Is This Flight Headed Downtown? : User Experience Considerations for Urban Air Mobility

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ABSTRACT

Urban Air Mobility (UAM) is an emerging form of aerial transport and is expected to pave the way for a new mobility experience. In order for UAM to be successfully integrated into the current urban transportation system, user experience (UX) considerations need to be explored. However, few studies have revealed the understanding of user needs and requirements from the perspective of transportation experience. In this regard, our research team conducted workshops with vehicle experts to explore important UX considerations for UAM usage according to the initial and mature phases of UAM operations. Also, we uncovered UAM usage motives, potential use cases, as well as three expected forms of UAM operations. The findings from this study contribute to providing insights and design guidelines for UAM UX developers in future urban contexts.

CCS CONCEPTS

• **Hardware**; • **Emerging technologies**; • **Analysis and design of emerging devices and systems;**; • **Human-centered computing**; • **Human-computer interaction (HCI)**; • **HCI design and evaluation methods**; • **User studies**;

KEYWORDS

Urban air mobility (UAM), User experience, Technology adoption, Emerging technologies

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1 INTRODUCTION

Urban air mobility (UAM) is considered an emerging form of urban air transportation, holding capacities to resolve inefficiencies of ground transportation and operate as an environmentally sustainable means of transport. Subsequently, researchers and practitioners have initiated their technological and service developments of UAM. Global companies such as Hyundai and Uber have unveiled their blueprints of UAM.

With UAM still in a very nascent phase, previous UAM research has been conducted within the limits of an early consumer perspective. In particular, existing research and market studies have mainly relied on questionnaires, invested in forecasting transportation service demands or factors for initial technology acceptance [1, 3–6, 13, 14, 17]. According to previous findings, the primary factor for UAM acceptance was safety concerns [1, 3, 4, 6, 13]. In addition, given that UAM is a means of urban transportation, its travel time was shown to influence usage intentions [5, 17].

Nevertheless, there is a lack of studies conducted from a user perspective of UAM which emphasize the context of technology use, not only pertaining to the introductory stages of a technology [8]. Due to its distinctive nature as an aerial vehicle, new UX considerations are expected to emerge for UAM. Exploring and addressing such issues in advance would support our understanding of plausible user scenarios and the corresponding user needs. This would further encourage successful integration of UAM into our current mobility system. In this regard, the main objective of the present study is to uncover UX considerations of UAM and provide a direction for future UAM UX design. As UAM is anticipated to be an aerial expansion of the existing automotive land transportation, we organized two live workshops at the 13th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, in order to gather opinions from vehicle experts [12]. Our research questions are as follows:

1. What UX factors will be of important considerations for UAM?
2. What type of operations are expected for UAM when integrated into the current transport system?

Table 1: UX Factors from Literature

Category	UX Factor(s)	Literature
Vehicle-related (10)	Perceived Safety, Trust, Control	[1, 2, 4]
	Security, Ride comfort	[4, 14]
	Noise & Vibration	[4, 15]
	Anxiety, Motion Sickness	[8, 9]
	Pleasure	[2, 9]
	Vehicle Aesthetics	[9]
Service-related (7)	Punctuality, Frequency, Cost	[1, 5, 6, 14]
	Service Information	[2]
	Accessibility	[6, 15]
	Ease of Use	[1, 2, 15]
	Scenery	[4]
Socioenvironmental (3)	Symbolism & Social Influence	[8]
	Environmental Pollution	[4, 15]
	Cybersecurity	[1, 11]

2 METHOD

2.1 Participants

Before the conference, the workshop was promoted through social media and related academic communities. As a result, we recruited a total of 17 participants (female = 9, male =8) all of whom had research experience relating to autonomous vehicles, and were participants of the ACM Automotive UI community. The nationalities of the participants' affiliation included Australia, China, Germany, the Netherlands, South Korea, and the United States.

2.2 Workshop Procedure

All workshops were conducted virtually online through the Zoom platform and was proceeded for a total of seventy minutes. The workshop began with a ten-minute introduction to the concept and background of UAM, followed by two twenty-minute small group discussion sessions. The workshop concluded with a twenty-minute presentation session of group discussion results.

The two discussion sessions addressed each of the research questions. Each small group consisted of four to five people, and participants were given an online link to a shared Google slides presentation (Figure 1) for the group discussions. Through the shared document, participants were enabled to edit the provided slides and conduct given activities by collaboratively working with group members.

2.2.1 Session One. As distinctive UX issues arise depending on the maturity of the technology, the first session was organized to separately identify significant factors to be considered in the initial and mature phase of UAM operations. Based on literature review relating to transportation mode choice [5], technology acceptance of vehicles [2, 9, 11], and aerial vehicle service [1, 4, 6, 8, 14, 15], we gathered UX factors and classified them into three categories (Table 1).

Specifically, seven 'Service-related' factors, ten 'Vehicle-related' factors, and three 'Socioenvironmental' factors were chosen for discussion. Participants were each assigned with individual slides, where these twenty UX factors were provided along with two 'baskets' that were labeled as 'Initial Stage' and 'Mature Stage.'

For the main activity, participants were asked to select a total of four factors they believed to be of the highest significance for the two phases. Participants were also requested to come up with one factor of their own for each of the two phases. In the last part of the session, the selected factors of all respondents were gathered, and we counted the number of times each factor was selected. The most chosen factors were identified, and participants shared additional factors they thought to be pivotal for UAM operations.

2.2.2 Session Two. Assuming that all technological limitations of UAM had been resolved, the second session aimed to unveil motives, scenarios for UAM usage, as well as position of UAM within the current mobility system. Thus, the session was proceeded in the context of mature UAM operations.

Participants first discussed their usage motivations and use cases for UAM with group members. Next, participants engaged in a group activity where each participant was assigned with individual 'stickers' to place on a given xy-plane. On the plane, the relative placement of various transportation means of the current mobility system were marked regarding their travel distance (x-axis) and last-mile distance (y-axis; distance from arrival point to final destination).

To elucidate, 'airplane' was placed on the top right corner of the xy-plane, as airports are generally located at a distance from residencies and are used to travel the furthest distance. Other transportation means included train, helicopter, greyhound, subway, bus, tram, and (autonomous) vehicle. With their computer mouse, participants were asked to manually click, drag, and place their stickers on the plane where they anticipated UAM to be placed in comparison to other transportation means.

2.3 Data Collection and Analysis

During the workshop, participants directly typed comments in the form of sentences or placed given items on the shared Google slides to communicate their opinions. Data analysis was mainly

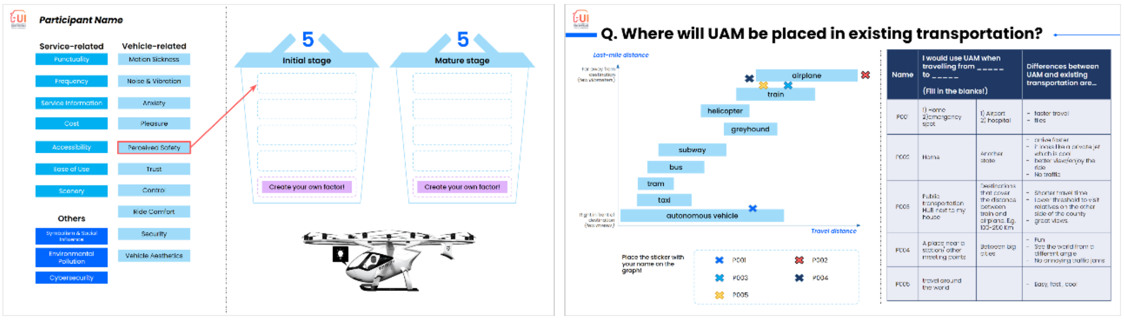

Figure 1: Screenshots of Google Slides (Left: Session One; Right: Session Two)

performed on the typed comments and placement of items on the Google slides.

To analyze the data collected from session one, all twenty of the given factors were listed on a spreadsheet using Microsoft Excel. The factors selected by all workshop participants were listed as well, resulting in seventy data points for the 'initial stage' and seventy-one data points for the 'mature stage.'

As for the 'initial stage,' two participants selected five factors instead of selecting four and providing a factor of their own, while three participants selected five factors for the 'mature stage.' We then counted the number each factor was selected for each of the two operational stages. Higher count implied a higher significance of the factor, as it was selected across multiple participants. Through such a process, the prioritized factors for the 'initial' and 'mature' stage were identified.

As for session two, all sentences written by the participants regarding UAM usage motivations and use cases were listed in the spreadsheet. Then the sentences were simplified into phrases consisting of key words. We used a qualitative approach for the phrases and performed a thematic analysis. First, the phrases that held similar implications were grouped together. Then each group was labeled with a common theme and the number of phrases for each thematic group was counted. Thus, we identified the frequency each theme was mentioned.'

3 RESULTS

3.1 Session One Results: Significant UX Factors for UAM Operation

Through the first session, the factors that users regarded to be most important for the initial and mature stage of UAM operations were each identified. As for the initial stage, 'Perceived Safety,' 'Trust,' 'Security,' 'Cost,' and 'Motion Sickness' were the five most selected factors. When asked to create their own UX factors for this preliminary phase, participants responded with factors such as 'Assistance and Guidance (participant seven)' and 'Communication with Pilot/On-ground Control Center (participant fifteen).' The participants commented that "Every time you introduce something new and people are unfamiliar with it, we would need assistance and guidance to gain trust in the new means of transportation (participant seven)" and "I would feel more safe and a sense of security if I could communicate with a pilot in the vehicle or an operator at the control center located on the ground (participant fifteen)."

On the other hand, 'Cost,' 'Comfort,' 'Accessibility,' 'Punctuality,' and 'Ease of Use' were the top five factors for mature UAM operations. In addition, participants came up with factors such as 'Twenty-four Seven Operation,' 'Stable operation regardless of weather conditions,' and 'Operation Density' mentioning them as important UX considerations. A participant commented that "We cannot find all transportations at night. However, I expect UAM to be operational at night as well, similar to airplanes. A transportation serviceable at night that does not require a driver could also be safer for minorities in big cities (participant eleven)." Other factors presented by the participants included different seating classes alike current airlines (economy, business, first class). For both phases of operation, socioenvironmental factors were given a low priority.

3.2 Session Two Results: Motives, Use Cases, and Operation Types of UAM

3.2.1 Motives for UAM Usage. After performing a thematic analysis, key motivations for UAM usage were classified into three general categories being 'Hedonic Motivation,' 'Utilitarian Motivation,' and 'Others.' We define Hedonic Motivation as behaviors in search of enjoyment and sensation, and refer to Utilitarian Motivation as that relating to decision effectiveness and goal orientation that drives an individual's willingness to act [11].

As shown in Figure 3, the motives for UAM usage were found to be primarily utilitarian, with 'Avoiding Congestion' and 'Faster' travel accounting for the largest proportion. Hedonic motivations reported to be next in percentage, and participants mentioned 'Great Views,' 'Fancy/Cool,' and 'Ride Enjoyment' as the main motives for usage. Other motives included 'Lower Pollution,' 'Private Space,' and 'Avoiding heat in car.'

3.2.2 Elicited Use Cases for UAM. Through the discussions relating to usage scenarios of UAM, use cases were derived as shown in Table 2. Based on the expected departure and arrival point of travel, the use cases were classified into two main categories being 'Intracity Travel' and 'Intercity Travel.' A greater number of uses cases were categorized as Intracity Travel, with commute and daily transport(A1) accounting for the highest proportion among the elicited use cases. Other usage scenarios included travelling between stations within a city(A2), sightseeing(A4), and medical emergencies(A5). As for Intercity Travel, participants expected to

Rank	Initial Stage	Count (70)	%	Mature Stage	Count(71)	%
1	Perceived Safety	10	14.3%	Cost	9	12.7%
2	Trust	10	14.3%	Comfort	9	12.7%
3	Security	7	10.0%	Accessibility	7	9.9%
4	Cost	6	8.6%	Punctuality	6	8.5%
5	Motion Sickness	6	8.6%	Ease of Use	5	7.0%
6	Environmental Pollution	5	7.1%	Aesthetics	5	7.0%
7	Accessibility	4	5.7%	Frequency	4	5.6%
8	Pleasure	4	5.7%	Motion Sickness	4	5.6%
9	Ease of Use	3	4.3%	Noise & Vibration	4	5.6%
10	Anxiety	3	4.3%	Symbolism & Social Influence	3	4.2%
11	Control	3	4.3%	Cybersecurity	3	4.2%
12	Service Information	2	2.9%	Service Information	2	2.8%
13	Noise & Vibration	2	2.9%	Pleasure	2	2.8%
14	Scenery	2	2.9%	Trust	2	2.8%
15	Punctuality	1	1.4%	Environmental Pollution	2	2.8%
16	Aesthetics	1	1.4%	Security	1	1.4%
17	Cybersecurity	1	1.4%	Anxiety	1	1.4%
18	Frequency	0	0.0%	Perceived Safety	1	1.4%
19	Comfort	0	0.0%	Scenery	1	1.4%
20	Symbolism & Social Influence	0	0.0%	Control	0	0.0%

Vehicle-related factors　Service-related factors　Others

Figure 2: UX Factor Priority for UAM Operations in Initial and Mature Stage

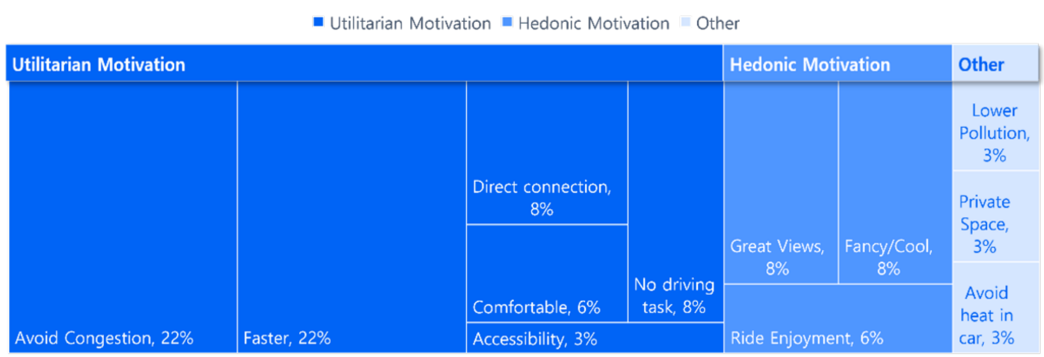

Figure 3: Classification and Proportion (box size) of UAM Usage Motivations

use UAM when travelling between stations located in different cities(B1), as well as for vacation(B3) and business trip(B4) purposes.

3.2.3 Anticipated Types of UAM Operations. Based on the opinions relating to the placement of UAM within the current urban transportation system received in the second group session, we were able to identify three main clusters. Within these clusters, two groups appeared to identify UAM as a means of public transport, while one group appeared to alike UAM as a private means of transport. The first group of UAM icons labeled as 'Public Intercity Aerial Vehicle' in Figure 5 predict UAM to be similar to that of an airplane or train, which travel relatively far distances, and have stations/ports which are distant from the traveler's final destination. UAM would have a comparatively low accessibility for everyday usage in such a scenario. The second cluster labeled as the 'Public Intracity Aerial Vehicle' identify UAM to be alternatives for helicopters/greyhounds/subways/buses. UAM would be used for relatively shorter distances mostly within a city during these operations. Lastly, the 'Private Aerial Vehicle' cluster is characterized by associating UAM with taxis or cars, which operate flexibly by accommodating to the users' transportation needs. Thus, UAM would be capable of both intracity and intercity travel in this last case.

Table 2: Elicited UAM Use Cases

		Use Case Results		
Intra/Inter	**No.**	**Use Case**	**Count**	**%**
Intracity	A1	Commute/daily transport	5	33.3
	A2	Traveling to/from stations	2	13.3
	A3	Traveling to/from city downtown	2	13.3
	A4	Sightseeing/tourism	2	13.3
	A5	Medical emergency	2	13.3
	A6	Other	2	13.3
Intercity	B1	Traveling to/from stations	3	37.5
	B2	Traveling to/from airport	3	37.5
	B3	Vacation	1	12.5
	B4	Business trip	1	12.5

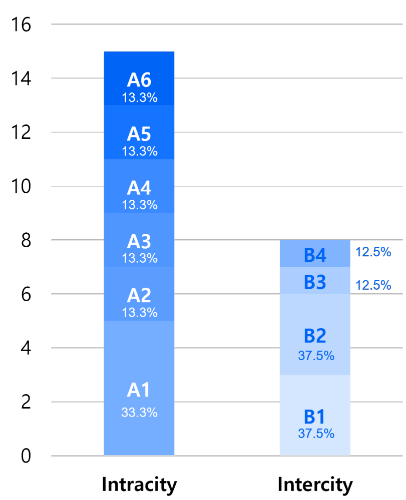

Figure 4: Use Case Category & Counts

4 DISCUSSION

The current study explored user experience considerations, as well as the expected form of UAM operations. Based on the results of the workshop activities, we provide potential design guidelines and insights that can be integrated in future UX design for UAM.

4.1 User Experience Design Implications According to Technology Maturity

As user expectations evolve according to the maturity of the technology, important factors that need to be considered when designing UAM UX was investigated in two separate contexts. The discussion outcomes imply that users place higher priority on vehicle-related factors for the nascent phases of UAM usage, while priority shifts to service-related aspects as the technology advances. Building from participant comments and existing literature, we provide potential UX design guidelines to promote the prioritized factors for each phase.

For the initial stage, participants appeared to place a higher priority for vehicle-related factors, such as 'Trust' and 'Safety.' Such results are in line with previous research relating to the adoption of emerging technologies such as autonomous vehicles, which have shown trust to be a pivotal factor for technology adoption and usage [2, 9]. As a means to promote trust and safety, UAM may be designed to:

- Provide guidance before/during/after flight
- Support means for communication with human operator/control center on ground
- Maintain system transparency by consistently providing passengers with feedback
- Have robust-appearing vehicle designs

On the other hand, participants assigned a higher priority in service-related factors for the mature stage of UAM operations, such as 'Cost,' 'Accessibility,' and 'Punctuality.' In other words, after adopting the technology into daily lives, people expect UAM to be as serviceable and operational as possible. Only one vehicle-related factor being 'Comfort' was given a high importance.

Such results are aligned with existing studies that emphasize the availability, cost, and accessibility of flights [1, 8, 15] for UAM services to appeal to new customers and become commercialized. While such service attributes are highly dependent on the business models of the service-providing firms, the following suggestions may support the usability of UAM services:

- Promote service reliability by providing real-time vehicle status/location information
- Allow for sufficient spacing (i.e., leg room) for passengers
- Maintain good air quality and overall passenger well-being

4.2 User Needs According to UAM Operation Type

From this study we identified three types of potential UAM operations. UAM may be considered as either a 'Public intracity aerial vehicle,' a 'Public intercity aerial vehicle,' or a 'Private aerial vehicle' encompassing both intracity and intercity travel. These operation types share common motives for usage.

Most notably, participants have commonly indicated faster commute as their main drive for UAM usage (Figure 3). Intracity travelers would be enabled to reduce travel time by avoiding inner-city congestions, especially during daily commutes [16]. Intercity travelers would experience enhanced traveling speed of the UAM vehicle during relatively long-distance commutes, such as trips to the airport or business trips (Table 2).

This has also been underscored in existing studies that expect UAM to support rural lifestyles for outside commuters and suburban dwellers. Participants have also mentioned great views and ride enjoyment as a general motivation for UAM usage. Thus, scenic and attractive routes should be considered to provide enriching flight experiences for passengers [16].

Despite such commonalities, differing user needs should be identified according to the user group of each form of UAM operation. When considering UAM as a 'Public intracity aerial vehicle,' the key

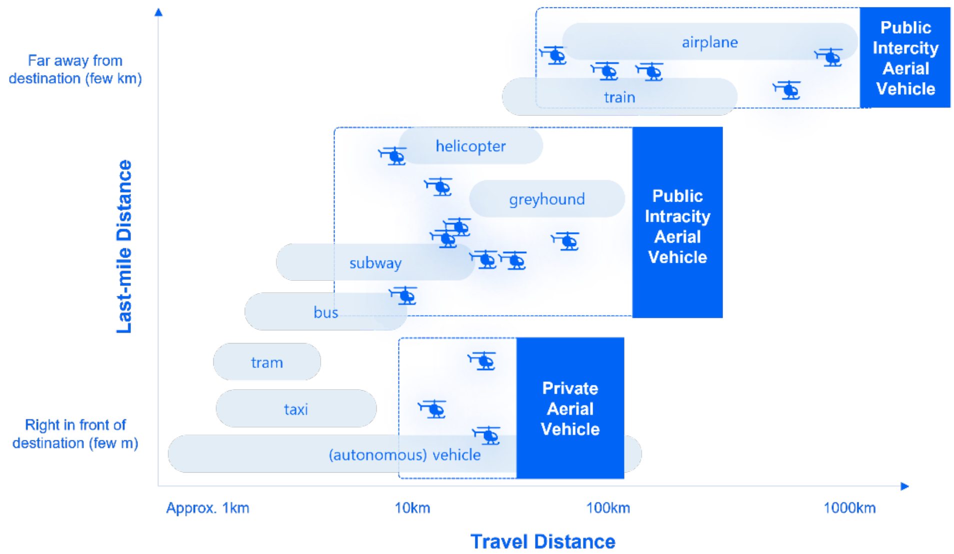

Figure 5: Anticipated Placement of UAM

Table 3: User Need by UAM Operation Type

Operation Type	Competing Transportations	User Need(s)
Public intracity aerial vehicle	subway, bus, helicopter	• Seamless transit between different transportation modes
Public intercity aerial vehicle	airplane, train	• Direct connection between point of departure and arrival
Private aerial vehicle	(autonomous) vehicle, taxi	• Guaranteed private space • Choice of travel route

design requirement is related to its seamless integration into the existing transportation system, allowing for smooth transits from one transportation mode to another. This group thus expects UAM to be harmonious with their daily commutes and leisure activities. As for the group intending to use UAM as a 'Public intercity aerial vehicle,' UAM operations should be designed to provide direct connections between the point of departure and arrival, absent of flight transfers.

Lastly, the group expecting to use UAM as a 'Private aerial vehicle' are those who have used taxis, personally owned cars, or other luxurious and privatized means of transport. This group values the private space and room for customization that is given within their choice of transport, thus requiring UAM to be designed as a comfortable unshared space.

5 CONCLUSION

At the current era, UAM is an emerging form of future urban transportation, undergoing the process of technological enhancements with the aim of resolving problems caused by existing urban transportation. However, concrete considerations from a user perspective to embrace UAM remain ambiguous. Thus, this study was proceeded to explore UX issues of UAM by conducting workshops with automotive vehicle experts.

Due to its virtual nature, the present study holds some limitations. First, this study was conducted in a virtual environment, allowing for only visual aids and vocal explanation of workshop organizers to provide an initial understanding of UAM. Consequently, participants were to assume certain scenarios, or base their opinions on previous experiences with urban transportation. In the future, we expect to conduct research that employs a physical setup, such as a flying simulator, to allow participants to directly experience a UAM-like environment and provide experience-based UX needs. In addition, as this study was mainly proceeded with vehicle experts, we plan to conduct future studies with individuals of varied demographics, backgrounds, and level of knowledge regarding UAM. This would allow for a more diverse pool of user needs and design implications, as well as a comprehensive viewpoint of UAM from potential passengers.

With our ever-evolving smart urban mobility system, not only is the advancement of technology itself important, but the adoption and tangible usage of such advancements by users are also critical to actualize the technology. Under such a context and with UAM in its infancy, this study explored important UX considerations for UAM usage according to the maturity of UAM operations. Moreover, we uncovered UAM usage motives, potential use cases, as well as expected forms of UAM operations. The derived UX implications from this study are anticipated to support UAM developers and designers from both a technological and service aspect. This study also contributes to enabling feasible UAM operations accepted by urban populations in the near future.

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