DISSERTATION

EVALUATING AND ENHANCING USER TRUST IN URBAN AIR MOBILITY AUTONOMOUS PASSENGER SYSTEMS

Submitted by

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ABSTRACT

EVALUATING AND ENHANCING USER TRUST IN URBAN AIR MOBILITY AUTONOMOUS PASSENGER SYSTEMS

Urban Air Mobility (UAM) is an emerging and disruptive technology which promises a significant increase in transportation network capacity, through means of Passenger Air Vehicles (PAVs). Successful implementation of these aerial vehicles, however, is largely dependent on acceptance and eventual use by the general public. This dissertation, conducted in two phases, aimed to interpret decision and motivation factors for individuals to use and trust this novel transportation technology.

In the first phase of the research study, a survey of 407 respondents in the United States provided perceptions and expectations of on-demand PAVs and autonomous aerial transportation concepts. Both the Technology Adoption Life Cycle Model and Technology Acceptance Model were used as constructs to characterize technology adopter profiles and rates of adoption. Key results, in which half of the respondents had prior familiarity with PAVs, indicated that all respondents expected additional in-flight safety feedback (i.e., displays relating to current and projected flight operations) beyond the level of safety standards found in conventional aircraft (i.e., seatbelts, air quality). Participants also indicated that PAVs are not perceived as an immediate replacement for daily trips and that in-cabin noise, which is often cited as a concern with community PAV acceptance, was not a crucial deterrent to ridership. Respondents characterized as earlier adopters of PAVs were more trusting of PAV technology, willing to pay more to ride, report shorter daily commutes, and riskier in their overall general behaviors. Later PAV adopters required more feedback in-flight and a pilot on-board to consider riding.

Leveraging the insights gained from the first phase of the research study, the second phase focused on addressing critical human factors for building passenger trust, particularly in the absence of a human pilot. Virtual PAV flight simulations were conducted to evaluate how different in-cabin human-machine interface (HMI) designs affected passenger trust in the aircraft and in-cabin display, situation awareness, and pilot preferences. Forty participants, equally split between early and late technology adopters, completed two simulated flights: a baseline flight without an HMI in use, and a second flight featuring one of four HMI types: information, audio, video with a professionally dressed remote pilot, or video with a casually dressed remote pilot. Results indicated that participants exposed to the professionally dressed remote operator reported significantly higher trust in the aircraft, trust in the HMI, and demonstrated higher situation awareness. Trust and situation awareness were not significantly influenced by technology adopter profile. Participants also stated a preference for the presence of an audible or visible remote operator, particularly among late technology adopters. These findings suggest that human-centered HMI designs, especially those that include visual cues of professionalism, can meaningfully improve passenger trust in autonomous air taxis.

Overall, this dissertation contributes to both theory and practice by advancing understanding of technology adoption in the context of UAM and by identifying actionable design strategies for fostering passenger trust in autonomous PAVs. By bridging adoption theory with applied human factors research, the findings provide a roadmap for stakeholders to anticipate user needs, mitigate barriers to acceptance, and support the safe and successful integration of PAVs into future transportation systems.

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DEDICATION

This dissertation is dedicated to all of the phenomenal engineering innovators and scholars who have blazed trails before me and whose shoulders I stand upon.

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LIST OF ACRONYMS

AAM	Advanced Air Mobility
AGL	Above Ground Level
ATC	Air Traffic Control
EASA	European Union Aviation Safety Agency
EVTOL	Electric Vertical Take-Off and Landing
FAA	Federal Aviation Administration
HITL	Human In The Loop
HOVTL	Human Over The Loop
HMI	Human Machine Interface
HSI	Human System Integration
IFAR	International Forum for Aviation Research
IRB	Institutional Review Board
MRO	Maintenance, Repair, Overhaul
NAS	National Air Space
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
OEM	Original Equipment Manufacturer
PAV	Passenger Air Vehicle
PIC	Pilot In Command
SAGAT	Situation Awareness Global Assessment Technique
SOS	System of Systems
UAM	Urban Air Mobility
UAV	Unmanned Aerial Vehicle
VFR	Visual Flight Rules
VTOL	Vertical Take-Off and Landing

Chapter 1:

Introduction

1.1 Problem Definition

The burden on roadway infrastructure is a growing concern as populations continue to rise in city centers. Increased traffic congestion leads to travel that is time-consuming, unpredictable, and environmentally unsustainable (Jilani et al., 2023; Nguyen-Phuoc et al., 2020; Yedavalli & Mooberry, 2019). It is estimated that on average, U.S. commuters spend over 42 hours each year stuck in traffic, with an annual cost of congestion delays and lost fuel totaling $160 billion dollars (Barami & Merrefield, 2016). The U.S. Department of Transportation's Beyond Traffic 2045 Report offers a comprehensive assessment on how population growth will influence future transportation system needs and priorities. It projects that by 2045, the U.S. population will increase by 70 million, to a total of 390 million people (Barami & Merrefield, 2016). According to the United Nations World Urbanization Report, globally there are more people living in urban areas (currently 55% of the world's population), with expected growth to 68% by 2050 (United Nations [UN], 2019). North America is the most urbanized region of the world, with 82% of its population living in urban areas (UN, 2019). Dramatic population increases in urban centers will translate to corresponding growth in travel demand on already capacity-strained transportation systems.

In response, an innovative, alternative mode of transport has emerged, referred to as Urban Air Mobility (UAM), which utilizes low-altitude airspace as a third dimension for navigating within urbanized environments. This novel aviation concept harnesses recent technological advancements in distributed electric propulsion, advanced energy storage, and autonomous flight operation systems, enabling the development of Passenger Air Vehicles (PAVs), which are on-demand, runway-independent air taxis (NASEM, 2020; Reich et al., 2018). Collaboratively developed by NASA, Federal Aviation Administration (FAA), and industry, PAVs are generally defined as safe, efficient, and highly automated aircraft operating at lower altitudes within the National Airspace System (NAS), designed to transport passengers and cargo in and around urban and suburban metropolitan areas (FAA, 2023; Thipphavong et al., 2018; Price et al., 2020). While current aviation heavily utilizes automated systems to aid in various flight phases, these new PAVs seek to operate fully autonomously, without an onboard pilot. Hence, fostering user trust and encouraging widespread adoption of PAVs will require overcoming the novelty and perceived risk associated with relinquishing all control to an autonomous and unfamiliar system.

Both societal acceptance and consumer adoption are widely acknowledged as impediments to successful UAM implementation (Shaheen et al., 2018; Yedavalli & Mooberry, 2019; Al Haddad et al., 2020; Cohen et al., 2021). Nonetheless, UAM is recognized as a significant area of sustainable transportation and economic growth for the United States, thus in 2022, the Advanced Air Mobility Coordination and Leadership Act was established, commissioning an interagency working group to examine and address community acceptance factors that may limit the full potential of the UAM industry (U.S. Congress, 2024). The industry envisions the first PAV entry into service by late 2025, with a U.S. potential market valuation of $115 billion USD by 2035 and global market potential of $318 billion USD by 2040 (Goyal et al., 2021).

Despite the potential transformational benefits of UAM, passenger trust remains a significant barrier to the widespread adoption of autonomous PAVs (Park & Nojoumian, 2022).

The construct of trust in a specific technology relates to an individual's trusting intention, trusting beliefs, and willingness to depend on the technology, even in real and/or perceived uncertain, risky situations (McKnight, et al., 2009). Trust in automation and autonomous systems is a complex issue influenced by various factors, including the design of human-machine interfaces (HMI) and the overall human systems integration (Hoff & Bashir, 2014; Miller et al., 2018). The influence of affect and emotions on human-technology interaction is an important factor of trust and should be considered in the design of high-consequence systems (Lee & See, 2004; Miller, 2018). Moreover, Lee and See (2004) found that when information is optimally designed and displayed in a way that provides concrete, consistent, and organized details, trust tends to increase. Conversely, if the system is not trusted, it is unlikely to be used.

Undoubtedly, the concept of PAVs may seem abstract to the average person. Reluctance to ride an autonomous PAV has been expressed by segments of the population. Winter et al., (2020) reported that between 30% and 50% of people are currently unwilling to use PAV technology due to a lack of trust in autonomous systems, concerns about safety, and anxieties related to flying without a human pilot on board. Ison (2024) surveyed 975 people, leveraging an existing willingness-to-fly scale designed specifically for assessing the acceptance of new aviation technologies, and found that 42% of respondents indicated neutral to no excitement or interest in taking a flight in a PAV, with a fair number of respondents indicating that they would wait several months before doing so.

Rogers' (2003) diffusion of innovation theory, which describes the process in which an innovation is communicated over time among the members of a social system or population, including the adoption of new technologies across individuals in a predictable sequence of stages (i.e., technology adoption life cycle model), has also been used by several researchers to understand willingness to use PAVs. Johnson et al. (2022) compared preferences, motivators, and trust factors of PAVs between Rogers' (2003) five technology adopter groups and found differences between early to laggard adopters. Specifically, they found that Earlier PAV adopters are trusting of the technology, willing to pay more to ride, and exhibit overall riskier behaviors. Later PAV adopters need more feedback in-flight and a pilot on-board.

In South Korea, research by Kim and Ji (2022) applied the technology adoption life cycle model to examine the influence of trust and service quality factors (i.e., timesaving, availability, flight comfort, and perceived cost) on the attitude and intention to use UAM. They surveyed 450 respondents and found that trust positively influences the intention to use UAM and has a greater impact on users' attitude toward UAM than perceived usefulness (Kim & Ji, 2022). Subedi et al. (2025) paired Rogers' (2003) diffusion of innovation theory framework with the unified theory of acceptance and use of technology (Venkatesh et al., 2003) to develop and conduct a survey of 910 people across the U.S., to examine their behavioral intentions to use an electric air taxi for relatively longer point-to-point trips (e.g., trips from airport to city center). Their findings indicated that an individual's innovativeness significantly shapes attitudes toward electric air taxis, with early adopters being more likely to embrace the technology (Subedi et al., 2025). Hu et al. (2025) integrated the technology acceptance model (Davis, 1989) with risk perception theory and trust theory models to explore how socio-psychological factors of trust and personal innovativeness influence the intentional decision to use UAM, specifically in the Chinese market using a survey from 553 respondents. Their findings revealed that initial trust was found to have an influential role in users' intention and readiness to adopt UAM, i.e., perceived usefulness and perceived ease of use were found to have a significant positive effect on initial trust in UAM, while perceived safety risk and perceived privacy risk were found to have a significant negative effect on initial trust in UAM (Hu et al., 2025).

To gain insight with respect to general perceptions, preferences, motivators, comfort and trust factors and overall acceptance of the new PAV concept by a broad public, this research study was structured and executed in two phases namely, Phase 1: PAV Technology Adoption and Perception Study, and Phase 2: PAV Flight Simulation Study. In Phase 1, a survey was developed and conducted to gain insights and general perceptions of PAVs, as an alternative transportation system in the realm of aviation. Additionally, the survey examined respondent's technology adoption profiles and adoption time horizons relative to full-scale PAV entry into service. In Phase 2, the research endeavored to examine passenger experience while in a simulated autonomous PAV flight, with various in-cabin human-machine interface display designs, in order to pinpoint various psychological barriers and perceived adoption challenges of integrating a revolutionary air taxi technology into the public domain. Both phases of the research were interdependent and leveraged synergies of each; that is, the insights and learnings of the PAV Technology Adoption and Perception Study (Phase 1) were leveraged to inform the survey questions as well as the human-machine interface design elements of the PAV Flight Simulation Study (Phase 2). This holistic approach served to examine an individual's willingness and likelihood to trust, accept and ultimately ride in an autonomously-piloted passenger air vehicle.

1.2 Research Aims and Research Questions

In this dissertation, there are three research aims targeted to gain greater understanding of an individual's motivating factors and general perceptions of passenger air vehicle technology, and moreover what drives a potential user to trust and feel comfortable using the system, so that the barriers to societal acceptance are minimized. Formulated from the research aims, the research questions serve as investigative guideposts which provide direction to conduct the research.

1.2.1 Research Aim 1

Identify the differences between early and late adopters of PAV technology.

- *Research Question 1.1*: What are the initial perceptions of PAV technology by the general public?
- *Research Question 1.2*: What are the differences between self-identified early technology adopters and late technology adopters with respect to PAV human-system integration?
- *Method:* Survey study with 407 participants.

1.2.2 Research Aim 2

Determine the human system interfaces that should be implemented to engender passengers' trust in riding an autonomously-piloted PAV.

- *Research Question 2.1:* How do in-cabin HMI interaction types (information only, audio only, professional “pilot”, casual “pilot”) influence trust, situation awareness, and remote-pilot expectations?
- *Method:* PAV flight simulation with 40 participants.

1.2.3 Research Aim 3

Examine the correlations between a passenger’s technology adoption profile, situational awareness and trust in PAVs.

- *Research Question 3.1:* How do early adopters and late adopters differ in their trust, situation awareness, and remote-pilot expectations?
- *Method:* PAV flight simulation with 40 participants.

1.3 Research Focus and Relevance

There is limited research on the human-system integration of PAVs and the extent to which trust in autonomous systems and perceived safety influence both near-term and long-term PAV technology adoption. Hence this dissertation, and associated findings, contributes to the emerging body of knowledge in this space.

This research is distinct as it examines human-system integration of PAVs and virtual flight experiences from a passenger perspective. The insights captured in this dissertation are beneficial to the ecosystem of UAM stakeholders, including manufacturers, operators, regulators and jurisdictions, as all seek for full-scale UAM system implementation to realize the envisioned value that the innovative transportation system can bring. Moreover, the findings will be integral to the viability of the UAM market as implementation and commercial success is contingent on both high passenger ridership demand and passengers' willingness to pay a premium over alternative transportation modes.

Chapter 2:

Background

2.1 Introduction

This chapter summarizes the current state of the art in the field of Urban Air Mobility (UAM) and Passenger Air Vehicles (PAVs), to establish context of the research study. The importance of understanding human-system integration factors as determinants of passenger ridership of PAVs is highlighted in this chapter.

2.2 Urban Air Mobility Overview

The National Aeronautics and Space Administration (NASA) defines UAM as safe, efficient and highly automated aircraft used at lower altitudes to transport passengers or cargo in and around urban and suburban metropolitan areas (Price et al., 2020). PAVs are a radical new aircraft concept, not yet commercially launched, which embody Urban Air Mobility. The current concept of UAM originated in 2020; it evolved from earlier urban aviation service concepts using helicopters, dating back to the 1950s (Cohen et al., 2021).

There are three primary use cases being explored for UAM: cargo transport (i.e. goods/parcels), air metro (i.e., scheduled routes), and air taxi (i.e., on-demand) (Hasan, 2019, Al Haddad et al., 2020). This dissertation examines the latter; the air taxi use case. Air taxi describes the service concept of a short-duration, on-demand, intra- and inter-city flight aboard a PAV. PAVs are within the electric vertical takeoff and land (EVTOL) aircraft classification, which offer quiet operation, zero emissions and enhanced safety features as compared to conventional rotor-powered aircraft such as helicopters. PAVs are at the heart of UAM and represent one of the core elements of the entire UAM ecosystem. The UAM ecosystem is a complex, multifaceted system of interconnected parts in collaboration to enable the actualization of a new form of urban aerial transit. Key constituents of the UAM ecosystem include infrastructure, operations and services, regulations and governance, and stakeholders (Cohen et al., 2021; Garrow et al., 2021). Infrastructure includes vertiports (i.e. dedicated platforms for PAV takeoff and landing), aircraft charging stations, and MRO (i.e. maintenance, repair and overhaul) stations. Operations and services include flight operations and air traffic management, while regulations and governance include federal agencies, safety/airworthiness standards, noise/environmental regulations and airspace integration standards. The stakeholders of the UAM ecosystem are represented by original equipment manufacturers (OEM), vehicle operators, infrastructure operators, service providers, regulators, real estate developers, city planners, and community members (i.e. potential PAV users).

UAM is considered a subset of the broader concept defined as Advanced Air Mobility (AAM) (FAA, 2023). AAM covers a wider geographic scope, to include urban, suburban, rural, and regional transport areas, while UAM specifically covers only urban and suburban areas. Success in UAM for passenger transport and the reduction of traffic congestion will be beneficial in the development of AAM, and its potential to change air transportation and transform communities (Price et al., 2020).

2.3 PAV Functional Requirements

The initial functional requirements for PAVs proposed by NASA include vertical takeoff and landing (VTOL) capability to enable runway independence, short duration hover capability, 60-hour battery life, 7-minute battery charging, payload capacity for four passengers and one pilot [and luggage], and a maximum payload weight not to exceed 980 pounds (Johnson & Silva, 2018). A PAV would operate at cruise speeds of 150 miles per hour and altitudes 1000-1500 feet above ground level (AGL) (Price et al., 2020). Figure 1 depicts a typical PAV flight mission profile, whereby the aircraft vertically lifts, then transitions to climb at 1000 feet/minute until it reaches cruise level, then descents (also at 1000 feet/minute) to land. PAVs can either be operated by an onboard pilot, a remote pilot, or be fully-autonomously piloted (Mathur et al., 2019). Additionally, PAVs would be designed to be energy efficient and eco-friendly by having reduced or zero emissions as compared to conventional, petroleum-fueled, ground-based modes of transport. PAV requirements relative to noise specifies that a PAV shall operate at reduced noise output around 70 decibels, which is significantly quieter than a traditional helicopter that produces noise output of 85 decibels (Moore, 2003). It is important to note that PAVs are still early in development, and their designs will likely be modified before deployment.

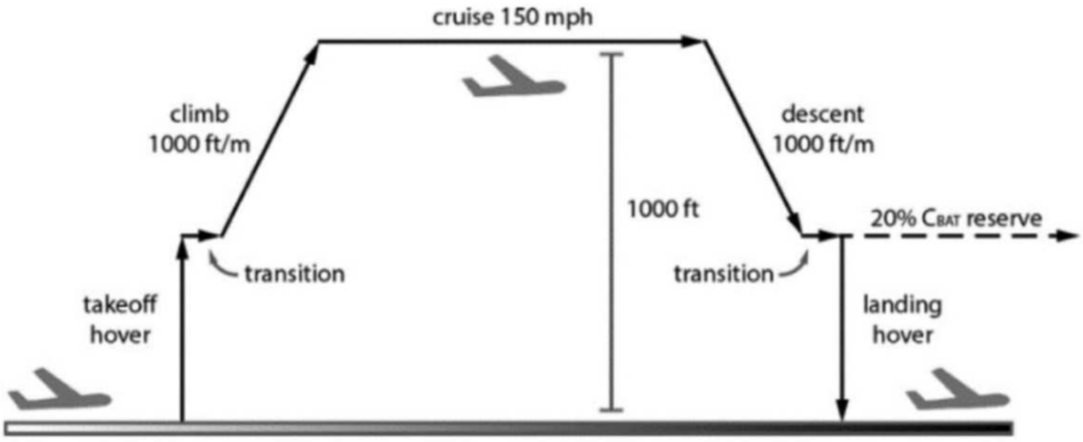


Figure 1. Typical PAV flight mission profile (Ugwueze et al., 2022)

2.4 PAV Design Configuration Concepts

Advancements in enabling technologies, specifically, distributed electrical propulsion systems, long-life lithium energy storage, advanced structural materials, and autonomous flight operation systems, have accelerated the development of PAVs and their progress towards full-scale implementation and commercialization (Goyal et al., 2018, Hasan, 2019). A wide range of PAV aircraft design configurations are in development by dozens of original equipment manufacturers. Globally, there are approximately 150 aircraft designs for PAV air taxi projects (Goyal et al., 2018). Aircraft design configurations are non-homogenous and vary amongst PAV manufacturers. There appears to be no consensus within the industry for a predominant configuration, hence each OEM has selected their preferred configuration to develop.

Proposed PAV design configurations as shown in Figure 2, include, but are not limited to, multi-copter (i.e. wingless), lift + cruise (i.e. fixed-wing, fixed-rotor), tilt-rotor (i.e. fixed-wing, adjustable-rotor) and vectored thrust (i.e. aerofoil wing, vectored duct) (Johnson & Silva, 2018; Goyal et al., 2018). These configurations generally include concepts which have a transition of the rotor from hovering configurations to a propeller configuration to enable vertical lift and mission cruise. Concepts also describe aircraft that use its thrusts independently or collectively, for both lift and cruise, or for lift only (Rizzi et al., 2020).

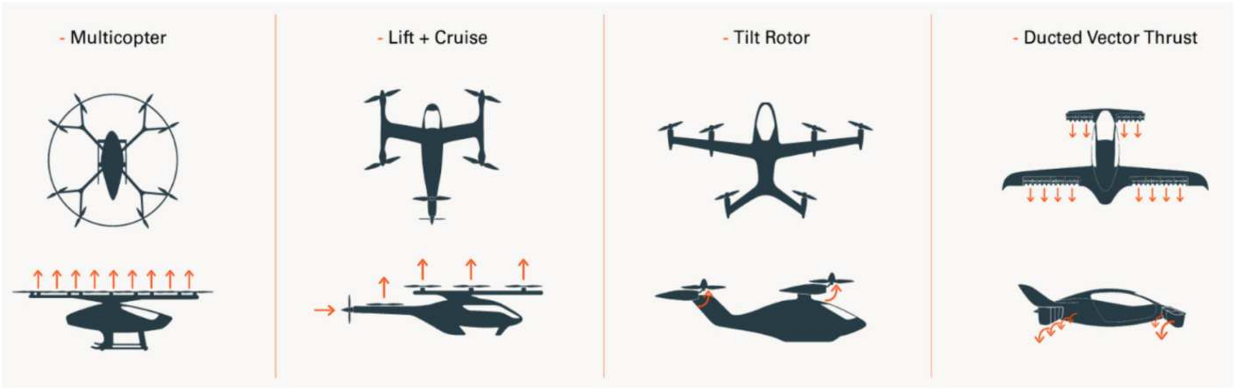


Figure 2. Type of eVTOL configurations (Chahba et al., 2023)

The Federal Aviation Administration Concept of Operations (ConOps) provides general guidance on how UAM will integrate into the National Airspace System (NAS). There are three levels of aircraft automation and pilot in command (PIC) engagement with the UAM aircraft enabling systems described below in Table 1 (Price et al., 2020).

In this research study, the PAV virtual flight experiment simulated a Human-over-the-Loop (HOVTL) autonomous system, whereby the human is informed by the automation (i.e., systems) to take action (if any, as required). Accordingly, the physical location of the pilot command (PIC) is remote (i.e. offboard). Several PAV/eVTOL operators have declared their intention to fly autonomously, either at the outset of commercial operations, or after a pre-determined transition timeframe from onboard piloted operations (Edwards, et al., 2020).

Table 1. Levels of UAM Aircraft Automation (Price et al., 2020)

UAM Automation Level	Description
Human-within-the-Loop (HWTL)	• Human is always in direct control of the automation (systems)
Human-on-the-Loop (HOTL)	• Human has supervisory control of the automation (systems) • Human actively monitors the systems and can take full control when required or desire
Human-over-the-Loop (HOVTL)	• Human is informed, or engaged, by the automation (systems) to take action • Human passively monitors the systems and is informed by automation if, and what, action is required • Human is engaged by the automation either for exceptions that are not reconcilable or as part of rule set escalation

The FAA envisions maturity of UAM operations to evolve through three stages: initial operations, midterm operations and mature state operations. In the initial stage, UAM will operate at a low tempo, leverage existing rules and regulations, with the PIC located onboard.

In the midterm stage, UAM operations are forecasted to be conducted at an increased tempo, with newly-defined, FAA-approved standards, and the PIC located onboard with remote PIC assistance. The mature state of UAM will operate with significantly higher tempo consistent with increased demand, with complex regulatory standards, and the PIC location will be fully remote.

Previous studies on virtual PAV flights provide useful context. For example, Jonetta and Hogrevve (2021) conducted PAV flight simulations using Virtual Reality technology at Ingolstadt University in Germany with 294 participants. Their findings revealed that respondents were concerned about safety, including potential technical errors of air taxis, collisions with other flying objects, and the risk of hackers gaining access to the system. Additionally, respondents were found to be concerned with the fact that there is no human pilot in the air taxi, which the authors concluded pointed towards trust in automation as one of the main challenges for the widespread adoption of UAM services.

NASA is actively researching PAV ride quality and passenger experience through simulated flight testing within a full-scale cabin prototype as part of the Revolutionary Vertical Lift Technology project. This research provides design guidance to industry manufacturers to ensure passengers will have a smooth and safe ride, wherein the aircraft will have low cabin noise, low vibration from rotors, high resistance to resistant to being upset by turbulence (NASA, 2020). To date, there have not been any PAV flight simulation research studies by NASA devoted to the passenger’s psychological feelings of trust and safety.

2.5 Technology Adoption and Acceptance Frameworks

Two sociological models serve as frameworks to ascertain individual behaviors for community integration of PAVs, which drive acceptance and adoption of new innovation and technology.

2.5.1 Technology Adoption Life Cycle Model

Rogers' (2003) Technology Adoption Life Cycle Model proposes that the rate of adoption of any new technology or innovation is normally distributed along a bell-shaped curve, segmented by standard deviations from the mean (see Figure 3). A normalized adoption curve would present five groups characterized as Innovators (2.5%), Early Adopters (13.5%), Early Majority (34%), Late Majority (34%) and Laggards (16%), where innovators and early adopters are often grouped together to represent early market. Innovators are first to adopt new technology, knowingly accepting risk with perceived reward. Early Adopters adopt new technology fairly early albeit more carefully in order to balance risk. Early Majority and Late Majority adopt new technology after most people have tried it, and do so with a bit of skepticism. Laggards may adopt technology, if at all, only after the technology has been available for some time and has been well-established.

Figure 3. Technology adoption life cycle categories (Rogers, 2003)

2.5.2 Technology Acceptance Model

The Technology Acceptance Model (Davis, 1989) (Figure 4) suggests that perceived usefulness and ease of use are two key determinants that drive individual behavior intentions to use a new system or technology. Perceived usefulness describes how an individual believes technology use would enhance job performance or life, while perceived ease of use describes the degree to which an individual believes using the technology requires effort (Venkatesh, 2000). External variables are indirect factors which affect usage attitudes and intentions, and are defined within general categories including (but not limited to): individual differences, social influence, system characteristics and facilitating conditions (Venkatesh et al., 2003).

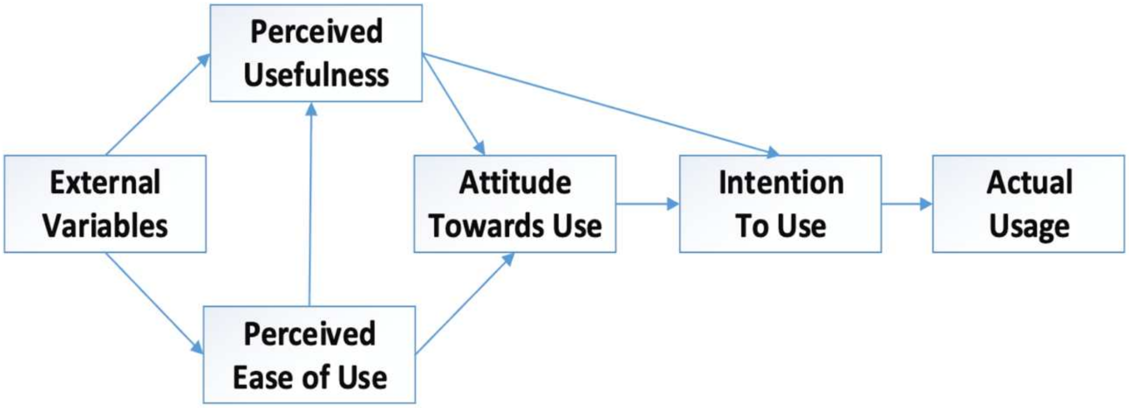


Figure 4. Technology acceptance model framework (Davis, 1989; Hade et al., 2022)

2.6 PAV Challenges

While excitement and momentum are building for PAVs to become a reality, several challenges and barriers remain to be overcome. NASA has identified five key gaps: (i) vehicle development and production, (ii) individual vehicle management and operations, (iii) airspace system design and implementation, (iv) airspace and fleet operations management, and (v) community integration (Price et al., 2020). Lineberger et al. (2021) additionally identified that safety, regulations, technology maturity, infrastructure and psychological barriers are key challenges to adoption of PAV technology.

This dissertation focuses on the challenge of community integration, a crucial component of public acceptance and adoption. Understanding the extent to which communities, who represent the potential market of passenger air vehicle passengers, adopt and ultimately accept Urban Air Mobility PAV technology systems, is imperative.

A study by the Community Air Mobility Initiative (CAMI) found that the extent to which passengers and the community trust and accept PAVs, is based on the knowledge that the operations are properly regulated (Hill, 2020). System integration challenges of PAVs are primarily regulatory in nature. The U.S. Federal Aviation Administration is working in collaboration with NASA to develop regulatory rules and standards for autonomous air vehicle integration into the national airspace. Moreover, Aircraft Safety and Airworthiness Certification, Airspace Integration, and Air Transport Management are the top issues that the FAA is tasked to address (FAA, 2023). Both NASA and the FAA have identified community integration as a key challenge to surmount to effect wholesale adoption of autonomous air taxi technology.

2.6.1 Cybersecurity

Public trust of UAM is reliant on the safe and secure operation of the system, which includes security from cyber threats. The digitally complex and interconnected nature of UAM, e.g. air traffic management, autonomous navigation systems, ground infrastructure and passenger interfaces, creates a vast attack surface for cyber threats (Tang, 2021; Freeman & Garcia, 2020; Lewis et al., 2024). Known vulnerabilities include global positioning system (GPS) spoofing and jamming, data link attacks, control system hacking, and malware infections. Rapid development of UAM technology and autonomous systems create evolving threats and increased sophistication of malicious actors, thereby necessitating operator vigilance and robust monitoring and defense (Lewis et al., 2024; Altawy & Youssef, 2016). Previous studies have highlighted the crucial role of human factors in cybersecurity (Lanigan et al., 2025; Aliebrahimi & Miller, 2023).

Freeman and Garcia (2021) highlight the use of the National Institute of Standards and Technology (NIST) Cybersecurity Framework, as an overall taxonomy for stakeholders to identify, understand and manage UAM cybersecurity risks, as well as help prioritize actions to reduce risks. Moreover, while UAM remains in development phases, an opportunity exists to design in operational safeguards with cybersecurity in mind, rather than as an afterthought. Tang (2021) found that implementing robust encryption protocols, enhanced detection and response systems, redundant operation systems, and blockchain technology, is a robust arsenal to ensure vulnerabilities are minimized. Simulations conducted by Lewis et al. (2024) found that the implementation of a host-based intrusion detection system is indispensable in identifying and countering threats.

UAM is not a standalone system but a “system of systems” that integrates diverse technologies. A cyber incident in one system component could potentially cause a ripple effect throughout the entire ecosystem, resulting in devastating impacts to public safety (Naeem et al., 2024; Lewis et al., 2024). Hence, addressing UAM cybersecurity is not only a technical requirement but a societal imperative. In order to realize the potential of UAM, cybersecurity assurances are crucial for public acceptance and trust. Left unaddressed, undermines trust and impedes widespread adoption (Freeman & Garcia, 2021).

2.6.2 Equity and Accessibility

The viability and public acceptance of UAM fundamentally hinges on how equitably and accessibly all communities will be served. Ahmed et al.(2025) identified disadvantaged groups within communities including elderly, youth, disabled individuals, and those with economic inequity, whose needs should be taken into consideration during the planning, design and implementation processes of the urban transportation system. without intentional design and policy, UAM risks reinforcing existing socio-economical and socio-spatial inequalities (Ahmed et al., 2025; Faghri et al., 2022).

Equity in UAM encompasses transport, mobility and environmental justice (Ahmed et al., 2025). Further, the general concept of transportation equity centers on how social, economic, and government institutions shape the distribution of transportation benefits and burdens in society. Pereira and Karner (2021) cite that transportation systems often privilege affluent, able-bodied users, while low-income and marginalized populations experience disproportionate exposure to noise, pollution, and displacement. Cohen and Shaheen (2021) also raise concerns about increased noise and activity over residential areas. Montejo et al. (2024), note in their NASA technical report that new transportation modes have historically favored upper social classes, an observation echoed by Cohen and Shaheen (2021), who point out that current UAM services may be considered premium offerings, raising concerns about their affordability for lower- and middle-income households. Environmental justice concerns cited by Faghri et al. (2022), highlight how transportation infrastructure decisions can exacerbate health disparities and social exclusion.

Accessibility in UAM centers on improving user-friendliness for people with disabilities, including those with mobility challenges, limited sight or hearing, or other differently-abled special needs. The current state of accessibility in UAM is still in development, as recent industry analysis and advocacy highlight that many eVTOL aircraft and vertiport designs do not yet fully address universal accessibility principles (Young, 2020). Features such as handrails, step-free access, tactile surfaces, large-print signage, and appropriate lighting, essentials for safe and comfortable journeys for differently-abled passengers, are noted as lacking or not prioritized in current UAM infrastructure. Zhang et al., (2024); Young (2020), advocate for inclusive vertiport designs featuring tactile navigation, barrier-free boarding, and multimodal integration. These efforts align with human-system integration principles, which necessitate designing technologies that accommodate a wide range of physical and cognitive abilities (Kapsalis et al., 2022).

Scholars are in concurrence around the notion that public trust in UAM will depend on how well it addresses these equity and accessibility concerns from the outset (Pak et al., 2023; Antipova et al., 2020). Ultimately, equity and accessibility are prerequisites for the social license to operate UAM systems. Robust community engagement, including consultation with disability and underrepresented groups during these early planning stages, will help to ensure the realization of UAM as a welcoming, sustainable and inclusive transport system, which is key to fostering broad-based public acceptance.

2.7 Human System Integration Overview

As defined by NASA, Human System Integration (HSI) is an interdisciplinary integration of the human as an element of a system to ensure that both human and software and hardware components cooperate, coordinate, and communicate effectively, to successfully perform a specific function or mission (Rippy, 2021).

The philosophy of HSI centers on the idea that the human element is a critical component of most complex systems and should be focused on in order to achieve benefits of complex systems. Recognizing the importance of the human element most likely will result in dramatic increase in productivity and dramatic reduction in cost (Booher, 2003).

With respect to HSI and PAVs, product design is the HSI activity which yields greatest benefit. User focus is leveraged to develop and implement user-center design procedures. From an integration standpoint, the intent is to utilize human factor skills and tools in the design and development of products, while performance is measured by evaluating human performance, safety and usability of products (Booher, 2003). Moreover, during the design and development processes, HSI enables discovery of nascent properties, behaviors and functions using Human In The Loop (HITL) simulation. This enables engineering design teams to increase system knowledge earlier than before, keeps design flexibility, and better management of resources. Hence implementation of HSI greatly supports the development of new industrial endeavors vis-à-vis PAV transportation systems (Boy & Kennedy, 2023).

2.8 Community Acceptance and Integration

While there are compelling benefits to UAM, the impacts of such new technology to communities, as well as the public expectations and concerns, must be considered. Safety, noise, emissions, privacy, land use and visual disruption from low-altitude aircraft operations have been identified as the most important societal and environmental concerns of UAM service, which affect community acceptance (Cohen & Shaheen, 2021; Pak et al., 2023; Holden & Goel, 2016). Residents express apprehension about aircraft flying over homes, impacting privacy and quality of life.

According to the most recent and extensive EASA survey (EASA, 2021) on the societal acceptance of UAM in Europe, safety, noise, and security are among the top concerns. Safety is, unquestionably, the first and foremost aim to fulfill. Air operations in the low-altitude airspace and high-density locations make safety concerns most important (Jordi Pons-Prats, 2022). Building community trust requires comprehensive public outreach campaigns that educate citizens on the technology, operational procedures, and benefits of UAM, while actively soliciting and addressing their concerns (EASA, 2021).

There appears to be a lack of alignment on the definition of what community acceptance and community integration is as it relates to the scale up and commercialization of UAM/PAVs. The community, which is comprised of potential PAV consumer passengers, cannot be regarded as an interchangeable term for passenger acceptance. For instance, the community may be concerned with the economic impacts (both positive and negative) UAM implementation may have on the community, whereas an individual may be concerned with the out-of-pocket economic impact (high or low cost) that may influence their decision to choose to ride a PAV.

2.9 Existing Gaps in Literature

Certification and full commercialization of PAVs has not yet been achieved. To date, the majority of research and development has focused on the technical design and operations of PAVs. There is limited literature research relating human-system integration, particularly the ways in which passenger trust, perceived safety, and overall ride experience shape adoption. Understanding these human-centered factors is critical, as the success of PAVs in a consumer-driven market ultimately depends on passengers' willingness to ride. This dissertation addresses that gap by advancing knowledge on the psychological and experiential dimensions of PAV adoption, and how PAV designs can enhance user trust and acceptance.

Chapter 3:

Methodology Overview

3.1 Data Sources for Research Aims

This dissertation uses different experimental methods tailored to each research aim and associated question(s). Table 2 summarizes the data source and sample size resulting from the method implemented. Further detailed information of the datasets and experimental methodologies used for each research question is provided in subsequent chapters in this dissertation (Chapter 4 for Aim 1, Chapter 5 for Aims 2 and 3).

Data collection for each research aim was fulfilled using human subjects. Informed consent was obtained from each participant prior to experiment start. The PAV technology adoption and perception survey (research aim 1) gained approval from the Colorado State University Institutional Review Board under Protocol 20-10371H. The PAV flight simulation experiment (research aims 2 and 3) gained approval from the Colorado State University Institutional Review Board under Protocol 3977. Approvals were granted in accordance with 45 CFR 46.111 of the 2018 IRB Requirements.

Table 2. Data Source and Sample Sizes per Research Question

Research Question	Data Source	Sample Size
RQ 1.1	PAV Technology Adoption and Perception Survey	407
RQ 1.2	PAV Technology Adoption and Perception Survey	407
RQ 2.1	PAV Flight Simulation - HMI Focus	40
RQ 3.1	PAV Flight Simulation - Technology Adoption Profile Focus	40

Chapter 4:

Research Aim 1

Aim 1: Identify the differences between early and late adopters of PAV technology

4.1 Introduction

Widespread adoption of PAVs is on a non-linear path to becoming a fully integrated system and revolutionizing transportation. The pace at which consumers embrace this potentially transformative technology is driven by dynamic factors and distinct characteristics between early and late adopters (Rogers, 2003). Understanding and defining their divergent motivations, risk tolerances, and perceptions of technology can significantly influence the development and implementation of PAVs in urban centers (Johnson et al., 2022). Thus, this chapter seeks to identify and examine the key differences between early and late adopters of PAV technology, highlighting how their unique perspectives can shape the trajectory of this emerging sector.

In this research phase, a quantitative survey was developed to gain insights and general perceptions of PAVs as an alternative aviation transportation system. The survey additionally examined individual technology adoption profiles and adoption time horizons relative to full-scale PAV entry into service. The following research questions are addressed in this chapter:

- **Research Question (RQ) 1.1**: What are the initial perceptions of PAV technology by the general public?
- **Research Question (RQ) 1.2**: What are the differences between self-identified early technology adopters and late technology adopters with respect to PAV human-system integration?

The results of this chapter have been published by Johnson et al. (2022), in the *International Journal of Aerospace Psychology.* Additionally, these findings were presented at the *Annual International Council on Systems Engineering (INCOSE) International Symposium* (Johnson and Miller, 2022).

4.2 Methods

4.2.1 PAV Technology Adoption and Perception Survey

An online survey was administered to evaluate the aforementioned research questions, RQ 1.1 and RQ 1.2. The survey gained approval from the Colorado State University Institutional Review Board (IRB), Protocol 20-10371H. The scope of the survey in its entirety can be found in Appendix A.

4.2.2 Survey Design

The survey incorporated a total of 22 questions, comprising both matrix questions and 5-point Likert scale questions. Eight questions related to participant demographics. The remaining 14 questions captured respondent's feedback on PAV systems (i.e., trust, safety, ease of use, usefulness, and interior and interface design requirements) and their general affinity to technological innovation and rate of technology adoption. Similar questions were grouped together into Likert matrices to alleviate workload (e.g., "To what extent do you agree or disagree with the following statements about your trust of PAVs…"). Questions were developed in alignment with the Technology Acceptance Model (Davis, 1989). There were nine questions related to participant demographics. The survey took approximately 15-20 minutes to complete.

4.2.3 Participants

A total of 470 participants completed the survey. After data cleaning, a net total of 407 survey responses was usable. The respondents were sampled through Pollfish®, an online survey platform. Pollfish® was paid $0.95 for each completed survey and respondents were compensated through Pollfish®. Data was collected over a period of nearly 3 weeks. Only respondents who lived in the United States were included, which was determined by a survey question which asked participants to provide their residential zip code.

4.2.4 Sample Size Determination

The participant sample size was calculated based on Cochran's formula (Bartlett et al., 2001; Pourfalatoun et al., 2023). As shown in Equation 4.1, preferred variables include 95% confidence level (Z = 1.96) and 5% margin of error (e = 0.05). According to data from the 2020 U.S. Census (U.S. Census Bureau, 2020), the population of adults (age 18 and over) in the United States was approximately 258.3 million. A conservative sample proportion value of 50% was selected (p = 0.5). The minimum required sample size to ensure accurate and reliable results was calculated as 384. Hence the sample size of 407 used for this study provides adequate number of participants within the margin area and confidence level, for statistical significance.

$$n_0 = \frac{Z^2 p(1-p)}{e^2} \Bigg/ 1 + \frac{Z^2 p(1-p)}{Ne^2} \tag{4.1}$$

$$n_0 = \frac{1.96^2 0.5(1-0.5)}{0.05^2} \Bigg/ 1 + \frac{1.96^2 0.5(1-0.5)}{258{,}300{,}00(.05)^2} = 384$$

where:

- n_0 is the calculated sample size
- Z is the Z-score (confidence level) from the Z-table
- p is the estimated proportion of the population
- e is the margin of error

4.2.5 Survey Introduction to Passenger Air Vehicles

The initial section of the survey provided a description of PAVs and a conceptual image of a PAV aircraft (Figure 5) to introduce and familiarize participants with the technology concept. The image depicts a fixed wing, small aircraft flying at low altitude above a metropolitan city of Los Angeles California. Aircraft design configurations vary amongst PAV manufacturers, and while the PAV concept introduced in the survey was a fixed-wing aircraft, the survey questions were developed to be agnostic to the type of PAV aircraft design.

Figure 5. Conceptual image of PAV flying over Los Angeles (Holden & Goel, 2016)

The definition provided to participants was aligned with NASA's standard definition of PAVs; participants were informed that:

> *Passenger Air Vehicles are on-demand, auto-piloted, electric aircraft that transport 1 to 4 passengers at low altitudes within urban and suburban areas. These air vehicles, or air taxis, are capable of vertical take-off and landing, thereby requiring no traditional runway, and offer a safe, quiet and eco-friendly alternative to road traffic emissions and congestion.*

4.2.6 PAV Adopter Groups

Participants were queried how soon after being available to the public they would be willing to ride a PAV, between a timeframe range of 0 months to 5+ years. This information was used to group participants into four PAV adopter groups: Early (0 to 6 months); Moderate (6 months to 1 year); Late (1 to 5 years); and Laggard (5 or more years).

4.2.7 Survey Data Analysis

Data was cleaned and analyzed using R (version 4.1.0). Chi-square tests were used to test for independence between the different PAV adopter groups and their various perceptions. Ordered logistic regression models were used for multivariate analysis of the different PAV adopter groups. Statistical significance was evaluated at $\alpha = 0.05$.

4.3 Results

4.3.1 Demographics

After removing incomplete responses from the 470 total survey responses collected, participant residential zip codes were cross referenced with known U.S. zip codes, resulting in (N=407) data responses used for the analyses. Participant residential locations dispersed across the United States are illustrated in Figure 6.

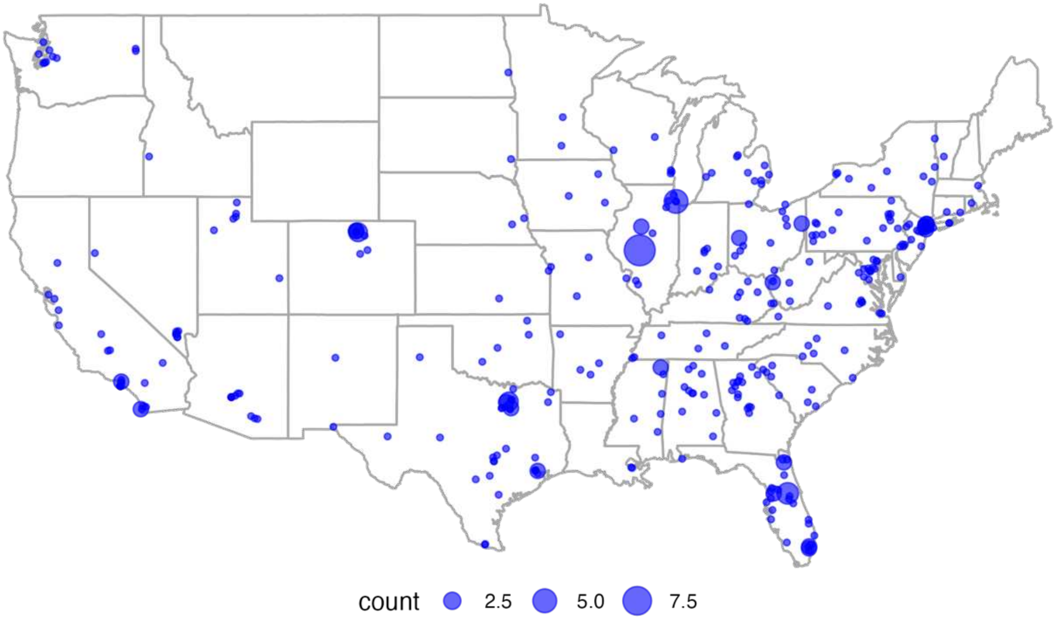


Figure 6. Participant residential locations across the US based on provided zip codes

Respondents represented a broad spectrum of education, employment and income statuses and residential locations (

Table 3). Comparative demographics from 2020 US Census data for individuals 18 and over are provided as appropriate in the table. Participant ages ranged from 18 to 74 years old (Avg = 39.3; SD = 12.6 years).

Table 3. Participant Demographics with Comparable US Demographics

Variable	Group	N Responses	% of Total	US Total (%)
Gender	Male	223	54.5	49.2
	Female	181	44.5	50.8
Education	Some HS	26	6.4	6.5
	HS Diploma	74	18.2	27.8
	Some College	81	19.9	17.5
	Associates	35	8.6	10.1
	Bachelors	76	18.7	22.1
	Postgraduate	115	23.6	11.4
Household Income ($)	< 25k	79	19.4	18.1
	25k-50k	95	23.3	19.7
	50k-100k	95	23.3	28.6
	100k-150k	66	16.2	15.3
	150k-250k	64	15.7	8.0
	> 250k	6	1.5	10.3
Employment Status	Student	11	2.7	--
	Employed	300	73.7	--
	Retired	37	9.1	--
	Unemployed	59	14.5	--
Residential Location	Rural	63	15.5	--
	Unincorporated	2	0.5	--
	Small Town	50	12.3	--
	Suburban	110	27.0	--
	Urban Core	118	29.0	--
	Urban Non-Core	60	14.7	--
	Unsure	4	1.0	--

4.3.2 PAV General Perceptions

Just over half of the respondents (50.8%) were not familiar with PAVs, while 21.1% and 11.1% were extremely familiar and very familiar with PAVs, respectively. Of the respondents who were at least slightly familiar with PAVs, 55.5% were willing to ride a PAV within the first year they become available to the public, while 34.5% were willing to ride between 1 and 5 years after availability. The remaining 6.5% stated they would wait at least 5 years to ride.

4.3.3 PAV Cabin Design Preferences

Respondents were asked to conceptually consider the interior of a PAV and rate the extent to which each feature was important to them. These are provided in descending order of importance (Figure 7), wherein importance ratings were captured using a 5-point Likert scale: Not at all important, Slightly important, Moderately important, Very important and Extremely important. A majority of respondents (> 64%) ranked each of the cabin interior features listed as either very important or extremely important. Safety, vis-à-vis, safety restraints was of paramount importance to respondents, garnering the highest rating amongst all cabin features. Second highest was high air quality (80%), which could be influenced by conducting the survey during the COVID-19 pandemic. Comfortable cabin seating (78%), with ample leg room (75%) and ample headroom (73%) were rated as very and/or extremely important by respondents. Respondents also rated large windows as the PAV interior cabin feature of moderate importance (26%) or less (11%). Regarding interior cabin noise, respondent’s perceptions of relatively quiet cabins were moderately (23%) to less important (8%) as a feature.

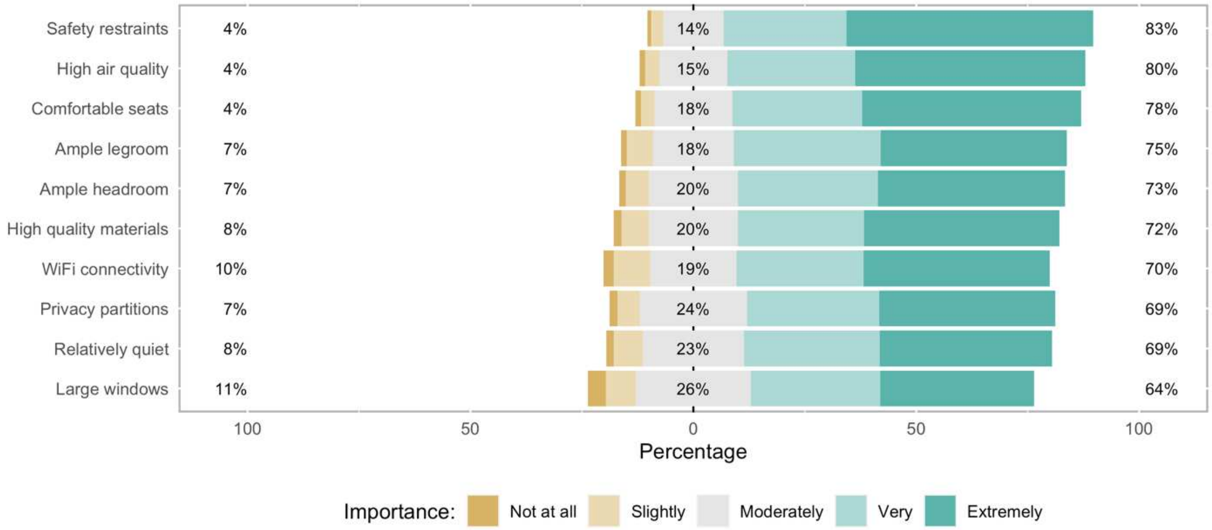


Figure 7. Perceived importance of various PAV cabin interior features

Similarly, participants were asked about their perceived importance of information presented on interior display screens within the PAV cabin (Figure 8), also on a 5-point Likert scale of importance. Participants rated weather condition information as the most important, with 83% rating it as very important or extremely important whereas participants rated a map of birds near the PAV presented on a display screen as least important, with respondents finding the information moderately (23%) or less (20%) important. Interestingly, aircraft battery life, which is information unique to PAV displays compared to conventional aircraft passenger displays, was the second highest (82% rate as very important or extremely important) on the list of important information to view on a display screen within the cabin. Typical information one would perceive to be important to view in a conventional aircraft, such as time to destination, route path and travel speed, were also rated as very/extremely important to respondents at 81%, 75% and 71%, respectively.

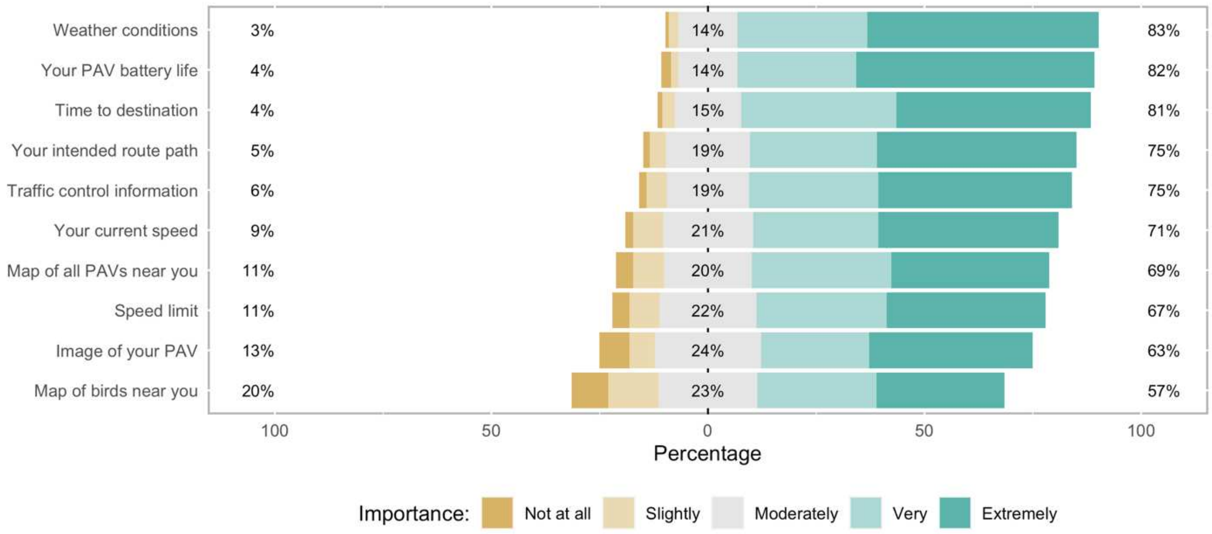


Figure 8. Perceived importance of information on PAV passenger interior display

4.3.4 PAV Adopter Groups

Participants were grouped according to how soon they would be willing to ride a PAV once available to the public, from early to moderate to late to laggard. Innovators and Early Adopters are often grouped together to represent early market. The Moderate category reflects Early Majority Adopters. Participants who responded as "not sure" (N = 44) were removed from this subsequent analysis, resulting in 361 responses. Table 4 provides demographic information for these four PAV adopter groups.

Table 4. PAV Adopter Group Demographics

Demographic Variable	**PAV Adopter Group**			
	Early *(0 – 6mo)*	**Moderate** *(6mo – 1yr)*	**Late** *(1 – 5yrs)*	**Laggard** *(5+ yrs)*
Total, *N (%)*	102 (28.0)	107 (29.6)	126 (34.9)	26 (7.2)
Age, *Average (SD)*	41.5 (13.7)	37.7 (11.5)	36.4 (11.5)	40.0 (10.7)
Male, *N (%)*	63 (61.8)	58 (54.2)	69 (54.8)	18 (69.2)
Live in Urban Area, *%*	40.2	52.3	46.8	30.8
At least Bachelor's degree, *%*	37.2	54.2	53.2	42.3

Chi-square tests of independence were performed to determine if there was a relationship between these PAV adopter groups and more broad concepts not directly related to PAV design and functionality.

First, a comparison between PAV adopter group and Rogers' (2003) Technology Adoption Life Cycle groups was performed. In the survey, participants were asked, when it comes to technology [in general], what best describes them: (a) wanting to be first to try new technology, (b) waiting awhile before trying new technology, (c) usually being the last to try new technology, and (d) preferring to stick with what they know. These definitions correspond to Rogers (2003) general technology adoption life cycle groups. Chi-square results revealed a significant relationship between these self-reported general technology adoption groups and the PAV adopter groups, χ^2 (9, N = 359) = 41.3, $p < .001$, where PAV adopter groups correspond to general technology adoption groups.

Next, a comparison between PAV adopter group and willingness to ride in an autonomous passenger car was performed. In which the chi-square test also revealed a relationship between PAV adopter groups and willingness to ride in an autonomous car, χ^2 (6, N = 359) = 23.732, $p = .0006$, where earlier PAV adopters were more willing to ride in an autonomous vehicle.

Additionally, a comparison between PAV adopter group and influence of airplane crashes on decisions to ride in an airplane were performed. A chi-square test showed a relationship between PAV adopter group and the influence of airplane crashes, χ^2 (12, N = 333) = 21.184, $p = .048$, where earlier PAV adopters were less likely to let reports of airplane crashes influence their decision to ride in an airplane.

Lastly, a chi-square test indicated no significant relationship (p = .53) between PAV adopter group and household income level.

4.3.5 Trips with PAVs

An ordered logistic regression model (Table 5) was used to evaluate differences between likely PAV trip purposes for the different PAV adopter groups. There was no significant difference between adopter groups and their intent to use PAVs for daily work commute and entertainment related trips, but later PAV adopters were less likely to use PAVs for occasional work commute and personal travel. Additionally, respondents with shorter work commute times were more likely to be early and moderate PAV adopters, χ^2 (15, N = 357) = 27.32, p = .026.

Table 5. Ordered Logistic Regression for PAV Adopter Group by PAV Trip Type

Variable: *Likely to use PAVs for…*	**Coefficient**	**Odds Ratio**	**SE**	**t-value**	**p-value**
Daily commute to/from work	-0.175	0.805	0.161	-1.09	ns
Occasional commute to/from work	-0.335	0.729	0.159	-2.10	.04
Personal, non-business travel	-0.430	0.751	0.159	-2.70	.01
Entertainment/sight-seeing	-0.028	0.916	0.161	-0.17	ns
Early | Moderate	1.090	-	0.129	8.26	< .01
Moderate | Late	0.206	-	0.106	1.94	.05
Late | Laggard	2.531	-	0.208	12.19	< .01

4.3.6 Technology Acceptance Model Attributes

Participants were asked about their perceived usefulness (Figure 9) and perceived ease of use (Figure 10) of PAVs. Two ordered logistic regression models were conducted with the dependent variable PAV adopter group with *(i)* the six variables relating to perceived usefulness, with somewhat and strongly agree ratings grouped together, as well as somewhat and strongly disagree ratings grouped together; and *(ii)* the five variables relating to perceived ease of use, also with somewhat and strongly ratings for agree and disagree grouped together, respectively.

For perceived usefulness, earlier adopters were statistically more likely to agree that PAVs are safe (Coefficient = -0.434, OR = 0.65, p = .02) and more reliable (Coefficient = -0.612, OR = .54, p < .01) but not cost less per mile (Coefficient = 0.366, OR = 1.44, p = .03).

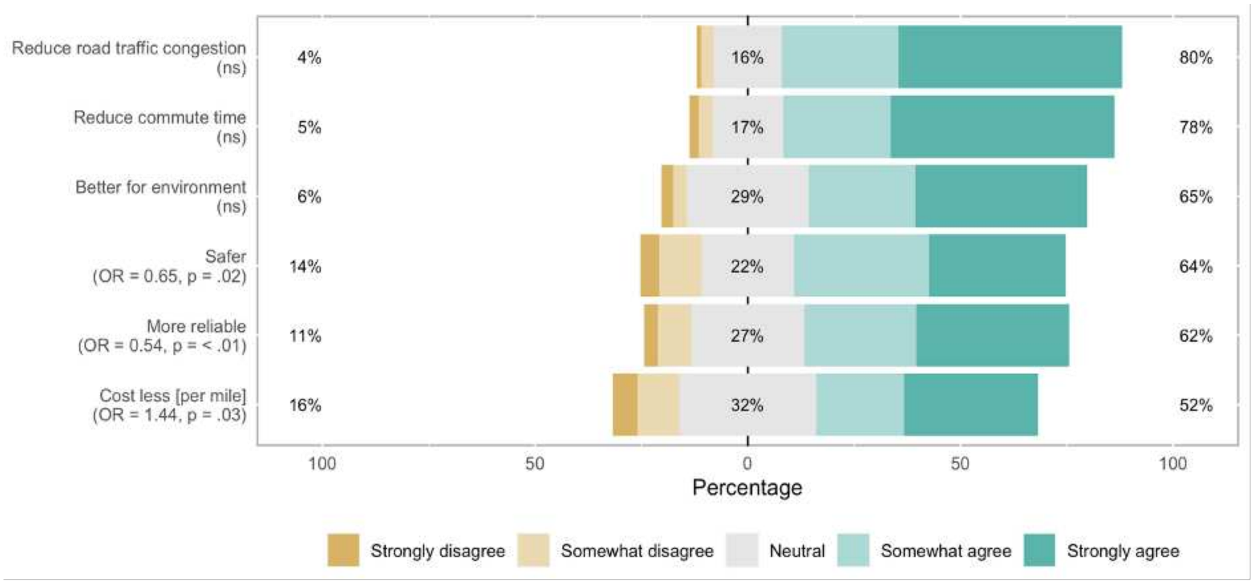


Figure 9. Perceived PAV usefulness with ordered logistic regression OR and p-values

For perceived ease of use, the only statistical correlation is that participants in the earlier adopter groups are more likely to agree that riding in PAVs would reduce stress (Coefficient = -0.633, OR = 0.531, p < .01).

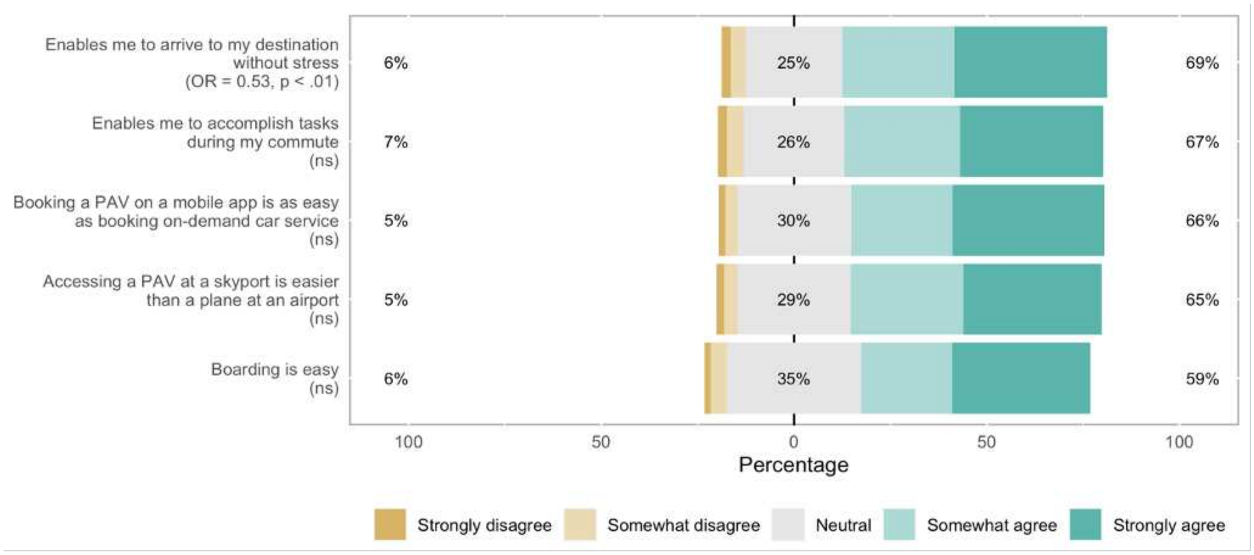


Figure 10. Perceived PAV ease of use with ordered logistic regression OR and p-values

4.3.7 Trust in PAVs

An ordered logistic regression model with dependent variable PAV adopter group and independent variables as various PAV trust concepts was used to identify differences in PAV trust that might lead to different PAV adoption times (Table 6).

The model showed that trust in later adopters improves with visual indicators providing feedback to passengers inside the PAV (Coefficient = 0.720); that early adopters are more likely to trust PAVs operated by an established brand (Coefficient = -0.708) and PAVs autonomously piloted (Coefficient = -0.364); and that trust in on-board piloted PAVs is not predictive of PAV adopter group (p > .05).

Table 6. Ordered Logistic Regression for PAV Adopter Group by Trust in PAVs

Variable	Coeff.	Odds Ratio	SE	t-value	p-value
Need visual indicators inside PAV to trust flight is operating safely *(agree)*	0.720	2.054	0.331	2.18	.03
Trust riding in a PAV operated by an established brand *(agree)*	-0.708	0.492	0.344	-2.06	.04

Trust riding in a PAV with a pilot on-board *(agree)*	-0.213	0.808	0.335	-0.64	ns
Trust riding a PAV that is autonomously piloted *(agree)*	-0.364	0.695	0.176	-2.07	.04
Early | Moderate	1.257	-	0.331	3.80	< .01
Moderate | Late	0.019	-	0.327	0.06	ns
Late | Laggard	2.380	-	0.361	6.39	< .01

4.4 Discussion

Capacity constrained roadways and developments in autonomous flight technology have made PAVs a viable option for urban mobility. However, successful integration and implementation of PAVs depend on both technology advancements and societal adoption and acceptance. This chapter aimed to gain insights and understand perceptions of emerging PAV technology systems from potential users. This chapter found that half of the respondents were not familiar with PAVs prior to participating in the survey, and as such, these findings represent general public perceptions and potential PAV community users, rather than PAV subject matter experts or similar stakeholders; which has often been the focus of many previous studies.

As is the case with conventional airplane passengers, safety is of prime importance for future PAV passengers (Cohen et al., 2021). Potential users perceive PAV cabins equipped with safety restraints as the most important feature, even more than cabin comfort (i.e., ample legroom and headroom). Safely and properly securing PAV passengers during take-off and landing appears to be an expectation, similar to conventional aircraft. Safety restraints are likely to be federally required on PAVs per existing FAA Code of Federal Regulations, 14 CFR 91.107 (Use of Safety Belts, Shoulder harnesses, and Child Restraint Systems, 1999).

Perhaps due to the heightened awareness of airborne pathogen transmission during the COVID-19 pandemic (Pourfalatoun & Miller, 2023; Wise et al., 2020), respondents rated PAV cabin air quality of extremely high importance (80%). The small cabin interior envisioned for PAVs creates a confined space of circulated air shared by passengers, where clean cabin air likely translates to perceived health safety. Literature on perceptions of COVID-19 shows that airplanes are viewed as the riskiest transport mode in terms of potential virus spread (Barbieri et al., 2021). Similarly, respondents correspondingly view PAV air quality as an important cabin feature necessary to minimize health safety risks.

Interestingly, respondents indicate having a relatively quiet PAV cabin as a less important feature. NASA and other UAM stakeholders have found that PAV noise is a key barrier to public acceptance of UAM (Price et al., 2020). The distinction noted is noise level experienced within a PAV (as surveyed in this study) versus PAV noise level experienced outside of a PAV cabin while on the ground within a city (as evaluated in the above mentioned research). A study predicted that PAVs flying within a typical city would emit a noise level of 65 decibels, comparable to a city bus or motorcycle noise level, which may be perceived as noise annoyance (Moore, 2003). Future research should investigate whether respondents who rated internal PAV noise as less important, would have the same or different rating for externally emitted PAV noise.

Unlike jet-fuel powered airplanes, PAVs are electrically powered, deriving energy from lithium-ion batteries. Participants perceived PAV battery life status as highly important information to display on a cabin human-machine interface (HMI) panel. PAV battery life information may convey a sense of safety to potential passengers, now armed with the knowledge that there is ample power for the range and duration of their trip. Conversely, HMI display panels in traditional aircraft typically do not display jet-fuel reserve status, nor do passengers expect to see such information displayed. However, the prevalence of electric vehicles (EVs) on the road, which are equipped with HMI displays of the EVs battery life, may influence the expectation and priority of visualizing real-time battery power consumption.

Respondents perceive weather conditions as the most important information to display on a PAV HMI. This perception agrees with studies that show PAVs are more susceptible to weather hazards based on their diminutive size, as well as their operation at lower altitude versus traditional airplanes, which are larger and fly at much higher altitudes, above conventional weather patterns (Steiner, 2019). Inclement weather is a challenge for any transit mode and PAVs are no exception, and in fact may experience more unique challenges. In addition to inclement conditions such as rainstorms, snow, ice, and fog, PAVs flying through high-rise building-dense cities may experience exceptionally high gusty wind conditions and urban canyon effects. Potential PAV passengers need reassurance of reliable and safe flight through real-time accurate weather reporting through in-cabin HMI display. PAV manufactures implementation of various weather-mitigating technologies such as AI-based prediction systems, rapid deicing systems, and enhanced vision systems (Steiner, 2019), will enable safe and reliable PAV flight operation and assure trust. Further, to support community acceptance efforts, targeted campaigns educating the public about PAVs robust capability to safely and reliably withstand extreme weather, should be considered.

Based on respondent’s self-reported time to adopt PAVs, the largest total percentage (34.9) ranked within the late adopter group, while the smallest total percentage (7.2) ranked within the laggard. In general, the distribution of respondents willing to adopt PAV technology correlates in alignment with the Technology Adoption Life Cycle distribution curve, wherein at the outset of a new technology introduction, and over time there is a tapering effect or otherwise outright rejection of the technology. This distribution generally characterizes adopters as early

(16%), early majority (34%), late majority (34%), and laggards (16%) (Rogers, 2003). Respondents were slightly skewed more towards early adopters than laggards, but largely representative across adopter groups.

Early PAV adopters were the oldest amongst all adopter groups (average 41 years old), overwhelmingly male (versus female) and the least educated (37.2% with bachelor degree). In contrast, laggards appear to live in rural areas (smallest % of urban dwellers) compared to all of the adopter groups. This is not surprising, as a key value proposition that the PAV market offers is adding transport capacity within already constrained cities and reducing commute time. Hence the laggards, who are likely less prone to the effects of congestion due to more rural household locations, are more likely to either never use a PAV or wait to ride PAVs until their safety has been established. Similarly, this study revealed that respondents who had relatively short commute time to work (30 minutes or less), were characterized as early adopters, while respondents who had relatively long commute time to work (greater than 30 minutes), were characterized as later adopters. These findings perhaps indicate that PAVs are not perceived to immediately deliver value as a suitable alternate transportation solution. Otherwise, the perception of a lengthy commute being so unbearable or undesirable, that it compels one to adopt PAV as a transit substitute sooner, rather than later, may not be valid. One might conclude that lengthy commute times would be undesirable and lead to adoption of alternative transportation, which has been seen with ride-hailing adoption and autonomous vehicle interest, where these modes allow riders to use long commute times more productively (Lavieri & Bhat, 2019; Moore, 2020). These previous findings do not immediately seem to transfer to PAVs.

Early PAV adopters were observed to be the highest of all PAV adopter groups to have higher trust in riskier situations beyond the scope of PAVs, e.g. by being most likely to ride in driverless cars and least likely to be influenced by airplane crashes on their decision to fly. This is an indication of early adopters' higher propensity to take (perceived) risks, specifically embarking into an unfamiliar experience of riding an air or land vehicle that is autonomously operated. In contrast, laggards' response is an indication of their propensity to be risk averse.

Autonomously-piloted PAVs represent an aspect of trust of the system. The study results reveal differentiation between adopter groups relative to PAVs operated with or without a pilot on board. Early adopters trust PAVs that are autonomously operated; essentially indicating a willingness to be first to ride a PAV regardless if there is a pilot on board or not. The same is not true for laggard adopters; results indicate they are less prone to trust PAVs that are autonomously operated, and without a pilot on board; Potentially explaining laggards' rationale to defer adoption of PAV technology, and willingness to ride a PAV, to a 5+ year plus time horizon post market introduction.

To trust that PAV flight is operating safely, both late and laggard adopters need visual indicators inside the PAV, whereas early adopters do not need visual indicators to trust the flight is operating safely. This finding coincides with previous research that shows how late and laggard adopters by nature are experiential and evidence-driven (Dedehayir et al., 2017). In their view, a technology must be proven, through prolonged use (evidenced by successful use by earlier technology adopters), in order for trust in the technology to be established.

Having visual indicators in the PAV is a prime example of an evidenced-based system that needs to be in place to earn later adopters' trust. Visual indicators do not need to be on board a PAV for an early adopter to trust that PAV flight is operating safely. Conversely, the experience-driven nature of an early adopter, trust is more freely and immediately granted to the system, in exchange for the opportunity to be the first to try a new technology.

4.5 Conclusions

This chapter provides keen insights about PAV adopters and what drives their human behavior and intention to adopt new technology. Utilizing the Technology Acceptance Model as contextual framework, PAV usefulness and PAV ease of use were examined. There is concurrence across all PAV adopters of the usefulness of PAVs in reducing road congestion and commute time. Early adopters translate PAVs' usefulness into perceived value by indicating their willingness to pay a premium for using PAV technology, i.e., early adopters do not perceive the cost per mile of PAV to have less value than alternative transportation modes. While later adopters perceive PAVs as useful, results indicate less willingness to pay a premium to ride. There appears to be a lack of concurrence across all PAV adopters, with respect to the ease of use, otherwise described as a convenience factor. Early adopters perceive PAVs as a stress-free, convenient mode of transport, while late and laggards perceive PAVs as a stressful, less-convenient mode of transport. The Technology Adoption Model posits that in conjunction, the usefulness and ease of use of a new technology as perceived by potential technology users, are strong influencers to driving behavior intention to adopt and use newly introduced technologies (Davis, 1989).

Overall, PAV manufacturers, PAV operators, jurisdictions, and both local and federal policymakers will need to consider public acceptance and adoption to achieve successful PAV integration into the transportation network. To satisfy expectations of all potential users, this study identified safety (i.e., seat belts, air quality, visual in-cabin feedback of safe trajectory) as a crucial element of PAVs. This study further identified PAV priorities that should be targeted in relative timeframes in order to satisfy near-term and long-term PAV users appropriately.

Chapter 5:

Research Aims 2 and 3

Aim 2: Determine the human system interfaces that should be implemented to engender passengers' trust in riding an autonomously-piloted PAV.

Aim 3: Examine the correlations between a passenger's technology adoption profile, situational awareness and trust in PAVs.

5.1 Introduction

Unlike conventional commercial aircraft, which use automation primarily to support pilots, PAVs are envisioned to operate entirely without a human pilot onboard. This fundamental shift places the burden of acceptance on passengers' willingness to trust an autonomous system to manage all aspects of flight. Building that trust is challenging, as it requires overcoming both the novelty of the technology and perceived risks of surrendering control.

Trust in automation is shaped by multiple dimensions, including system transparency, the design of human-machine interfaces (HMIs), and the broader human-systems integration context (Hoff & Bashir, 2014). Prior research underscores the critical role of human-machine interface (HMI) displays in fostering passenger trust and acceptance of autonomous vehicles, factors that ultimately influence their widespread adoption (Frison et al., 2019; Miller & Boyle, 2018; Miller & Boyle, 2017; Chellin & Gallegos, 2024).

In this regard, HMI systems designed with intuitive audio and/or visual cues about aircraft operation and status are especially crucial. This chapter aims to identify in-cabin HMI requirements and their implications for passenger trust and readiness to adopt this emerging technology. Thereby, bridging the gap between passenger experience and trust in autonomously piloted aircraft, and elucidating requirements that foster trust and encourage consumer demand.

Since PAVs are not yet commercially available, a PAV flight simulation was used as an experimental methodology to replicate real-world flight scenarios in a controlled and safe environment. The findings of this chapter inform the design of PAV systems by providing actionable insights into HMI features that enhance passenger trust, ultimately supporting the development and adoption of consumer-ready urban air mobility solutions. The chapter addresses the following research questions:

- **Research Question (RQ) 2.1:** How do in-cabin HMI interaction types (information only, audio only, professional "pilot", casual "pilot") influence trust, situation awareness, and remote-pilot expectations?
- **Research Question (RQ) 3.1:** How do early and late technology adopters differ in their trust, situation awareness, and remote-pilot expectations?

The results of this chapter have been submitted for publication in the *Journal of Aviation/Aerospace Education & Research* Special Issue on Human Factors in Aviation (Johnson & Gallegos, 2025).

5.2 Methods

A desktop flight simulation study was conducted for an autonomously-piloted PAV with various in-cabin HMI display conditions. Approval for the study was granted per research protocol #3977 by the Colorado State University Institutional Review Board (IRB) committee.

A 2 (technology adopter group, between-subject) x 4 (HMI display, between-subject) factorial design was employed, in which each participant experienced two simulated PAV flights. The first PAV simulated flight, referred to as the baseline flight, was conducted without an HMI display in use, while the second PAV simulated flight, referred to as the HMI flight, was conducted with one of four different types of HMI displays in use: 1) information only, 2) audio only, 3) video with a professionally dressed remote pilot, or 4) video with a casually dressed remote pilot. Participants were randomly assigned to the type of HMI display they would experience. Moreover, participants were not privy to the four types of HMI displays that were available and utilized for the PAV flight simulation.

5.2.1 Participants

A total of 40 participants (20 males, 20 females) completed the experiment, ranging in age from 18 to 42 years old (mean = 26.2, SD = 7.9). Participants were recruited from the Colorado State University campus through word of mouth, personal networks, and advertisement flyers. Compensation was not provided for participation in the study; however, extra credit was offered for study participation in one undergraduate and one graduate-level course.

5.2.2 Participant Technology Adopter Group Categorization

The experimental design sought an even balance of early (N = 20) and late (N = 20) technology adopters. Adoption group categorization was leveraged per the Technology Adoption Life Cycle Model (Rogers, 2003), where the model features a normalized bell-shaped curve that characterizes technology adopter groups relative to a time versus risk continuum. Early adopters are described as those who are first to adopt new technology and knowingly accept risk with perceived reward. Late adopters are described as those who adopt new technology after most people have tried it and do so with a bit of skepticism while minimizing personal risk.

To populate these groups, recruitment material included a link to an online survey that asked participants for their contact information along with a prompt for the following technology adoption question, as shown in Table 7. Participants were asked to select which of the options best described them when it comes to technology (i.e., left column of Table 7), without being shown the technology adopter group categorization (i.e., right column of Table 7), to determine their personal affinity to technology. Participants who selected one of the first two options, i.e. "I love new technologies and am among the first to experiment with and use them", or "I like new technologies and use them before most people I know" were designated as Early Adopters, while participants who selected one of the last two options, i.e. "I am usually one of the last people I know to use new technologies" or "I am skeptical of new technologies and use them only when I have to" were designated as Late Adopters. Participants who selected the middle option, "I usually use new technologies when most people I know do", were not recruited for this study in order to create two uniquely separated technology adopter groups.

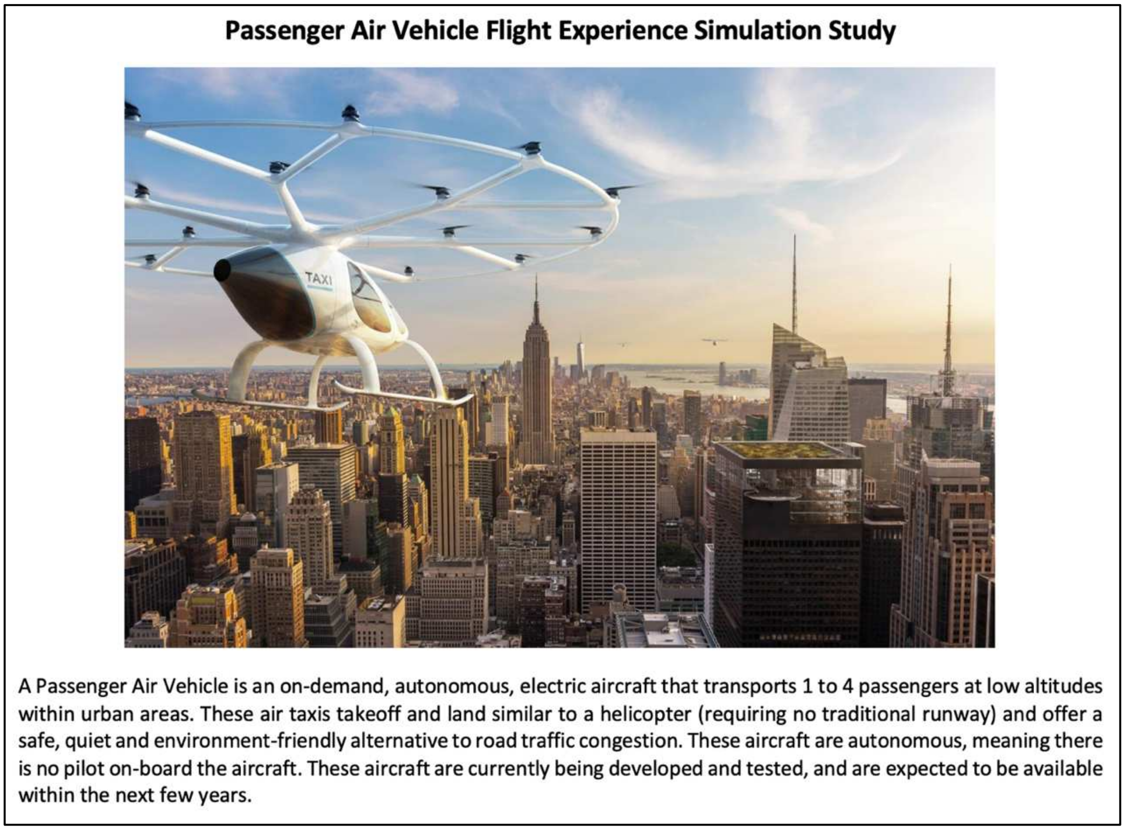
Table 7. Technology Adopter Categorization Questionnaire

Which of the following best describes you when it comes to technology?	**Technology Adopter Group**
I love new technologies and am among the first to experiment with and use them.	Early Adopter
I like new technologies and use them before most people I know.	Early Adopter
I usually use new technologies when most people I know do.	Not Recruited
I am usually one of the last people I know to use new technologies.	Late Adopter
I am skeptical of new technologies and use them only when I have to.	Late Adopter

5.2.3 Participant Orientation

Upon arrival to the experimental lab, the researcher verbally provided participants with an overview of the study objectives and the sequence of tasks they would be performing. To orient and provide conceptual context of what a PAV aircraft is, for those participants who may have been unfamiliar, the researcher also shared a one-page document (Figure 11) which consisted of an image of a PAV in flight (which was similar to the PAV aircraft featured in the flight simulation video) along with the following text:

> *A Passenger Air Vehicle is an on-demand, autonomous, electric aircraft that transports 1 to 4 passengers at low altitudes within urban areas. These air taxis takeoff and land similar to a helicopter (requiring no traditional runway) and offer a safe, quiet and environment-friendly alternative to road traffic congestion. These aircraft are autonomous, meaning there is no pilot on-board the aircraft. These aircraft are currently being developed and tested, and are expected to be available within the next few years.*



Passenger Air Vehicle Flight Experience Simulation Study

A Passenger Air Vehicle is an on-demand, autonomous, electric aircraft that transports 1 to 4 passengers at low altitudes within urban areas. These air taxis takeoff and land similar to a helicopter (requiring no traditional runway) and offer a safe, quiet and environment-friendly alternative to road traffic congestion. These aircraft are autonomous, meaning there is no pilot on-board the aircraft. These aircraft are currently being developed and tested, and are expected to be available within the next few years.

Figure 11. Participant overview sheet provided during study

Expectations were set with participants that the flight simulation experience would take about 25 minutes of their time. Prior to the start of the study, participants were asked if they had any questions or concerns. Researchers ensured each participant's comfort and then gave a verbal confirmation that the first flight video was ready to begin.

5.2.4 Experimental Lab Setup

Experiments were conducted in an office in the Engineering Building, as well as in the Powerhouse Building on Colorado State University campus. Participants were seated in a four-legged office chair, located in front of a 6' x 30" x 30" table draped in a black cloth. During the simulated flight videos, the overhead lights were turned off such that the room was darkened, creating a more immersive environment. The climate control in the room was set at normal, ambient temperature.

In front of the participants was a 40-inch TV monitor that played the flight simulation video/audio at a standardized volume level for all participants. Positioned in front of the TV monitor in the lower left corner was a 12-inch Surface Pro® tablet that provided the HMI display. During the baseline flight, this HMI display was turned off, such that it was still present, but the screen was black. A researcher pressed start on the computer, which began both the flight video and HMI display so that the two were in sync. A photo of the experimental setup is shown in Figure 12.

Figure 12. Experimental lab setup from participant view (left) and researcher view (right)

5.2.5 Flight Simulation

Microsoft Flight Simulator® (version 2022), which included an eVTOL PAV aircraft branded Volocity® by German air taxi manufacturer Volocopter, was used for the study. The researchers captured a videorecording of a Volocity flight across and back downtown Chicago, Illinois to use for the simulated flight. Each flight was approximately six minutes in length. The PAVs were flown during the daytime, with sunny skies, moderate wind, and overall favorable weather conditions. Chicago was chosen as the city to simulate the PAV flight as it is a large, well-known American city, which offers a scenic cityscape filled with numerous skyscrapers along the shores of Lake Michigan. It also represents the type of metropolitan area that has a burgeoning population and associated road traffic congestion, conditions in which an alternate transit option such as UAM aims to address.

The beginning of each takeoff flight commenced with a panoramic video around the aircraft, to orient participants to the PAV aircraft they were about to virtually enter, sit down and travel in (see Figure 13 for Flight 1 and Figure 14 for Flight 2).

Figure 13. PAV aircraft view from Flight 1 (no HMI)

Figure 14. PAV aircraft view from Flight 2 (with HMI)

During the flights, the participants had a view outside the front window of the aircraft, where the HMI was displayed on a second monitor located in the bottom left (see Figure 15). There were some video angles during the flight where participants also had views from the side windows, giving a panoramic effect from inside of the aircraft cabin.

Figure 15. Flight simulation screenshot from baseline flight

During the experiment, the videos automatically paused after each takeoff, cruise, and landing segment in order to ask participants a series of brief survey questions. The baseline flight (without HMI display), Flight 1, departed from the top of a rooftop helipad/vertiport structure (i.e. Midway Air Taxi Heliport), flew towards and landed at Chicago’s Navy Pier, with flight segment durations of 1:00 minutes (takeoff), 3:12 minutes (cruise), and 1:18 minutes (landing). Total duration for Flight 1 was 5:30 minutes. The second flight (with HMI display), Flight 2, departed the Navy Pier and traveled west to a rooftop helipad, with flight segment durations of

1:15 minutes (takeoff), 3:44 minutes (cruise), and 1.00 minutes (landing). Total duration for Flight 2 was 5:53 minutes. Table 8 summarize flight time durations per flight phase, for both Flight 1 and Flight 2.

Table 8. Durations of Each Flight Phase

Flight Info	Total	Takeoff	Cruise	Landing
Flight 1: Midway to Navy Pier without HMI	00:05:30	00:01:00	00:03:12	00:03:44
Flight 2: Navy Pier to Midway with HMI	00:05:53	00:01:09	00:01:18	00:01:00

5.2.6 Experimental Procedure

Participants were provided with a high-level overview of the research experiment activities and required tasks, as well as a general introduction to the concept of PAVs. Participants were invited and encouraged to imagine themselves being fully immersed in the futuristic flight experience. Participants were told that the purpose of the study was to understand passenger experience aboard a simulated autonomous drone air taxi, called a passenger air vehicle (PAV). They were provided with an information sheet about PAVs, which included a large picture of a PAV flying over a metropolitan city center with a brief paragraph describing these aircraft. It was emphasized that the aircraft are on-demand (similar to hailing a rideshare service), electric, fly at low altitude skyline in urban areas, takeoff/land similar to a helicopter, and that they are entirely autonomous without an onboard pilot.

At the start of the session, participants first experienced the baseline flight, where the HMI display was turned off. After takeoff was complete, the video paused and participants were prompted to answer five questions to assess their situation awareness (SA), i.e. what they were able to recall/remember during the flight segment. Situation awareness was measured using the Situation Awareness Global Assessment Technique (SAGAT) (Endsley, 1995).

Once the participant completed the takeoff SAGAT questions, then the video resumed for the cruise portion of the flight and paused right before the landing phase so that participants could answer another five SAGAT questions. The video then resumed for the landing portion of the flight, after which participants answered another five SAGAT questions in addition to a set of questions about their overall PAV flight experience.

Once confirmed ready, participants began the second simulated PAV flight, in which the researcher turned on the HMI display. Participants completed a new set of five SAGAT questions for each flight phase (takeoff, cruise, landing), as well as the post-flight survey regarding their overall trust experienced during the second PAV flight, with an assigned HMI condition. Lastly, participants were asked a set of survey questions regarding their personal demographics (i.e. age, gender, education).

5.2.7 Experimental Process Flow

Figure 16 graphically depicts the process map used for this flight simulation experiment. In summary, the first step in the process is the pre-flight setup, with sub-steps of participant orientation and technology adoption categorization as early or late adopters. The second step in the process is baseline Flight #1, with sub-steps of (3) SAGAT surveys administered in-between (3) flight segments (takeoff, cruise, land). The third step in the process is Flight #2, with sub-steps of randomly assigned HMI condition, (3) SAGAT surveys administered in-between (3) flight segments (takeoff, cruise, land), and a final overall experience and trust survey, administered just prior to the end of the experimental process.

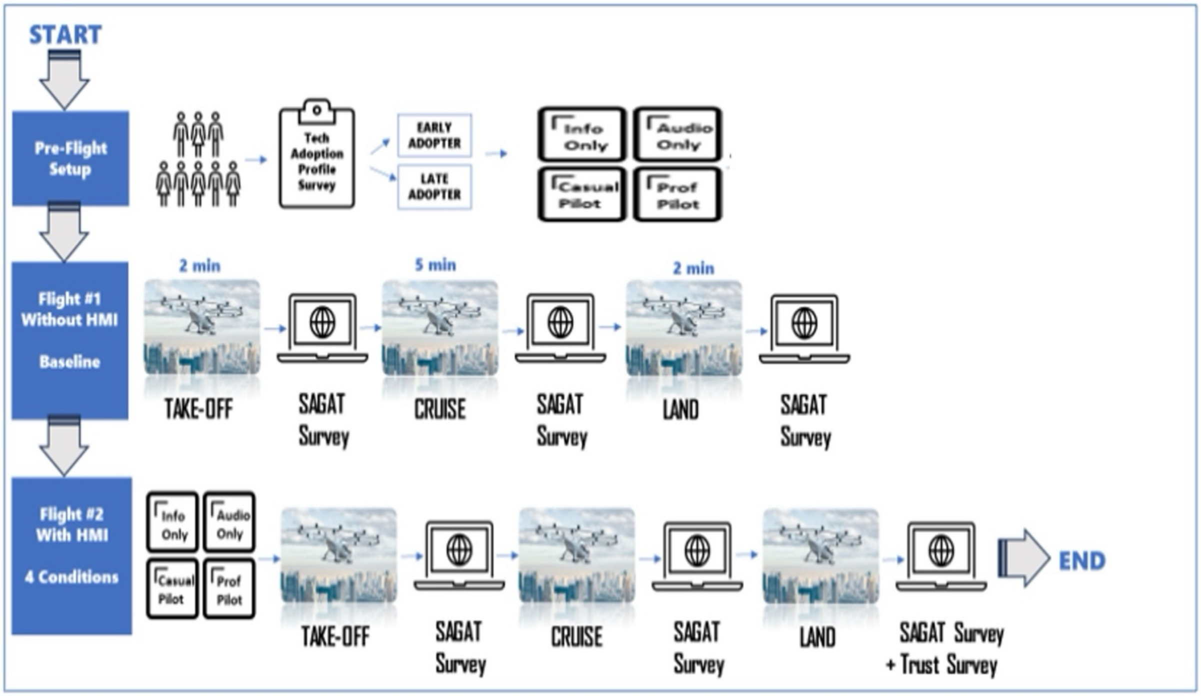


Figure 16. Experimental Process Map

5.2.8 Independent Variable Design

Table 9 outlines the conditions of the 2 × 4 factorial design, where the technology adopter group had two levels (early, late) and the HMI display group had four levels (information-only, audio-only, video professional [remote pilot], video casual [remote pilot]). Each cell reflects the distinct condition combinations, having N = 5 participants per instance.

Table 9. Number of Participants in Each Experimental Condition

Technology Adopter Group	**HMI Display Group**			
	Information	*Audio*	*Video Casual*	*Video Professional*
Early	5	5	5	5
Late	5	5	5	5

In order to compare the effects of HMI display types on trust and user experience, as each participant only experienced one HMI, a baseline flight with no HMI was used across all participants. This allowed for analysis to account for individual variability and compare differences across participants relative to changes from the baseline flight to the HMI flight within participants.

5.2.9 HMI Display Groups

Each participant experienced one of four HMI display types on their second PAV flight. Participants were randomly assigned to which HMI display they would experience. A comparison of the four HMI displays is shown in Figure 17, where the information only is provided in the upper left, audio only in upper right, video professional [remote pilot] in bottom left, and video casual [remote pilot] in bottom right. The same remote operator and script was used in the audio only, video professional, and video casual conditions, hence the only difference between these conditions is the modality of conveying the information rather than the actual information content itself.

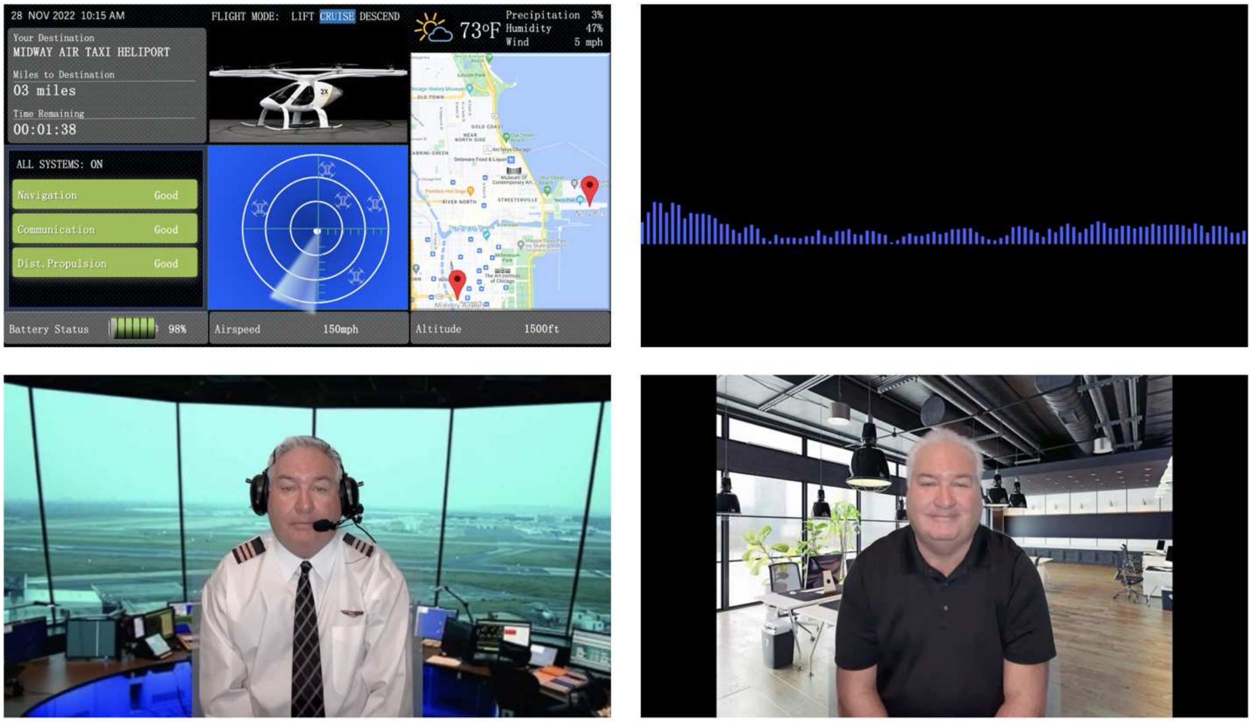


Figure 17. HMI displays types used in study

The HMI display design images were created based on key findings from the survey study in Research Aim 1 (Chapter 4), i.e., the PAV Technology Adoption and Perception Survey, where respondents indicated types of information they would like to have while riding in a PAV. To reiterate more specifically, study respondents deemed (75% and higher favorable ratings) the following information as very important, or extremely important elements to integrate onto an in-vehicle PAV HMI display: 1) Weather condition, 2) Flight path route, 3) Battery life, 4) Time to destination, 5) Current airspeed.

As such, the information only HMI conveyed visual information relating to these deemed important elements. Similarly, the remote pilot's script in the video professional, video casual, and audio only HMIs included auditory updates related to these important elements.

5.2.9.1 Stakeholder Needs and Requirements Definition Process

One of the fundamental technical processes of Systems Engineering is defining the stakeholder needs and requirements of the system of interest. The purpose of this process as outlined by INCOSE (2023) is to delineate the system capabilities needed by users for the system of interest to accomplish its intended mission. The research endeavored to elicit perceptions, as well as the needs, wants, expectations of potential users (i.e. stakeholders) of the PAV technology. The stakeholder needs and requirements definition process was facilitated through the aforementioned PAV Technology Adoption and Perception survey to a broad U.S.-based adult population. This effort effectively captured the voice of the customer from a conceptual standpoint and synthesized both quantitative and qualitative data into an integrated set of user needs which served as foundational inputs. Needs statements and rationale are captured in Table 10. They are documented from the perspective of the potential PAV user in terms of what attributes they need the HMI display interface to capably provide. This integrated set of user need statements was then transformed into a set of design-input requirements for the experimental PAV HMI display features.

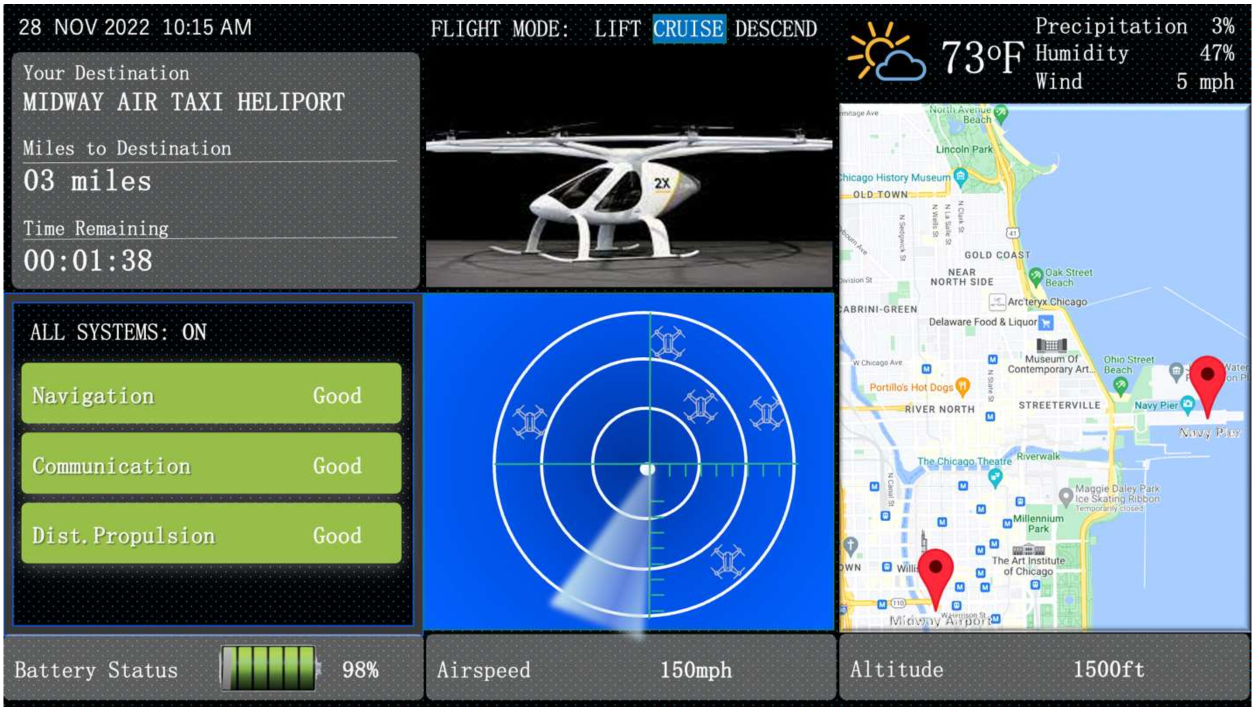
The process of defining the needs and subsequent requirements of PAV stakeholders is a critical exercise, especially during this pre-commercialization phase of PAV development. Subsequent stakeholder requirements definition will serve as inputs to PAV system verification and validation efforts (SEBoK, 2024), specifically pinpointing whether PAVs are built right, in addition to whether PAVs are in fact, the right technology to build.

Table 10. Stakeholder Needs Statements Table

ID	Name	Needs Statement	Rationale
N1	Weather Conditions	The user needs to visualize the current weather conditions on the HMI display panel	Gain knowledge of any adverse conditions not suitable for flight
N2	Battery Life	The user needs to visualize the percentage level of available battery on the HMI display panel	Battery life status information is standard in electric vehicles and should be expected in electric aircraft
N3	Time to Destination	The user needs to be informed of the elapsed time during flight	Awareness of the flight duration is an indicator of standard operations
N4	Route Path	The user needs to visualize the flight itinerary coordinates	Awareness of the flight path is an indicator of standard operations
N5	Speed	The user needs to visualize the current speed of the aircraft on the HMI display panel	Awareness of the aircraft speed is a standard operating expectation

5.2.9.2 Information Only HMI Display

The information only HMI display (Figure 18) provided real-time visual information (refreshing once per second) of key flight operation systems, which were in alignment with participants' previously stated display requirements. These flight operation systems and display requirements included: weather information (e.g., 73 degrees temperature, 3% precipitation, 47% humidity, 5 miles per hour windspeed), PAV battery status (e.g., 100% initial level), airspeed (e.g., 150 miles per hour), altitude (e.g., 1500 feet), time and distance to destination, flight path map (departure and arrival points marked with red pins), and radar map of other PAVs in flight. Flight systems including navigation, communication and distributed propulsion were displayed with bright green backlight and bolded font indicating that all systems, were “Good”, and all systems were “On”. The color schemes and verbiage for these particular flight systems were strategically selected to convey (subliminally or otherwise) to participants a sense that the PAV was operating normally and safely, which would then perhaps engender a sense of trust of the system. This design strategy was consistent with findings by Johnson et al. (2022), and research aim 1 of this dissertation, which highlighted that both late and laggard adopters need visual indicators inside the PAV to trust that the PAV flight is operating safely. Interestingly, as found in Research Aim 1, early adopters reported not needing visual indicators to trust the flight is operating safely, since they tend to automatically trust the system in exchange for the opportunity to be the first to use the system; this stated preference is further evaluated in this research aim. Other key elements incorporated into the information-only HMI display included: destination (Midway Air Taxi Heliport), flight mode (lift, cruise, descend), date and time information, and a static image of the PAV aircraft being flown.


28 NOV 2022 10:15 AM

FLIGHT MODE: LIFT CRUISE DESCEND

73oF

Precipitation 3%

Humidity 47%

Wind 5 mph

Your Destination

MIDWAY AIR TAXI HELIPORT

Miles to Destination

03 miles

Time Remaining

00:01:38

ALL SYSTEMS: ON

Navigation Good

Communication Good

Dist. Propulsion Good

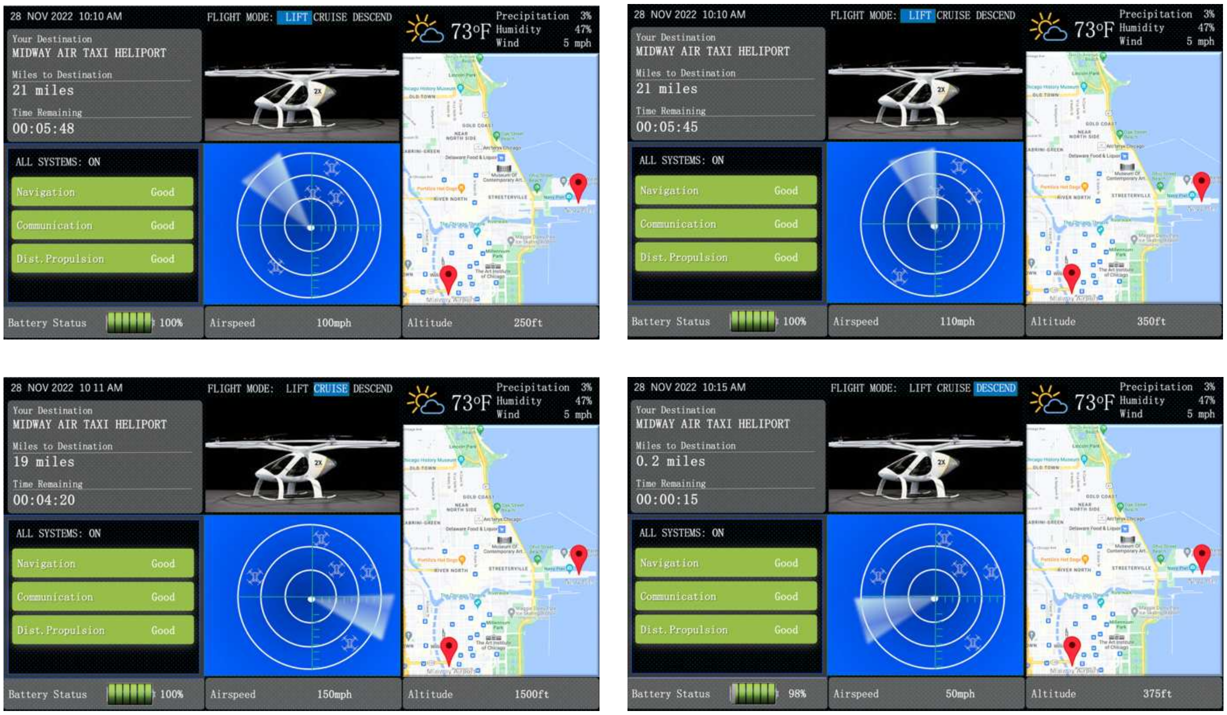
Battery Status 98%

Airspeed 150mph

Altitude 1500ft

Figure 18. Information only HMI display

The information-only HMI display was developed using Microsoft PowerPoint® software, with each slide automatically transitioning every 1-second, to create a live-feed effect. From the participant's perspective, this effect enabled a seamless, dynamic video in which they observed the flight radar screen sweeping in the clockwise direction and advancing images of other PAV aircraft flying nearby. Participants also observed dynamic status changes in battery life depletion, miles to destination remaining flight time, airspeed, altitude the selected flight mode. An example of various screen captures during the flight is provided in Figure 19 to demonstrate the transitions of the information only HMI display.



28 NOV 2022 10:10 AM
FLIGHT MODE: LIFT CRUISE DESCEND
73°F
Precipitation 3%
Humidity 47%
Wind 5 mph
Your Destination
MIDWAY AIR TAXI HELIPORT
Miles to Destination
21 miles
Time Remaining
00:05:48
ALL SYSTEMS: ON
Navigation Good
Communication Good
Dist.Propulsion Good
Battery Status 100%
Airspeed 100mph
Altitude 250ft

28 NOV 2022 10:10 AM
FLIGHT MODE: LIFT CRUISE DESCEND
73°F
Precipitation 3%
Humidity 47%
Wind 5 mph
Your Destination
MIDWAY AIR TAXI HELIPORT
Miles to Destination
21 miles
Time Remaining
00:05:45
ALL SYSTEMS: ON
Navigation Good
Communication Good
Dist.Propulsion Good
Battery Status 100%
Airspeed 110mph
Altitude 350ft

28 NOV 2022 10 11 AM
FLIGHT MODE: LIFT CRUISE DESCEND
73°F
Precipitation 3%
Humidity 47%
Wind 5 mph
Your Destination
MIDWAY AIR TAXI HELIPORT
Miles to Destination
19 miles
Time Remaining
00:04:20
ALL SYSTEMS: ON
Navigation Good
Communication Good
Dist.Propulsion Good
Battery Status 100%
Airspeed 150mph
Altitude 1500ft

28 NOV 2022 10:15 AM
FLIGHT MODE: LIFT CRUISE DESCEND
73°F
Precipitation 3%
Humidity 47%
Wind 5 mph
Your Destination
MIDWAY AIR TAXI HELIPORT
Miles to Destination
0.2 miles
Time Remaining
00:00:15
ALL SYSTEMS: ON
Navigation Good
Communication Good
Dist.Propulsion Good
Battery Status 98%
Airspeed 50mph
Altitude 375ft

Figure 19. Information only HMI transitions

5.2.9.3 Audio Only HMI Display

The audio only HMI display (Figure 20), provided live audio information communicated by a remote, on ground "pilot" in real-time. The audio only display was designed as a sound spectrum visualizer with a live-motion effect, in sync with the voiceover communication from the remote pilot video. The audio portion of the remote pilot video was spliced and augmented with a video having vivid blue, vertical sound spectrum bars. This dynamic visual component of the display was incorporated on the audio-only HMI display, to maintain consistency with the other HMI display types which had a visual component.

Figure 20. Audio only HMI display

Participants who experienced the audio only HMI display heard the exact same remote pilot's voice, delivering the identical prepared pilot script used in both the professional attire and casual attire video conditions. In this version however, the interaction was limited exclusively to auditory communication, with no visual representation of the pilot provided. Instead of a "live" video feed, participants viewed only a simple animated display of moving sound spectrum bars, which served as a visual indicator that speech was occurring. This stripped-down presentation allowed us to isolate the effect of voice-based communication, independent of visual cues such as facial expressions, attire, or background setting. Between communication updates from the remote operator, the HMI display defaulted to a blank black screen, reinforcing the impression of inactivity until the pilot's next message. An illustration of these audio only visual elements, including the spectrum bars and inactive state, is provided in Figure 21.

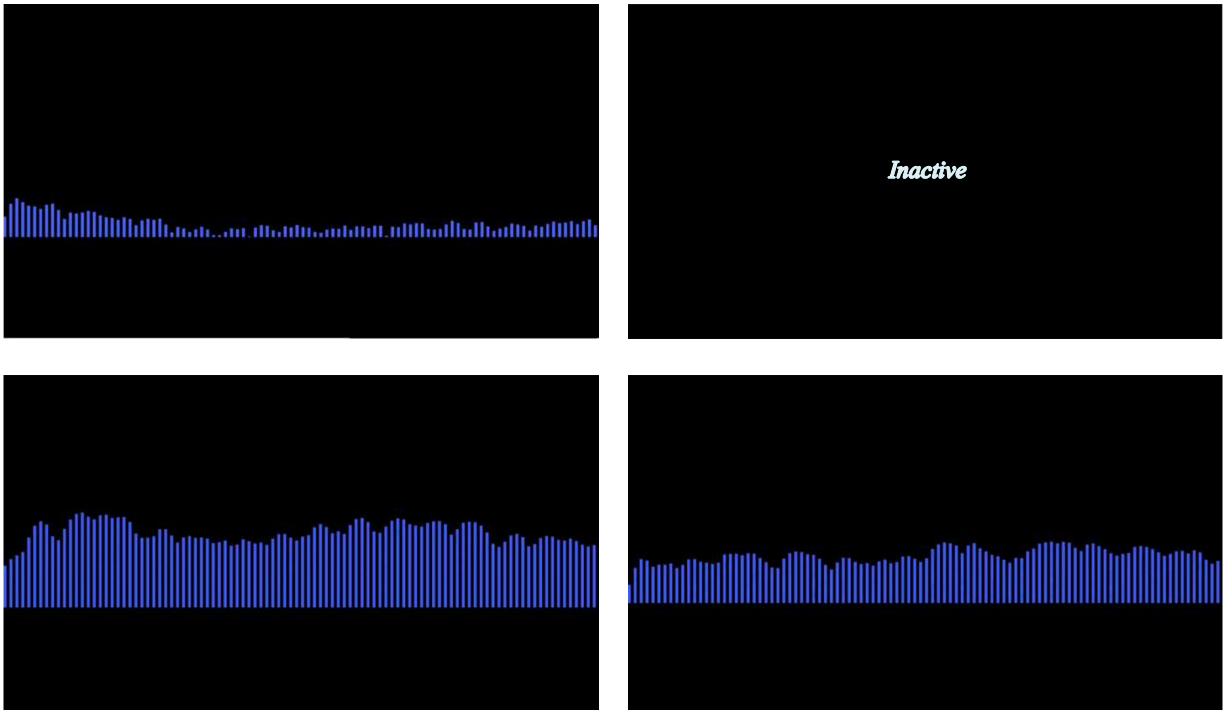


Figure 21. Audio only HMI transitions

5.2.9.4 Pilot Professional Attire HMI Display

The pilot professional attire HMI display (Figure 22) was intentionally designed to represent “live”, real-time audio and video communication with a remote “pilot” on the ground. To produce the video display featuring a remote pilot, a freelance contractor was recruited (and paid a nominal fee) to record video footage in front of a green screen, presenting as a PAV pilot, while narrating a prepared pilot script (see Appendix B). In the pilot professional attire condition, the contractor wore a traditional pilot uniform (attire), i.e. white collared shirt, dark colored tie, professional epaulette shoulder bars and an airplane wing-themed lapel pin. He also wore an over-the-ear style headset and microphone and was stationed in what appeared to be a panoramic all-glass airplane control tower center.

Figure 22. Video professional pilot HMI display

Similar to both the audio-only and video casual conditions, the HMI defaulted to a blank, black screen during periods without active communication from the remote pilot. This design choice was intended to provide a clear visual indication of when the pilot was not speaking, while also avoiding unnecessary distractions that might compete with the primary flight displays. When the remote pilot re-engaged, the screen transitioned seamlessly to display the live video feed, creating a sense of dynamic interaction and immediacy. An example of these transitions and the flow of interaction between inactive and active states of the HMI is illustrated in Figure 23, demonstrating how users experienced both silence and engagement within the interface.

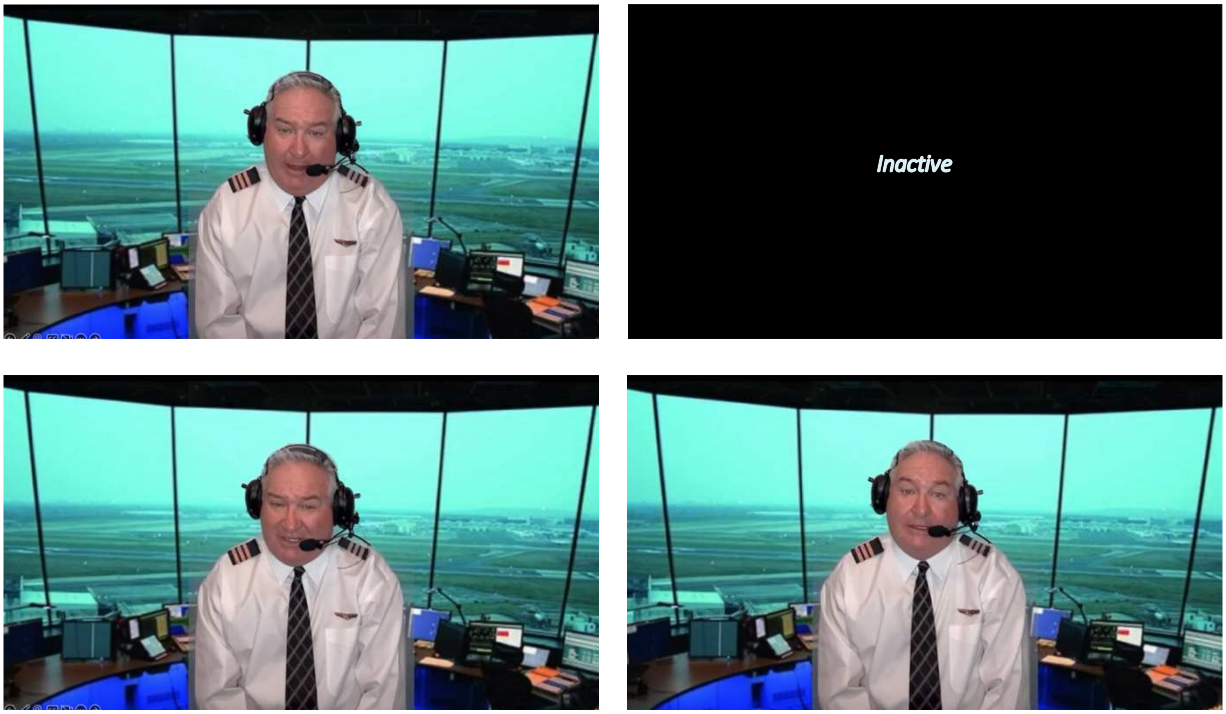


Figure 23. Video professional HMI transitions

5.2.9.5 Pilot Casual Attire HMI Display

The pilot casual [attire] HMI display (Figure 24) was also designed to represent “live,” real-time audio and video communication with a remote “pilot.” To create the display, the same freelance contractor was filmed in front of a green screen, this time presenting as a PAV pilot while narrating a prepared pilot script. However, unlike the professional pilot version, in which the individual appeared in full pilot attire, this variation portrayed him in business casual clothing, specifically a black short-sleeved polo shirt. He also wore in-ear AirPod®-style headphones and was situated in what resembled a modern, high-tech office setting rather than an aviation control environment. This deliberate design choice was meant to convey a realistic person who could plausibly serve as a remote operator, but without signaling the same authority or specialized expertise that a uniformed pilot in a control tower would naturally project. In doing so, the HMI created a contrast between professional, domain-specific credibility and a more casual, relatable representation of human involvement in PAV operations.

Figure 24. Video casual pilot HMI display

As with the other HMI conditions, a set of representative screen captures is provided to illustrate the appearance and behavior of this display. These images include examples of the plain black screen that was shown during periods without active communication from the remote operator, as well as frames captured while the operator was engaged in interaction. Together, these visuals help convey how the display alternated between inactive and active states, providing participants with a clear and consistent indication of when the remote pilot was speaking. A compilation of these screen captures is presented in Figure 25.

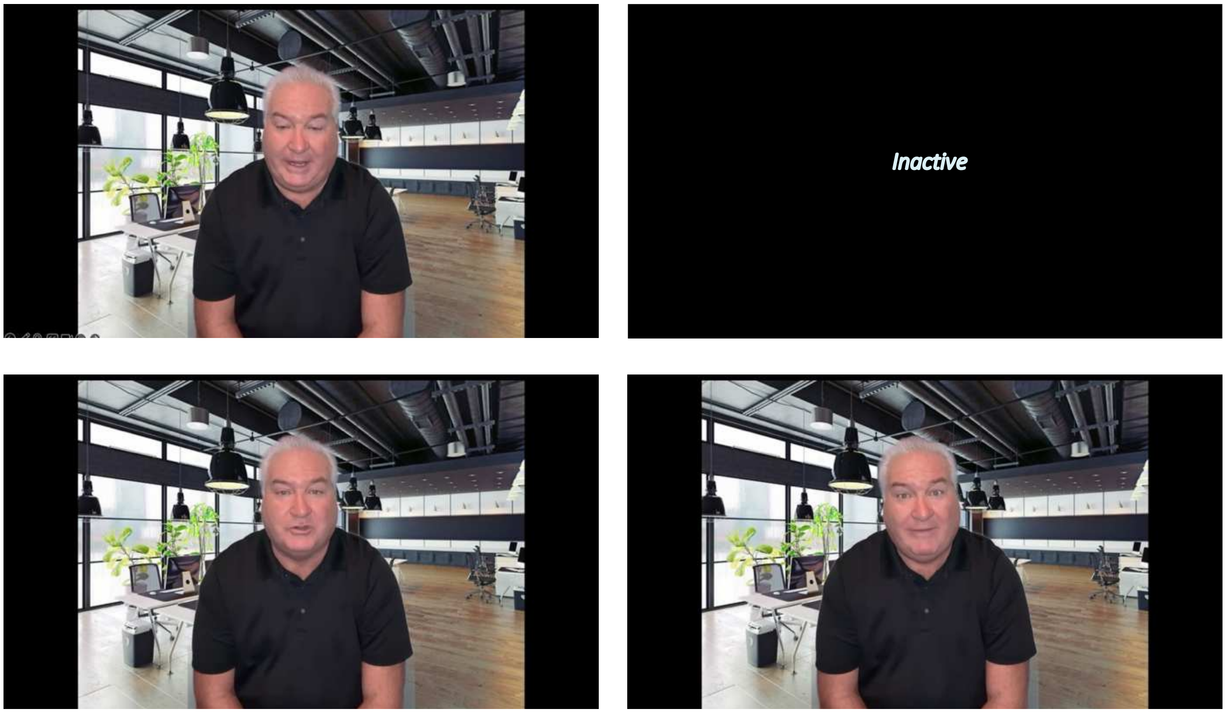


Figure 25. Video casual HMI transitions

5.2.9.6 Remote Pilot's Script

The remote pilot's script (Table 11) was developed to provide general flight operation and status information during each phase of flight (i.e., takeoff, cruise, landing). The information aligned with the information deemed important from research aim 1 of this dissertation, such as time to destination, weather updates, PAV system updates, PAV airspeed, altitude, and destination information.

This exact same script was used in each of the three HMI conditions with a remote pilot (audio only, video professional, and video casual). The script included three updates communicated at evenly spaced intervals throughout the takeoff phase, three during the cruise phase, and three during the landing phase.

The experience was analogous to a conventional commercial airplane flight, when the pilot makes periodic announcements to passengers on the public address (PA) system.
An outline of flight duration times integrated with pilot script communication, is located in Appendix E.

Table 11. Remote Pilot Script for Audio Only, Video Professional, and Video Casual HMIs

Flight Segment	Script
Takeoff	Hello and welcome aboard this passenger aerial vehicle.
Takeoff	My name is Captain Wright, and I will be your remote pilot today. Even though I am not physically on the plane, I will be monitoring your aircraft's operations from my ground control station. Please sit back as you begin your liftoff.
Takeoff	Today, your itinerary is a direct flight to Midway Air Taxi Heliport from Chicago's Navy Pier, with an approximate flying time of 6 minutes. Please enjoy your flight and the views of the city as you fly through the beautiful downtown City of Chicago.
Cruise	Hello. This is your remote pilot again, Captain Wright. You have now reached cruising altitude of 1500 feet, and are traveling at an airspeed of 150 miles per hour. The weather along your route through downtown Chicago is partly sunny, 73 degrees average temperature, with no rain in the forecast.
Cruise	This is Captain Wright again, just checking in from ground control to let you know everything is running smoothly. All aircraft system operations are functioning effectively, and you will be at your destination shortly.
Cruise	Once again, this is your remote pilot, Captain Wright. You are approaching your destination. Remain seated for descent and landing. Your aircraft is beginning its landing.
Landing	Welcome to the other side of downtown Chicago. You have arrived at your destination, Midway Air Taxi Heliport. Thank you for flying with us today in our passenger aerial vehicle.
Landing	Remain seated until the aircraft doors open, and then you are good to exit.
Landing	Have a great rest of your day.

5.2.10 Dependent Variables

All dependent measures were derived from the surveys administered in-between and post each flight segment. There were a variety of survey questions aimed at collecting a comprehensive assessment of participants' situation awareness, trust in the PAV, trust in the HMI, and trust in a remote pilot.

5.2.10.1 SAGAT Questions

As previously mentioned, the SAGAT questions were used to assess participants' level of situation awareness during each flight segment. Each SAGAT question had four multiple choice answer options, relating to content observed out of the PAV window or from the HMI display, and were scored as either correct or incorrect. Situational awareness (SA) scores on each segment ranged from 0 (poor SA) to 5 (good SA). The questions were administered on an Apple iPad ® tablet provided by the researcher.

12 below lists SAGAT questions presented to participants at the end of each flight segment, during the baseline flight (Flight 1). Correct answers are indicated with bolded and underlined font. The complete list of SAGAT questions presented to participants at the end of each flight segment, during each assigned HMI flight (Flight 2), is located in Appendix B.

Table 12. Example SAGAT Questions by Flight Segment for Baseline Flight

TAKE OFF	CRUISE	LANDING
1. What was printed on the side of the aircraft? **a. Volocity** b. Vector Air c. PAV d. Chicago Air Taxi	1. There was a unique colored building in the skyline. What color was the building? a. Silver **b. Red** c. White d. Black	1. How many aircraft were present on the helipad upon landing? a. 1 b. 2 c. 3 **d. None**
2. How many wheels were on the aircraft? a. 4 b. 6 c. 8 **d. None**	2. What type of bird was flying nearby the aircraft? a. Hawk b. Seagull c. Crow **d. There was no bird**	2. How many rotors were visible through the aircraft windshield? a. 1 **b. 2** c. 3 d. I did not notice the rotors
3. How many doors were on the aircraft? a. 1 **b. 2** c. 3 d. 4	3. How many rotors were visible through the aircraft windshield? a. 1 **b. 2** c. 3 d. I did not notice the rotors	3. How many cars were present near the heliport upon landing? a. None b. 1 **c. 2** d. Too many to count
4. How many rotors were visible through the aircraft windshield? a. 1 **b. 2** c. 3 d. I did not notice the rotors	4. How many sports stadiums were in view? a. 0 **b. 1** c. 2 d. Not sure	4. As you landed, did you notice what was painted on the heliport pavement? a. Smiley Face **b. Letter H** c. Letter X d. Nothing
5. What direction did the aircraft turn to begin its journey? a. Left **b. Right** c. Straight (aircraft did not turn) d. Not sure	5. What do you anticipate the aircraft to do next? a. Land at the destination **b. Slowly descend from cruise altitude** c. I do not anticipate anything d. Not sure	5. What color was the building that the aircraft landed on? a. Silver **b. Pale Pink** c. Red d. Not sure

5.2.10.2 Trust in Aircraft

Trust in the aircraft was measured using a series of six questions asked at the end of each flight (i.e., baseline flight and HMI flight). Trust questionnaire can be found in Appendix C. The questions used a 5-point Likert scale from strongly agree (5) to strongly disagree (1). Participants' scores across the six questions were summed for a composite score, ranging from 5 (low trust in aircraft) to 30 (high trust in aircraft). The questions were as follows:

- The aircraft felt reliable.
- The aircraft felt safe.
- The aircraft was in control.
- I felt stressed while riding. (reverse coded)
- I would ride in an actual PAV.
- I would feel comfortable doing other things while riding (e.g., reading a book).

5.2.10.3 Trust in HMI

Trust in the HMI was measured based on a series of six questions asked at the end of the second flight (i.e., HMI flight). These questions also used a 5-point Likert scale from strongly agree (5) to strongly disagree (1), with a composite score summing their responses, ranging from 5 (low trust in HMI) to 30 (high trust in HMI). The questions were based on the constructs of trust defined in Jian et al. (2000), which is one of the most widely used and validated self-report trust scales in automated systems. Regardless of the HMI experienced, these same questions were asked across participants, with the exception of the wording “information” for the information-only HMI and “remote operator” for the audio, video professional, and video casual HMIs. The questions were as follows:

- The [information/ remote operator] was trustworthy.
- The [information/ remote operator] was reliable.
- The [information/ remote operator] made me feel safe.
- I understood the [information/ communication by the remote operator].
- The [display/ remote operator] kept me adequately informed of aircraft operations.
- The [display/ remote operator] added value to my trip.

5.2.10.4 Trust in Pilot

There were three additional questions in the overall perceptions of PAVs section of the survey (asked at the very end), which aimed to understand participants' expectations for a pilot/remote pilot. These questions were each evaluated individually, rather than computing a composite score. Each question used a 5-point Likert scale from strongly agree to strongly disagree. The questions were as follows:

- I prefer to have an onboard pilot.
- I prefer to have a remote operator that I can hear.
- I prefer a remote operator who appears professionally dressed.

5.3 Results

5.3.1 Data Cleaning and Analysis

Data cleaning was conducted in Excel, data analysis in JASP (version 0.19.3), and data visualizations created using RStudio (R version 4.4.2). Statistical significance was assessed at $\alpha = 0.05$. Situation awareness was evaluated using repeated measures analysis of covariance (ANCOVA), as it evaluated SA at each flight segment for the HMI flight (i.e., repeated observations per participant) and included baseline SA as the covariate to control for baseline effects. Trust in the aircraft during the HMI flight was evaluated using ANCOVA, with baseline trust as the covariate. Each question related to trust in the pilot was evaluated using chi-square tests. Independent variables across the models included HMI group (4 levels) and technology adopter group (2 levels). Table 13 below summarizes the scope of data analyses conducted.

Table 13. Data Analyses Summary

Analytical Method	Dependent Variable	Independent Variable
ANOVA (repeated measures)	Delta SAGAT (by flight segment)	HMI Group Tech Adoption Group Flight Segment
ANOVA (repeated measures)	SAGAT [for HMI flight] (by flight segment)	Baseline SAGAT HMI Group Tech Adoption Group Flight Segment
ANCOVA	Trust in Aircraft [for HMI flight]	Baseline Trust HMI Group Tech Adoption Group
ANOVA	Trust in HMI [for HMI flight]	HMI Group Tech Adoption Group
Chi-Square	I prefer to have an on-board pilot	Tech Adoption Group
Chi-Square	I prefer to have a remote operator I can hear	Tech Adoption Group
Chi-Square	I prefer a remote operator that is professionally dressed	HMI Group
Chi-Square	How would you compare this PAV flight experience to a conventional airplane flight?	HMI Group
Chi-Square	How would you compare this PAV flight experience to a conventional airplane flight?	Tech Adoption Group

5.3.2 Demographics

Participant demographic data are summarized in Table 13 and Table 15. Across the sample, there is an evenly balanced gender distribution at 20 (50%) males and 20 (50%) females. The largest age group is 18-22 years old, making up 42.5% of participants, followed by 31-40 years old (27.5%), 23-30 years old (25%), and only 2 participants (5%) are over 40 years old. The age and education distribution appears to reflect the high number of undergraduate college students who were recruited from the university campus. The age and gender distributions are similar within the technology adopter groups and HMI groups, with the exception of more females in the HMI video casual group. Participants were randomly assigned to HMI groups based on technology adopter groups and not based on demographics.

Table 14. Age and Gender of Study Sample by Experimental Condition

Independent Variable	**Age** (years old)			**Gender** (N)	
	Mean	*St Dev*	*Range*	*Male*	*Female*
Tech Adopter Group					
Early	27.1	6.6	18-38	11	9
Late	25.4	9.2	18-42	9	11
HMI Group					
Info	26.9	7.2	18-37	6	4
Audio	29.1	9.9	18-41	6	4
Casual	22.1	5.6	18-34	2	8
Professional	26.9	8.0	18-42	6	4
Entire Sample	26.2	8.0	18-42	20	20

Table 15. Education Level of Study Sample by Experimental Condition

Independent Variable	**High School Diploma** (N)	**Associate Degree** (N)	**Bachelor's Degree** (N)	**Post-Grad Degree** (N)
Tech Adopter Group				
Early	6	0	5	9
Late	10	2	6	2
HMI Group				
Info	2	1	3	4
Audio	4	0	4	2
Casual	7	0	1	2
Professional	3	1	3	3
Entire Sample	16 (40%)	2 (5%)	11 (27.5%)	11 (27.5%)

5.3.3 PAV Awareness and Interest

Participants were queried about their familiarization level of PAVs and willingness and timing of riding an actual PAV once commercially available. Responses were at the end of the study, after completing both PAV flight simulations. These insights help provide general frame of reference of participants and are aligned with previous studies (Ison, 2024) which explored consumers' willingness to fly factors and PAV adoption time horizons.

Depicted in Figure 26 is the total count of survey responses, by technology adopter group, to the question, *Had you ever heard of PAVs before this study?*. Of the 20 total early adopters, 12 (60%) responded “no” and 8 (40%) responded “yes”, while 13 (65%) late adopters responded “no” and 7 (35%) responded “yes”.

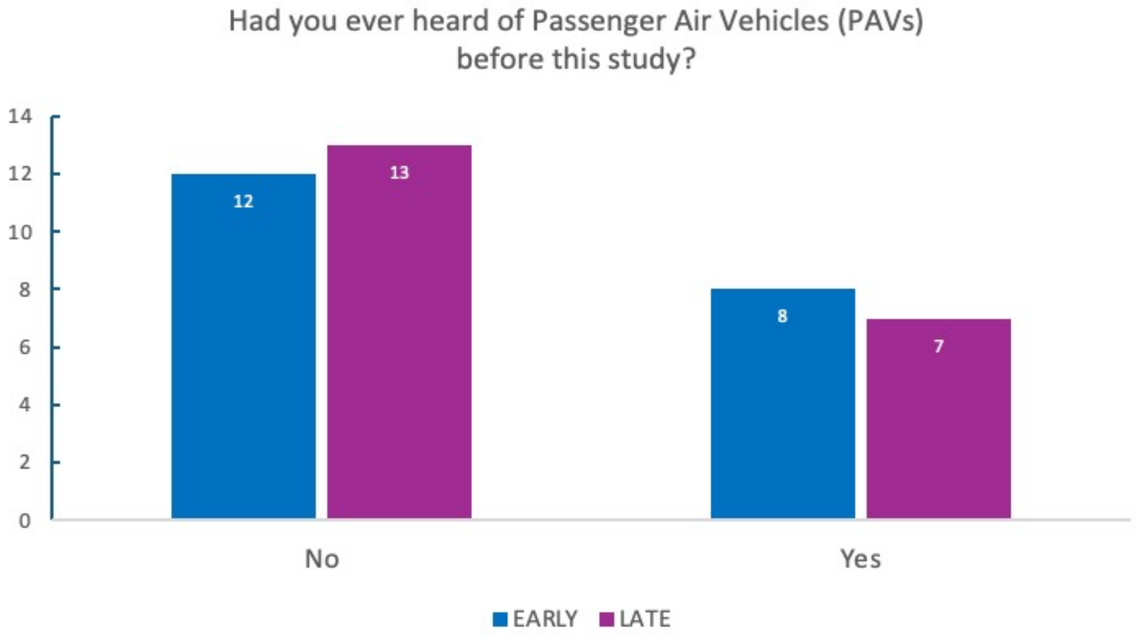


Figure 26. Familiarization with PAVs prior to study

The total count of survey responses to the question, *How soon after being available to the public would you be willing to ride in a PAV ?”* Results (as shown in Figure 27) indicate that 19 (95%) of the early adopters would be willing to ride within the first 2 years, while 14 (70%) of the late adopters are willing to ride within the same 2 year timeframe. Two (10%) late adopters responded their willingness to ride is 5 years or more, after PAVs are publicly available.

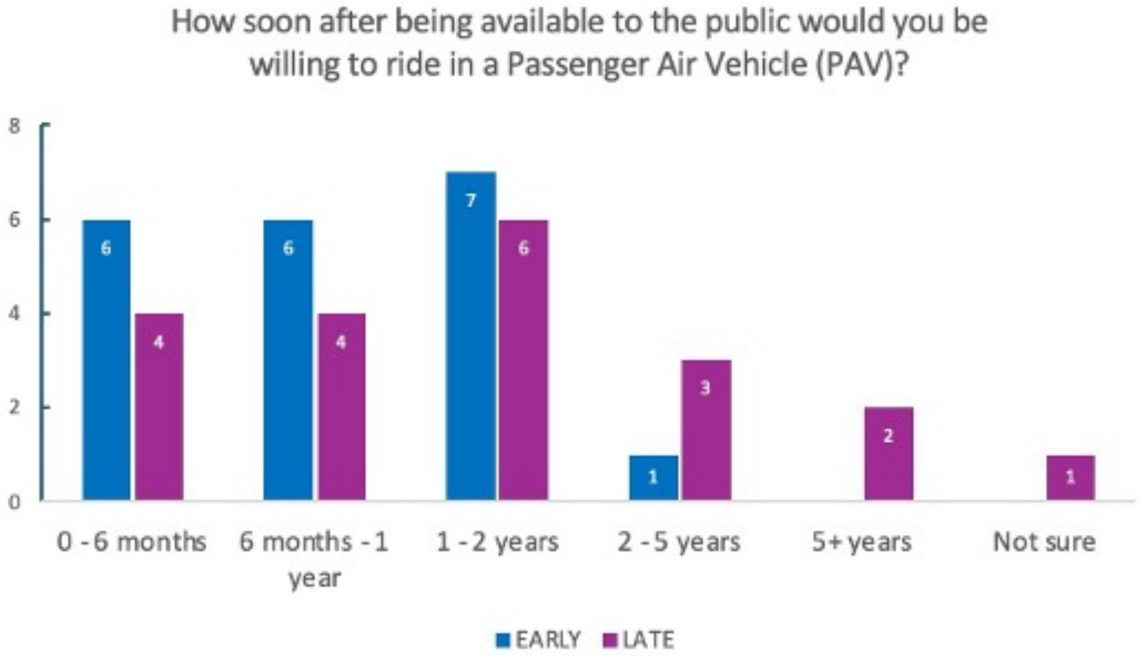


Figure 27. Participants' timing and willingness to ride PAVs

5.3.4 Situation Awareness

Situation Awareness Global Assessment Technique (SAGAT) measures the participant's perception of a situation during a snapshot in time. In this study, the flight simulation was paused at three distinct time intervals (takeoff, cruise, landing) in order to facilitate SAGAT scoring. The effects of HMI group and technology adoption group, across the three flight segments, on HMI flight SAGAT scores were examined through repeated measures analysis of covariance (ANCOVA), see Table 16. Baseline SAGAT scores were included in the analysis as the covariate.

A statistically significant effect is found for flight segment, $F(2, 112) = 3.330$, $p = 0.039$, indicating that situation awareness varies across the different flight segments. Additionally, there is a significant effect found for HMI group, $F(3, 112) = 7.604$, $p < 0.001$, suggesting that the type of HMI interface experienced by participants has a strong influence on situation awareness.

In contrast, no significant effects are observed for baseline SAGAT score (F(1, 112) = 0.3066, p = 0.5809) and technology adoption group (F(1, 112) = 0.1636, p = 0.6866), suggesting these factors do not influence situation awareness during the HMI flight.

Table 16. ANCOVA Results Summarizing Effects on Post-HMI SAGAT Score

Variables	DF	Sum Sq	Mean Sq	F value	p-value
Baseline SAGAT Score	1	0.218	0.218	0.307	0.5809
Flight Segment	2	4.739	2.370	3.330	0.0394
HMI Condition	3	16.231	5.410	7.604	0.0001
Tech Adopter Group	1	0.116	0.116	0.164	0.6866
Residuals	112	79.687	0.712	--	--

Examination of the change in situation awareness from baseline per HMI condition, across each flight segment, reveals interesting findings (see Figure 28). At takeoff, both HMI video groups (casual and professional) experience the greatest change in SA from baseline, while HMI information-only group experience the least change in SA from baseline. This result is likely due to the auditory and visual cues integral to HMI videos, translating to increased user perception keenness. During cruise flight segment, HMI information-only group experience a negative change in situational awareness, i.e., the baseline SA score is greater than the HMI flight SA score, a delta primarily due to decreased user reliance on HMI interface feedback. During landing, user HMI reliance increases, resulting in increased delta in SA for HMI information-only group, while HMI audio and video casual groups experience decreased SA compared to their baseline flights.

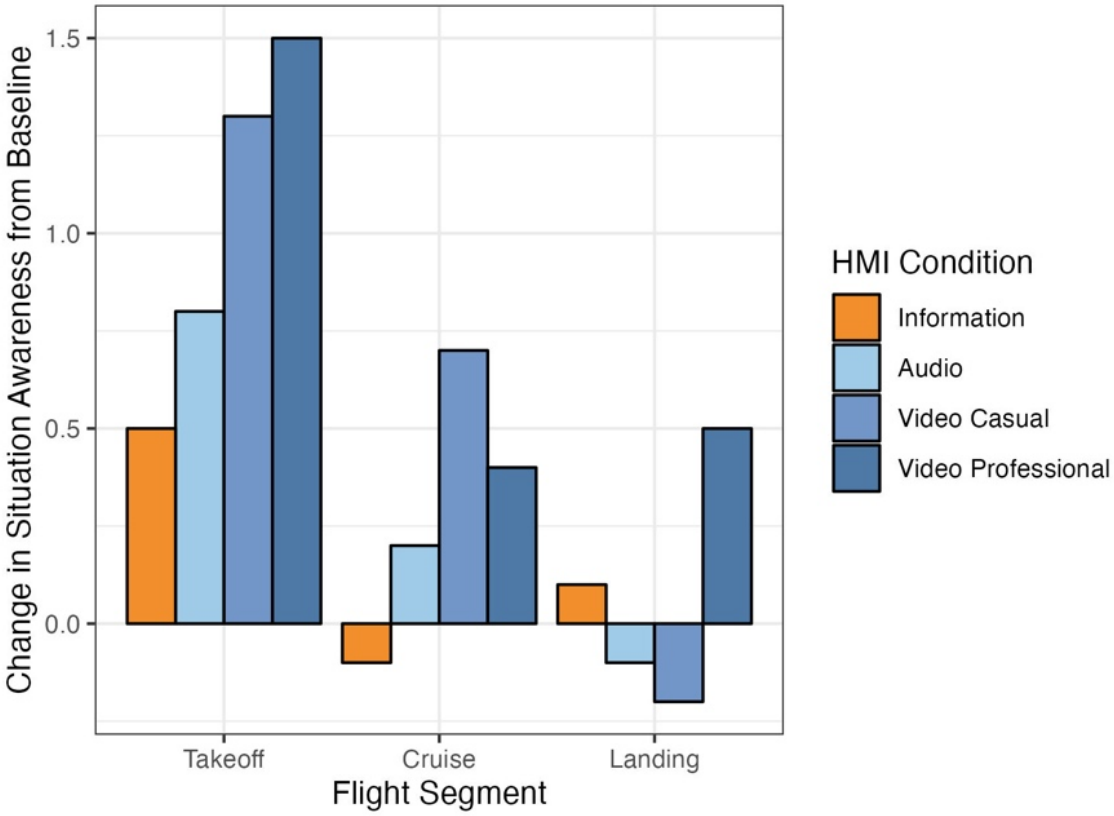


Figure 28. Difference from baseline in situation awareness by HMI group

5.3.5 Trust in Aircraft

An analysis of covariance (ANCOVA) was conducted to examine the effect of technology adoption group and HMI group on participants' trust in the aircraft during their HMI-specific PAV flight, while controlling for participants' baseline levels of trust in the aircraft, see Table 17. The structure of this analysis is similar to the ANCOVA on SA, but without segmenting by flight segment.

ANCOVA results indicate that the covariate (baseline trust in aircraft) is significant, $F(1, 34) = 49.13$, $p < 0.001$, suggesting that initial trust influences HMI trip trust scores. Additionally, there is a significant effect of HMI group on trust in the aircraft during the HMI flight, F(3, 34) = 3.52, p = 0.026. Pairwise comparisons reveal that participants exposed to the video professional HMI condition report significantly higher levels of trust in the aircraft following their HMI trip. The effect of technology adoption group is not statistically significant, F(1, 34) = 2.83, p = 0.10, indicating no clear difference between early and late adopters in their trust in aircraft resulting from their HMI flight.

Table 17. ANCOVA Results Summarizing Effects on Post-HMI Trust in Airplane Score

Variables	DF	Sum Sq	Mean Sq	F value	p-value
Baseline Trust in Aircraft	1	185.93	185.93	49.13	< 0.001
HMI Condition	3	39.93	13.31	3.52	0.026
Tech Adopter Group	1	10.72	10.72	2.83	0.102
Residuals	34	79.69	0.71	--	--

Figure 29 further shows the comparison of trust in aircraft across the HMI groups, which is statistically significant. This figure accounts for baseline trust, by providing means with standard error ranges by subtracting baseline trust in aircraft from trust in aircraft for HMI flight. Positive values represent higher trust in HMI flight compared to baseline flight, while negative values represent lower trust during the HMI flight. Notably, trust is much higher for the video professional condition.

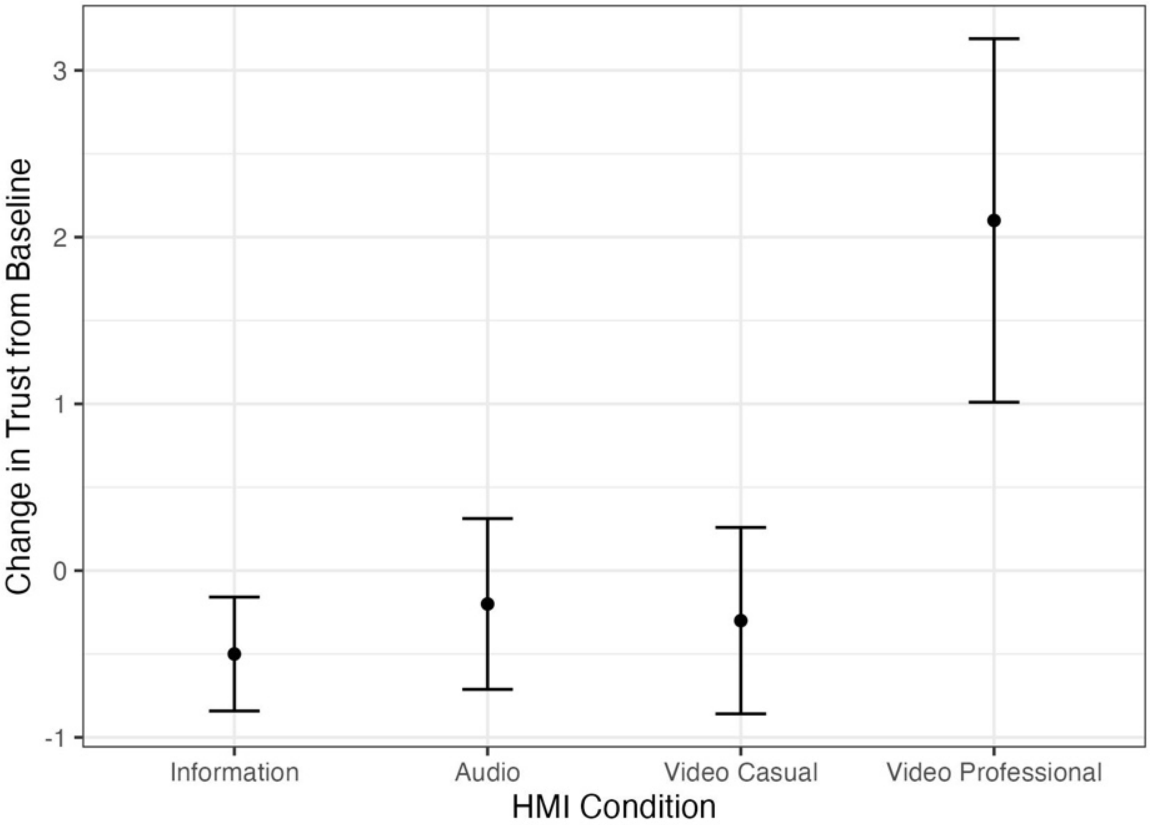


Figure 29. Difference from baseline in trust in aircraft by HMI group

5.3.5.1 Comparison of PAV to Conventional Airplane Flight

To contextualize the flight experience of an autonomously-piloted PAV versus the flight experience of a human-piloted airplane, participants were asked, "*how would you compare this PAV flight experience to a conventional airplane flight?"* With rating selections of 1) very comparable experience, 2) moderately/somewhat comparable experience, or 3) experience not comparable at all. Chi-square tests were conducted to explore potential associations between responses to this question with HMI groups and technology adopter groups (Table 18). A significant association is observed between HMI group and perceived experience relative to a traditional airplane flight, $\chi^2(6, N = 40) = 13.07$, $p = 0.042$, which suggests that the type of HMI design influences how the PAV experience is evaluated. There is no significant association found between technology adopter group and how participants evaluate the PAV experience, $\chi^2(2, N = 40) = 2.58$, $p = 0.275$.

Table 18. Chi-Square Results for Comparison to Conventional Flight

Variables 1	Variable 2	χ^2	df	N	p-value	Interpretation
PAV comparison to conventional flight	HMI Group	13.07	6	40	0.042	Significant
PAV comparison to conventional flight	Tech Adopter Group	2.58	2	40	0.275	Not Significant

The distribution of response based on HMI group is provided in Figure 30, which illustrates that the information HMI group tend to lean more towards not comparable at all. The video professional and audio HMI groups consider the PAV flight moderately to very comparable to a conventional airplane. The video casual HMI group split the most across all options, with most reporting the PAV to be not comparable at all or moderately comparable.

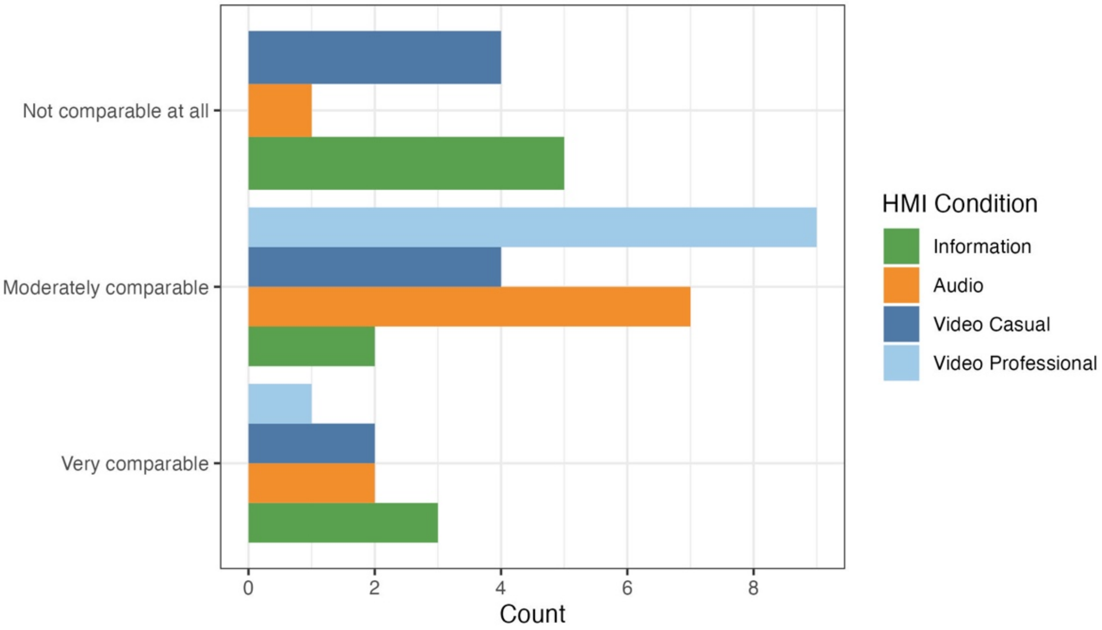


Figure 30: Comparison of PAV flight to a conventional airplane flight

5.3.6 Trust in HMI

Trust in human-machine interfaces is crucial for user interaction and acceptance. Analysis of variance (ANOVA) was conducted to examine how different technology adopter profiles and HMI group affect trust in HMI scores. Since trust in the HMI was only measured once, no baseline covariate is included in this model. The ANOVA results indicate no significant differences in trust scores based on technology adopter profiles, F(1, 35) = 0.36, p = 0.554. There is a significant difference in trust based on HMI group, F(3, 35) = 3.79, p = 0.019. This is also provided in Table 19.

Table 19. ANOVA Results Summarizing Effects on Trust in HMI

Variables	DF	Sum Sq	Mean Sq	F value	p-value
HMI Condition	3	96.47	32.16	3.791	.0187
Tech Adopter Group	1	3.03	3.03	0.357	.5542
Residuals	35	296.88	8.48	--	--

This is further visualized in Figure 31, which shows trust in HMI is highest for those who experience video professional and lowest for those who experience video casual.

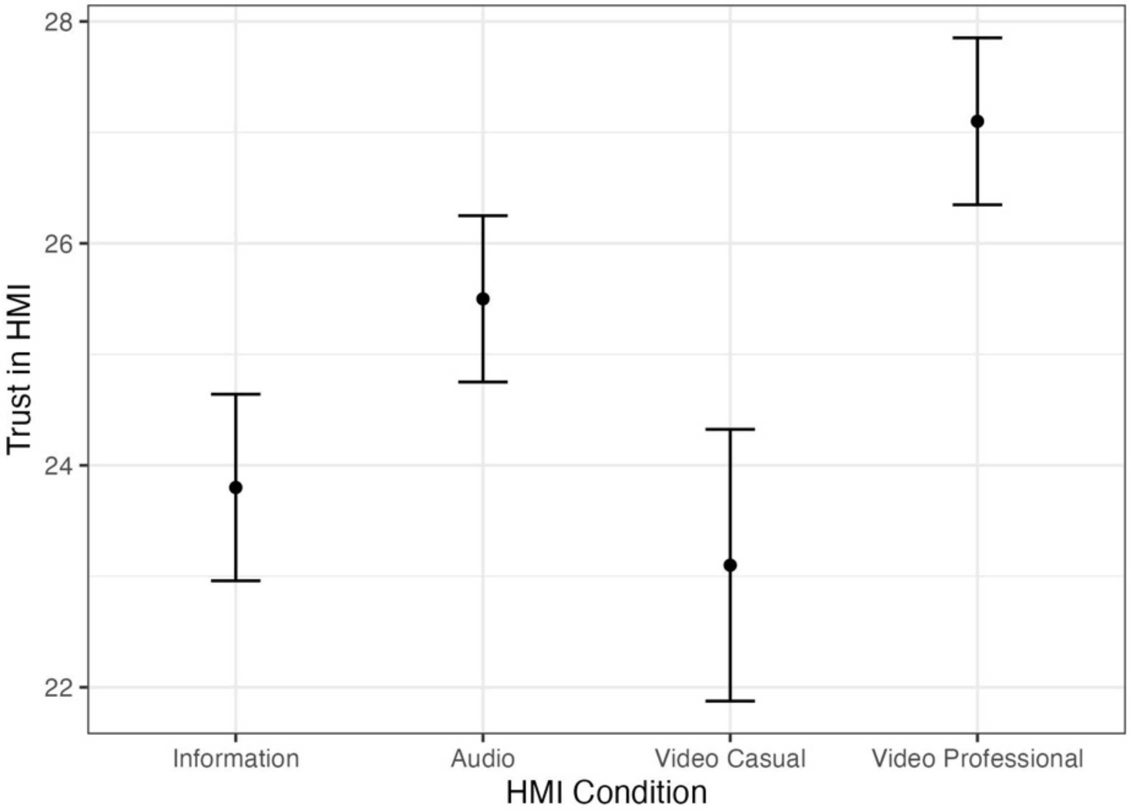


Figure 31: Trust in HMI by HMI group

5.3.7 Trust in Pilot

One of the distinguishing aspects of the autonomous PAV flight experience, as compared to a conventional flight experience, is the absence of a human pilot aboard the aircraft. Early versus late technology adopters' preference for an on-board pilot and remote operator was examined. Results from a chi-square test indicate a significant relationship between technology adopter group and preference in having an on-board pilot, χ^2 (4, *N* = 40) = 10.84, p = .028, suggesting technology adopter profile influences views on human presence in flight.

Additionally, another chi-square test shows a significant relationship between adopter profile and the preference for having a remote operator that can be audibly heard, $\chi^2(4, N = 40) = 9.96$, $p = .041$, implying that attitudes toward remote communication differ by adopter type.

Figure 32 compares these preferences between technology adopter groups, where late technology adopters are more likely to prefer to have a remote operator that they can hear and to have an on-board pilot, compared to early technology adopters.

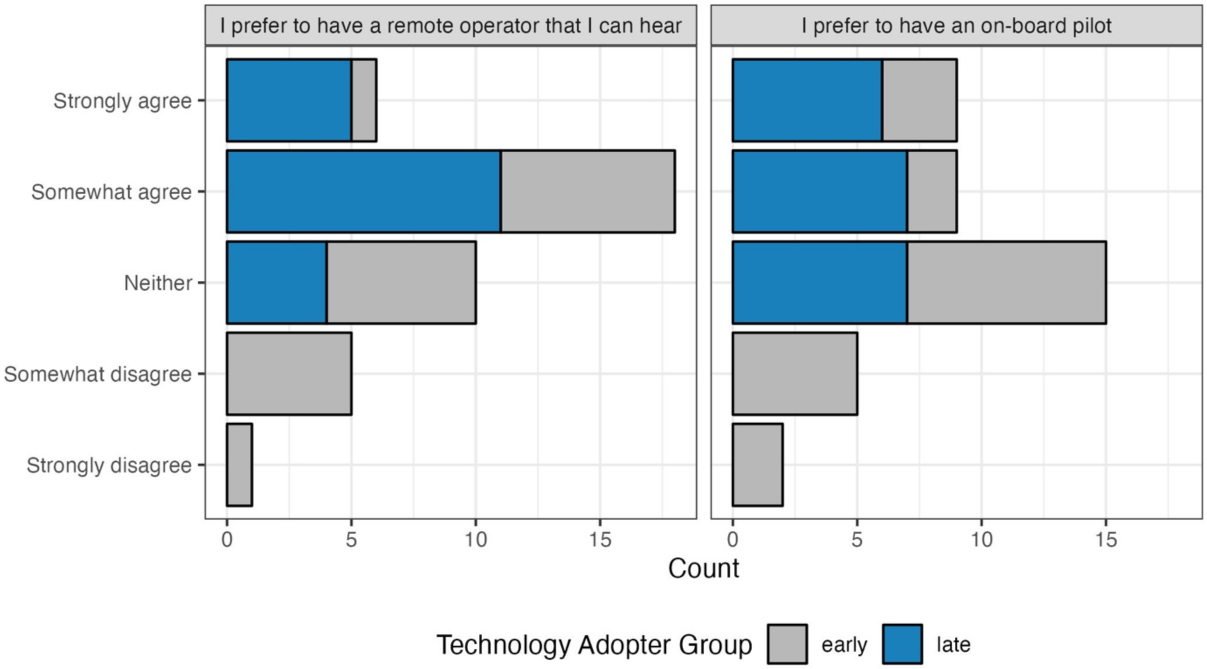


Figure 32. Remote operator and pilot preference by technology adopter group

Comparisons in pilot preferences were also compared between HMI groups. Specifically, a chi-square test of independence was conducted to examine the relationship between participants' preference for a professionally dressed remote operator and their HMI group, where a significant difference is found: $\chi^2(12, N = 40) = 10.84$, $p = .028$. As shown in Figure 33, participants exposed to the video professional condition are significantly more likely to express a preference for a professionally dressed remote operator compared to the other HMI conditions.

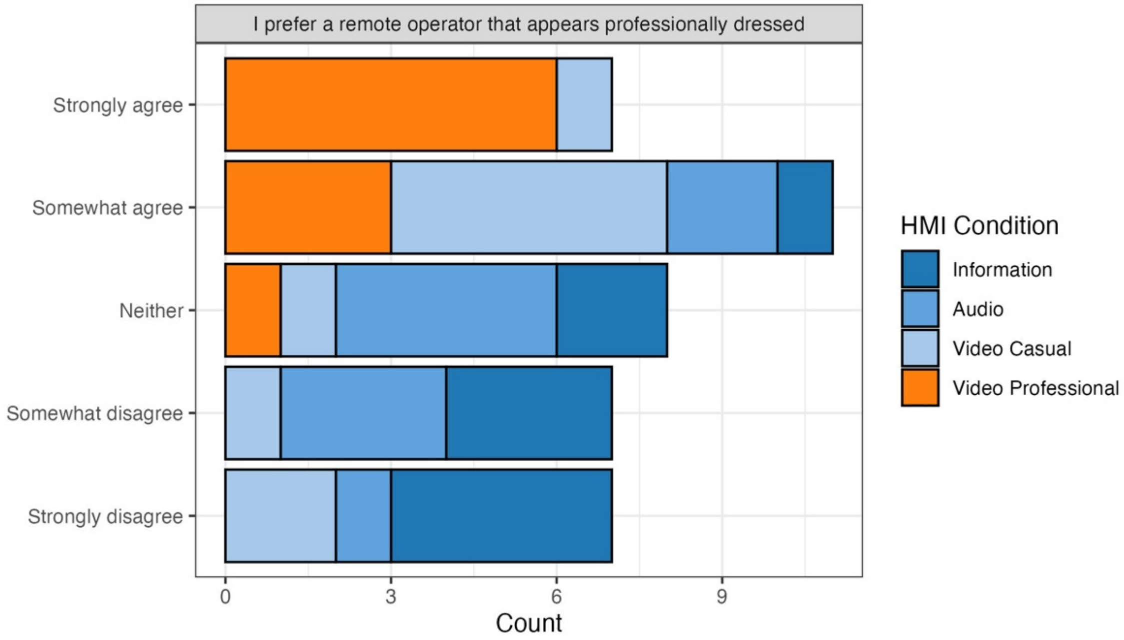


Figure 33. Preference for a remote pilot by HMI condition

A summary of these three tests relating to trust in the pilot are provided in Table 20.

Table 20. Chi-Square Results for Trust in Pilot

Variables 1	Variable 2	χ^2	df	N	p-value	Interp.
On-board pilot preference	Tech Adopter Group	10.84	4	40	0.028	Significant
Remote pilot that can be heard	Tech Adopter Group	9.96	4	40	0.041	Significant
Pilot that is professionally dressed	HMI Group	10.84	12	40	0.028	Significant

5.4 Discussion

This chapter investigated how in-cabin human-machine interface (HMI) designs influence passenger trust in fully autonomous Passenger Air Vehicles (PAVs) operating within Urban Air Mobility (UAM) systems, building upon findings from research aim 1.

As autonomous air taxis begin to emerge as a potential solution to urban congestion, public trust remains a critical barrier to adoption. Using a simulation environment, this study explored trust responses across four types of HMI designs – ranging from minimal information displays to audio and video messages from a remote operator – with a focus on how these interfaces affect trust among early and late technology adopters. Understanding which in-cabin design features foster trust is essential for developing UAM systems that are both acceptable and reassuring to the general public, particularly given the unfamiliar and high-stakes nature of pilotless air travel.

Prior research emphasizes that situational awareness across flight phases is dynamic (Endsley, 1995; Nguyen et al., 2019; Shen et al., 2024). Accordingly, the results observed in this study for the significant effect of flight segment on SAGAT scores suggest that situational awareness varies with time and operational setting. The significant effect of HMI design on SAGAT scores substantiates previous findings by Darejeh et al. (2024), which show that user awareness is affected by interface design and usability. Moreover, Endsley (1995) highlighted that well-designed interfaces enhance situational awareness by providing timely and relevant information. In contrast, the lack of significant effect of technology adopter group on HMI flight SAGAT scores suggests that individual affinity or readiness for technology adoption may be less influential than user-centric interface design in autonomous aircraft.

Examination of trust in the aircraft pre- and post-specific HMI flight conditions reveals that baseline trust in aircraft significantly predicts HMI flight trust scores, i.e., participants who start with higher trust in aircraft are more likely to have higher trust levels after the HMI-specific PAV flight. The HMI group, which reflects a specific interface design, had a statistically significant effect on trust in the aircraft. Specifically, the group that experienced the video interaction with a professionally dressed pilot reported significantly higher trust in the aircraft. This finding suggests that appearance does matter when it comes to trust, both in having a visual of a remote pilot (versus just a display of aircraft information), but that said pilot appears to be a “trusted” professional by the way they are presented. Additionally, professional dress can be considered an important visual social cue, especially during video interactions, which influences trust and perceived competence (Bickmore & Cassell, 2005; Nass & Moon, 2000). In Lee & See’s (2004) research in human-automation interaction, professional attire and formal presentation styles was shown to increase perceived trustworthiness and expertise. Findings further reveal that when a human operator is visually present, their attire becomes a proxy for competence and authority, thus shaping user attitudes toward the system and/or technology.

Participants who experienced the video casual condition, yielded a majority response of somewhat and strongly agree, in favor of preferring a remote operator that appears professionally dressed. This response suggests that the pilot presented in the video wearing casual attire was less preferred by participants. Previous studies by (Parasuraman & Miller, 2004) found that informal or unprofessional interactions can detract from users’ sense of security and confidence in a new technology.

Comparing early adopters and later adopters with respect to preferences for an on-board pilot and an audible remote pilot potentially reflects differences in risk perception and trust levels, which is aligned with the aforementioned technology acceptance model (Rogers, 2003). That is, late adopters characteristically tend to have stronger preference and need for visible, human control (Rogers, 2003), likely based on risk-adverse attitudes towards autonomous systems such as PAVs. As pointed out in Lee & See (2004), late adopters may associate the physical presence of a pilot with safety, and/or reassurance. Conversely, early adopters may be more accepting of autonomous systems, i.e., more comfortable with remote, automated aircraft operation, and hence showing less reliance on traditional symbols of control such as an onboard pilot. Integrating audio feedback, with a live two-way communication option, into the HMI design may prove beneficial for both early and late adopters, especially for late adopters, in easing user anxiety and enhancing user comfort and trust.

Perceptions of the PAV flight experience as compared to a conventional airplane flight experience were found to be recognized differently amongst HMI groups, but not between technology adopter groups. Participants whose PAV flight experience incorporated an HMI with video rated the PAV flight more favorable than those without an HMI video, i.e., information-only display. This finding supports previous research that suggests strong, human-centered interactions through video and audio improve user experiences in emerging autonomous systems (Luo et al., 2025; Kim & Ji, 2024). The HMI video professional group likely experienced greater situational awareness, emotional reassurance, and human kinship, all factors that enhance comfort, especially in novel transportation environments (Waytz et al., 2014). In contrast, the HMI information group lacked both audio and visual feedback cues to create a comfortable and satisfying user experience. From a design standpoint, it appears to be advantageous to include video in the HMI display, versus excluding it, to boost passenger satisfaction and trust.

To overcome reluctant behavioral intentions of riding aboard a PAV, potential users will initially rely on their own frame of reference of flying aboard a traditional jet airplane, as traditional air travel is the closest perceptual system to a PAV. Examination of flight comparisons by HMI group reveals that the video professional group had the highest number of participants rating the PAV flight experience as moderately comparable to a traditional airplane flight, while fewer in this group rated the flight experience as very comparable, and none rated it as not comparable at all. These results align with the fact that professional pilots are resident within a traditional aircraft, and the HMI video professional group interfaced with a professional pilot image during the simulation, which made it a highly comparable experience. Conversely, participants in the HMI video casual group evenly rated their flight comparisons between moderately comparable, very comparable, and not comparable at all, likely based on mixed perceptions of being familiar with interfacing with a pilot in the cabin, however, not experiencing a pilot who is dressed in expected professional attire. The HMI information group had a high rating of not comparable at all, and mid to low reports of moderately to very comparable flight experiences. For this group, their results support the fact that traditional airplanes are typically equipped with HMI interfaces containing flight operations and other status information, however, presented somewhat differently than what was presented on the HMI information group's interface. The HMI audio group had a high rating of moderately comparable, versus mid to low ratings for very comparable and not comparable at all. This finding aligns with the experience of hearing a pilot in command of a traditional aircraft over the intercom system in the cabin, including communication from the pilot regarding flight information and status. Overall, these flight comparison findings provide a key takeaway for PAV designers and manufacturers to strategically integrate user-centric HMI interface design requirements that feature audio and video interfaces, to enable familiarity and a high-comfort factor for potential users.

5.5 Conclusions

This chapter investigated the requisite HMI design features to include in PAV aircraft cabins, particularly those that foster trust and support acceptance of emerging UAM transit systems. Given the nascent stage of PAV development, understanding how HMI designs influence trust and situation awareness is vital for implementing systems that are both reliable and user-friendly.

Research Question 2.1 examined differences in trust, situation awareness, and remote-pilot expectations across four HMI interaction types: information only, audio only, professional "pilot," and casual "pilot." The professional pilot interaction consistently generated the highest levels of trust, indicating that users feel more confident and secure when guided by an authoritative, expert voice. In contrast, the audio-only condition resulted in the lowest trust and certainty in the PAV, likely due to the absence of visual cues and detailed system information.

Research Question 3.1 explored how these same factors varied between Early and Late technology adopters. Findings showed subtle but meaningful differences between how Early and Late adopters experienced the simulated PAV flight, underscoring the need for adaptable HMI designs that consider user familiarity and comfort with autonomous systems.

Overall, the results emphasize the critical role of in-cabin display interactions in shaping passenger trust and satisfaction. Key findings reveal that the interaction with a professional pilot garnered the highest preference amongst other types of interactions, suggesting that users value expert communication when interacting with autonomous PAV systems. User preference for HMI displays of aircraft system operation information is prioritized only in conjunction with video and audio feedback.

As PAV technology continues to evolve, prioritizing human-centric interfaces that leverage the power of video and audio, autonomous PAV systems can become more intuitive, efficient, trustworthy, and user-friendly across diverse user groups, ultimately leading to better user experiences.

Chapter 6:

Conclusions

6.1 Summary of Research Findings

This dissertation addressed three primary research aims, in conjunction with four specific research questions. Briefly outlined below is a summary of the research aims, research questions, and the derived key findings.

6.1.1 Research Aim 1 Findings

Identify the differences between early and late adopters of PAV technology

RQ 1.1: What are the initial perceptions of PAV technology by the general public?

> **Answer:** All respondents, both early and late adopters, expect additional in-flight safety feedback (i.e., displays relating to current and projected flight operations) beyond the level of safety standards found in conventional aircraft (i.e., seatbelts, air quality). Participants also indicated that PAVs are not perceived as an immediate replacement for daily trips and that in-cabin noise, which is often cited as a concern with community PAV acceptance, was not a crucial deterrent to ridership.

RQ 1.2: What are the differences between self-identified early technology adopters and late technology adopters with respect to PAV human-system integration?

> **Answer:** Early adopters of PAVs were more trusting of PAV technology, willing to pay more to ride, have shorter daily commutes, and present riskier in their overall general behaviors. Later PAV adopters require more feedback in-flight and a pilot on-board to consider riding.

6.1.2 Research Aim 2 Findings

Determine the human system interfaces that should be implemented to engender passengers' trust in riding an autonomously-piloted PAV.

RQ 2.1: How do in-cabin HMI interaction types (information only, audio only, professional “pilot”, casual “pilot”) influence trust, situation awareness, and remote-pilot expectations?

> **Answer:** Participants who interacted with a professionally dressed remote operator reported greater trust in both the aircraft and the HMI, along with improved situation awareness. Interactions with the professional pilot consistently yielded the strongest trust ratings, suggesting that users feel more assured and confident when supported by an authoritative expert. Conversely, the audio-only condition produced the lowest levels of trust and confidence in the PAV, likely because it lacked visual cues and detailed system feedback.

6.1.3 Research Aim 3 Findings

Examine the correlations between a passenger's technology adoption profile, situational awareness and trust in PAVs.

RQ 3.1: How do early adopters and late adopters differ in their trust, situation awareness, and remote-pilot expectations?

> **Answer:** A significant relationship was found between technology adoption group and preference for having an on-board pilot, indicating that adoption group shapes pilot expectations. Late adopters, in particular, preferred both an on-board pilot and a remote operator they could hear, while early adopters showed less need for these supports. In terms of situation awareness, no significant differences were observed between early and late adopters, suggesting that adoption group does not impact SAGAT scores. Similarly,

adoption group did not significantly affect trust in the aircraft following the HMI flight. Across conditions, participants generally preferred having either an audible or visible remote operator, with this preference strongest among late adopters.

Overall, the research, which aimed to examine how different in-cabin HMI display interaction types affected trust in PAV systems, offers a few practical, yet nuanced takeaways:

- Multi-modal interaction feedback (i.e., both visual and auditory) is optimal in mitigating user uncertainty and fostering trust in PAV autonomous systems.
- Real human-based display interactions in PAV autonomous systems can greatly enhance trust by promoting a sense of reliability and control.
- Trust in PAV systems is not only determined by the detailed information presented, but also by the perceived authority and context in which the information is delivered.

These takeaways suggest that PAV developers focus on designing in-cabin HMI interactions, based on defined user requirements, that are authoritative and professional, specifically in the early phases of user engagement with PAV systems. Such interactions are likely to increase both user trust and comfort level with the technology, ultimately leading to higher adoption rates.

6.2 Research Contributions

The potential contributions of this dissertation are threefold. First, this research advances the relatively limited body of UAM research by examining the behavioral intentions of potential passengers to ride a PAV, and the time horizon in which PAV adoption occurs. Second, this research distinctly investigates PAV in-cabin human-machine interface requirements, from a passenger perspective, to better understand rider comfort and trust determinants. Third, this research provides relevant passenger insights on autonomous PAV systems, vis-à-vis remote pilot access, as the industry models the transition from non-autonomous PAVs (i.e. onboard pilot) to fully-autonomous PAVs (i.e. remote and/or no pilot). These dissertation contributions underscore the importance of finding resolutions to the well-documented challenge of passenger acceptance and community integration of PAVs, which has beneficial value to UAM stakeholders and the future of sustainable aviation at large.

This research is distinct as it examines PAV human-system integration and virtual flight experience from a passenger perspective. Insights captured in this study are beneficial to the ecosystem of UAM stakeholders, including manufacturers, operators, regulators and jurisdictions, as all seek for full-scale UAM system implementation to realize the envisioned value the innovative transportation system would bring. Moreover, the findings will be integral to the viability of the UAM market as implementation and commercial success is contingent on both high passenger ridership demand and passengers' willingness to pay a premium over alternative transportation modes. Ultimately, these contributions strengthen the foundation for both the practical deployment of UAM systems and the broader goal of creating a safe, efficient, and widely accepted autonomous air transportation ecosystem.

Moreover, the findings from this study have relevance beyond PAVs and UAM. Lessons learned about passenger trust, comfort, and interaction with HMI displays can be applied to other autonomous transport systems, such as driverless cars, which are currently being deployed. These more near-term applications highlight the potential to leverage the results to inform design and operational strategies in existing autonomous mobility solutions, accelerating adoption and improving user experiences across multiple transportation modalities.

6.3 Limitations

It is noted that PAVs are conceptual technologies and may pose limitations to survey respondents' full comprehension. Also noted are limitations in extrapolating the sample size used in this study to the entire US adult population. However, this study aimed to capture representation of the general public and is comparable in sample size to similar studies that gauged passenger perceptions and willingness to try new technology for emerging autonomous road vehicles (Smith et al., 2017; McLeay et al., 2021). The initial phase of the research, which addressed Research Question 1, was conducted at the onset of the global pandemic, a time when normal daily commutes were halted, which may have impacted perceptions around emerging transportation options.

While the sample size (N = 40) of the flight simulation study may be considered modest, it yielded valuable initial insights into user interactions and preferences of autonomous PAV flights, in a timely and cost-effective manner. As PAVs have not yet entered into commercial service, this exploratory research represents an important step in laying the groundwork for future larger-scale studies.

The selection of the remote pilot to feature in the video was limited due to resource availability. Unconscious bias may have inadvertently been introduced as the physical presentation of the selected pilot featured stereotypical attributes of gender, age, and race. Broadening the study by featuring various pilot types may potentially have different effects on the level of trust in the aircraft or desire to have access to a remote pilot. Winter et al. (2014) examined whether physical traits such as age, weight, gender, and ethnicity influenced an individual's trust in pilots; they found that social stigmas, emotional factors, and personal biases affected the level of pilot trust, with younger, slimmer, male pilots receiving higher trust scores than their counterparts.

6.4 Future Work

Further quantitative research could include segmentation and modeling of gender, age and income demographic dynamics, such as through additional surveys across larger samples (Ahmed et al., 2024a; Ahmed et al., 2024b). Additionally further study of PAV acceptance between individuals on the ground (i.e., community) versus individuals in the air (i.e., passengers), may prove worthwhile and beneficial.

Future PAV flight simulation studies could benefit from having enhanced virtual reality apparatus or higher fidelity PAV simulators to enable a more life-like sensory PAV experience, thereby optimizing the passenger perspective in assessing their like or dislike of the technology (Ledgerwood & Gallegos, 2024; Ledgerwood et al., 2024).

The original experimental design for Phase 2 included heart rate for additional performance measures. However, heart rate data was collected using an Empatica E4 device, which was bricked by the manufacturer during data collection. Moreover, the Empatica E4 relies on wrist-based photoplethysmography (PPG), which is highly susceptible to artifacts. Future research could benefit from comparing physiological indicators of stress, such as heart rate variability, for trust and comfort with PAVs, as prior studies have demonstrated the usefulness of heart rate variability in assessing trust (Miller & Boyle, 2015; Miller, 2013; Miller & Boyle, 2013). Similarly, eye tracking could be used in future studies to evaluate eyes-on-HMI durations, and compare trends across different interface designs or flight contexts. Similar simulator studies used eye glance behavior to understand trust in automated systems (Strle et al., 2021; Jenness et al., 2020, Miller & Boyle, 2019; Boyle et al., 2013).

6.5 Publications

As presented in this dissertation, research has been conducted on general perceptions and insights from PAV adopters with respect to the usefulness and ease of use of PAVs, and PAV human-centered design requirements. These findings have resulted in peer-reviewed published works and international industry conference proceedings. Details outlined below.

1. **Johnson, R.**, Miller, E.E., & Conrad, S. (2022). Technology adoption and acceptance of urban air mobility systems: Identifying public perceptions and integration factors. *International Journal of Aviation Psychology*, *32*(4), 240-253. https://doi.org/10.1080/24721840.2022.2100394.
    a. This published paper focused on research questions 1.1 and 1.2.
    b. As of September 2025, this paper has 26 citations.

2. **Johnson, R.**, & Miller, E.E. (2022). Perceptions of emerging urban air mobility systems: Differences between early to laggard adopters of passenger air vehicles. *Presented at the 32nd Annual International Council on Systems Engineering (INCOSE) International Symposium. June 2022: Detroit, Michigan USA.*
    a. This conference presentation focused on research questions 1.1 and 1.2.

3. **Johnson, R.**, & Gallegos, E.E. (submitted for review May 2025). Impact of in-cabin human machine interface designs on passenger trust in urban air mobility. *The Journal of Aviation/Aerospace Education & Research (JAAER)*.
    a. This paper submission focused on research questions 2.1 and 3.1.

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APPENDICES

Appendix A: PAV Technology Adoption and Perception Survey

Introduction

You are invited to participate in a survey about Urban Air Mobility and Passenger Air Vehicle (PAV) concepts. Below is a conceptual image of a Passenger Air Vehicle. Passenger Air Vehicle is an on-demand, auto-piloted, electric aircraft that transports 1 to 4 passengers at low altitudes within urban and suburban areas. These air vehicles, or air taxis, are capable of vertical take-off and landing, thereby requiring no traditional runway, and offer a safe, quiet and environment-friendly alternative to road traffic congestion. In this survey, you will be asked 15 questions about your opinions regarding this emerging new mode of transportation. It will take approximately 5-7 minutes to complete the survey. Your participation is completely voluntary, and you may withdraw from the survey at any point. Survey responses will be confidential and data from this research will be reported only in the aggregate. Your responses will be anonymous. If you have questions or concerns, you may contact the lead researcher, Ricole

Johnson, by email at ricole.johnson@colostate.edu. Thank you very much for your time and participation.

Q3 Had you ever heard of Passenger Air Vehicles (PAVs) before this survey?

○ Yes

○ No

Q4 How familiar are you with Passenger Air Vehicles (PAVs)?

○ Extremely familiar

○ Very familiar

○ Moderately familiar

○ Slightly familiar

○ Not familiar at all

Q5 How soon after being available to the public would you be willing to ride in a Passenger Air Vehicle (PAV)?

○ 0 - 6 months

○ 6 months - 1 year

○ 1 - 2 years

○ 2 - 5 years

○ 5+ years

○ Not sure

○ Never

Q6 What would be your primary reason for riding a PAV?

○ Daily commute to and from work

○ Occasional commute to and from work

○ Business travel

○ Personal, non-business related travel

○ Entertainment/Sightseeing

○ Transfer to/from Airport

○ Other

○ Not sure

Q7 What would have the most influence on your decision to ride a PAV?

○ A friend or family member's recommendation

○ A celebrity or social media influencer recommendation

○ Same or lower cost ($/mile) than other transportation modes

○ Faster time to destination than other transportation modes

○ Better for the environment than other transportation modes

○ Avoid congested road traffic

End of Block: General PAV

Start of Block: Likert PAV

Q8 To what extent do you agree or disagree with the following statements about your trust of PAVs?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I need more information about how PAVs operate to trust the technology	○	○	○	○	○
I need visual indicators inside the PAV to trust the flight is in safe operation	○	○	○	○	○
I trust flying in a PAV that is operated by an established brand	○	○	○	○	○

I trust riding a PAV with a pilot on-board	○	○	○	○	○
I trust riding a PAV that is only autonomously piloted	○	○	○	○	○
I trust riding a PAV that meets federal regulations by the U.S. Federal Aviation Agency (FAA)	○	○	○	○	○

I trust riding in a PAV even after a reported accident	○	○	○	○	○

Q9 To what extent do you agree or disagree with the following statements? Compared to your typical within-city travel, PAVs will...

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Reduce commute time	○	○	○	○	○
Reduce road traffic congestion	○	○	○	○	○
Be better for the environment	○	○	○	○	○
Offer greater convenience	○	○	○	○	○
Cost less ($/mile)	○	○	○	○	○
Be safer	○	○	○	○	○
Be more reliable	○	○	○	○	○

Q10 How might you agree with the following statements about ease of use for PAVs?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Boarding a PAV is easy	○	○	○	○	○
Accessing a PAV at a skyport is easier than accessing an airplane at an airport	○	○	○	○	○
Booking a PAV using a mobile app is as easy as booking an on-demand car service (e.g. Uber, Lyft)	○	○	○	○	○

Riding a PAV enables me to accomplish tasks during my commute	○	○	○	○	○
Riding a PAV enables me to arrive to my destination without stress	○	○	○	○	○

Q11 <p>Consider the following features of the PAV cabin interior. How important is each feature to you?</p>

	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Comfortable Seats	○	○	○	○	○
Ample legroom	○	○	○	○	○
Ample headroom	○	○	○	○	○
High quality materials	○	○	○	○	○
High air quality	○	○	○	○	○
Wifi connectivity	○	○	○	○	○
Relatively quiet	○	○	○	○	○
Large windows	○	○	○	○	○
Safety restraints	○	○	○	○	○

Privacy partitions	○	○	○	○	○
Other (specify)	○	○	○	○	○

Q12 Consider the following features of the PAV in-flight display panel. How important is each feature to you?

	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Image of your PAV	○	○	○	○	○
Map of all PAVs near you	○	○	○	○	○
Map of birds near you	○	○	○	○	○
Speed limit	○	○	○	○	○
Current speed	○	○	○	○	○
Intended route path	○	○	○	○	○
Traffic control information	○	○	○	○	○
Time to destination	○	○	○	○	○

Battery life	○	○	○	○	○
Weather conditions	○	○	○	○	○
Other (specify)	○	○	○	○	○

End of Block: Likert PAV

Start of Block: About You

Q13 Prior to COVID-19, what was your average daily commute time from home to work?

○ No commute

○ 15 minutes or less

○ 15-30 minutes

○ 30-45 minutes

○ 45-60 minutes

○ More than 60 minutes

Q14 Prior to COVID-19, what was your primary mode of transport for your work commute?

○ Personal vehicle with 1 (solo) passenger

○ Personal vehicle with 2 or more passengers

○ On-demand Car Service (Uber/Lyft)

○ Vanpool

○ Public transportation (Bus, Train/Subway, Light Rail)

○ Motorcycle

○ Bicycle

○ Walk

○ Other

○ No Commute/Not Applicable

Q15 To what extent do news reports of airplane accidents influence your decision to fly in an airplane?

○ Strongly influence

○ Moderately influence

○ Somewhat influence

○ Slightly influence

○ No influence at all

Q16 When it comes to technology, what best describes you?

○ Early Adopter - I want to be first to try new technology

○ Moderate Adopter - I will wait awhile before trying new technology

○ Late Adopter - I am slow to try new technology

○ Non-Adopter - I am unwilling to try new technology and prefer to stick with what I know

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Q17 How willing are you to ride in a driverless [automated] car?

○ Willing

○ Somewhat willing

○ Undecided

○ Somewhat not willing

○ Not willing

Q18 What is your age?

____

Q19 What is your gender?

○ Female

○ Male

○ Prefer not to answer

Q20 What is your zip code?

____

Q21 How would you describe your residential area?

- ○ Urban Core (Downtown)
- ○ Urban Non-Core
- ○ Suburban
- ○ Small City/Town
- ○ Unincorporated
- ○ Rural
- ○ Not sure

Q22 What is the highest level of education you have completed?

○ Some High School

○ High School Diploma

○ Some College

○ Associate Degree

○ Bachelor's Degree

○ Master's Degree

○ Doctorate Degree

Q23 What is your current employment status?

○ Not currently employed

○ Self-Employed

○ Employed Full-Time

○ Employed Part-Time

○ Retired

○ Full-Time Student

○ Part-Time Student

Q24 What is your annual household income level?

○ $0 - $25,000

○ $25,000 - $50,000

○ $50,000 - $100,000

○ $100,000 - $150,000

○ $150,000 - $250,000

○ Above $250,000

End of Block: About You

Appendix B: SAGAT Questionnaire

SAGAT Questions by Flight Segment – Per HMI Flight

	TAKE OFF	CRUISE	LANDING
HMI Info Only	1. What was the battery percentage right at the pause? a. **100 %** b. 95% c. 75% d. Not sure 2. How many other PAVs were visible on the radar screen? a. 2 b. **4** c. 6 d. Not sure 3. What was the time remaining at takeoff? a. **6:55** b. 5:55 c. 7:05 d. Not sure 4. What direction did the aircraft turn to begin its journey? a. Left b. **Right** c. Straight (No Turn) d. Not sure 5. How many rotors were visible through the aircraft windshield ? a. 1 b. **2** c. 3 d. 4	1. What speed was your aircraft traveling right before it was paused? a. 350 miles per hour b. 200 miles per hour c. **150 miles per hour** d. Not sure 2. What was the status of the Navigation System? a. **Good** b. Paused c. Stable d. Not sure 3. What is the wind speed? a. **5 miles per hour** b. 10 miles per hour c. 20 miles per hour d. Not sure 4. There was a unique colored building on your left. What color was the building? a. Silver b. **Red** c. White d. Black 5. What letters were on the colored building? a. CNN **b.** **CNA** c. USA d. Not sure	1. How many cars were present near the heliport upon landing? 2. What is the status of the Communication System? **a.** **Good** b. Paused c. Stable d. Not sure 3. What is the flight mode upon landing? a. **Descend** b. Cruise c. Approach d. Arrive 4. As you landed, did you notice what was painted on the heliport pavement? a. Smiley Face b. **Letter H** c. Letter X d. Nothing 5. What color was the building that the aircraft landed on? a. Silver **b.** **Pale Pink** c. Red d. Not sure
	TAKE OFF	CRUISE	LANDING
HMI Audio Only	1. What is the remote pilot's name? a. Captain Steve b. **Captain Wright** c. 1st Officer James	1. At what altitude are you flying? a. 15,000 feet b. **1500 feet** c. 150 feet d. Not sure	1. Where will your aircraft be landing? a. Chicago Navy Pier b. Downtown Chicago c. O'Hare Airport

	d. I don’t remember 2. How long is your flight? a. 55 minutes b. 15 minutes c. **6-1/2 minutes** d. Not sure 3. Where is your remote pilot located? a. **Ground Control station** b. Air Traffic Control tower c. Federal Aviation Administration d. Not sure 4. What direction did the aircraft turn to begin its journey? a. Left b. **Right** c. Straight (aircraft did not turn) d. Not sure 5. How many birds were near the aircraft windshield during takeoff? a. 1 b. 2 c. **0 (there were no birds)** d. Not sure	2. What speed was your aircraft traveling right before it paused? a. 300 miles per hour b. **150 miles per hour** c. 100 miles per hour d. Not sure 3. What is today’s average temperature? a. **73 degrees** b. 70 degrees c. 80 degrees d. 85 degrees 4. There was a unique colored building on your left. What color was the building? a. Blue **b. Red** c. White d. Not Sure 5. What letters were on the colored building? a. CNN **b. CNA** c. USA d. Not sure	d. **Midway Air Taxi Heliport** 2. What were the remote pilot’s instructions to prepare for landing (select all that apply) a. **Remain seated** b. Fasten seatbelts c. Gather belongings d. Turn off cellphone 3. When are you able to exit the aircraft? a. **When aircraft doors open automatically** b. When I open the aircraft doors c. When engines shut down d. When remote operator provides “all clear” 4. As you landed, did you notice what was painted on the heliport pavement? a. Smiley Face b. **Letter H** c. Letter X d. Nothing 5. What color was the building that the aircraft landed on? a. Silver b. **Pale Pink** c. Red d. Not sure
	TAKE OFF	**CRUISE**	**LANDING**
HMI Video – Professional Pilot	1. What was the shape of the remote pilot’s eyeglasses? a. Round b. Oval c. Square d. **Remote pilot was not wearing eyeglasses** 2. What color was the remote pilot’s tie? a. Blue b. **Black** c. Red	1. There was a unique colored building on your left. What color was the building? a. Silver b. **Red** c. White d. Black 2. What letters were on the colored building? a. CNN **b. CNA** c. USA	1. How many aircraft were present on the helipad upon landing? a. 1 b. 2 c. 3 d. **None** 2. As you landed, did you notice what was painted on the heliport pavement? a. Smiley Face b. **Letter H** c. Letter X

	d. Not sure 3. How many other remote pilots were present? a. **None** b. 1 c. 2 d. Not sure 4. During takeoff, how many other aircraft were present? a. **None** b. 1 c. 2 d. Not sure 5. What direction did the aircraft turn to begin its journey? a. Left b. **Right** c. Straight (aircraft did not turn) d. Not sure	d. Not sure 3. How many rotors were visible through the aircraft windshield? a. 1 b. 2 c. **3** d. I did not notice the rotors 4. What type of bird was flying nearby the aircraft? a. Hawk b. Seagull c. Crow d. **There was no bird** 5. What is the wind speed? a. **5 miles per hour** b. 10 miles per hour c. 20 miles per hour d. Not sure	d. Nothing 3. What color was the building that the aircraft landed on? a. Silver b. **Pale Pink** c. Red d. Not sure 4. Describe the rotor action as the aircraft landed? a. Rapidly spinning **b. Slowly spinning** c. Not spinning (stopped) d. Not sure 5. How many cars were present near the heliport upon landing? a. **None** b. 1 c. 2 d. Too many to count
	TAKE OFF	**CRUISE**	**LANDING**
HMI Video – Casual Pilot	1. What color was the remote pilot's headphones? **a. White** b. Silver c. Black d. Not Sure 2. What color was the remote pilot's shirt? a. Blue b. **Black** c. Red d. Not sure 3. How many other remote pilots were present? a. 1 b. 2 c. **None** d. Not sure 4. During takeoff, how many other aircraft were present? a. 1 b. 2 c. **None** d. Not sure	1. There was a unique colored building on your left. What color was the building? a. Silver b. **Red** c. White d. Black 2. What letters were on the colored building? a. CNN b. **CNA** c. USA d. Not sure 3. How many rotors were visible through the aircraft windshield? a. 1 b. **2** c. 3 d. I did not notice the rotors 4. How many sports stadiums were in view? a. **1** b. 2	1. How many aircraft were present on the helipad upon landing? a. 1 b. 2 c. 3 d. **None** 2. As you landed, did you notice what was painted on the heliport pavement? a. Smiley Face b. **Letter H** c. Letter X d. Nothing 3. What color was the building that the aircraft landed on? a. Silver b. **Pale Pink** c. Red d. Not sure 4. Describe the rotor action as the aircraft landed. a. Moderately spinning b. Highly spinning

	5. What direction did the aircraft turn to begin its journey? a. Left b. **Right** c. Straight (aircraft did not turn) d. Not sure	c. None d. Not sure 5. What type of bird was flying nearby the aircraft? a. Hawk b. Seagull c. Crow d. **There was no bird**	**c. Not spinning (stopped)** d. Not sure 5. How many cars were present near the heliport upon landing? a. 1 b. 2 c. **None** d. Not sure

Question ID	Question
	Baseline (HMI off) - Takeoff SAGAT
S_Base1_Takeoff	How many other aircraft were present as your flight was taking off?
S_Base2_Takeoff	Where was the tall red and white radio tower located as your flight was taking off?
S_Base3_Takeoff	Which of the following statements is true?
S_Base4_Takeoff	As the aircraft was taking off, bright rays of sunlight appeared on which side?
S_Base5_Takeoff	Which of the following statements is true?
	Baseline (HMI off) - Cruise SAGAT
S_Base1_Cruise	Right as the video paused, how many mountains were present?
S_Base1_Cruise	There was a unique colored building visible during the flight. What color was the building?
S_Base1_Cruise	Which of the following statements is true:
S_Base1_Cruise	At the end of the video, how many major roads did you notice?
S_Base1_Cruise	What type of amusement ride was in view at the end of the video?
	Baseline (HMI off) - Landing SAGAT
S_Base1_Landing	How many boats were in the marina?
S_Base2_Landing	How many aircraft were present on the helipad?
S_Base3_Landing	How many buildings were located on the helipad?
S_Base4_Landing	What was printed on the helipad?
S_Base5_Landing	As your flight was landing, there was a bridge nearby. How many pillars were on the bridge?
	HMI Info - Takeoff SAGAT
S_HMI_Info1_Takeoff	What was the battery percentage right at the beginning of take off?
S_HMI_Info2_Takeoff	How many other Passenger Air Vehicles (PAVs) were visible on the radar screen?
S_HMI_Info3_Takeoff	Which of the following statements is true?
S_HMI_Info4_Takeoff	Which of the following statements is true?
S_HMI_Info5_Takeoff	What was the printed name on the aircraft?
	HMI Audio - Takeoff SAGAT
S_HMI_Audio1_Takeoff	What is the remote pilot’s name?

S_HMI_Audio2_Takeoff	According to your remote pilot, where was he located?
S_HMI_Audio3_Takeoff	What was the printed name on the aircraft?
S_HMI_Audio4_Takeoff	Where were the skyscrapers located during takeoff?
S_HMI_Audio5_Takeoff	Which of the following statements is true?
	HMI Video Professional - Takeoff SAGAT
S_HMI_Pro1_Takeoff	What color was the remote pilot’s shirt?
S_HMI_Pro2_Takeoff	How many additional remote pilots were present in the background on the display screen?
S_HMI_Pro3_Takeoff	What was the printed name on the aircraft?
S_HMI_Pro4_Takeoff	During takeoff, how many other aircraft were present?
S_HMI_Pro5_Takeoff	What is the remote pilot’s name?
	HMI Video Casual - Takeoff SAGAT
S_HMI_Cas1_Takeoff	What is the remote pilot’s name?
S_HMI_Cas2_Takeoff	What was the printed name on the aircraft?
S_HMI_Cas3_Takeoff	What color was the remote pilot’s shirt?
S_HMI_Cas4_Takeoff	How many additional remote pilots were present in the background on the display screen?
S_HMI_Cas5_Takeoff	During takeoff, how many other aircraft were present?
	HMI Info - Cruise SAGAT
S_HMI_Info1_Cruise	What was the temperature displayed on the screen?
S_HMI_Info2_Cruise	What type of aircraft was displayed on the screen?
S_HMI_Info3_Cruise	There was a unique colored building visible during the cruise. What color was the building?
S_HMI_Info4_Cruise	What letters were visible on the unique colored building?
S_HMI_Info5_Cruise	Right before the video paused, which of the following was true about the road below?
	HMI Audio - Cruise SAGAT
S_HMI_Audio1_Cruise	What was the approximate flight time mentioned by the remote pilot?
S_HMI_Audio2_Cruise	What was the aircraft's cruising altitude?
S_HMI_Audio3_Cruise	What did the remote pilot say today's average temperature was?
S_HMI_Audio4_Cruise	There was a unique colored building visible during the cruise. What color was the building?
S_HMI_Audio5_Cruise	What letters were visible on the unique colored building?
	HMI Video Professional - Cruise SAGAT
S_HMI_Pro1_Cruise	There was a unique colored building visible during the cruise. What color was the building?
S_HMI_Pro2_Cruise	What letters were visible on the unique colored building?
S_HMI_Pro3_Cruise	What did the remote pilot say today's average temperature was?
S_HMI_Pro4_Cruise	What type of bird was flying nearby the aircraft?
S_HMI_Pro5_Cruise	According to the remote pilot, what was the aircraft's cruising altitude?
	HMI Video Casual - Cruise SAGAT
S_HMI_Cas1_Cruise	There was a unique colored building on your left in this trip. What color was the building?

S_HMI_Cas2_Cruise	What letters were visible on that unique colored building?
S_HMI_Cas3_Cruise	What did the remote pilot say today's average temperature was?
S_HMI_Cas4_Cruise	According to the remote pilot, what was the aircraft's cruising altitude?
S_HMI_Cas5_Cruise	What type of bird was flying near the aircraft?
	HMI Info - Landing SAGAT
S_HMI_Info1_Landing	Where were the skyscrapers located as the aircraft was landing?
S_HMI_Info2_Landing	What color was the tall radio tower?
S_HMI_Info3_Landing	What was present on the landing pad?
S_HMI_Info4_Landing	What color was the landing pad surface?
S_HMI_Info5_Landing	Which of the following statements is true about the road below?
	HMI Audio - Landing SAGAT
S_HMI_Audio1_Landing	What color was the tall radio tower?
S_HMI_Audio2_Landing	Where were the skyscrapers located as the aircraft was landing?
S_HMI_Audio3_Landing	According to the remote pilot, when are you able to exit the aircraft?
S_HMI_Audio4_Landing	What number was painted on the landing pad?
S_HMI_Audio5_Landing	What color was the landing pad surface?
	HMI Video Professional - Landing SAGAT
S_HMI_Pro1_Landing	What color was the tall radio tower?
S_HMI_Pro2_Landing	What was present on the landing pad?
S_HMI_Pro3_Landing	Which of the following statements is true about the road below?
S_HMI_Pro4_Landing	What was the color of the landing pad surface?
S_HMI_Pro5_Landing	According to the remote pilot, when are you able to exit the aircraft?
	HMI Video Casual - Landing SAGAT
S_HMI_Pro1_Landing	What color was the tall radio tower?
S_HMI_Pro2_Landing	What was present on the landing pad?
S_HMI_Pro3_Landing	Which of the following statements is true about the road below?
S_HMI_Pro4_Landing	What color was the landing pad surface?
S_HMI_Pro5_Landing	According to the remote pilot, when are you able to exit the aircraft?

Appendix C: Trust Questionnaire

Based on the entire simulated PAV flight you just experienced (takeoff to landing), how strongly do you agree with the following statements about the aircraft?

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)
The aircraft felt reliable (14)	○	○	○	○	○
The aircraft felt safe (21)	○	○	○	○	○
The aircraft was in control (22)	○	○	○	○	○
I felt stressed while riding (29)	○	○	○	○	○
I would ride in an actual PAV (27)	○	○	○	○	○

I would feel comfortable doing other things while riding (e.g., reading a book) (28)	○	○	○	○	○
I need the ability to communicate to a remote operator to feel safe (30)	○	○	○	○	○
I need a display with information to feel safe (31)	○	○	○	○	○
I wish I had access to a remote operator (11)	○	○	○	○	○

Based on the entire simulated PAV flight you just experienced (takeoff to landing), how strongly do you agree with the following statements about the <u>information display screen (HMI)</u>?

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)
The information was trustworthy (7)	○	○	○	○	○
The information was reliable (26)	○	○	○	○	○
The information made me feel safe (21)	○	○	○	○	○
The display contained all the information I needed (11)	○	○	○	○	○

I understood the information (9)	○	○	○	○	○
The display kept me adequately informed of the aircraft operations (24)	○	○	○	○	○
The display added value to my trip (10)	○	○	○	○	○

Based on the entire simulated PAV flight you just experienced (takeoff to landing), how strongly do you agree with the following statements about the <u>aircraft</u>?

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)
The aircraft felt reliable (14)	○	○	○	○	○
The aircraft felt safe (21)	○	○	○	○	○
The aircraft was in control (22)	○	○	○	○	○
I felt stressed while riding (29)	○	○	○	○	○
I would ride in an actual PAV (27)	○	○	○	○	○

I would feel comfortable doing other things while riding (e.g., reading a book) (28)	○	○	○	○	○
I need the ability to communicate to a remote operator to feel safe (30)	○	○	○	○	○
I need a display with information to feel safe (31)	○	○	○	○	○
I wish I had access to a remote operator (11)	○	○	○	○	○

Based on the entire simulated PAV flight you just experienced (takeoff to landing), how strongly do you agree with the following statements about the remote operator?

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)
The remote operator was trustworthy (7)	○	○	○	○	○
The remote operator was reliable (26)	○	○	○	○	○
The remote operator made me feel safe (21)	○	○	○	○	○
I feel the remote operator cared about me (11)	○	○	○	○	○

I am confident the remote operator was in control of the aircraft (22)	○	○	○	○	○
I am confident in the remote operator's ability to maintain the aircraft (23)	○	○	○	○	○
I understood the communication by the remote operator (9)	○	○	○	○	○

The remote operator kept me adequately informed of the aircraft operations (24)	○	○	○	○	○
The remote operator added value to my trip (10)	○	○	○	○	○

Based on the entire simulated PAV flight you just experienced (takeoff to landing), how strongly do you agree with the following statements about the <u>aircraft</u>?

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)
The aircraft felt reliable (14)	○	○	○	○	○
The aircraft felt safe (21)	○	○	○	○	○
The aircraft was in control (22)	○	○	○	○	○
I felt stressed while riding (29)	○	○	○	○	○
I would ride in an actual PAV (27)	○	○	○	○	○

I would feel comfortable doing other things while riding (e.g., reading a book) (28)	○	○	○	○	○
I need the ability to communicate to a remote operator to feel safe (30)	○	○	○	○	○
I need a display with information to feel safe (31)	○	○	○	○	○

Based on your overall impression of PAVs, how strongly do you agree with the following statements?

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)
I prefer to have an on-board pilot (14)	○	○	○	○	○
I prefer to have a remote operator that I can easily call (11)	○	○	○	○	○
I prefer to have a remote operator that I can hear (26)	○	○	○	○	○
I prefer to have a remote operator that I can see and hear (12)	○	○	○	○	○

I prefer a remote operator that appears professionally dressed (24)	○	○	○	○	○

Q41 How would you compare this PAV flight experience to a conventional airplane flight?

○ Very comparable experience (1)

○ Moderately/somewhat comparable experience (2)

○ Experience not comparable at all (3)

Q42 Had you ever heard of Passenger Air Vehicles (PAVs) before this study?

○ Yes (1)

○ No (2)

Q43 How soon after being available to the public would you be willing to ride in a Passenger Air Vehicle (PAV)?

○ 0 - 6 months (1)

○ 6 months - 1 year (2)

○ 1 - 2 years (3)

○ 2 - 5 years (4)

○ 5+ years (5)

○ Never (6)

○ Not sure (7)

What is the highest level of education you have completed?

○ Some High School (1)

○ High School Diploma (2)

○ Associate Degree (3)

○ Bachelor's Degree (4)

○ Postgraduate Degree (5)

What is your age?

____

What is your gender?

○ Male (1)

○ Female (2)

○ Non-Binary / Third Gender (3)

○ Prefer Not to Say (4)

Appendix D: Pilot Script

Hello and welcome aboard this passenger aerial vehicle.

My name is Captain Wright, and I will be your remote pilot today. Even though I am not physically on the plane, I will be monitoring your aircraft's operations from my ground control station. Please sit back as you begin your liftoff.

Today your itinerary is a direct flight to Midway Air Taxi Heliport from Chicago's Navy Pier, with an approximate flying time of 6 minutes. Please enjoy your flight and the views of the city as you fly through the beautiful downtown City of Chicago.

Hello. This is your remote pilot again, Captain Wright. You have now reached cruising altitude of 1500 feet, and are traveling at an airspeed of 150 miles per hour. The weather along your route through downtown Chicago is partly sunny, 73 degrees average temperature, with no rain in the forecast.

This is Captain Wright again, just checking in from ground control to let you know everything is running smoothly. All aircraft system operations are functioning effectively. And you will be at your destination shortly.

Once again, this is your remote pilot, Captain Wright. You are approaching your destination. Remain seated for descent and landing. Your aircraft is beginning its landing.

Welcome to the other side of downtown Chicago. You have arrived at your destination Midway Air Taxi Heliport. Thank you for flying with us today in our passenger aerial vehicle.

Remain seated until the aircraft doors open, and then you are good to exit.

Have a great rest of your day.

Appendix E: Flight 2 Time Duration with Pilot Script

Flight 2: Navy Pier to Midway with HMI, Pilot Script (Duration 5:53)

Phase	Time	Duration	Script
Takeoff *(1:09)*	0:00	9 sec	--
	0:09	5 sec	Hello and welcome aboard this passenger aerial vehicle.
	0:14	20 sec	--
	0:34	16 sec	My name is Captain Wright, and I will be your remote pilot today. Even though I am not physically with you, I will be monitoring your aircraft's operations from my ground control terminal. Please be seated for departure.
	00:50	19 sec	--
Cruise *(3:44)*	0:00	30 sec	--
	0:30	19 sec	Today your itinerary is a direct flight from Chicago's Navy Pier to Midway Air Taxi Heliport, with an approximate flying time of 6 and a half minutes. Please enjoy the flight and the views of the city as you fly through downtown Chicago.
	0:49	45 sec	--
	1:34	23 sec	This is your remote pilot again. You have now reached cruising altitude of 1500 feet and are traveling at an airspeed of 150 miles per hour. The weather along your route calls for

			a smooth flight through downtown Chicago, with clear skies and an average temperature of 73 degrees.
	1:57	50 sec	--
	2:47	15 sec	This is Captain Wright again, just checking in from ground control to let you know everything is running smoothly. All aircraft systems are functioning normally. And you will arrive at your destination shortly.
	3:02	42 sec	--
Landing *(1:00)*	0:00	5 sec	--
	0:05	15 sec	Once again, this is your remote pilot, Captain Wright. You are approaching your destination. Please remain seated for the duration of the flight. Your aircraft is beginning its descent into Midway.
	0:20	5 sec	--
	0:25	28 sec	Welcome to the other side of downtown Chicago. You have arrived at your destination Midway Air Taxi Heliport. Thank you for flying with us today in our passenger aerial vehicle. Please remain seated until the aircraft doors open, then you are free to exit. Thanks again and have a great day.
	0:53	7 sec	--

Appendix F: PAV Flight Experience Passenger Overview Sheet

Passenger Air Vehicle Flight Experience Simulation Study

A Passenger Air Vehicle is an on-demand, autonomous, electric aircraft that transports 1 to 4 passengers at low altitudes within urban areas. These air taxis takeoff and land similar to a helicopter (requiring no traditional runway) and offer a safe, quiet and environment-friendly alternative to road traffic congestion. These aircraft are autonomous, meaning there is no pilot on-board the aircraft. These aircraft are currently being developed and tested, and are expected to be available within the next few years.