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Considerations for Cabin Design in Urban Air Mobility's Personal Air Vehicles With a Focus on User Experience

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ABSTRACT

Urban Air Mobility (UAM) era is predicted to arrive, with the commercialization of Personal Air Vehicle (PAV) expected by 2025. The cabin design direction of traditional aircraft and PAV differs significantly, and considering the perspective of a new space that users have not previously experienced, it is necessary to understand user perceptions in order to provide an environment that ensures satisfaction, comfort, and stability. Furthermore, while the cockpit in traditional aircraft is separated and disconnected, PAV may have direct interaction points between pilots and passengers, necessitating consideration of social factors related to pilot-passenger interaction. The purpose of this study is to identify the physical and social servicescape factors in PAV cabins that may influence the experiences of passengers and pilots. According to the survey results, both pilots and passengers rated the "Safety in Emergencies" element as the most important. It takes into account the confined interior of the cabin, examining environmental factors that impact not only passengers but also pilots, thus providing a holistic understanding and presentation of the overall aspects.

Keywords: Urban air mobility, Personal air vehicle, Cabin design, User experience, Future passenger, Pilot

INTRODUCTION

The importance of research and development in the field related to Urban Air Mobility (UAM) is increasing as the era of UAM is predicted to arrive, and Personal Air Vehicles (PAVs) are expected to be commercialized by 2025 (Ministry of Land, Infrastructure and Transport, 2021). Previous research has primarily focused on aspects such as user acceptance, technical aspects of the aircraft, societal changes resulting from commercialization, and prerequisites for commercialization and realization (Cha et al., 2021; Edwards et al., 2020; Kim et al., 2021; Rajendran and Srinivas, 2020; Yun and Hwang, 2020). Although research on user experience (UX) and Comfort Design has been being conducted (Moerland-Masic et al., 2021; Park et al., 2021), it

is challenging to find studies that consider and present overall environmental conditions during passenger travel time. However, in the past, research on the experience design aspect of existing in-flight services has explored the physical environmental factors and social factors that influence customer satisfaction and loyalty (Ahmadpour et al., 2016; Kim et al., 2012; Wang et al., 2021). Such research has been approached through the concept of "servicescape," which refers to the space or environment in which the service is provided to customers.

There is a significant difference in cabin design direction and usage between traditional aircraft and PAVs. Considering that PAVs offer a new space that users have not experienced before, it is essential to understand users' perceptions to provide a satisfying, comfortable, and stable environment. Additionally, in contrast to conventional aircraft, where the cockpit is separated and isolated, PAVs' spatial characteristics may lead to direct interaction points between pilots and passengers. Therefore, it is necessary to consider social factors related to the interaction between pilots and passengers. To ensure public acceptance, it is expected that for a certain period from the commercialization stage, the environment where pilots also board the PAVs will be anticipated (Ministry of Land, Infrastructure and Transport, 2022).

The purpose of this study is to identify the physical and social servicescape factors that may influence the experiences of passengers and pilots in the PAV cabin. To achieve this, an online survey was conducted targeting future passengers and pilots. This study stands out from previous research by comprehensively considering both physical environmental factors and social factors from the servicescape perspective. Additionally, it takes into account the confined interior of the cabin, examining environmental factors that impact not only passengers but also pilots, thus providing a holistic understanding and presentation of the overall aspects.

METHODS

This study considers both physical environmental factors and social factors as influencing factors on user experience from the servicescape perspective in the design of the PAV cabin. To present considerations for the PAV cabin design, the detailed research methodology and procedure are as follows. Firstly, relevant elements requiring consideration from both physical and social perspectives were derived based on prior research on servicescape in conventional aircraft and previous studies related to UAM and PAV. These derived elements were then incorporated into the survey content (see Table 1).

Secondly, from December 2021 to January 2022, a survey was conducted to identify the importance of physical and social factors among future passengers (aged 20-30, 37 participants) and individuals with pilot qualifications or airline- affiliated pilot regardless of age (37 participants). Table 2 below presents the general characteristics of the survey and experimental participants.

Table 1. Physical environmental factors and social factors to consider in PAV design.

Servicescape		Pilot experience perspective	Passenger experience perspective
Physical environmental factor	Seating Comfort: Ease of seating, adjustable backrest, comfortable posture, sufficient seat width, convenient armrest, etc.	•	•
	Space Layout: Seat spacing, seat space availability, legroom, convenient seat arrangement, etc.	• (Seat Arrangement for Pilots and Passengers)	• (Seat Arrangement among Passengers)
	Functionality: Tables, luggage storage space, coat hangers, etc.	•	•
	Aesthetics: Interior design, finishing colors, attractive design of in-flight items, etc.	•	•
	Cleanliness: Seat cleanliness, cleanliness of convenience devices, etc.	•	•
	Comfort: Air conditioning environment (temperature, air, humidity), lighting, noise reduction, etc.	•	•
	Visibility: Window outside view, window light control function, etc.	•	•
	Minimization of Motion Sickness/Noise/Vibration.	•	•
	Safety in Emergencies: Operation of seat belts, emergency evacuation systems, passenger briefing on safety procedures (emergency exit locations, etc.).	•	•
	Passenger Entertainment Experience: In-flight entertainment, various music, diverse programs, comfortable screen, user-friendly features, etc.		•
	Opportunities for Diverse In-flight Activities: Meals, sleep, conversation, etc.		•
	High Accessibility for All Passengers: Facilities for passengers with disabilities, baby care facilities, etc.		•
Social factor	Passenger Attitudes and Demographics: Customer attitudes, number of passengers, presence of foreign passengers, etc.	•	
	Attitude and Professionalism of Pilots: Friendliness, communication, piloting skills, appearance, etc.		•

Table 2. General characteristics of survey participants and experimental participants.

Age	Gender	Pilot Number (Percentage)	Future Passenger Number (Percentage)
20s	Male	5 (13.5)	11 (29.7)
	Female	0 (0.0)	5 (13.5)
30s	Male	25 (67.6)	14 (37.8)
	Female	1 (2.7)	7 (18.9)
40s and above	Male	6 (16.2)	-
Total		37 (100.0)	37 (100.0)

SERVICESCAPE ELEMENTS FOR PILOT AND PASSENGER EXPERIENCE

For the pilots, a survey on 10 servicescape elements was conducted, and for the future passengers, 13 servicescape elements were examined. In addition

to the common servicescape factors for both pilots and passengers, the future passengers' survey included aspects related to various indoor activities during travel time, entertainment experiences, meals, sleep, and more, considering their ability to engage in different activities during the journey. Furthermore, accessibility-related aspects (such as facilities for people with disabilities and childcare functions) were also assessed. The survey results are presented in Table 3.

Table 3. Results of importance survey on servicescape elements.

Servicescape	Pilot experience perspective		Passenger experience perspective	
	Mean*	SD	Mean*	SD
Seating Comfort: Ease of seating, adjustable backrest, comfortable posture, sufficient seat width, convenient armrest, etc.	3.68	0.91	4.14	0.79
(Seat Arrangement for Pilots and Passengers) Space Layout: Seat spacing, seat space availability, legroom, convenient seat arrangement, etc.	3.81	0.88	-	-
(Seat Arrangement among Passengers) Space Layout: Seat spacing, seat space availability, legroom, convenient seat arrangement, etc.	-	-	4.14	0.67
Functionality: Tables, luggage storage space, coat hangers, etc.	3.43	0.90	3.30	0.91
Aesthetics: Interior design, finishing colors, attractive design of in-flight items, etc.	3.19	0.91	3.24	0.95
Cleanliness: Seat cleanliness, cleanliness of convenience devices, etc.	3.78	0.89	4.11	0.70
Comfort: Air conditioning environment (temperature, air, humidity), lighting, noise reduction, etc.	3.97	0.87	4.30	0.66
Visibility: Window outside view, window light control function, etc.	4.24	0.80	3.84	0.93
Minimization of Motion Sickness/Noise/Vibration.	4.19	0.78	4.16	0.80
Safety in Emergencies: Operation of seat belts, emergency evacuation systems, passenger briefing on safety procedures (emergency exit locations, etc.).	4.54	0.65	4.35	0.82
Passenger Entertainment Experience: In-flight entertainment, various music, diverse programs, comfortable screen, user-friendly features, etc.	-	-	4.03	0.99
Opportunities for Diverse In-flight Activities: Meals, sleep, conversation, etc.	-	-	3.19	0.94
High Accessibility for All Passengers: Facilities for passengers with disabilities, baby care facilities, etc.	-	-	3.35	0.95
Passenger Attitudes and Demographics: Customer attitudes, number of passengers, presence of foreign passengers, etc.	3.86	0.92	-	-
Attitude and Professionalism of Pilots: Friendliness, communication, piloting skills, appearance, etc.	-	-	3.76	0.89

* Likert 5-point scale (1: Not important at all, 3: Neutral, 5: Extremely important)

Both pilots and passengers rated "Safety in Emergencies" as the most important element. This includes the operation of seat belts, emergency evacuation systems, and passenger briefings on safety procedures (emergency exit

locations, etc.), making safety-related aspects essential and crucial to be considered. The next most important elements, as indicated by passengers, is "Comfort," which involves the air conditioning environment (temperature, air quality, humidity), lighting, and noise reduction. For pilots, "Visibility" emerged as a significant element, requiring considerations in cockpit design, such as window outside views and window light control functions. Additionally, both pilots and passengers emphasized the high importance of "Minimization of Motion Sickness/Noise/Vibration," highlighting the need to address measures to reduce motion sickness and mitigate noise and vibration for a pleasant journey. For passengers, "Seating Comfort" and "Space Layout" were also highly rated in terms of importance, emphasizing the significance of ensuring comfortable seating and an efficient use of space for passenger satisfaction. On the other hand, "Aesthetics" was deemed the least important element for pilots, whereas for passengers, the "Opportunities for Diverse In-flight Activities" had the lowest level of importance.

CONCLUSION

This study placed significant importance on the servicescape aspect to identify the factors that need to be considered in the cabin design of PAV, which is expected to be commercialized in the near future. To understand the physical environmental and social factors that influence user satisfaction, important servicescape elements were explored for both pilots and future passengers. The results showed differences in perceptions between pilots and passengers, but the element of "safety" emerged as the most critical factor shared by both groups. The significance of this study lies in recognizing the potential for interaction between pilots and passengers in the novel PAV environment, which has not been experienced before. Additionally, it provided a comprehensive presentation of servicescape factors, thereby contributing to a better understanding of cabin design considerations. As the commercialization period approaches, it becomes essential to validate specific design elements and cabin designs for both pilots and future passengers.

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