The State of Urban Air Mobility Research: An Assessment of Challenges and Opportunities

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***Abstract*— Electric vertical take-off and landing aircraft-based urban air mobility (UAM) service in conjunction with personal flying cars are anticipated to offer mobility benefits in terms of reduced travel time, alleviate demand from overburdened ground transportation systems; and bring forth a paradigm shift in travel patterns. Furthermore, uncrewed aerial vehicles or drones have significant potential in package and food delivery and in various disaster responses. In this context, this paper aims to provide a systematic review of current research and studies covering crucial aspects of urban air mobility and flying car ecosystems including public perception, potential market demand, infrastructure requirements, operations and traffic management processes, and policy formulation. Insights offered by the current studies encompassing these areas are summarized and discussed in this paper.**

***Index Terms*— Advanced air mobility (AAM), advanced air vehicles (AAV), flying cars, literature review, urban air mobility (UAM).**

I. Introduction

THE demand for passenger and goods transportation has increased considerably in recent decades, even more so in urban areas. To keep up with the ever-increasing demand, an expansion of the transportation infrastructure has been taking place in the form of new roadway construction, the addition of buses, trams, and subway trains, creation of intermodal and multimodal transport hubs, and so on. Despite these efforts, ground-based transportation systems are nearing or exceeding capacity. To expand urban transportation system capacity, the third and arguably the least utilized spatial dimension, low altitude airspace, has begun to receive increasing attention from various transportation stakeholders. Recent technological advances and substantial investments have paved the way toward the conceptualization and development of a new urban transportation mode, popularly referred to as urban air mobility (UAM), which seeks to utilize a low-altitude flying scheme for transporting passengers and goods within urban environments, (urban and suburban areas within a single metropolitan area). Due to the operational characteristics of UAM, it is considered a disruptive transportation technology that brings the possibility of lowering travel time, and increasing travel time reliability in dense, congested urban settings. In addition, UAM offers considerable potential for enhancing emergency response, critical medical services, and disaster relief operations.

Both the mainstream media and academic experts have begun paying increasing attention to UAM due to the recent research and development in commercial space. Hundreds of academic research efforts covering a multitude of topics relating to UAM have been conducted and published in the past few years. These studies address issues related to public perception towards UAM technologies (in terms of willingness to use, safety and security related concerns; infrastructure requirements), UAM aircraft design and certification, air traffic control, management of low-altitude airspace and the integration with existing commercial air service, and so on.

In this context, the objective of this paper is to present a comprehensive review of published academic works on UAM and related technologies. It should be noted that the Federal Aviation Administration (FAA) has recently recognized Urban Air Mobility (UAM) and builds upon the UAM concept by identifying potential use scenarios, some of which are no longer restricted to urban settings [1]. The inclusion of broader use scenarios encompassing intercity transportation of passengers or goods (regional air mobility) and reaching to underserved rural areas (rural air mobility), led to the concept of advanced air mobility (AAM). In this context, UAM constitutes a sub-set of AAM, as it focuses only on transportation operations and services in a single metropolitan area [1]. In addition, prior to the formal adoption of the aforementioned terminologies, the terms "flying cars", "flying taxis", "air taxis", "hybrid flying cars" have been exchangeable in the literature. With that being said, this review paper also covers studies that have used the aforementioned alternate terminologies for these conceptually similar transportation

Received 18 July 2023; revised 10 May 2024 and 15 October 2024; accepted 28 November 2024. Date of publication 16 December 2024; date of current version 4 February 2025. The Associate Editor for this article was H. Khayyam. *(Corresponding author: Panagiotis Ch. Anastasopoulos.)*

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Digital Object Identifier 10.1109/TITS.2024.3511453

TABLE I
KEYWORDS AND USAGE SCHEME FOR STUDY IDENTIFICATION

Keyword	Usage
• "Urban Air Mobility"	Standalone
• "UAM"	
• "Advanced Air Mobility"	
• "AAM"	
• "Flying cars"	
• "Flying taxi"	
✓ "Willingness to use"	In combination with the above
✓ "Willingness to pay"	
✓ "Public perception"	
✓ "Acceptance"	

modes. It should be noted, though, that this paper does not explicitly cover studies focusing on Uncrewed Aerial Vehicles (UAVs) or delivery drones.

The paper starts by presenting the study selection and compilation criteria. The paper then goes on to review and summarize the findings of studies that have investigated: 1) public perceptions toward UAM, advanced air mobility (AAM) and flying car technologies; 2) the promise of air mobility technologies as well as challenges and implementation strategies of these technologies; 3) future market demand of UAM/AAM services and their potential fleet size requirements; 4) potential travel time savings offered by UAM/AAM relative to alternate transportation modes; 5) UAM/AAM infrastructure requirements; and 6) policy implications and regulatory requirements for UAM/AAM ecosystem. Finally, a summary of the findings is presented, and directions towards future work are briefly discussed in the context of these findings.

II. Methodology

A keyword-based database query approach was leveraged to identify the relevant published work. Several previous studies featuring reviews of current evidence have employed a comparable methodological approach [2], [3], [4]. Two popular academic study indexing services, Scopus and Web of Science, were used to carry out the database query [5], [6]. To identify relevant research efforts, the keywords that were used in both standalone and combination scheme are shown in Table I.

The results returned from the queries formulated the baseline study list. From this list, the duplicate entries were first removed to generate a first-tier shortlist. Afterwards, the studies included in the first-tier shortlist were categorized as per the study scope. Once the categorization was completed, each individual study was further investigated to retrieve any remaining relevant studies that did not show up in the query-based approach. This can be considered as a forward and backward snowballing approach to find relevant studies [7].

After finding the relevant studies through this approach, they were augmented into the categorized shortlist of studies. Interestingly, a deeper investigation of the aforementioned studies revealed further duplication of contents, which stemmed from the fact that several studies were initially and partially published as one or more conference papers and were eventually published as journal articles. Because these studies evolved over time (both the titles and write-ups), the findings from this sequence of studies were reviewed as a whole and discussed accordingly.

III. Public Perception Towards Urban Air Mobility (UAM), Advanced Air Mobility (AAM) and Flying Cars

A. Comparison of Scopes and Methodologies

As summarized in Table II, eighteen out of twenty studies have conducted online surveys to obtain public perception towards UAM, AAM, and flying cars. There are two exceptions to this. Straubinger et al. [8] combined responses from an online survey and in-person paper-based surveys, and Ilahi et al. [9] utilized travel diaries and paper-based surveys. In addition, Rajendran and Pagel [10] stood out from the rest because they used online reviews of helicopter services to study the topic.

Regarding geographical coverage, most of the studies have evaluated survey responses from the United States, three of the studies focused on respondents from India, and one from Germany. The rest of the studies included responses from several countries across the world. Three of the studies employed a Delphi technique to gather opinions from subject experts across the world [11], [12], [13]. Other studies have focused on gathering opinions from the general public.

For response analysis techniques, a number of studies [14], [15], [16] conducted descriptive analyses of survey-collected responses. Ragbir et al. [17] and Ward et al. [18] utilized analysis of variance (ANOVA) to analyze the differences in the received responses. Garrow et al. [19] used factor analysis and clustering techniques to analyze the received responses. Several studies estimated discrete choice models to analyze survey-collected data [9], [20], [21], [22], [23], [24], [25], [26]. Finally, Rajendran and Pagel [10] employed optical character recognitions, bigrams and trigrams text mining techniques, and Rautray et al. [27] used a customer requirement decomposition technique to analyze their data.

Many studies that sought to understand public interest or willingness to use UAM/AAM and flying cars have used Likert-scale based questionnaire structures [14], [15], [18], [19], [25], [28]. In contrast, studies aimed at assessing the appeal of UAM/AAM and flying cars relative to other modes

TABLE II
SUMMARY OF THE REVIEWED STUDIES ON URBAN AIR MOBILITY (UAM) AND ADVANCED AIR MOBILITY (AAM)

Reference	Publication year	Publication type	Survey framework	Location	Number of responses collected	Analysis method	Key findings
Reiche et al. (2018) [14]	2018	Report	Online survey	5 US cities (Houston, Los Angeles, New York, San Francisco Bay area, Washington D.C.)	1,700	Descriptive analysis	• Young, male, and individuals with higher income were more interested in UAM. • Piloted operation preferred over autonomous operation.
Shaheen et al. (2018) [15]	2018	Report	Online survey	5 US cities (Houston, Los Angeles, New York, San Francisco Bay area, Washington D.C.)	1,700	Descriptive analysis	• More interest in using UAM for traveling to the airport, or long-distance recreational trips over commuting.
Eker et al. (2019) [20]	2019	Peer-reviewed journal article	Online survey	United States	584	Bivariate probit and univariate probit models with correlated grouped random parameters and heterogeneity in means	• Younger respondents were found to be more receptive towards flying cars. • Lack of familiarity with ADAS resulted in skepticism towards flying cars.
Fu et al. (2019) [21]	2019	Peer-reviewed journal article	Online survey	Munich, Germany	248	Multinomial Logit	• Young (18-35) and low-income individuals were more interested in UAM. • Older (46-65) individuals were less interested. • Individuals with low-income, lower education level were less interested. • No gender-specific differences in interest toward UAM were found.
Schuurman et al. (2019) [11]	2019	Conference paper	Online survey	Worldwide	12	Delphi technique	• On-board pilot human error, ground pilot human error, and mid-air collision are identified as the most likely causes of UAM accidents.
Haddad et al. (2020) [22]	2020	Peer-reviewed journal article	Online survey	Munich, Germany	221	Multinomial Logit, Ordered Logit	• Safety and trust were found to affect UAM adoption horizon. • Expectation of service reliability and on-time performance were found to influence early adoption of UAM. • Public transportation users were found to be late adopters.
Eker et al. (2020a) [24]	2020	Peer-reviewed journal article	Online survey	United States, and 17 other countries	692	Bivariate probit model with grouped random parameters	• Younger individuals (less than 30 years old) were more likely to use flying cars. • Ethnically Asians were more likely to use flying cars compared to other ethnicities. • Individuals with low-income (less than $30k per annum) were less likely to use flying cars.
Garrow et al. (2020) [19]	2020	Conference paper	Online survey	5 US cities (Atlanta, Boston, Dallas-Ft. Worth, San Francisco Bay area, Los Angeles combined statistical areas)	1,405	Factor analysis, Cluster analysis	• Pro-flying, tech-conscious, environmentally conscious individuals were very enthusiastic towards UAM. • 18-44 years old, have child in home – cautiously enthusiastic. • Older individuals, female, pro-car, and environmentally indifferent individuals had adverse perception towards UAM.

TABLE II
(Continued.) SUMMARY OF THE REVIEWED STUDIES ON URBAN AIR MOBILITY (UAM) AND ADVANCED AIR MOBILITY (AAM)

Ragbir et al. (2020) [17]	2020	Peer-reviewed journal article	Online survey	United States, India	US – 496, India - 286	ANOVA	• US and India participants had similar attitudes towards autonomous UAM. • Not willing to use autonomous UAM in inclement weather, and over water bodies. • Willing to use autonomous UAM for shorter trips (~5 minutes) over longer trips (~30 minutes).
Rajendran and Pagel (2020) [10]	2020	Peer-reviewed journal article	Online helicopter service review mining	N/A	5,000	OCR, Bigrams, Trigrams	• Helicopter service reviews were analyzed to draw recommendations for future UAM services. • Potential users value simple user interface, and a multitude of payment options. • Safety was the single most important determinant. • Knowledgeable pilots were warranted.
Rautray et al. (2020) [27]	2020	Conference paper	Online survey	India	224	Customer requirement (CR) decomposition	• Respondents desired a hybrid vehicle that works both on land and air. • Autonomous flying systems were desired, with minimum user input. • Adequate cabin space desired to reduce vertigo and claustrophobia. • Respondents were concerned about operational safety.
Straubinger et al. (2020) [8]	2020	Book chapter	Online, in-person	N/A	52 studies	Meta-analysis	• Travel time and travel cost are significant determinants of UAM adoption. • Potential users were willing to pay more for UAM than for public transit. • Young, more educated individuals were more interested in UAM. • Older and high-income individuals were also interested about UAM, compared to low-income individuals.
Ahmed et al. (2021b) [28]	2021	Peer-reviewed journal article	Online survey	United States, and 17 other countries	692	Bivariate probit with correlated grouped random parameters	• Older individuals were less likely to use UAM. • Females were willing to use human operated UAM. • Cost-related concerns were identified as barriers towards UAM adoption. • Expectations of lower and more reliable travel time, reduction in safety incidents were identified as motivating factors.
Ahmed et al. (2022) [25]	2021	Peer-reviewed journal article	Online survey	United States	584	Bivariate probit, and binary probit with correlated grouped random parameters	• Older individuals, individuals currently living in suburban or rural areas are less likely to consider relocating residence. • Eco-conscious individuals were more likely to consider relocating to rural areas.
Desai et al. (2021) [12]	2021	Peer-reviewed journal article	Online survey	US, Europe, UK, South Africa, Canada, Singapore, India, the Middle East, China, and Australia.	51	Delphi technique	• Medical/emergency usage were identified as the best use case. • Intracity transportation was identified as worst use case (due to complexity vs. benefits). • Community backlash was identified as the most significant potential barrier towards UAM implementation.
Haan et al. (2021) [26]	2021	Peer-reviewed journal article	Online survey	5 US cities (Atlanta, Boston, Dallas-Ft.	1,405	Mixed logit	• New York and Los Angeles were found to be the most promising launch cities for UAM.

TABLE II

(Continued.) SUMMARY OF THE REVIEWED STUDIES ON URBAN AIR MOBILITY (UAM) AND ADVANCED AIR MOBILITY (AAM)

				Worth, San Francisco Bay area, Los Angeles combined statistical areas)			
Ilahi et al. (2021) [9]	2021	Peer-reviewed journal article	Travel diary, paper-based survey	Greater Jakarta, Indonesia	5,143	Mixed logit	• High-income individuals were more interested in UAM. • UAM is preferred for long-distance travel.
Nehk et al. (2021) [13]	2021	Peer-reviewed journal article	Online survey	16 countries worldwide	126	Delphi technique	• All-weather operation of UAM is unlikely. • Human-piloted operation, and semi-autonomous operation with operator on ground were found to be favorable over full-autonomy.
Reiche et al. (2021) [16]	2021	Peer-reviewed journal article	Online survey	5 US cities (Houston, Los Angeles, New York, San Francisco Bay area, Washington D.C.)	1,702	Descriptive analysis	• Respondents were apprehensive towards flying in UAM during inclement weather conditions (snow, rain, low visibility, turbulence). • General hot or cold weather did not affect willingness to fly in UAM.
Ward et al. (2021) [18]	2021	Peer-reviewed journal article	Online survey	United States, India	Two studies: 1,011; 859	ANOVA	• People in India were found to be more willing to fly in UAM. • Availability of parachute on-board increased the willingness to fly in UAM, more so in Americans than in Indians. • No difference was found between willingness to fly in UAM with or without remote pilot systems.

have tended to use various stated-preference survey structures [9], [21], [22].

B. Comparison of Results

The survey-based studies are analyzed in four parts. The first part presents the key findings of these studies (summarized in Table II). The second part discusses the effects of sociodemographic characteristics on UAM/AAM and flying car adoption (presented in Table III). The third part focuses on the effects of attitudinal variables and personal opinions on UAM/AAM and flying car adoption (presented in Table IV). Finally, the fourth part discusses the effects of trip characteristics and operational conditions on the willingness to use UAM/AAM and flying cars (summarized in Table V).

As depicted in Table II, regarding the general findings, preferences towards human piloted and autonomous operations were found to vary across studies. Reiche et al. [14] and Nehk et al. [13] found that human piloted operation of UAM aircraft was preferred over autonomous operation. However, Rautray et al. [27] reports that autonomous operation was preferred (with minimum user input). Inclement weather conditions were found to have an adverse effect on the willingness to use UAM [16], [17]. In terms of expected features from UAM aircraft, respondents preferred ample cabin space to avoid potential vertigo and claustrophobia [27], and the availability of a parachute for emergency evacuation [18]. The operational safety of UAM aircraft was found to be a key concern [27], [29]. Community backlash, likelihood of pilot error and mid-air collisions have also been identified as sources of concern [11], [12]. An interesting observation was drawn by Desai et al. [12], where the medical/emergency use of UAM aircraft was identified as one of the most promising early applications. However, Chappelle et al. [30] argued that the use of UAM aircraft is not financially viable in the near-term. Even in the long-term, financially viable emergency medical services operations using UAM aircraft would only be possible with a secondary mission-oriented autonomous operation.

The effect of sociodemographic characteristics on willingness to use UAM/AAM and flying cars is summarized in Table III. Gender-wise, Reiche et al. [14] and Garrow et al. [19] reported that males were more likely to use UAM. Haddad et al. [22] reported that females are less likely to be early adopters of UAM. This is in contrast with the findings by Ahmed et al. [28] where females were found to be more likely to adopt UAM. In two other studies, gender-specific effects were not observed [9], [21]. Regarding age and income level, generally consistent findings have been observed across studies. Younger individuals have been found to be more enthusiastic about UAM and flying cars, and willing to use them relative to their older counterparts [9], [14], [19], [21], [28]. Similarly, individuals from higher-income households were found to be more willing to use UAM and flying cars compared to individuals from lower-income households [14], [21], [22], [28]. Furthermore, highly educated

TABLE III
EFFECTS OF SOCIODEMOGRAPHIC CHARACTERISTICS ON URBAN AIR MOBILITY (UAM) ADOPTION

Predictor	Dependent variable	Effect on dependent variable	Study	Notes
Gender	Willingness to use	Male - positive	Reiche et al. (2018) [14]	Male respondents were more likely to use UAM.
	Willingness to use	No significant effect	Fu et al. (2019) [21]	Gender-specific differences not found.
	Willingness to adopt/use	Female - negative	Haddad et al. (2020) [22]	Female respondents showed lower interest to immediately adopt UAM compared to males.
	Enthusiasm towards UAM	Female - negative	Garrow et al. (2020) [19]	Female respondents have adverse perception towards UAM
	Willingness to use	Female - positive	Ahmed et al. (2021b) [28]	Female respondents were more willing to use Human operated UAM, compared to male respondents.
	Willingness to use	No significant effect	Ilahi et al. (2021) [9]	Gender-specific differences not found.
Age	Willingness to use	Young - positive	Reiche et al. (2018) [14]	
	Willingness to use	Young - positive; Old - negative	Fu et al. (2019) [21]	Young (18-35 years); old (46-65 years)
	Enthusiasm towards UAM	Young – positive; Old - negative	Garrow et al. (2020) [19]	Young (18-44 years); old (55 years and above)
	Willingness to use	Old - negative	Ahmed et al. (2021b) [28]	Negative correlation with age.
	Willingness to use	Young – positive	Ilahi et al. (2021) [9]	Positive correlation with age.
Income	Willingness to use	High income - positive	Reiche et al. (2018) [14]	
	Willingness to use	Low income - negative	Fu et al. (2019) [21]	
	Willingness to adopt/use	High income - positive	Haddad et al. (2020) [22]	
	Willingness to pay	High income - positive	Ahmed et al. (2021b) [28]	Annual household income $100k or above
Education	Willingness to use	Lower education - negative	Fu et al. (2019) [21]	
	Willingness to adopt/use	Doctoral level education - negative	Haddad et al. (2020) [22]	Doctoral degree holders expressed lower interest to be early adopters of UAM.
	Willingness to use	University educated - positive	Ilahi et al. (2021) [9]	Holds university degree.
Children in household	Enthusiasm towards UAM	Have child - positive	Garrow et al. (2020) [19]	Cautiously enthusiastic

TABLE IV
EFFECTS OF ATTITUDINAL VARIABLES AND PERSONAL OPINIONS ON URBAN AIR MOBILITY (UAM) ADOPTION

Predictor	Dependent variable	Effect on dependent variable	Study	Notes
Tech-savviness	Willingness to use	Positive	Reiche et al. (2018) [14]	Familiar with UAM.
	Enthusiasm towards UAM	Positive	Garrow et al. (2020) [19]	
	Willingness to adopt/use	Positive	Haddad et al. (2020) [22]	Affinity towards automation, social media.
Familiarity with advanced vehicle features	Willingness to use	Positive	Ahmed et al. (2021b) [28]	Familiar with ADAS.
	Receptive towards safety and security benefits	Negative		Unfamiliar with ADAS.
Driving joy/Pro-car attitude	Enthusiasm towards UAM	Lower pro-car attitude - positive	Garrow et al. (2020) [19]	Enthusiastic towards UAM.
	Enthusiasm towards UAM	Higher pro-car attitude - negative	Garrow et al. (2020) [19]	Adverse towards UAM.
	Willingness to use	Concerned about loss of driving joy – no significant effect.	Ahmed et al. (2021b) [28]	
Environmental consciousness	Enthusiasm towards UAM	Environmentally conscious -positive	Garrow et al. (2020) [19]	Super enthusiastic towards UAM.
	Enthusiasm towards UAM	Environmental indifference - negative	Garrow et al. (2020) [19]	Adverse towards UAM.
	Willingness to use	Expect environmental benefit - positive	Ahmed et al. (2021b) [28]	Expects less CO_2 emission from UAM, thus willing to use UAM.
Frequent air-traveler	Enthusiasm towards UAM	Positive	Garrow et al. (2020) [19]	Super enthusiastic towards UAM.

(university graduates) individuals were found to be more enthusiastic towards UAM and flying cars compared to high school educated individuals [9], [21]. Interestingly, Doctoral degree holders were found to be less likely to adopt UAM [22], which is in contrast to the findings of other studies. Finally, individuals from households with children, although being cautious, have been found to be keen to adopt UAM relative to other households [19].

The effect of attitudinal variables and personal opinions on UAM/AAM and flying car adoption are summarized in Table IV. Several attitudinal factors have been found to have a relatively consistent effect on individuals' interest towards UAM and flying cars. Individuals who were tech-savvy [14], [19], [22] familiar with advanced vehicle features [28], and eco-conscious [19], [28], have been found to be generally enthusiastic about UAM/AAM and flying cars. In countries with car-dependent transportation systems (such as the United States), driving is often considered as being synonymous with freedom, as well as being associated with the ability to engage more freely in recreational activities. Garrow et al. [19] reported that individuals with pro-car attitudes were less interested in UAM. However, Ahmed et al. [28] did not find any statistically significant effect of individuals' concern about loss of driving joy on willingness to use UAM. Finally, individuals who frequently traveled by traditional airplanes were found to be very enthusiastic about the introduction of UAM as a transportation mode [19].

Finally, Table V summarizes individuals' willingness to use UAM for different trip purposes and trip lengths, as identified from the studies. Individuals expressed interest in using UAM to travel to and from airports [14], [15]. This elevated interest in the use UAM for airport trips can be attributed to the utilization of air as the medium for both airplanes and UAM aircraft. Interestingly, despite the potential of UAM to reduce travel time within densely populated and congestion-prone urban areas, experts from across the world have deemed intracity trips (trips within a city) to be unrealistic due to the various associated complexities with air traffic control and so on [12]. This is supported by the findings of Reiche et al. [14] and Shaheen et al. [15]. However, the findings of Eker et al. [24] still showed a high degree of respondent interest in the use of UAM for short distance trips. It should be noted here that the definition of "short-distance" adopted in the aforementioned studies have been different, and the findings

TABLE V
EFFECTS OF TRIP CHARACTERISTICS ON URBAN AIR MOBILITY (UAM) ADOPTION

Predictor	Dependent variable	Effect on dependent variable	Study	Notes
Trip length	Willingness to use	Long-distance recreational – positive; Long-distance intercity – positive; Very short - negative	Reiche et al. (2018) [14]; Shaheen et al. (2018) [15]	Intercity trips: LA to San Diego, Washington D.C. to Baltimore.
	Willingness to use	No significant effect	Fu et al. (2019) [21]	Trip length did not have significant effect on willingness to use.
	Willingness to use	Short trips - positive	Ragbir et al. (2020) [17]	Short trips ~5 minutes.
	Willingness to use	Long-distance trips – positive	Ilahi et al. (2021) [9]	
	Willingness to use	Short distance trips – positive	Eker et al. (2020a) [24]	Trip length less than 50 miles.
	Willingness to use	Medium and long distance trips – negative	Eker et al. (2020a) [24]	Trip length greater than 50 miles.
Trip type	Willingness to use	Trip to airport - positive	Reiche et al. (2018) [14]; Shaheen et al. (2018) [15]	
	Willingness to use	Intracity trips - negative	Desai et al. (2021) [12]	Delphi study corresponds to expert opinion from across the world.
	Willingness to use	Work trip – positive	Eker et al. (2020a) [24]	
	Willingness to use	Educational activities – positive	Eker et al. (2020a) [24]	
	Willingness to use	Short-term shopping – positive	Eker et al. (2020a) [24]	

of various studies often cannot be directly compared. In terms of trip purpose, respondents expressed a willingness to use UAM for work trips, trips dedicated to educational activities, and short-term shopping trips [24].

IV. UAM/AAM AND FLYING CAR ECOSYSTEM – BENEFITS, CHALLENGES, AND IMPLEMENTATION STRATEGIES

Researchers have identified several potential benefits from the use of UAM/AAM and flying cars (summarized in Table VI). The most notable benefit is the potential of faster travel time in dense, congestion-prone urban areas by reducing demand from existing ground-based transportation infrastructures [31], [32]. Interestingly, one of the earlier studies on UAM highlighted the potential of UAM to reduce noise and air pollution in urban settings [31]. While this may be a feasible outcome, the majority of more recent studies have argued against these noise and pollution benefits [33], [34], [35].

Regarding infrastructure, because existing airfields and helipads can be repurposed as vertiports, initial infrastructure cost for UAM might be less than that of other new ground-based infrastructure construction (new road construction, public transportation network expansion) [32]. The possibility of faster package delivery using delivery drones (or UAM aircraft) compared to ground-based operation is also highlighted as a benefit [35].

Since UAM/AAM and flying car technology is still in its infancy, a pragmatic approach towards assessing the potential challenges is crucial. Existing studies have highlighted several challenges associated with the future introduction of UAM/AAM and flying car technology. First of all, the cost of UAM service has been identified as a major barrier, and it has been forecasted that UAM service would be a niche product for the economically affluent [33]. Also, if the cost of UAM cannot be reduced to an accessible level for the larger population, long term profitability would likely be a serious challenge for operators [33].

Ensuring safe and secure operation of UAM fleets has also been identified as a major challenge [23], [32], [35]. In addition, the existing air traffic control framework has been deemed inadequate to serve UAM networks, and a high level of automation would be required to make a large UAM

TABLE VI
SUMMARY OF THE STUDIES INVESTIGATING THE PROMISES, CHALLENGES, AND IMPLEMENTATION STRATEGIES OF URBAN AIR MOBILITY (UAM) AND ADVANCED AIR MOBILITY (AAM)

Reference	Publication year	Publication type	Topics covered	Key findings
Bandyopadhyay et al. (2018) [31]	2018	Conference paper	• Benefits • Implementation strategies	• Quicker travel in dense urban environment. • Unhindered goods transportation. • Congestion alleviation from city roads. • Noise and air contamination reduction.
Thipphavong et al. (2018) [32]	2018	Conference paper	• Benefits • Challenges • Implementation strategies	• Faster and more reliable travel time in congested cities. • Required infrastructure cost might be less than ground-based modes. • Major challenges were achieving balanced economic value, ensuring safe and secure operation, achieving community acceptance. • Developing reliable air traffic integration framework with redundancy.
Tuchen (2018) [40]; Tuchen (2020) [41]	2018	Conference paper	• Challenges	• A reliable data sharing framework among all transportation service providers is needed. • Integration of inter-modal and end-to-end mobility through connecting existing and future modes (namely, public transit, ride sharing – autonomous and human operated, UAM). • Ensuring data privacy in the interconnected data sharing framework for improved customer trust.
Vascik and Hansman (2018) [37]; Vascik et al. (2018) [38]	2018	Conference paper, Peer-reviewed journal article	• Challenges	• Existing ATC separation services will not serve UAM aircraft, requiring revisions. • High level of ATC automation required to maintain high capacity UAM network. • Ground infrastructure capacity mismatch with UAM demand will lead to delays, and congestion in airspace.
Kunchulia et al. (2019) [36]	2019	Conference paper	• Challenges • Implementation strategies	• Drone-based package delivery (up to 5lbs) is selected as minimum viable product for UAM introduction. • Existing regulations, safety and security issues were identified as the major concerns. • Faster delivery with real-time air location tracking have been identified as key advantages over ground-based operation.
Mathur et al. (2019) [39]	2019	Conference paper	• Challenges	• UAM implementation challenges in two paths: piloted operation, pilotless operation. • For piloted operation, expansion of existing ATC framework, pilot training and certification, and achieving community affirmation were identified as key challenges. • For pilotless operation, community affirmation, development of automated ATC operation, development of safety-critical software and certification process, and development of unambiguous human-machine interface for UAM were identified as key challenges.
Ahmed et al. (2020) [23]	2020	Peer-reviewed journal article	• Challenges • Implementation strategies	• Seven domains of challenges were identified: safety, pilot training and certification, infrastructure, environmental concern, logistics and sustainability, cyber security, and human factors.
Holbrook et al. (2020) [120]	2020	Conference paper	• Implementation strategies	• Relaxing existing regulations that mandate pilot requirement for each passenger aircraft. • Enable pilotless operation of aircraft. • Increase airspace capacity to accommodate high number of UAM aircrafts. • Relax pilot certification requirements for UAM aircrafts.
Shaheen and Cohen (2021) [33]; Cohen et al. (2021) [35]	2021	Report, Peer-reviewed journal article	• Challenges • Implementation strategies	• At launch, UAM is predicted to be an expensive, niche market. • Visual and noise pollution were identified as barriers. • Increased UAM activity at lower altitudes over residential areas is a major concern. • Range anxiety due to electric operation is another concern. • Development of remote piloting and autonomous UAM operation, in combination with unmanned traffic management (UTM) is a major technological challenge. • For operators, long-term profitability is a key concern. • Medical/emergency usage were identified as viable entry point for UAM technology.
Filippone and Barakos (2021) [34]	2021	Peer-reviewed journal article	• Challenges	• Existing battery and propulsion technologies were identified as inadequate to meet the claims. • UAM aircraft, as of now, would cause severe turbulence during take-off and landing – rendering them unusable in most residential setting. • Lack of redundancy in case of mechanical failure is highlighted for the UAM aircraft concepts. • Loud operating noise is identified as a key concern.

network operationally viable [33], [37], [38], [39]. Integration of UAM services with the existing ground-based transportation modes to ensure door-to-door mobility has also been identified as another major challenge [40]. To achieve this, a reliable data sharing framework would be needed among all transportation service providers (public transportation, transportation network companies, UAM services). Otherwise, it would not be possible to integrate transportation services to achieve true door-to-door mobility without experiencing intermodal delays. However, such data sharing understandably gives rise to concerns associated with data security. Customers would likely only trust data sharing schemes where they are assured that their personal information is safe [23], [40], [41].

Appropriate pilot training and certification process for human piloted UAM operation has also been identified as a challenge, as has the development of safety-critical software and software certification processes for pilotless autonomous operation [23], [39]. In addition to the aforementioned technical challenges, several societal barriers have been identified in the literature. Visual and noise pollution, high turbulence induced disturbances on the ground during low altitude operation and other such issues may result in community backlashes towards UAM [33], [34].

In terms of energy usage, corresponding emissions, and environmental impacts resulting from UAM fleet operation, Filippone and Barakos [34] expressed skepticism towards the zero-emission claims made by the proponents of electrical power. It was suggested that even though the battery-based operation itself may not result in emissions, the energy used to charge the batteries may or may not be produced from renewable sources. In a simulation-based UAM emission analysis conducted by Pukhova [42], it was found that if the electricity consumed by UAM is fully generated through renewable means (such as hydro-electric power plants), then UAM would have little to no adverse effect on current emission levels. This is also supported by the findings by Kasliwal et al. [43]. The latter study also found that for 100 km long trips, an electric vertical take-off and landing (eVTOL) vehicle with one pilot (and no passengers) would result in 35% lower emissions as compared to a single occupant conventional gas-operated ground vehicle, and 28% greater emissions as compared to a battery-operated ground vehicle with the same occupancy. It was also found that the benefits of eVTOL in terms of reduced emissions over gas-operated ground vehicles for trips shorter than 35 km is insignificant. As a result, the contribution of eVTOLs towards environmentally sustainable mobility systems may be limited.

Considering the aforementioned challenges, researchers have suggested a variety of implementation strategies. These include the development of a reliable and highly automated air traffic control system [37], [38], and developing highly reliable remote and autonomous piloting systems [33]. In terms of energy usage and emission standards, even though these topics are not explicitly addressed in the existing literature, it is crucial to engage in constructive discussions on the notion of restricting energy production to renewable sources (such as solar, wind, hydro-electric, and geothermal), and in synergetic efforts to achieve net emission reduction from the use of UAM and battery-operated ground vehicles.

V. UAM/AAM Market Demand Assessment

The mobility benefits of UAM/AAM are contingent on its potential to capture market share from existing transportation modes (personal car, transportation network companies, public transportation). Since UAM/AAM services have yet to enter the transportation network, researchers have relied on different types of simulation-based market demand assessment frameworks to pragmatically forecast the market share of UAM/AAM. Findings from the existing studies investigating this topic are summarized in Table VII.

Prior to the introduction of the term UAM, researchers often relied on different terminologies (on-demand air mobility – ODAM, on-demand mobility – ODM) to refer to the UAM concept. Kreimeier and Stumpf [44] forecasted that ODAM can capture up to 19% of modal share in Germany (entire country), when the per kilometer ODAM cost is assumed to be €0.4. However, only €0.1 increase in this cost was expected to result in a massive reduction to only 2% of modal share, demonstrating the highly price sensitive nature of an ODAM service. In the context of Northern California region and Washington D.C.-Baltimore area in the United States, Syed et al. [45] reports similar price sensitive nature of ODM market share. Their analysis indicated that the per mile cost of ODM should be kept between $1.0 and $1.25 for an ODM service to be viable. Otherwise, travelers will almost invariably lean towards personal cars and other existing transportation modes. The highly price sensitive nature of forecasted UAM market share is also supported by the work of Balac [46], where a forecasted daily trip demand of 1,027,000 at a cost of $1.94/km drops to only 29,000 at $5.82/km.

Assuming a 10-vertiport UAM network in Sioux Falls, United States, Rothfeld et al. [47] modeled the daily demand of UAM and found that UAM would capture a 4% trip share compared to 74% share belonging to car, and the rest belonging to public transportation and walking. Interestingly, walking yielded a share of 5%, greater than that of UAM. According to the simulation results by Tarafdar et al. [48], daily UAM demand in northern California was found to be sensitive to the number of vertiports in the network. Increasing the number of vertiports from 200 to 400 resulted in a greater than four times increase in daily UAM demand, while assuming a per mile cost of $1.74. Rajendran and Shulman [49] assumed a relatively simpler 5-vertiport network in New York City and estimated the weekly passenger count to be approximately 195,000, with 70 UAM aircraft operating in the network. In a subsequent study focusing on the same city [50], it was forecasted that the daily peak passenger count would be approximately 10,000. Bulusu et al. [51] modeled daily UAM demand in San Francisco Bay area, and forecasted that under congested road conditions, UAM would capture approximately 45% of the total commuter count of 327,579. However, when uncongested roads were considered, the share drops to only 3%. In a separate study [52], a 7% share for UAM was predicted in San Francisco, which is closer to the non-congested share percentage predicted by Bulusu et al. [51]. Wu and Zhang [53] introduced a method of estimating the UAM demand shift from ground transportation by combining network design and mode choice in an expanded single allocation hub-and-spoke problem. Assuming a 30-vertiport scenario in Tampa Bay Region, their study showed 0.2% of shifted demand (trips longer than 10 miles or with ground transportation time more than 30 minutes) at the price level of a base price $30 and unit distance cost $2 per flying mile. Rimjha et al. [54] forecasted a market share of UAM between 2.4% and 3.6% in the Greater Los Angeles area, when the cost per passenger per mile were $4 and $3, respectively. Another study [55], focusing

TABLE VII
SUMMARY OF STUDIES INVESTIGATING URBAN AIR MOBILITY (UAM) AND ADVANCED AIR MOBILITY (AAM) DEMAND ASSESSMENT AND/OR FLEET SIZE ESTIMATION

Reference	Publication year	Publication type	Location	Application scenario	Key findings
Kreimeier and Stumpf (2017) [44]	2017	Conference paper	Germany	Passenger transportation	• On-demand air mobility (ODAM) services capture 19% market share or 235 million annual trips, when competing against cars and CS-25 aircraft. • ODAM market share highly sensitive to the cost gap between ODAM and car. • If ODAM cost increases from 0.4 €/km to 0.5 €/km, the market share drops from 19% to 2%. • A cruise speed of 300 km/h is found to be optimal over greater speeds. • ODAM aircraft range between 400-500 km can cover 69% to 88% of total estimated ODAM trip demand.
Syed et al. (2017) [45]	2017	Conference paper	United States (Northern California, D.C.-Baltimore area)	Passenger transportation	• Conditional logit model calibrated to compute on-demand mobility (ODM) market share, against automobile and public transit at different cost and service scenarios. • Addition of $15 base fare substantially reduces ODM market share. • ODM market share is highly sensitive to the cost of automobile. • If automobile cost per mile reduces from 54 cents to 30 cents, ODM market share reduces by almost half. • For ODM to be competitive against automobile, per mile cost should be kept between $1.0 and $1.25.
Chappelle et al. (2018) [30]	2018	Conference paper	United States	EMS	• Investment in eVTOL-based EMS service is not financially viable in the near-term, compared to existing helicopter and aircraft-based services. • Near-term eVTOL performance capabilities do not match the EMS-specific needs. • Secondary-mission oriented, and autonomous operation of eVTOL may mitigate the financial and operational concerns in long-term.
Rothfeld et al. (2018) [47]	2018	Conference paper	Sioux Falls, United States	Passenger transportation	• With 10 vertiports assumed in the network, 6,179 daily UAM trips is predicted. • UAM yields 4% mode share, compared to 74% share belonging to car, 18% to public transit, and 5% to walking.
Balac et al. (2019) [121]	2019	Conference paper	Zurich, Switzerland	Passenger transportation	• Using a 10% population sample from Zurich, total daily UAM trip demands were estimated. • Daily demand is highly sensitive to the per kilometer cost, less sensitive to cruise speeds (60 km/h, 120 km/h, 240 km/h). • At 240 km/h cruise speed, the daily trip demand drops from approx. 350 to 75, when the variable cost increases from 0.6 CHF/km to 1.2 CHF/km.
Tarafdar et al. (2019) [48]	2019	Conference paper	Greater Northern California region, United States	Passenger transportation	• When compared to automobiles, daily UAM roundtrip demand increases from 7,924 to 15,790, then to 32,733 (assuming 200, 300 and 400 landing sites, respectively). • UAM demand sensitivity to per-mile cost not evaluated.
Fu et al. (2022) [57]	2020	Conference paper	Greater Munich area, Germany	Passenger transportation	• At different operation scenarios, UAM only accounts for 0.03% to 1.29% of total daily trips at most. • For 60-120 km long trips, the share increases to approx. 8%.
Mayakonda et al. (2020) [59]	2020	Conference paper	31 cities across the world	Passenger transportation	• UAM demand in 31 large cities across the world is forecasted in the year 2035. • At different pricings and different vertiport densities, UAM is forecasted to have a market share varying between 0.001% (highest cost, lowest vertiport density) and 8.507% (lowest cost, highest vertiport density).
Peksa and Bogenberger (2020) [122]	2020	Conference paper	Munich, Germany	Passenger transportation	• With 11 vertiports assumed in the network, an average of 633 daily trips per O-D pair is predicted. • The daily trip demand is sensitive to the pricing.
Ploetner et al. (2020) [58]	2020	Peer-reviewed journal article	Munich, Germany	Passenger transportation	• With 74 vertiports assumed in the network, approx. 125,000 passengers per day were projected to use UAM compared to 14 million daily trips. • This number represents approx. 1% of total daily trips. • For trips longer than 30 km, the share increases to 3-4%.

TABLE VII
(Continued.) SUMMARY OF STUDIES INVESTIGATING URBAN AIR MOBILITY (UAM) AND ADVANCED AIR MOBILITY (AAM) DEMAND ASSESSMENT AND/OR FLEET SIZE ESTIMATION

Rajendran and Shulman (2020) [49]	2020	Peer-reviewed journal article	New York City, United States	Passenger transportation	• With 5 vertiports assumed to serve in the most demanding locations, the weekly UAM passenger count is forecasted to be approx. 195,000. • In total, 70 UAM aircrafts were found to provide optimal network performance in terms of passenger time spent in network, and passenger waiting time.
Anand et al. (2021) [60]	2021	Conference paper	542 cities from 83 countries	Passenger transportation	• Two scenarios evaluated to predict UAM demand in 2035, 2040, 2045 and 2050. • In low demand scenario (120 km/h speed, 60 km range, low vertiport density) total UAM passenger trips were predicted to reach 58.34, 82.61, 99.41 and 127.8 billion in 2035, 2040, 2045 and 2050, respectively. • In high demand scenario (240 km/h speed, 120 km range, high vertiport density), total UAM passenger trips were predicted to reach 227.3, 279.1, 334.5 and 405.5 billion.
Balac (2021) [46]	2021	Conference paper	United States (11 largest combined statistical areas)	Passenger transportation	• For the 11 combined statistical areas, daily demand of 137,000 UAM trips is estimated with $3.88/km price for UAM. • The demand increases to 1,027,000 daily trips with $1.94/km price. • The demand decreases to only 29,000 with $5.82/km price. • New York City area has the highest overall demand compared to the other 10 areas.
Bulusu et al. (2021) [51]	2021	Peer-reviewed journal article	San Francisco Bay area (United States)	Passenger transportation	• For a given number of vertiports and under congested road conditions, 45% of commuters could benefit from UAM in terms of travel time savings. • With uncongested road conditions, 3% of commuters could benefit from UAM in terms of travel time savings.
Goyal et al. (2021) [56]	2021	Peer-reviewed journal article	United States	Passenger transportation	• AAM daily demand could reach 82,000 passengers, with approx. 4,000 AAM aircraft. • Total market share is predicted to be between 0.5% and 1%. • Demand is expected to be concentrated on trips that takes longer than 30 minutes with ground transportation modes.
Rajendran et al. (2021) [50]	2021	Peer-reviewed journal article	New York City, United States	Passenger transportation	• Daily UAM peak demand is found to be approx. 10,000 commuters. • Trips where at least 40% time is saved with UAM compared to other ground transportation modes, and trips without transfer requirements were considered.
Rimjha et al. (2021) [54]	2021	Conference paper	Los Angeles, United States	Airport trip demand	• UAM has the potential to capture between 2.4% and 3.6% market share of airport trips at a cost of $3 and $4 per passenger per mile, respectively. • The demand is less sensitive to the number of vertiports spread across Greater Los Angeles area.
Rothfeld et al. (2021) [52]	2021	Peer-reviewed journal article	Munich, Germany; Paris, France; San Francisco, United States	Passenger transportation	• With 24 assumed vertiports in the study region, UAM captures 3%, 13% and 7% of total motorized trips in Munich, Paris, and San Francisco, respectively.
Wu and Zhang (2021) [53]	2021	Peer-reviewed journal article	District 5, Florida, United States.		• The UAM market share varies between 0.187% and 2%, under most favorable and unfavorable pricing scenarios, respectively. • Increasing the number of vertiports in the network increases market share. However, the increase in market share becomes insignificant if more than 80 vertiports were added to the network.

on the Orlando/Space Coast area of Florida, forecasted an even lower market share for short take-off and landing aircraft (STOL)-based UAM service, varying between 0.187% and 2%. In the context of the entire United States, Goyal et al. [56] predicted that UAM would capture between 0.5% to 1% market share, with peak daily demand reaching 82,000 passengers, assuming that 4,000 UAM aircrafts were being operated.

In studies focusing on the Greater Munich area of Germany, both Fu et al. [57] and Ploetner et al. [58] forecasted a very small UAM market share (between 0.03% and 1.29% in the former, approximately 1% in the latter), whereas Rothfeld et al. [52] reported approximately a 3% market share. Rothfeld et al. [52] also forecasted the market share of UAM in Paris, France to be 13%, substantially higher than that of Munich.

In a global context, Mayakonda et al. [59] forecasted that in 31 large cities across the world in the year 2035, UAM would gain a market share between 0.001% and 8.507%, with the former achieved at highest forecasted per-trip cost and lowest vertiport density, and latter achieved at lowest forecasted per-trip cost and highest vertiport density. In a subsequent study [60], 542 cities from 83 countries were considered and the forecasts showed that yearly combined UAM passenger trip demand in all these cities may reach beyond 100 billion by 2050.

From the preceding discussion, it is clear that forecasted UAM trips and passenger numbers cover very broad ranges. This can be attributed to the vastly varying assumptions corresponding to the speed, capacity, recharging time requirements of UAM aircraft, number and capacity of vertiports. Since no reference UAM aircraft and corresponding performance specifications have been available, researchers have relied upon the specifications provided by different UAM aircraft and eVTOL manufacturers, resulting in such massive variations in forecasted UAM demands. To mitigate such issues, standardized UAM aircraft and vertiport specifications with maximum permitted deviations are needed so that demand forecasting efforts from different researchers and practitioners can produce meaningful and comparable results. In this context, the recently released vertiport design standards [61] can serve as a substantial step forward.

VI. Travel Time Comparison Between UAM/AAM and Other Transportation Modes

The key value proposition of UAM/AAM is the reduction of travel time over other existing transportation modes. To pragmatically assess this, researchers have conducted simulation-based travel time comparisons between UAM/AAM and other ground-based transportation modes, as well as with traditional air travel. An abundance of studies undertook this assessment. For example, Wei et al. [55] compared commuting time requirements for 4,528 origin-destination pairs located in five counties in South Florida for trips made by short take-off and landing aircraft (STOL) and personal cars. Utilizing the existing 500ft or longer runways and a cruise speed of 160 knots, a 45% reduction in trip time is achieved with STOL for trips that take 45 minutes or longer in personal cars. In other work, Swadesir and Bil [62] conducted travel time comparisons among UAM, personal car, public transportation and bicycling for trips made in Melbourne Australia metropolitan area. In 88% of cases, on-demand UAM was found to be the fastest travel mode. The travel time benefit was particularly greater for trips that were at least 10 kilometers or longer. In this analysis, 35 minutes of UAM ground processing time was assumed.

Even though UAM promises to reduce travel time in congested urban areas, a key concern is the potential competition of UAM with public transportation systems. In this context, Rothfeld et al. [52] presented intriguing findings. Motorized trips in Munich, Paris and San Francisco were analyzed, and hypothetical market shares of UAM were predicted. The results showed that 40% of public transportation trips in San Francisco were captured by UAM. Furthermore, 49% and 74% of public transportation trips were captured by UAM in Munich and Paris, respectively. These findings clearly suggest that UAM may start gaining modal share by capturing trips that are originally made by using public transportation. Zapico et al. [63] reports similar findings for the city of Chicago, where potential daily trip counts were predicted assuming \$5.73, \$1.86, and \$0.44 per passenger per mile cost of UAM in the initial, short, and long term, respectively. With the initial cost, UAM was unable to attract any trips at all when competing against personal car and public transportation. With the short-term cost, only 0.87% of trips were predicted to be captured by UAM. With the long-term cost, UAM captures approximately 39% of all daily trips. This is achieved at the expense of "cannibalizing" almost 43% of the trips made by public transportation.

Another potential use for UAM/AAM is regional trips. Roy et al. [64] evaluated the potential of advanced conventional take-off and landing (CTOL) aircraft powered by fuel (and their electric counterparts - eCTOL) in serving as a viable mode for making regional trips, with the US Midwest as the study region. The analysis results showed that for 200-300 miles long trips, CTOL/eCTOL based AAM services offer shorter trip durations relative to personal cars, and traditional short-haul commercial airline flights. However, when value of time is considered, the benefit gained through travel time reduction becomes marginal. Furthermore, after considering the affordability of CTOL-based services, it is estimated that only 2.42% of individuals in the Midwest would be able to afford such a service. For eCTOL, however, it was estimated that 8.7% of the individuals would be able to afford them.

VII. Infrastructure Requirements

For safe and efficient operation of UAM aircraft, a take-off and landing infrastructure is needed for the operation of UAM services, which constitutes the most significant part of the UAM infrastructure requirement. Such infrastructure is given the names of vertiport, vertipad, and vertistop [61] Vertiport refers a large facility with multiple take-off and landing (TLOF) pads, charging stations, and passenger waiting areas. Vertipad and vertistop are exchangeable terms, referring to a single TLOF pad and primarily serving as a pickup and drop-off point. However, STOLs are also often imagined as an alternative aircraft for UAM service. To accommodate these two broader categories of aircraft, existing facilities such as helipads, short airfields and runways can potentially be repurposed. Such repurposing could be retrofitting an entire helipad to a vertistop, constructing vertiport(s) on airport aeronautical use surface without using existing runways (for more busy commercial airports), or using part of existing runways and facility at airports for accommodating AAM service (for underutilized commercial and general aviation airports). Furthermore, in high demand locations in dense urban settings or underserved rural areas where no such facilities are available, newly constructed vertiports would be needed [23], [65].

For repurposing or new construction, vertiport development faces two similar major issues, ensuring safe take-off and landing of eVTOLs and STOLs and the integration with existing air traffic patterns, and ensuring that the locations of these facilities are optimal for UAM operation and would be able to fulfill the travel demand. To address the first issue, several factors must be considered. For example, the aerodynamics of the facilities would play a crucial role in safe approach and take-off of UAM aircrafts [66], [67]. Specifically, vertiports located on the rooftop of existing buildings would be affected by the wind flow pattern and shape of the building, as they directly result in vortexes and consequently affect take-off and landing of UAM aircraft. The presence and effect of surrounding obstacles on take-off and landing maneuvers is also important because the ascending and descending angles and corresponding vertical and horizontal clearances are determined by them [68]. To solve this, the importance of developing vertiport approach control frameworks at the individual vertiport level has been demonstrated [69], [70]. In addition, for vertiports on or near commercial airports, arrival and departure procedures, or 4-D trajectories within the concept of Trajectory Based Operations, of eVTOLs and STOLs need to be carefully planned without interfering commercial flight operations. Given assumed vertiport locations on Tampa International Airport, study [71] applied Rapidly Exploring Random Tree (RRT) algorithm to design minimum cost VTOL trajectories that stay a specified distance from current manned operations, terrain features, and obstacles.

With regard to the second issue (ensuring that the locations of vertiports and vertistops are optimal for UAM operation and would be able to fulfill the travel demand), this is essentially a network design problem that needs to consider the interactions between the siting of the vertiport and mode competition between UAM and existing ground transportation modes. Some studies addressed the problem from demand side and have the vertiports located in areas with highest demand, so that maximum number of travelers can be served [65], [72]. [73]. The decision of repurposing existing helipads or airfield as vertiports and developing new ones depends on the contribution of the facilities to the overall UAM network performance [72], [73]. In two separate studies [74], [75], a K-means clustering algorithm was employed to identify reasonable locations for vertiport placement for UAM services in Seoul, South Korea metropolitan area. In the former study, the number of vertiports allowed within the network was varied incrementally from 2 to 36, with an increment of 2 in each simulation run. In the latter study, two scenarios with 40 and 100 vertiports were analyzed, and 100 vertiports was found to be optimal for the Seoul Metropolitan Area. Another instance of employing a K-means clustering algorithm to identify vertiport placement sites is found in the work of Tarafdar et al. [48], where the Northern California region was studied. Wei et al. [76] utilized a P-median clustering approach to identify optimal vertiport placement sites in the South Florida region. Given certain level of OD demand, several optimization schemes have been proposed in the UAM literature to determine the optimal locations of vertiports. Daskilewicz et al. [65] modeled the vertiport placement problem for San Francisco and Los Angeles, using a Gurobi optimization solver for a variable maximum number of vertiports allowed in the network. Chen et al. [77] proposed a grid-based optimization framework with novel local neighborhood search step, where the travel demands were allowed to be spread across entire metropolitan areas, and provisions of excluding certain grid cells due to safety/geographic reasons were incorporated. Willey and Salmon [78] employed a modified P-hub median location algorithm to identify optimal vertiport placement sites in three major metropolitan areas of the United States (Salt Lake City-Provo-Orem, Dallas-Fort Worth, and Washington-Baltimore-Arlington). Kai et al. [79] proposed an adaptive discretization scheme to optimize the number, locations, and capacities of vertiports in a UAM network. This approach combines the mixed-integer second-order conic optimization and a non-convex demand function to achieve a global optimum solution in the optimization scheme. Finally, Shin et al. [80] formulated a hub location problem to find optimal vertiport locations in Gangnam and Seocho Districts of Seoul Metropolitan area, South Korea. To solve the hub location problem, a heuristic algorithm based on a genetic algorithm was employed. Wu and Zhang [53] extended single allocation hub and spoke modeling by adding a set of deterministic mode choice constraints for determining the optimal locations of vertiports, shifted demand from ground transportation, allocation of passengers to vertiports, and their access and egress modes. In all of the aforementioned studies, census data corresponding to the study area, and trip origin-destination databases, either at the aggregate or disaggregate levels, were utilized as inputs, without considering induced demand that might possibly occur due to the introduction of the new transportation mode.

Some studies investigated arrival and departure scheduling optimization for increasing the utilization of vertiport capacity. For a given number of available landing and take-off pads, appropriate arrival and departure scheduling frameworks have been shown to be critical [81]. Among the proposed scheduling frameworks, first-come first-served scheduling [82], rolling-horizon take-off and landing scheduling [83], branch queuing approach [84], hybrid simulation goal programming [85], Markov decision process algorithm-based departure and arrival scheduling [86], [87], mixed-integer linear programming-based arrival and departure scheduling [88], [89], and heuristic insertion and local search combined with mixed-integer linear programming and time-advance algorithm employed arrival scheduling [90], have been the most prominent approaches. It is important to note that the aforementioned studies did not adopt standardized assumptions regarding the operational characteristics of the UAM aircraft (passenger capacity, cruise speed), and vertiport characteristics (number of pads, physical dimensions of the pads, capacity of passenger waiting area etc.). Thus, it is not feasible to identify any specific scheduling framework that performs the best since to make valid comparisons the adoption of both standardized operational characteristics of UAM aircraft and vertiports would be necessary.

To address the ambiguity in the physical specification of UAM landing pads, the Federal Aviation Administration released design standards for vertiports in late 2022 [61]. This guideline consists of detailed geometric characteristics, lighting-marking-visual aid characteristics, and specifications for charging and electric infrastructures. Furthermore, distinct requirements for vertiports located on airports and on the rooftops of existing structures are also provided. With the standardized guidelines taken into consideration, any ambiguity stemming from the use of varying vertiport types in prior studies would be substantially minimized, and results from future studies adopting these standards would be more directly comparable and transferable. In addition, state and local municipalities will play significant roles in vertiport development approval [91]. Florida Department of Transportation is taking the lead in developing land use and zoning guidelines for vertiport development, which include suggested processes for vertiport developing companies to follow when they consider constructing on-airport and off-airport vertiports and vertistops.

VIII. Policy Implications and Regulatory Directions for the UAM Ecosystem

The present air transportation system is a highly regulated ecosystem. Airplanes and helicopters are subject to rigorous certification processes, the airspace is classified and controlled accordingly, and airports and helipads are subject to strict conformation to safety and operational regulations. Since UAM aircraft will utilize the airspace to transport passengers and goods from one place to another, they will have to share the airspace with the traditional aircraft such as helicopters, turboprop, and jet airplanes [32], [86]. An additional layer of complexity would be added by the presence of smaller uncrewed civilian drones [91]. In this context, as the likelihood of a congested airspace keeps growing, a strict airspace regulatory framework is crucial to ensure safe and secure operation of all airspace users.

Over the last decade, the meteoric rise of transportation network companies (Uber, Lyft, DiDi, Grab, Careem, Beat) as well as food delivery services (Uber Eats, Grubhub, DoorDash, Postmates, Zomato, Meituan, Ele.me, Wolt, Lieferando, Rappi) have brought forth substantial regulatory challenges to government and public entities [93]. The speed at which regulatory entities operate has historically been substantially slower than the speed at which new technical innovations are introduced. Regarding ground-based ridesharing services, the extent of safety and security concerns was not substantial because they utilized existing vehicles that already had to conform to various regulations. However, this is in clear contrast to the envisioned UAM ecosystem due to the planned use of new aircraft, utilization of low-altitude airspace, and construction of vertiports. Thus, it is crucial to have strict regulations to ensure safe and secure operation of UAM services prior to their entry to the existing transportation ecosystem. These regulations should encompass minimum performance, safety, and physical dimension standards for UAM aircraft, design standards for vertiports, airspace management system to ensure vertical and horizontal separation among airspace users [94], [95], [96], as well as energy usage and emission standards for UAM aircraft to ensure sustainable operation [33], [97], [98], [99], [100], [101], [102]. In addition to the aforementioned core requirements, there are additional concerns about restricting airspace near sensitive infrastructures and areas important to national security [20].

From an environmental and societal point of view, one of the key concerns with the future introduction of UAM is the operational noise caused by the propulsion mechanism of the UAM aircraft [31], [33], [34]. This is particularly important because prolonged exposure to noise emitted from aircraft has been shown to lead to health issues including speech interference [103], sleep disruption [104], increased risk of hypertension and cardiovascular disease [105], as well as economic consequences such as the loss of property value due to close proximity to airports/vertiports [37]. To identify the upper threshold of tolerable noise from UAM operation for individuals located on ground, a citizen participatory noise sensing approach has been proposed [106]. This approach is expected to assist in devising appropriate UAM noise threshold regulations for different land-use cases (thresholds in central business district – CBD – areas, suburban residential areas, mixed use areas).

Another issue uncovered in existing studies shows that despite UAM bringing travel time benefits, it often does so at the expense of the public transportation market share in larger cities with more developed and well connected public transportation network [52], [57], [63]. This has important implications, especially in the context of European cities, because the loss in public transportation ridership may eventually lead to service reductions in terms of coverage and frequency, and consequently affect access to mobility for travelers who solely rely on public transportation. In addition, it is likely that the UAM fleet may consume more energy than rapid public transportation powered by renewable energy when serving the same routes, thereby adversely affecting the environment and contributing to climate change. Furthermore, the literature on UAM market share and demand analysis demonstrates that even if the per passenger per mile cost of UAM is reduced to the personal car ownership level, UAM's market share gain may not be substantial [63]. This implies that UAM may tend to be a niche market for the affluent individuals, who have higher values of time. Taking the aforementioned issues into account, it is of public interest to encourage cooperation instead of competition between UAM operations and public transportation, for example, co-locating vertiports with metro stations to expand the coverage of public transportation and reduce the single vehicle access to and egress from stations.

It is also important to recognize that the secure operation of UAM fleets would rely on multiple forms of wireless communication. These include the communication with airspace management system, inter-UAM aircraft communication to ensure vertical and horizontal separation and dynamic flight path planning, and reception of short-term wind and precipitation forecasts. To reliably carry out the aforementioned tasks, the applicability of the third generation partnership project, fifth generation cellular network technology [107], radio frequency and/or optical communication emitters and receivers are currently being investigated [108], [109], [110]. Communication channels impervious to external interferences, as well as to cyber-attacks are crucial for secured operation of UAM fleets. Regulatory frameworks delineating exclusive radio frequencies for UAM communications, specifications of the radio frequencies and optical sensors, and the maximum simultaneous data throughput capacity based UAM network operation (maximum number of simultaneously operable UAM aircrafts in a network) would be needed.

Even though the envisioned UAM ecosystem holds the promise for safe passenger transportation, the likelihood of accident occurrence cannot be discarded [111], [112]. In the long run, the possibility exists for UAM to go from single-piloted and ground assisting to automated flying and ground monitoring. In this context, establishing a rigorous training and certification program for UAM pilots and ground operators would be needed [39]. When an accident occurs within the existing air transportation and ground transportation systems, rigorous frameworks must be in place to initiate investigations to identify the cause. This is especially true for airplanes, such as the inclusion of black box where the activities of all important components are recorded to aid in post-crash investigations. For UAM aircrafts regulations mandating the inclusion of such tools during vehicle designing and manufacturing stages would be needed [11], [39].

Despite the aforementioned challenges in the policy and regulatory domains, several countries have explored various aspects of such new transport modes. For example, Singapore's Economic Development Board (EDB) signed Memorandums of Understanding (MOU) with Skyports and Volocopter to utilize Seletar Aerospace Park for an AAM development hub [113]. In the United Kingdom, the government has collaborated with several British aviation companies to assess the feasibility of AAM in the country [114]. The Transportation Ministry of Germany and the Government of Saudi Arabia have also invested in UAM/AAM development projects [115], [116]. In Dubai, the United Arab Emirates (UAE) authorities have signed an agreement with the Canadian company VPorts to develop an AAM integrator center where companies investigating multiple aspects of the AAM ecosystem would be invited to make progress towards the introduction of AAM [117]. In July 2022, the National Aviation Authorities (NAA) network was established, which includes the United Kingdoms, Australia, Canada, New Zealand, and the USA [118]. The mission of the NAA network is to foster cooperation on emerging challenges in aviation and aerospace, improving innovation and safety. Safely integrating AAM into existing airspace systems is one of the main challenges that this network aim to address. In addition, the US Federal Aviation Administration (FAA) signed Declarations of Cooperation with the counterparts in Japan and Korea to collaborate on the development of safety oversight frameworks including airworthiness, licensing and operation related regulations and policies [119]. The National Academies of Sciences, Engineering and Medicine recently published a detailed guideline aimed at the US state DOTs and other transportation agencies summarizing the risks and challenges related to disruptive emerging transportation technologies, one of which is AAM [123]. These recent developments illustrate actions at government level to explore UAM/AAM ecosystem which can be viewed as precursor to the eventual formulation of pragmatic and holistic policies and regulatory frameworks.

IX. Summary and Conclusion

Even though UAM/AAM and flying car technologies are not yet available to the general public and no specific launch time is on the horizon, the studies reviewed in this paper shed light on several important issues. Public perception-oriented studies revealed that UAM would be popular among young people, people with college educated backgrounds, and people from high-income households. In addition, tech-savvy and environmentally conscious individuals, individuals familiar with advanced vehicle features, and frequent air travelers are expected to be more likely to be early adopters of this technology. Long-distance intercity and recreational trips have been identified as favorable use cases, whereas for very short trips UAM usage has been generally identified as unfavorable.

Faster and more reliable travel time in congested city environments has been identified as the most desirable benefit offered by this technology. However, the associated challenges are multifaceted. Societal challenges and concerns include noise and visual pollution, high turbulence induced annoyances in residential areas. Technical challenges include the necessity of a highly automated and reliable air traffic management system, a reliable communication infrastructure, an extensive pilot and ground operator training and certification process for human piloted operation, certification of safety-critical autonomous piloting software, and an efficient integration framework for UAM and other currently existing transportation modes.

From a regulatory perspective, a rigorous airspace regulatory framework is warranted to ensure safe and secure usage by the airspace users. For the UAM aircraft, minimum performance, safety, and physical dimension standards are needed, along with the design standards for vertiports. Furthermore, regulations defining the maximum noise thresholds, energy consumption and emission standards are also needed. Safe and secure operation of UAM would also rely on reliable wireless communication framework, warranting rigorous regulatory framework to standardize the minimum requirements. In the unfortunate event of accidents involving UAM aircraft, investigations would need to be carried out quickly and efficiently to identify the cause. To accomplish this, tools (comparable to airplane black box) that enable post-crash investigation would need to be mandated in UAM aircraft design.

Studies forecasting UAM demands have generally demonstrated that UAM would occupy a minor amount of the overall market share and would be costly in the near-term and, even with a marginal cost reduction in the long-term, the technology is still likely to be a niche segment. Studies suggested that the UAM network should be carefully designed to integrate with existing multimodal transportation systems to provide seamless door-to-door service. Moreover, if UAM services are offered in routes already served by rapid public transportation systems, there is ample evidence from past studies that public transportation ridership can be expected to drop, which is undesirable from a transportation equity perspective and would need to be mitigated through appropriate regulations.

Overall, the introduction of UAM/AAM and flying car technology into the existing transportation network would be faced by multifaceted, multidisciplinary challenges. Despite public interest, current evidence suggests it would be difficult to offer UAM service for the masses at a reasonable cost. Research findings suggest that it is highly likely that UAM would remain as a niche segment primarily serving the affluent. However, with this said, it is a possibility that UAM may become an important component of a future transportation system, initially serving a modest and high-value role in much the same way as traditional air transportation established its place among transportation modal alternatives.

REFERENCES

[1] Federal Aviation Administration. *Urban Air Mobility and Advanced Air Mobility*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.faa.gov/uas/advanced_operations/urban_air_mobility

[2] M. G. Bellizzi, L. Eboli, and G. Mazzulla, "Air transport service quality factors: A systematic literature review," *Transp. Res. Proc.*, vol. 45, pp. 218–225, Jan. 2020.

[3] F. Benita, "Human mobility behavior in COVID-19: A systematic literature review and bibliometric analysis," *Sustain. Cities Soc.*, vol. 70, Jul. 2021, Art. no. 102916.

[4] M. A. Ilham, A. Fonzone, G. Fountas, and L. Mora, "To move or not to move: A review of residential relocation trends after COVID-19," *Cities*, vol. 151, Aug. 2024, Art. no. 105078.

[5] Clarivate. *Web of Science*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.webofscience.com/

[6] Elsevier. *Scopus*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.scopus.com/

[7] B. V. Wee and D. Banister, "How to write a literature review paper?" *Transp. Rev.*, vol. 36, no. 2, pp. 278–288, Mar. 2016.

[8] A. Straubinger, U. Kluge, M. Fu, C. Al Haddad, K. O. Ploetner, and C. Antoniou, "Identifying demand and acceptance drivers for user friendly urban air mobility introduction," in *Towards User-Centric Transport in Europe 2: Enablers of Inclusive, Seamless and Sustainable Mobility*, B. Müller and G. Meyer, Eds. Cham, Switzerland: Springer, 2020, pp. 117–134.

[9] A. Ilahi, P. F. Belgiawan, M. Balac, and K. W. Axhausen, "Understanding travel and mode choice with emerging modes; A pooled SP and RP model in Greater Jakarta, Indonesia," *Transp. Res. A, Policy Pract.*, vol. 150, pp. 398–422, Aug. 2021.

[10] S. Rajendran and E. Pagel, "Recommendations for emerging air taxi network operations based on online review analysis of helicopter services," *Heliyon*, vol. 6, no. 12, Dec. 2020, Art. no. e05581.

[11] M. J. Schuurman, B. Rattanagraikanakorn, C. Kassapoglou, and R. De Breuker, "Urban air mobility (UAM) vehicle design considerations to facilitate future accident investigation," in *Proc. AIAA Aviation Forum*, 2019, p. 3628.

[12] K. Desai, C. Al Haddad, and C. Antoniou, "Roadmap to early implementation of passenger air mobility: Findings from a delphi study," *Sustainability*, vol. 13, no. 19, p. 10612, Sep. 2021.

[13] N. Nehk, V. Tiberius, and S. Kraus, "Urban air mobility: Projections for air taxis," *Int. J. Innov. Technol. Manage.*, vol. 18, no. 7, Nov. 2021, Art. no. 2150033.

[14] C. Reiche et al., "Urban air mobility market study," National Aeronaut. Space Admin., Washington, DC, USA, Tech. Rep., 2018. [Online]. Available:https://doi.org/10.7922/G2ZS2TRG

[15] S. Shaheen, A. Cohen, and E. Farrar, "The potential societal barriers of urban air mobility (UAM)," Nat. Aeronaut. Space Admin., Tech. Rep., 2018. [Online]. Available: https://doi.org/10.7922/G28C9TFR

[16] C. Reiche, A. P. Cohen, and C. Fernando, "An initial assessment of the potential weather barriers of urban air mobility," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6018–6027, Sep. 2021.

[17] N. K. Ragbir, S. Rice, S. R. Winter, E. C. Choy, and M. N. Milner, "How weather, distance, flight time, and geography affect consumer willingness to fly in autonomous air taxis," *Collegiate Aviation Rev. Int.*, vol. 38, no. 1, pp. 69–87, 2020.

[18] K. A. Ward et al., "Safety systems, culture, and willingness to fly in autonomous air taxis: A multi-study and mediation analysis," *J. Air Transp. Manage.*, vol. 91, Mar. 2021, Art. no. 101975.

[19] L. A. Garrow, P. Mokhtarian, B. German, and S.-S. Boddupalli, "Commuting in the age of the jetsons: A market segmentation analysis of autonomous ground vehicles and air taxis in five large us cities," in *Proc. AIAA Aviation Forum*, 2020, p. 3258.

[20] U. Eker, S. S. Ahmed, G. Fountas, and P. C. Anastasopoulos, "An exploratory investigation of public perceptions towards safety and security from the future use of flying cars in the United States," *Analytic Methods Accident Res.*, vol. 23, Sep. 2019, Art. no. 100103.

[21] M. Fu, R. Rothfeld, and C. Antoniou, "Exploring preferences for transportation modes in an urban air mobility environment: Munich case study," *Transp. Res. Rec., J. Transp. Res. Board*, vol. 2673, no. 10, pp. 427–442, Oct. 2019.

[22] C. Al Haddad, E. Chaniotakis, A. Straubinger, K. Plötner, and C. Antoniou, "Factors affecting the adoption and use of urban air mobility," *Transp. Res. A, Policy Pract.*, vol. 132, pp. 696–712, Feb. 2020.

[23] S. S. Ahmed et al., "The flying car—Challenges and strategies toward future adoption," *Frontiers Built Environ.*, vol. 6, p. 106, Jul. 2020.

[24] U. Eker, G. Fountas, and P. C. Anastasopoulos, "An exploratory empirical analysis of willingness to pay for and use flying cars," *Aerosp. Sci. Technol.*, vol. 104, Sep. 2020, Art. no. 105993.

[25] S. S. Ahmed, G. Fountas, U. Eker, and P. C. Anastasopoulos, "Are we willing to relocate with the future introduction of flying cars? An exploratory empirical analysis of public perceptions in the United States," *Transportmetrica A, Transp. Sci.*, vol. 18, no. 3, pp. 1025–1052, Dec. 2022.

[26] J. Haan, L. A. Garrow, A. Marzuoli, S. Roy, and M. Bierlaire, "Are commuter air taxis coming to your city? A ranking of 40 cities in the United States," *Transp. Res. C, Emerg. Technol.*, vol. 132, Nov. 2021, Art. no. 103392.

[27] P. Rautray, D. J. Mathew, and B. Eisenbart, "Users' survey for development of passenger drones," in *Proc. Design Society, Design Conf.*, vol. 1, 2020, pp. 1637–1646.

[28] S. S. Ahmed, G. Fountas, U. Eker, S. E. Still, and P. C. Anastasopoulos, "An exploratory empirical analysis of willingness to hire and pay for flying taxis and shared flying car services," *J. Air Transp. Manage.*, vol. 90, Jan. 2021, Art. no. 101963.

[29] U. Eker, G. Fountas, P. C. Anastasopoulos, and S. E. Still, "An exploratory investigation of public perceptions towards key benefits and concerns from the future use of flying cars," *Travel Behaviour Soc.*, vol. 19, pp. 54–66, Apr. 2020.

[30] C. Chappelle, C. Li, P. D. Vascik, and R. J. Hansman, "Opportunities to enhance air emergency medical service scale through new vehicles and operations," in *Proc. Aviation Technol., Integr., Operations Conf.*, Jun. 2018, p. 2883.

[31] A. Bandyopadhyay, N. S. S. Raj, and J. T. Varghese, "Coexisting in a world with urban air mobility: A revolutionary transportation system," in *Proc. Adv. Sci. Eng. Technol. Int. Conf. (ASET)*, Feb. 2018, pp. 1–6.

[32] D. P. Thipphavong et al., "Urban air mobility airspace integration concepts and considerations," in *Proc. Aviation Technol., Integr., Operations Conf.*, Jun. 2018, p. 3676.

[33] S. Shaheen and A. Cohen, "Urban air mobility: Opportunities and obstacles," in *International Encyclopedia of Transportation*. Berkeley, CA, USA: Transportation Sustainability Research Center, 2021.

[34] A. Filippone and G. N. Barakos, "Rotorcraft systems for urban air mobility: A reality check," *Aeronaut. J.*, vol. 125, no. 1283, pp. 3–21, Jan. 2021.

[35] A. P. Cohen, S. A. Shaheen, and E. M. Farrar, "Urban air mobility: History, ecosystem, market potential, and challenges," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6074–6087, Sep. 2021.

[36] A. Kunchulia, T. Edwards, S. Hasan, and G. Price, "Urban air mobility minimum viable product," in *Proc. AIAA Aviation Forum*, Jun. 2019, p. 2874.

[37] P. D. Vascik and R. J. Hansman, "Scaling constraints for urban air mobility operations: Air traffic control, ground infrastructure, and noise," in *Proc. Aviation Technol., Integr., Operations Conf.*, Jun. 2018, p. 3849.

[38] P. D. Vascik, R. J. Hansman, and N. S. Dunn, "Analysis of urban air mobility operational constraints," *J. Air Transp.*, vol. 26, no. 4, pp. 133–146, Oct. 2018.

[39] A. Mathur, K. Panesar, J. Kim, E. M. Atkins, and N. Sarter, "Paths to autonomous vehicle operations for urban air mobility," in *Proc. AIAA Aviation Forum*, Jun. 2019, p. 3255.

[40] S. Tuchen, "Role of aviation in seamless end-to-end mobility," in *Proc. IEEE/AIAA 37th Digit. Avionics Syst. Conf. (DASC)*, Sep. 2018, pp. 1–8.

[41] S. Tuchen, "Multimodal transportation operational scenario and conceptual data model for integration with uam," in *Proc. Integr. Commun. Navigat. Surveill. Conf. (ICNS)*, Sep. 2020, pp. 1–15.

[42] A. Pukhova, "Environmental evaluation of urban air mobility operation," Master's thesis, Dept. Civil, Geo Environ. Eng., Tech. Univ Munich (TUM) Munich, Germany, 2018.

[43] A. Kasliwal et al., "Role of flying cars in sustainable mobility," *Nature Commun.*, vol. 10, p. 1555, Apr. 2019.

[44] M. Kreimeier and E. Stumpf, "Market volume estimation of thin-haul on-demand air mobility services in Germany," in *Proc. 17th AIAA Aviation Technol., Integr., Operations Conf.*, Jun. 2017, p. 3282.

[45] N. Syed et al., "Preliminary considerations for ODM air traffic management based on analysis of commuter passenger demand and travel patterns for the silicon valley region of California," in *Proc. 17th AIAA Aviation Technol., Integr., Operations Conf.*, Jun. 2017, p. 3082.

[46] M. Balac, "The market potential of urban air mobility in the USA: Analysis based on open-data," in *Proc. IEEE Int. Intell. Transp. Syst. Conf. (ITSC)*, Sep. 2021, pp. 1419–1424.

[47] R. Rothfeld, M. Balac, K. O. Ploetner, and C. Antoniou, "Initial analysis of urban air mobility's transport performance in sioux falls," in *Proc. Aviation Technol., Integr., Operations Conf.*, Jun. 2018, p. 2886.

[48] S. Tarafdar, M. Rimjha, N. Hinze, S. Hotle, and A. A. Trani, "Urban air mobility regional landing site feasibility and fare model analysis in the greater northern California region," in *Proc. Integr. Commun., Navigat. Surveill. Conf. (ICNS)*, Apr. 2019, pp. 1–11.

[49] S. Rajendran and J. Shulman, "Study of emerging air taxi network operation using discrete-event systems simulation approach," *J. Air Transp. Manage.*, vol. 87, Aug. 2020, Art. no. 101857.

[50] S. Rajendran, S. Srinivas, and T. Grimshaw, "Predicting demand for air taxi urban aviation services using machine learning algorithms," *J. Air Transp. Manage.*, vol. 92, May 2021, Art. no. 102043.

[51] V. Bulusu, E. B. Onat, R. Sengupta, P. Yedavalli, and J. Macfarlane, "A traffic demand analysis method for urban air mobility," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6039–6047, Sep. 2021.

[52] R. Rothfeld, M. Fu, M. Balać, and C. Antoniou, "Potential urban air mobility travel time savings: An exploratory analysis of munich, paris, and san Francisco," *Sustainability*, vol. 13, no. 4, p. 2217, Feb. 2021.

[53] Z. Wu and Y. Zhang, "Integrated network design and demand forecast for on-demand urban air mobility," *Engineering*, vol. 7, no. 4, pp. 473–487, Apr. 2021.

[54] M. Rimjha, S. Hotle, A. Trani, N. Hinze, and J. C. Smith, "Urban air mobility demand estimation for airport access: A Los Angeles international airport case study," in *Proc. Integr. Commun. Navig. Surveill. Conf. (ICNS)*, 2021, pp. 1–15.

[55] L. Wei, C. Y. Justin, S. I. Briceno, and D. N. Mavris, "Door-to-door travel time comparative assessment for conventional transportation methods and short takeoff and landing on demand mobility concepts," in *Proc. Aviation Technol., Integr., Operations Conf.*, Jun. 2018, p. 3055.

[56] R. Goyal, C. Reiche, C. Fernando, and A. Cohen, "Advanced air mobility: Demand analysis and market potential of the airport shuttle and air taxi markets," *Sustainability*, vol. 13, no. 13, p. 7421, Jul. 2021.

[57] M. Fu, A. Straubinger, and J. Schaumeier, "Scenario-based demand assessment of urban air mobility in the greater Munich area," in *Proc. AIAA Aviation Forum*, Jun. 2020, p. 3256.

[58] K. O. Ploetner et al., "Long-term application potential of urban air mobility complementing public transport: An upper bavaria example," *CEAS Aeronaut. J.*, vol. 11, no. 4, pp. 991–1007, Dec. 2020.

[59] M. Mayakonda et al., "A top-down methodology for global urban air mobility demand estimation," in *Proc. AIAA Aviation Forum*, Jun. 2020, p. 3255.

[60] A. Anand, H. Kaur, C. Y. Justin, T. Zaidi, and D. N. Mavris, "A scenario-based evaluation of global urban air mobility demand," in *Proc. AIAA Scitech Forum*, Jan. 2021, p. 1516.

[61] R. Bassey, "Engineering brief, no 105, vertiport design," U.S. Dept. Transp., Federal Aviation Admin., Washington, DC, USA, Tech. Rep., 2022.

[62] L. Swadesir and C. Bil, "Urban air transportation for Melbourne metropolitan area," in *Proc. AIAA Aviation Forum*, Jun. 2019, p. 3572.

[63] J. Martinez Zapico, D. Sun, and W. A. Crossley, "Assessing potential urban air mobility traffic density in a metropolitan area like Chicago," in *Proc. AIAA Scitech Forum*, Jan. 2021, p. 1628.

[64] S. Roy, A. Maheshwari, W. A. Crossley, and D. A. DeLaurentis, "Future regional air mobility analysis using conventional, electric, and autonomous vehicles," *J. Air Transp.*, vol. 29, no. 3, pp. 113–126, Jul. 2021.

[65] M. Daskilewicz, B. German, M. Warren, L. A. Garrow, S.-S. Boddupalli, and T. H. Douthat, "Progress in vertiport placement and estimating aircraft range requirements for eVTOL daily commuting," in *Proc. Aviation Technol., Integr., Operations Conf.*, Jun. 2018, p. 2884.

[66] A. Kazurov and O. Suslova, "Aerodynamic features of buildings with runways unit," *IOP Conf. Ser., Mater. Sci. Eng.*, vol. 675, no. 1, 2019, Art. no. 012019.

[67] A. Garcia-Magariño, R. Bardera, S. Sor, and J. C. Matias-Garcia, "Flow control devices in cities for urban air mobility," in *Proc. AIAA Aviation Forum*, Jun. 2020, p. 3254.

[68] L. A. Somers, C. Y. Justin, and D. N. Mavris, "Wind and obstacles impact on airpark placement for STOL-based sub-urban air mobility," in *Proc. AIAA Aviation Forum*, Jun. 2019, p. 3121.

[69] E. Yilmaz, M. Warren, and B. German, "Energy and landing accuracy considerations for urban air mobility vertiport approach surfaces," in *Proc. AIAA Aviation Forum*, Jun. 2019, p. 3122.

[70] K. Song, H. Yeo, and J.-H. Moon, "Approach control concepts and optimal vertiport airspace design for urban air mobility (UAM) operation," *Int. J. Aeronaut. Space Sci.*, vol. 22, no. 4, pp. 982–994, Aug. 2021.

[71] R. Frej Vitalle, Y. Zhang, B. Normann, and N. Shen, "A model for the integration of UAM operations in and near terminal areas," in *Proc. AIAA Aviation Forum*, Jun. 2020, p. 2864.

[72] K. R. Antcliff, M. D. Moore, and K. H. Goodrich, "Silicon valley as an early adopter for on-demand civil VTOL operations," in *Proc. 16th AIAA Aviation Technol., Integr., Operations Conf.*, Jun. 2016, p. 3466.

[73] J. N. Robinson, M.-D.-R. Sokollek, C. Y. Justin, and D. N. Mavris, "Development of a methodology for parametric analysis of STOL airpark geo-density," in *Proc. Aviation Technol., Integr., Operations Conf.*, Jun. 2018, p. 3054.

[74] E. Lim and H. Hwang, "The selection of vertiport location for on-demand mobility and its application to Seoul metro area," *Int. J. Aeronaut. Space Sci.*, vol. 20, no. 1, pp. 260–272, Mar. 2019.

[75] J. Jeong, M. So, and H.-Y. Hwang, "Selection of vertiports using K-means algorithm and noise analyses for urban air mobility (UAM) in the Seoul metropolitan area," *Appl. Sci.*, vol. 11, no. 12, p. 5729, Jun. 2021.

[76] L. Wei, C. Y. Justin, and D. N. Mavris, "Optimal placement of airparks for STOL urban and suburban air mobility," in *Proc. AIAA Scitech Forum*, Jan. 2020, p. 0976.

[77] L. Chen, S. Wandelt, W. Dai, and X. Sun, "Scalable vertiport hub location selection for air taxi operations in a metropolitan region," *Informs J. Comput.*, vol. 34, no. 2, pp. 834–856, Mar. 2022.

[78] L. C. Willey and J. L. Salmon, "A method for urban air mobility network design using hub location and subgraph isomorphism," *Transp. Res. C, Emerg. Technol.*, vol. 125, Apr. 2021, Art. no. 102997.

[79] W. Kai, A. Jacquillat, and V. Vaze, "Vertiport planning for urban aerial mobility: An adaptive discretization approach," *Manuf. Service Oper. Manage.*, vol. 24, no. 6, pp. 3215–3235, Nov. 2022.

[80] H. Shin, T. Lee, and H.-R. Lee, "Skyport location problem for urban air mobility system," *Comput. Oper. Res.*, vol. 138, Feb. 2022, Art. no. 105611.

[81] P. D. Vascik and R. J. Hansman, "Development of vertiport capacity envelopes and analysis of their sensitivity to topological and operational factors," in *Proc. AIAA Scitech Forum*, Jan. 2019, p. 0526.

[82] N. M. Guerreiro, G. E. Hagen, J. M. Maddalon, and R. W. Butler, "Capacity and throughput of urban air mobility vertiports with a first-come, first-served vertiport scheduling algorithm," in *Proc. AIAA Aviation Forum*, Jun. 2020, p. 2903.

[83] I. C. Kleinbekman, M. Mitici, and P. Wei, "Rolling-horizon electric vertical takeoff and landing arrival scheduling for on-demand urban air mobility," *J. Aerosp. Inf. Syst.*, vol. 17, no. 3, pp. 150–159, Mar. 2020.

[84] K. Song and H. Yeo, "Development of optimal scheduling strategy and approach control model of multicopter VTOL aircraft for urban air mobility (UAM) operation," *Transp. Res. C, Emerg. Technol.*, vol. 128, Jul. 2021, Art. no. 103181.

[85] S. Rajendran, "Real-time dispatching of air taxis in metropolitan cities using a hybrid simulation goal programming algorithm," *Exp. Syst. Appl.*, vol. 178, Sep. 2021, Art. no. 115056.

[86] J. Bertram, P. Wei, and J. Zambreno, "Scalable FastMDP for pre-departure airspace reservation and strategic de-conflict," in *Proc. AIAA Scitech Forum*, Jan. 2021, p. 0779.
[87] J. Bertram and P. Wei, "An efficient algorithm for self-organized terminal arrival in urban air mobility," in *Proc. AIAA Scitech Forum*, Jan. 2020, p. 0660.
[88] I. C. Kleinbekman, M. A. Mitici, and P. Wei, "EVTOL arrival sequencing and scheduling for on-demand urban air mobility," in *Proc. IEEE/AIAA 37th Digit. Avionics Syst. Conf. (DASC)*, Sep. 2018, pp. 1–7.
[89] N. Venkatesh, A. P. Payan, C. Y. Justin, E. Kee, and D. Mavris, "Optimal siting of sub-urban air mobility (sUAM) ground architectures using network flow formulation," in *Proc. AIAA Aviation Forum*, Jun. 2020, p. 2921.
[90] P. Pradeep and P. Wei, "Heuristic approach for arrival sequencing and scheduling for eVTOL aircraft in on-demand urban air mobility," in *Proc. IEEE/AIAA 37th Digit. Avionics Syst. Conf. (DASC)*, Sep. 2018, pp. 1–7.
[91] *Report and Recommendations—Advanced Air Mobility Working Group*, FDOT, Tallahassee, FL, USA, 2023.
[92] S. Ayyalasomayajula, K. Vlachou, and L. Zhang, "Small UAS demand estimation," in *Proc. AIAA/IEEE 39th Digit. Avionics Syst. Conf. (DASC)*, Oct. 2020, pp. 1–8.
[93] A. Straubinger, "Policies addressing possible urban air mobility market distortions—A first discussion," *Transp. Res. Proc.*, vol. 41, pp. 64–66, Jan. 2019.
[94] I. Greenfeld, "Urban air mobility command and control," in *Proc. AIAA Aviation Forum*, Jun. 2020, p. 3262.
[95] A. Bauranov and J. Rakas, "Designing airspace for urban air mobility: A review of concepts and approaches," *Prog. Aerosp. Sci.*, vol. 125, Aug. 2021, Art. no. 100726.
[96] O. Ivashchuk and I. Ostroumov, "Separation minimums for urban air mobility," in *Proc. 11th Int. Conf. Adv. Comput. Inf. Technol. (ACIT)*, Sep. 2021, pp. 633–636.
[97] C. Y. Justin and D. N. Mavris, "Environment impact on feasibility of sub-urban air mobility using STOL vehicles," in *Proc. AIAA Scitech Forum*, Jan. 2019, p. 0530.
[98] B. R. Sutherland, "Flying cars for green transportation," *Joule*, vol. 3, no. 5, pp. 1187–1189, May 2019.
[99] S. S. Ahmed, S. S. Pantangi, U. Eker, G. Fountas, S. Still, and P. Anastasopoulos, "Public willingness to use autonomous vehicles and flying cars for airport access trips," Presented at the 15th Annu. Int. Conf. Tourism, 2019.
[100] S. P. Melo, F. Cerdas, A. Barke, C. Thies, T. S. Spengler, and C. Herrmann, "Life cycle engineering of future aircraft systems: The case of eVTOL vehicles," *Proc. CIRP*, vol. 90, pp. 297–302, Jan. 2020.
[101] A. Mofolasayo, "Potential policy issues with flying car technology," *Transp. Res. Proc.*, vol. 48, pp. 8–22, Jan. 2020.
[102] S. V. Mudumba, H. Chao, A. Maheshwari, D. A. DeLaurentis, and W. A. Crossley, "Modeling CO_2 emissions from trips using urban air mobility and emerging automobile technologies," *Transp. Res. Rec., J. Transp. Res. Board*, vol. 2675, no. 9, pp. 1224–1237, Sep. 2021.
[103] O. Zaporozhets, V. Tokarev, and K. Attenborough, *Aircraft Noise: Assessment, Prediction and Control*. Boca Raton, FL, USA: CRC Press, 2011.
[104] D. S. Michaud, S. Fidell, K. Pearsons, K. C. Campbell, and S. E. Keith, "Review of field studies of aircraft noise-induced sleep disturbance," *J. Acoust. Soc. Amer.*, vol. 121, no. 1, pp. 32–41, 2007.
[105] M. Basner et al., "Aviation noise impacts: State of the science," *Noise Health*, vol. 19, no. 87, p. 41, 2017.
[106] H. Eißfeldt, "Sustainable urban air mobility supported with participatory noise sensing," *Sustainability*, vol. 12, no. 8, p. 3320, Apr. 2020.
[107] M. C. Ertürk, N. Hosseini, H. Jamal, A. Şahin, D. Matolak, and J. Haque, "Requirements and technologies towards UAM: Communication, navigation, and surveillance," in *Proc. Integr. Commun. Navig. Surveill. Conf. (ICNS)*, 2020, pp. 1–15.
[108] A. J. Bateman, J. Burkholder, T. Summers, and N. D. Richards, "Incorporating RF coverage analysis in mission planning for future airspace operations," in *Proc. AIAA Scitech Forum*, 2019, p. 1059.
[109] A. Herschfelt, A. Chiriyath, D. W. Bliss, C. D. Richmond, U. Mitra, and S. D. Blunt, "Vehicular RF convergence: Simultaneous radar, communications, and PNT for urban air mobility and automotive applications," in *Proc. IEEE Radar Conf.*, Sep. 2020, pp. 1–6.
[110] F. A. Miranda et al., "An overview of key optical communications technologies under development at the NASA Glenn Research Center," *Proc. SPIE*, vol. 11692, pp. 130–144, Mar. 2021.
[111] U. Eker, G. Fountas, S. S. Ahmed, and P. C. Anastasopoulos, "Survey data on public perceptions towards flying cars and flying taxi services," *Data Brief*, vol. 41, Apr. 2022, Art. no. 107981.
[112] S. Washington, M. G. Karlaftis, F. Mannering, and P. Anastasopoulos, *Statistical and Econometric Methods for Transportation Data Analysis*. Boca Raton, FL, USA: CRC Press, 2020.
[113] Urban Air Mobility News. *Singapore To Set Up Advanced Air Mobility Hub With Skyports and Volocopter*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.urbanairmobilitynews.com/government-investment/singapore-to-set-up-advanced-air-mobility-hub-with-skyports-and-volocopter/
[114] FutureFlight. (2022). *UK's Future Flight Challenge Funds New 'Advanced Mobility Ecosystem Consortium*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.futureflight.aero/news-article/2022-07-15/uks-future-flight-challenge-funds-new-advanced-mobility-ecosystem
[115] *Unmanned Airspace. German Transport Ministry Invests 15 Million Euros in Urban Air Mobility Projects*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.unmannedairspace.info/latest-news-and-information/german-transport-ministry-invests-15-million-euros-in-urban-air-mobility-projects/
[116] A. Asharq. *Saudi Arabia Invests in Electric Urban Air Mobility*. Accessed: Jan. 1, 2023. [Online]. Available: https://english.aawsat.com/home/article/3966786/saudi-arabia-invests-electric-urban-air-mobility
[117] FutureFlight. *Dubai Advanced Air Mobility 'Integrator Center' Will Support EVTOL Aircraft Operations in the UAE*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.futureflight.aero/news-article/2022-12-07/dubai-advanced-air-mobility-integrator-center-will-support-evtol-aircraft
[118] Department for Transport. (2022). *UK Joins Up With Closest Allies To Create New Forum To Work Together To Tackle Aviation's Biggest Challenges*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.gov.uk/government/news/uk-joins-up-with-closest-allies-to-create-new-forum-to-work-together-to-tackle-aviations-biggest-challenges
[119] Federal Aviation Administration. *Advanced Air Mobility | Air Taxis*. Accessed: Jan. 1, 2023. [Online]. Available: https://www.faa.gov/air-taxis
[120] J. Holbrook et al., "Enabling urban air mobility: Human-autonomy teaming research challenges and recommendations," in *Proc. AIAA Aviation Forum*, Jun. 2020, p. 3250.
[121] M. Balac, R. L. Rothfeld, and S. Hörl, "The prospects of on-demand urban air mobility in Zurich, Switzerland," in *Proc. IEEE Intell. Transp. Syst. Conf. (ITSC)*, Oct. 2019, pp. 906–913.
[122] M. Peksa and K. Bogenberger, "Estimating UAM network load with traffic data for Munich," in *Proc. AIAA/IEEE 39th Digit. Avionics Syst. Conf. (DASC)*, Oct. 2020, pp. 1–7.
[123] *Transportation Research Board, and National Academies of Sciences, Engineering, Medicine, Risks Related to Emerging and Disruptive Transportation Technologies: A Guide*, Nat. Academies Press, Washington, DC, USA, 2024.

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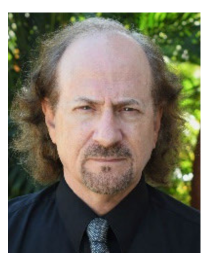

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