj et al. (2022) emphasized the need for a suitable ground-based infrastructure to supply UAM vehicles, including networks of take-off and landing sites, facilities for maintenance, energy supply, and navigation and communication capabilities. Thipphavong et al. (2018) discussed airspace integration concepts and considerations needed for safe and efficient UAM operations alongside other airspace users. Pukhova et al. (2021) found that UAM may not reduce road congestion in metropolitan areas with well-developed road and transit networks, and may only serve selected markets such as emergency vehicles or longer trips between remote areas. Balac (2021) found that UAM has the potential to reduce travel time but not generalized cost, and its market share is likely to be low. Marzouk (2022) provided an overview of UAM and flying cars, including examples and prospects for air taxis as a nontraditional mode of transportation. Çetin et al. (2022) proposed mitigation measures to reduce public concerns about UAV operations in urban areas. Hogreve & Janotta (2021) found that factors affecting the adoption of UAM services include perceived safety, reliability, and convenience. Al Haddad et al. (2020) revealed the importance of safety and trust, affinity to automation, data concerns, social attitude, and socio-demographics for public acceptance. Rizzi & Rafaelof (2021) discussed the initial development of a method to assess the acoustic impact of UAM fleet operations on the community, indicating that noise is a concern for communities close to UAM operations. According to Yedavalli & Mooberry's (2019) study, which surveyed the general population across four locations, the type and volume of sound generated by eVTOL aircraft were the second and third highest factors affecting UAM public acceptance. The exploratory study conducted by Shaheen et al. (2018) in Los Angeles, Washington, D.C., and five U.S. cities, found that noise levels could impact public support for UAM, while participants also expressed concerns about passenger safety during the booking, boarding, and on-board process, from departure to arrival. Jordan et al. (2022) evaluated the cybersecurity risks in UAM operational environment, including the need for secure data exchange and interoperability with existing air transportation systems. Wu & Zhang (2020) discussed the impact of uncertainties on UAM's transportation system performance, including optimal infrastructures location identification, facility capacities, and aircraft fleet size. Takacs & Haidegger (2022) highlighted the need for careful infrastructure planning and regulation to ensure that UAM is sustainable and does not have negative environmental impacts. Bauranov & Rakas (2021) discussed different urban airspace concepts and assessed them based on safety-related factors, social factors, system factors, and aircraft factors. Bulusu (2019) found that UAM can be a viable alternative to road transport for hub-to-door and door-to-door urban services, especially for movement of unconsolidated goods. Kaoy et al. (2020) found that customers accept the use of UAVs for delivery service. Postorino & Sarne (2020) suggested that the anticipated advantages of flying cars will depend on factors including trip origin/destination points, average distances traveled within urban areas, and the location of transition nodes - which serve as interchange points between aerial and ground modes of transportation - as revealed by preliminary findings from test networks examining the effects of travel costs.

4. Methodology

To collect data, a survey questionnaire was developed. The survey questionnaire was designed in accordance with the research objectives and was pre-tested with expert opinions. The survey was made available online and participants were sent a link to access it. Data was collected through responses to the survey questions. The survey questionnaire consisted of two parts. The first part collected information on the demographic characteristics of the participants. The second part consisted of questions about the benefits and challenges of UAM. The survey questions were based on important topics and findings from the literature. The benefits and challenges identified through the literature review are shown in the Table 1.

Table 1. The benefits and challenges of UAM

Benefits	Challenges
Advanced emergency supplies	Air space management
Economic opportunities	Integration with existing land transportation networks
Environmental benefits	Noise
Reduced travel times	Public acceptance
Reducing infrastructure costs	Safety
Significant flexibility in transportation	Security

Participants provided pre-consent prior to taking the survey, and participation was voluntary. Participants were selected by simple random sampling method. Participants' privacy and anonymity were protected. The data was analyzed using the SPSS (Statistical Package for the Social Sciences) program. Data analysis was conducted using descriptive statistics, including frequency, percentage, and mean. The independent samples t-test and one-way analysis of variance (ANOVA) were used for detailed analyses between groups.

It is crucial that the sample of the study represents individuals who have access to UAM services and who may have diverse demographic characteristics. For this purpose, the survey was conducted on individuals living in Istanbul and Ankara, Türkiye's two most populous cities, where heavy traffic and frequent use of public transportation are common, to ensure a representative sample. While there are currently no UAM practices in these cities, the concept will gain even more importance in the future, considering the possible congestion that may occur in land mobility with the continuously increasing population.

5. Result and Discussion

5.1. Demographic characteristics of the participants

A total of 518 individuals living in the cities of Ankara and Istanbul participated in the study. The demographic characteristics of the participants are shown in Table 2.

In the study, individuals living in Istanbul and Ankara, which are the provinces with the highest population density in Türkiye (TUİK, 2023a), were selected as the sample. This selection provides a valuable perspective to understand the viewpoints of individuals living in different urban areas. Of the participants, 314 (60.6%) were from Istanbul, while 204 (39.4%) were from Ankara. Considering that Istanbul has the highest population density in Türkiye, it is believed that the opinions of participants from Istanbul will contribute significantly to the study's understanding of UAM.

The study exhibited a distribution where the proportion of female participants is higher compared to male participants, with a frequency of 330 (63.7%) for females and 188 (36.3%) for males. It was observed that female participants display a greater interest in UAM, which offers a novel approach to urban transportation.

When examining the distribution of participants by age groups, the highest proportion was observed among participants in the 30-39 age range. The frequency of participants in this age range was determined as 197 (38.0%). Following that, participants in the 18-29 age range come next, with a frequency of 170 (32.8%). This distribution indicates that the study encompasses the perspectives of individuals from different age groups and facilitates a comprehensive understanding of various generational viewpoints on UAM. Additionally, according to the population statistics of Türkiye, the median age was 32.8 for males and 34.2 for females in 2022 (TUİK, 2023b). Considering these statistics, it can be observed that the 30-39 age range with the highest participation in the survey is in line with this average. This suggests that the age distribution in the survey represents the general trends of the Turkish population.

Table 2. Demographic characteristics of the participants

		n	%
City	İstanbul	314	60.6
	Ankara	204	39.4
Gender	Female	330	63.7
	Male	188	36.3
Age	18-29	170	32.8
	30-39	197	38.0
	40-49	106	20.5
	50+	45	8.7
Education	Bachelor's degree	240	46.3
	Graduate degree	278	53.7
Monthly Average Income	0- 15.000 TL	146	28.2
	15.001- 30.000 TL	188	36.3
	30.001- 50.000 TL	116	22.4
	50.001 TL +	68	13.1
Frequency of Urban Transportation Usage	Throughout the day	30	5.8
	Half of the day	64	12.4
	Few hours a day	261	50.4
	Few times a week	94	18.1
	Rarely	69	13.3
Total		518	100.0

The participants consist of individuals with diverse educational backgrounds. The majority of participants have completed undergraduate education, with a frequency of 240 (46.3%). On the other hand, participants with graduate degrees have a slightly higher representation, with a frequency of 278 (53.7%). This two-dimensional diversity in the study allows for a multidimensional qualitative analysis of UAM and takes into account the perspectives of individuals with different levels of education. It can be stated that as the educational level increases, interest in such new applications also increases.

The study encompasses participants from various income levels. The largest group consists of participants in the income range of 15,001-30,000 TL, with a frequency of 188 (36.3%). This is followed by participants in the income range of 0-15,000 TL, with a frequency of 146 (28.2%).

Taking into consideration the frequency of participants' urban transportation usage, it was indicated that the majority of participants use urban transportation for few hours a day, with a frequency of 261 (50.4%). This is followed by those who use urban transportation a few times a week, with a frequency of 94 (18.1%). This distribution demonstrates that the study includes participants who utilize urban transportation in various ways, enabling us to comprehensively understand their expectations and perceptions regarding UAM.

5.2. Benefits of UAM

Regarding the identified six benefits in the literature, participants were asked to provide responses using a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). Average scores and standard deviations for each benefit are shown in Table 3.

Table 3. Mean and standard deviation of benefits

	Mean	Std. Deviation
Advanced emergency supplies	4.691	0.6103
Reduced travel times	4.371	0.7927
Significant flexibility in transportation	4.232	0.8324
Environmental benefits	4.064	0.9764
Economic opportunities	4.039	0.9567
Reducing infrastructure costs	3.878	1.0364

Advanced emergency supplies: Participants highly rated this benefit with an average score of 4,691 and a low standard deviation of 0,6103. This indicates that participants generally agree on the effective advantage of UAM in advanced emergency services.

Reduced travel times: The average rating for reducing travel times is 4,371, indicating that participants acknowledge the potential of UAM in decreasing travel durations. With a standard deviation of 0,7927, while there is some variation in responses, it can be inferred that UAM generally offers a benefit in reducing travel times.

Significant flexibility in transportation: Participants expressed agreement that UAM would provide greater flexibility in transportation, with an average rating of 4,232. The low standard deviation of 0,8324 suggests a general consensus among participants regarding increased flexibility in transportation through UAM.

Environmental benefits: Participants recognized the positive environmental impact of UAM with an average score of 4,064. Although there is some variation in opinions, as indicated by the standard deviation of 0,9764, participants generally agree that this mode of transportation can bring environmental benefits.

Economic opportunities: The average rating for economic opportunities related to UAM was determined as 4,039. With a standard deviation of 0,9567, it is evident that there are varying opinions among participants regarding the potential economic advantages associated with this mode of transportation.

Reducing infrastructure costs: Participants evaluated the potential of UAM in reducing infrastructure costs with a relatively lower rating of 3,878. The higher standard deviation of 1,0364 suggests a lack of consensus regarding the effective reduction of infrastructure costs.

Among the benefits, advanced emergency supplies received the highest average score, indicating that UAM can provide significant benefits in emergency situations. This suggests that UAVs can enhance emergency response capabilities, facilitate rapid and effective delivery of critical supplies, and potentially save lives in emergencies. The high ratings for reducing travel times and providing significant flexibility in transportation indicate the potential of UAM to substantially shorten travel durations and offer increased mobility options, particularly in dense urban areas, thereby enhancing overall accessibility and comfort for passengers. The positive ratings for environmental benefits and economic opportunities underscore the significance of UAVs within the context of UAM, as their adoption can contribute to reducing carbon emissions and pollution while creating new job opportunities and promoting economic growth in the aviation industry. Although reducing infrastructure costs received a lower average rating, it is still acknowledged as a potential benefit, indicating that UAM has the potential to minimize infrastructure investments in cities, optimize financial resources, and improve the feasibility and operations of such systems.

The benefit level of the UAM system was calculated by averaging the six benefits related to the UAM concept, as described in the literature and detailed above. The analysis results based on the variables are shown in Table 4 and Table 5.

According to the analysis conducted based on the city variable, the average UAM benefit level was found to be 4,2054 with a standard deviation of 0,58286 for individuals residing in Istanbul, while it was determined to be 4,2230 with a standard deviation of 0,56218 for individuals residing in Ankara. These results indicate that there is no statistically significant difference in UAM benefit levels between Istanbul and Ankara ($t = -0,341$; $p = 0,733$).

Regarding the gender variable, the analysis revealed that the average UAM benefit level for females was 4,2672 with a standard deviation of 0,56351, while for males, it was 4,1161 with a standard deviation of 0,58193. These findings indicate a statistically significant difference in UAM benefit levels between genders ($t = 2,899$; $p = 0,004$*). Since $p < 0,05$, this difference is considered statistically significant.

In terms of the education variable, the analysis showed that individuals with an undergraduate degree had an average UAM benefit level of 4,2243 with a standard deviation of 0,59268, while individuals with a graduate degree had an average UAM benefit level of 4,2020 with a standard deviation of 0,55886. These results indicate that there is no statistically significant difference in UAM benefit levels based on education levels ($t = 0,440$; $p = 0,660$).

In the analysis based on the age variable, no significant difference was found in UAM benefit levels among different age groups. The average UAM benefit level for individuals aged 18-29 was found to be 4,2422 with a standard deviation of 0,60244, and similar results were obtained for other age groups. Therefore, it was determined that there is no statistically significant difference in UAM benefit levels among age groups ($F = 0,245$; $p = 0,865$).

Regarding the income variable, no significant difference was found in UAM benefit levels among different income groups. When examining the average UAM benefit levels and standard deviations across different income groups, no statistically significant difference was observed ($F = 0,382$; $p = 0,766$).

In the analysis based on the frequency of public transportation usage variable, a significant difference was found in UAM benefit levels among different usage frequencies. When examining the average UAM benefit levels and standard deviations for individuals with different usage frequencies, it is evident that those who use public transportation "Throughout the day" exhibit the highest UAM benefit level. This difference is statistically significant ($F = 2,397$; $p < 0,05$).

Based on this analysis, it can be concluded that age and monthly income level variables do not have a significant impact on UAM benefit levels, while the frequency of public transportation usage variable does. Furthermore, significant differences were observed in UAM benefit levels based on the gender variable, with higher UAM benefit levels reported by female participants. Additionally, the frequency of public transportation usage variable has a significant effect on UAM benefit levels, with individuals using public transportation throughout the day deriving greater benefits from UAM services compared to those using it for a few hours daily.

In conclusion, there were no significant differences in UAM benefit levels based on the city, education, age, and monthly income variables, while a significant difference was observed based on the gender and public transportation usage variables. Female participants in the study had higher UAM benefit levels compared to male participants. The analysis revealed that individuals using public transportation throughout the day derive more benefits from UAM services than those using it for a few hours daily.

5.3. Challenges of UAM

In the study, responses were obtained from participants regarding six challenges identified in the literature related to UAM, using a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). The average scores and standard deviations for each challenge are shown in Table 6.

Table 6. Mean and standard deviation of challenges

	Mean	Std. Deviation
Air space management	3.846	0.9870
Security	3.809	0.9835
Safety	3.795	0.9916
Public acceptance	3.544	1.0412
Noise	3.517	1.0364
Integration with existing land transportation networks	3.512	1.0532

In the study, responses were obtained from participants regarding six challenges identified in the literature related to UAM, using a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). The average scores and standard deviations for each challenge are shown in Table 6.

Air space management: Participants evaluated the challenge of air space management with an average score of 3,846 and a standard deviation of 0,9870. This indicates that participants generally recognize the complexities and challenges of effectively managing airspace in the context of UAM operations. However, the fact that not everyone is familiar with airspace and air traffic-related matters is also evident.

Security: The average score for security is 3,809, indicating that participants acknowledge the importance of security in the context of UAM. With a standard deviation of 0,9835, it is evident that there are some differences and varying levels of concern or consensus among participants regarding this challenge.

Safety: Participants acknowledged the challenge of flight safety in the implementation of UAM with an average score of 3,795. With a standard deviation of 0,9916, it is evident that there are some differences and varying levels of concern or consensus among participants regarding this challenge.

Public acceptance: Participants evaluated public acceptance of UAM as a challenge with an average score of 3,544 and a standard deviation of 1,0412. This indicates the challenges associated with securing public acceptance for UAM initiatives. The high standard deviation suggests differing views and attitudes among participants. It is natural for people to have reservations when it comes to adopting new methods, especially when the study discusses a method intended to be implemented in the near future. Therefore, it is expected for individuals to approach the subject with some reluctance.

Noise: The potential noise impact of UAM was evaluated with an average score of 3,517 and a standard deviation of 1,0364. This indicates that participants have concerns about the increased noise levels associated with this mode of transportation. The high standard deviation suggests varying perceptions and sensitivities regarding this issue.

Integration with existing land transportation networks: The challenge of integrating UAM with existing land transportation networks was evaluated with an average score of 3,512 and a standard deviation of 1,0532. This demonstrates participants' recognition of the complexities involved in seamlessly integrating this new mode of transportation with existing infrastructure. However, the high standard deviation indicates differing views and uncertainties regarding the integration process. The reluctance towards something new is also evident in this aspect.

Among the UAM challenges, Air Space Management received the highest average score, indicating that it is perceived as a significant challenge in the implementation of UAM. This highlights the importance of coordinating and regulating air traffic, effective use of airspace, and integration between manned and UAVs as essential factors. Security and flight safety also received high scores, emphasizing the importance of operating UAM systems in a secure and safe manner. This suggests the need for implementing effective security protocols, surveillance, and risk reduction strategies to address potential security threats and instill public confidence. Public acceptance emerged as another important aspect, albeit with a slightly lower average score. This indicates the significance of gaining societal acceptance and addressing concerns related to privacy, noise, and overall public perception. It is crucial to earn public trust for successful adoption and integration of UAM solutions. Noise and integration with existing land transportation networks received slightly lower average scores, yet they still highlight significant focal points. Reducing noise pollution caused by UAVs and seamlessly integrating them with existing transportation infrastructure are essential for minimizing environmental impact and ensuring smooth transitions within the multimodal transportation system.

The challenge level of the UAM system was calculated by averaging the six challenges related to the UAM concept, as described in the literature and detailed above. The analysis results based on the variables are shown in Table 7 and Table 8.

In the analysis conducted according to the city variable, the average UAM challenge level was found to be 3,6805 with a standard deviation of 0,65375 for individuals living in Istanbul, while it was found to be 3,6552 with a standard deviation of 0,59567 for individuals living in Ankara. According to these results, there was no statistically significant difference in UAM challenge levels between Istanbul and Ankara ($t=0,444$; $p=0,657$).

In the analysis conducted according to the gender variable, the average UAM challenge level was found to be 3,6682 with a standard deviation of 0,63826 for females, while it was found to be 3,6746 with a standard deviation of 0,61985 for males. According to these results, there was no statistically significant difference between genders in terms of UAM challenge levels ($t=-0,112$; $p=0,911$).

In the analysis conducted according to the education variable, the average UAM challenge level was found to be 3,7174 with a standard deviation of 0,65175 for individuals with a bachelor's degree, while it was found to be 3,6301 with a standard deviation of 0,61091 for individuals with a master's degree. According to these results, there was no statistically significant difference between education levels in terms of UAM challenge levels ($t=1,572$; $p=0,117$).

In the analysis conducted according to the age variable, a significant difference was found in UAM challenge levels among different age groups (F=6,921; p<0,05). The average UAM challenge level for individuals aged 50 and above (4,0407) was higher compared to other age groups. This result indicates that age has an impact on UAM challenge levels. Additionally, a significant difference was noted between individuals aged 50 and above and the 18-29 age group.

In the analysis conducted according to the income variable, there was no statistically significant difference in UAM challenge levels among different income groups (F=0,523; p=0,667). Upon examining the average UAM challenge levels and standard deviations among different income groups, no statistically significant difference was observed.

In the analysis conducted according to the frequency of public transportation use variable, there was no statistically significant difference in UAM challenge levels based on different usage frequencies of public transportation (F=1,315; p=0,263). Upon examining the average UAM challenge levels and standard deviations among individuals with different usage frequencies, no statistically significant difference was found.

In conclusion, there was no statistically significant difference in UAM challenge levels based on the city, education, gender, monthly income, and frequency of public transportation use variables in the study. Therefore, it can be concluded that these variables do not have a determining effect on UAM challenge levels and UAM services can cater to a wide range of users. However, age was found to have a significant impact on UAM challenge levels. The analysis revealed that individuals aged 50 and above experience higher UAM challenge levels compared to other age groups. This indicates that age is an important factor in the field of UAM. The influence of age on UAM challenge levels suggests the need to consider different user needs and design services accordingly for different age groups. For example, the higher challenges faced by individuals aged 50 and above when using UAM services highlight the importance of addressing the mobility needs of the elderly population.

Table 4. Analysis results of UAM benefit levels based on city, gender, and education variables (t-test)

	Group	n	Mean	Std. Deviation	t	Sig.
City	İstanbul	314	4.2054	0.58286	-0.341	0.733
	Ankara	204	4.2230	0.56218		
Gender	Female	330	4.2672	0.56351	2.899	0.004*
	Male	188	4.1161	0.58193		
Education	Bachelor's degree	240	4.2243	0.59268	0.440	0.660
	Graduate degree	278	4.2020	0.55886		

*p<0,05; Significant differences.

Table 5. Analysis results of UAM benefit levels based on age, income, and frequency of public transportation usage variables (ANOVA)

	Group	n	Mean	Std. Deviation	F	Sig.	Variation
Age	18-29	170	4.2422	0.60244	0.245	0.865	
	30-39	197	4.1954	0.54217			
	40-49	106	4.2075	0.56849			
	50+	45	4.1852	0.62887			
Monthly Average Income	0- 15.000 TL	146	4.2420	0.58659	0.382	0.766	
	15.001- 30.000 T	188	4.2057	0.58675			
	30.001- 50.000 TL	116	4.1710	0.52542			
	50.001 TL +	68	4.2377	0.60011			
Frequency of Urban Transportation Usage	Throughout the day	30	4.4611	0.57349	2.397	0.049*	Throughout the day > Few hours a day
	Half of the day	64	4.3073	0.60072			
	Few hours a day	261	4.1679	0.57624			
	Few times a week	94	4.1738	0.55353			
	Rarely	69	4.2367	0.54638			

*p<0,05; Significant differences.

Table 7. Analysis results of UAM challenge levels based on city, gender, and education variables (t-test)

	Group	n	Mean	Std. Deviation	t	Sig.
City	İstanbul	314	3.6805	0.65375	0.444	0.657
	Ankara	204	3.6552	0.59567		
Gender	Female	330	3.6682	0.63826	-0.112	0.911
	Male	188	3.6746	0.61985		
Education	Bachelor's degree	240	3.7174	0.65175	1.572	0.117
	Graduate degree	278	3.6301	0.61091		

Table 8. Analysis results of UAM challenge levels based on age, income, and frequency of public transportation usage variables (ANOVA)

	Group	n	Mean	Std. Deviation	F	Sig.	Variation
Age	18-29	170	3.5941	0.64177	6.921	0.000*	50+>18-29; 50+>30-39; 50+>40-49.
	30-39	197	3.6210	0.60810			
	40-49	106	3.7280	0.61650			
	50+	45	4.0407	0.60109			
Monthly Average Income	0- 15.000 TL	146	3.6244	0.63240	0.523	0.667	
	15.001- 30.000 TL	188	3.6676	0.60339			
	30.001- 50.000 TL	116	3.7011	0.61287			
	50.001 TL +	68	3.7255	0.73288			
Frequency of Urban Transportation Usage	Throughout the day	30	3.8778	0.62657	1.315	0.263	
	Half of the day	64	3.5885	0.59315			
	Few hours a day	261	3.6533	0.59873			
	Few times a week	94	3.7234	0.66647			
	Rarely	69	3.6498	0.72488			

*p<0,05; Significant differences.

5.4. Knowledge

The study utilized a 4-item scale for participants to indicate their level of knowledge about UAM. The frequencies and percentages for each response option are shown in Table 9.

Table 9. Frequency and percent of knowledge level

	n	%
No knowledge	192	37.1
Limited level	191	36.9
Moderate level	106	20.5
High level	29	5.6
Total	518	100.0

The majority of participants (37,1%) indicated a lack of knowledge about UAM. This finding demonstrates that a significant portion of the sample has not been exposed to this concept.

A similar proportion (36,9%) reported having limited knowledge about UAM. This suggests that some individuals have heard about the topic or have a basic understanding of it but may require more information and clarification to fully comprehend the concept and its implications.

Approximately one-fifth of the participants (20,5%) stated having a moderate level of knowledge about UAM. This indicates that a subset of the sample possesses an average understanding of the topic, likely having come across relevant information, research, or industry developments.

A smaller percentage (5,6%) expressed having a high level of knowledge. This suggests that these individuals have acquired specialized knowledge, engaged in academic or professional research, or have direct involvement in the field.

Overall, the findings reveal that participants have limited knowledge about UAM, and the level of knowledge varies considerably. This underscores the importance of informing, educating, and raising awareness about UAM through informational campaigns, educational initiatives, and awareness-building efforts.

5.5. Attitudes

In the study, a 3-point scale was used for participants to indicate their attitude towards UAM. The frequencies and percentages for each option are shown in Table 10.

Table 10. Frequency and percent of attitudes towards UAM

	n	%
Yes. it could be very beneficial	238	45.9
Maybe. it could be useful in certain situations	276	53.3
No. it is not necessary or other transportation options are more suitable	4	0.8
Total	518	100.0

The majority of participants (45,9%) exhibited a positive attitude by indicating that UAM could be highly beneficial in meeting the transportation needs of the community. This finding indicates that a significant portion of the sample foresees the potential advantages of UAM and believes it can provide valuable solutions to transportation challenges.

With a slightly higher percentage (53,3%), participants displayed a more cautious attitude, believing that UAM could be beneficial in certain situations or conditions. This suggests that participants acknowledge the potential benefits of UAM but have concerns about its widespread applicability or specific limitations.

A very small percentage of participants (0,8%) expressed the view that UAM is unnecessary or that other transportation options are more suitable. This percentage suggests that some participants may have concerns about the feasibility, cost-effectiveness, or safety aspects of UAM and believe that alternative modes of transportation are more appropriate.

The analysis of participants' attitudes towards UAM in the study reflected varying opinions regarding the ability of UAM to meet the transportation needs of the community. While a significant portion of participants sees great potential in UAM, others hold a more cautious or skeptical perspective.

5.6. Willingness to use

In the study, a 4-point scale was used to assess participants' willingness levels regarding the use of UAM. The frequencies and percentages of each option are shown in Table 11.

A small percentage of participants (6,2%) indicated that they had no intention of using UAVs as a mode of transportation within the scope of UAM. This finding suggests that a small portion of the sample has serious reservations or concerns regarding the use of UAVs, which could be attributed to factors such as security, reliability, or other related considerations.

Table 11. Frequency and percent of willingness to use

	n	%
Absolutely unwilling to use	32	6.2
Might consider using	161	31.1
Would like to use occasionally	181	34.9
Would like to use frequently	144	27.8
Total	518	100.0

A significant portion of participants (31,1%) expressed their willingness to consider using UAVs, indicating an open approach to exploring their potential benefits and possibilities. These individuals may be interested in UAVs as a transportation option but may require further information or assurance before making a definitive decision about their usage.

A slightly higher percentage (34,9%) expressed a desire to occasionally use UAVs. This group may acknowledge the potential advantages of UAVs and view them as a suitable option for specific situations or special needs but may not prefer them as their primary mode of transportation.

Another notable segment (27,8%) demonstrated a strong inclination toward frequent use of UAVs. These participants showed a close alignment with the idea of integrating UAVs into their daily transportation system and regarded them as a preferred and reliable means of travel within the framework of UAM.

The research findings indicate variations in participants' willingness to use UAVs as a mode of transportation within the context of UAM. While a minority showed resistance, a significant number of participants expressed a desire for usage and even indicated a preference for frequent use.

6. Conclusion

According to the participants in the study, UAM is generally perceived as a beneficial concept. Based on the findings, UAM can be considered particularly suitable and beneficial for emergency situations. This perception can be attributed to people viewing air transportation as the fastest mode of travel. The findings regarding travel times also support this notion. Environmental pollution is a common issue in large cities, and UAM is seen as a potential solution to address this problem in the study. However, participants expressed concerns about infrastructure costs. It is undeniable that the establishment of a new system would incur significant expenses, and participants did not dismiss this issue.

The authors consider the management of airspace and traffic as the most thought-provoking factors for UAM. These thought-provoking factors are also corroborated by participants' perspectives. Another factor influencing these issues is safety. The management of the increasing national and international air traffic and the optimal utilization of capacity affect safety. The concentration of air vehicles in urban transportation can also have a negative impact on safety. This perception is supported by participants' views. Another significant concern is security. The events of September 11, 2001, are widely known and immediately come to mind as a major security vulnerability. The image of planes crashing into the Twin Towers is deeply ingrained in people's minds. In such a scenario, it is natural for societal acceptance to be influenced as a consequence of security concerns. Although UAM is seen as a solution to environmental pollution, participants have doubts regarding noise.

In terms of demographic characteristics, female participants tend to have more flexible and positive views on UAM. It can be stated that female is more inclined and willing to embrace this mode of transportation. Additionally, individuals who actively use urban transportation are almost unanimous in believing that UAM would benefit them.

Priority should be given to providing UAM services in areas with high public transportation demand and integrating them into users' daily routines, as this would increase the adoption of such services. However, it can be said that relatively older participants approach UAM more cautiously. As people age, their routines become more established, and their preferences for tasks such as work, travel, etc., become more rigid. Therefore, marketing efforts can involve older individuals as well. Additionally, it is important to make necessary arrangements to ensure that these individuals can easily access and use UAM services and feel secure. Furthermore, individuals who heavily rely on urban transportation can be consulted to enhance the concept of UAM.

Considering the differences in knowledge level, attitudes, and willingness to use UAM, it is crucial to inform the public accurately and comprehensively about this new technology. Efforts should be made to address existing concerns and raise awareness levels. Furthermore, it is deemed necessary to conduct further research to promote the acceptance and adoption of UAVs within the framework of UAM by the society. Research conducted by decision-makers, policymakers, and stakeholders focusing on alleviating public concerns and legislative efforts can contribute to the potential of UAM in providing a more sustainable and efficient transportation solution.

The primary aim of this study is to give an idea to the studies to be carried out for the concept of UAM. In addition, the study evaluates people's view of urban air transport or emergency activities that will be used and will be used in Türkiye. With this study, it is aimed to shed light on the studies to be carried out within the scope of the subject in the coming years.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Cite this article: Çınar, E., Tuncal, A. (2023). A Comprehensive Analysis of Society's Perspective on Urban Air Mobility. Journal of Aviation, 7(3), 353-364.