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Investigating the Need for Urban Air Mobility in Tehran City

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ABSTRACT

The increase in urbanization has led to the creation of dense population in urban areas, along with economic development and the increase in vehicles, which has led to an increase in demand and consequently an increase in many challenges regarding mobility and infrastructure. Solving these challenges or reducing the effects of these challenges can have significant effects on people's daily lives. Various solutions have always been proposed to solve these challenges, some of which have been successful and some of which have not. In the city of Tehran, too, challenges have arisen due to the rapid growth of urbanization, population, and vehicles, and solutions have been proposed to solve these challenges or improve the conditions, but due to the current conditions in Tehran, these solutions have not been able to appear as successful as they should be. In this paper, by examining the conditions of Tehran in terms of noise pollution, energy and fuel consumption, air pollution, traffic conditions, public and road transportation, it is proved that Tehran needs a new mode of transportation. According to today's needs of Tehran, this new mode of transportation can be an urban air mobility (UAM) that can be used in areas such as passenger and goods transportation. The presence of this mode of transportation in the transportation system of Tehran, in addition to improving the level of transportation of this city, helps to improve and even solve the challenges of today's transportation in Tehran, such as the high noise pollution of this city.

Introduction

Increasing urbanization has led to a dense population in urban areas and economic development along with rapid urbanization has led to a significant increase in motor vehicles and challenges in terms of mobility and infrastructure. (Riza et al., 2024; Sinha & Rajendran, 2023) As a result, traffic congestion in urban areas has been exacerbated in recent times due to a failure to meet the demand requirements (Sun et al., 2019; Geronimo et al., 2021). This has a significant impact on the national economy (Rajendran et al., 2021) as well as on an individual's health (Sanchez et al., 2020).

Shared mobility services could provide a suitable solution, requiring lower demand for parking options, no vehicle ownership, and an emission-saving mobility approach (Baptista et al., 2014). Autonomous transportation may offer a safe and comfortable mobility experience, and vehicle manufacturers increasingly focus on such technologies (Bimbraw, 2015). This trend has led to research growth in shared mobility and highlighted a dimension that has received little attention thus far in public transport: the third dimension of space (al Haddad et al., 2020). Aviation can be seen as an exemplary case of mobility that is currently facing major challenges. Mobility of the Third Dimension, referring to opportunities in the air, also known as Advanced Air Mobility (AAM), represents a new-to-market approach to rethink aviation innovatively and sustainably. Concepts and Business Models The concepts of AAM transport solutions are diverse. They are mostly wingless aircraft concepts that use at least four fixed propellers. Usually, the number of passengers varies from one to eight, depending on the model. Various stakeholders in the transportation industry are investing, most notably prominent aviation players such as aircraft manufacturers, airports, and airlines. In this article, we have investigated whether Tehran needs urban air mobility or not.

1 .Advanced Air Mobility

Electrification of aircraft with innovation-driven engineering advances and high degrees of automation are enabling new ways of transporting goods and people in urban, suburban, and rural environments, in an environmentally sustainable and cost-effective way. This new mode of air transportation is often referred to as Advanced Air Mobility (AAM), and it is expected to revolutionize segments of the aviation industry. So, it is probably not surprising that interest in this evolution is growing globally, both from investors and engineering startups, to be part of what is already a multi-billion dollar industry. (https://www.intervistas.com/ , 2024)

The first AAM use cases will likely include cargo and medical transport services, with passenger transport following. Air cargo may prove an early case, given issues regarding safety, insurance, and cautious operating models. Cargo is also more likely to operate between airports, warehouses, and distribution centers located away from residential areas, gradually building confidence and growing acceptance of these new types of vehicles among the public. As three-dimensional mobility (adding a vertical airspace component to two-dimensional ground surface travel) is expected to provide significant travel time savings, passenger transport will focus on intracity, inter-city, and regional air mobility. This means that large hub airports near congested cities may see AAM first as a form of shuttle service between the airport and downtown, starting with premium clientele before a wider adoption among the public. Perhaps in the midterm, regional and general aviation airports are also likely to benefit from AAM, preserving or enhancing regional connectivity, making flights to smaller markets a possibility. (https://www.intervistas.com/ , 2024)

AAM could connect communities that have historically been underserved or not served at all, without substantial investment costs or real estate footprints. AAM involves new types of aircraft operating in the airspace. In the urban environment, electric Vertical take-off and Landing (EVTOL) aircraft with a typical seating capacity of three to four passengers will likely be the first to enter the market. These aircraft can take off and land like a helicopter, but they do so with significantly less noise and at a lower operating cost. Advancements in electric propulsion and autonomy technologies are leading to the development of a new class of electric vertical take-off and landing (EVTOL) aircraft (Langford & Hall, 2020). In the suburban and regional context, EVTOL, electric Conventional Take-off and Landing (ECTOL), and electric Short Take-off and Landing (ESTOL) aircraft are all likely to operate. ESTOL aircraft are similar to conventional aircraft, as they do need a runway, but the required runway length can be as little as 100 to 300 feet, meaning that existing athletic fields, open spaces, and rooftops of warehouses or large buildings could serve as potential "runway" candidates. (https://www.intervistas.com/ , 2024). These new EVTOL aircraft are expected to be safer, quieter, and less expensive to operate and maintain than existing vertical takeoff and landing aircraft, i.e., helicopters (Uber, 2016). These aircraft could transform how we transport people and goods in our cities and regional markets by overflying ground traffic congestion and shortening door-to-door travel times for one or more trip purposes, including commute trips, trips to the airport, trips to major attractions such as sporting events, shuttles between business or medical facilities, and emergency response trips (Straubinger et al., 2021). EVTOLs rely on fixed wings for dynamic lift production during horizontal flight segments, leading to higher aerodynamic efficiency and, therefore, a larger achievable range. Multicopter eVTOL concepts are similar to conventional helicopters but feature multiple horizontally mounted rotors. This leads to a far more limited operational range due to lower aerodynamic efficiency, making it a suitable technology for urban areas. (Bruehl et al., 2021). In Fig.1, some examples of AAMs that will be used in the future are given along with their specifications.

Figure 1: specifications of some AAMs that will be used in the future

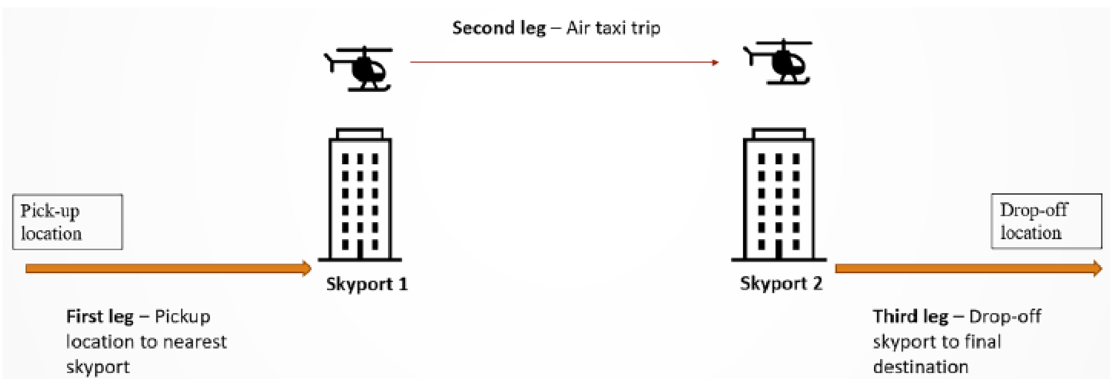
	VOLOCOPTER	ARCHER	JOBY	VERTICAL AEROSACAPE	LILIUM	BETA	EHANG
Country	Germany	CA, USA	CA, USA	United Kingdom	Germany	VT, USA	China
Market Cap	$620M	$1.6B	$5.3B	$2.2B	$2.6B	$1.4B	$1.4B
Number of Passengers	1 passenger	4 passengers	4 passengers	4 passengers	6 passengers	Cargo or 5 passengers	2 passengers
Operation	Piloted	Piloted	Piloted	Piloted	Piloted	Piloted	Autonomous
Range, speed	25 miles, 70 mph	60 miles, 150 mph	150 miles, 200 mph	100 miles, 200 mph	155 miles, 175 mph	250 miles	25 miles, 80 mph
Entry into service	2023	2024	2024	2024	2025	2024	2022

Source: https://www.intervistas.com/ , 2024

2 *Urban air mobility*

Urban air mobility (UAM) has emerged as a new category for aerial vehicles and shared mobility concepts (Riza et al., 2024). Electric vertical take-off and landing (EVTOL) aircrafts, also known as air taxis, are considered the vehicle foundation of UAM, offering a local, emission-free, and infrastructure-conserving mode of transportation (Planing & Pinar, 2019). In recent years, air taxis have demonstrated their growing technical maturity and at least initial capabilities through various demonstration flights (Riza et al., 2024). An air taxi refers to a small aerial vehicle capable of providing point-to-point, on-demand passenger mobility services. These vehicles are also known by a variety of names, such as passenger drones, urban air mobility, personal aerial vehicles, etc. The idea of personal air transportation has existed since the early 1900s, long before the appearance of the Jetsons. Personal air transportation is already available in the form of helicopter airlines, but the current trend toward piloted or pilotless electric vertical takeoff and landing (EVTOL) technologies has only been demonstrated in recent years. The main motivation for this type of transport is travel time savings(Lin et al., 2020). In Fig.2 conceptual representation of the UAM network is given.

Figure 2: Conceptual representation of the UAM network

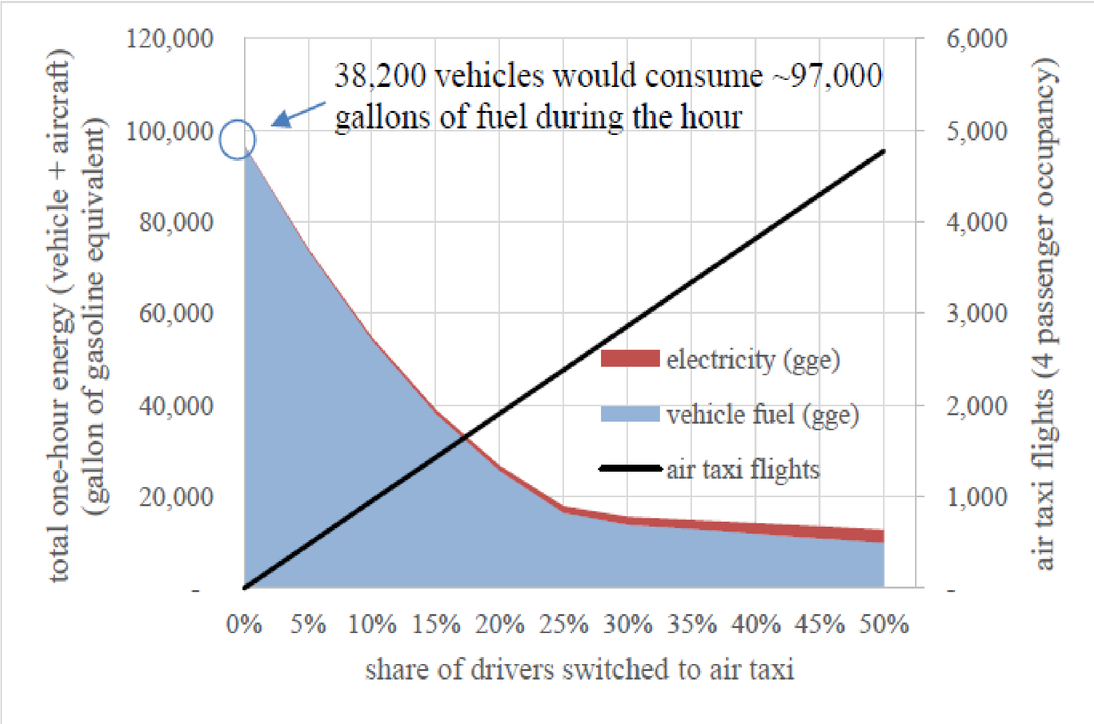


Source: (Sinha & Rajendran, 2023)

In the last years, Urban Air Mobility (UAM) has been receiving increasing attention and even if the first services are expected to be launched shortly, there is still uncertainty about which type of commercial services (e.g., airport shuttles or city taxis) will be implemented at an early stage, as well as which price point will be perceived as affordable by travelers. Based on data collected through a large-scale survey campaign in the Milan metropolitan area (Italy), passengers' value of travel time savings for different UAM services is estimated using advanced discrete choice modeling. Estimated mixed logit models allowed for comparative analysis of the differences between the two potential use cases, i.e., airport shuttle and city-taxi services.

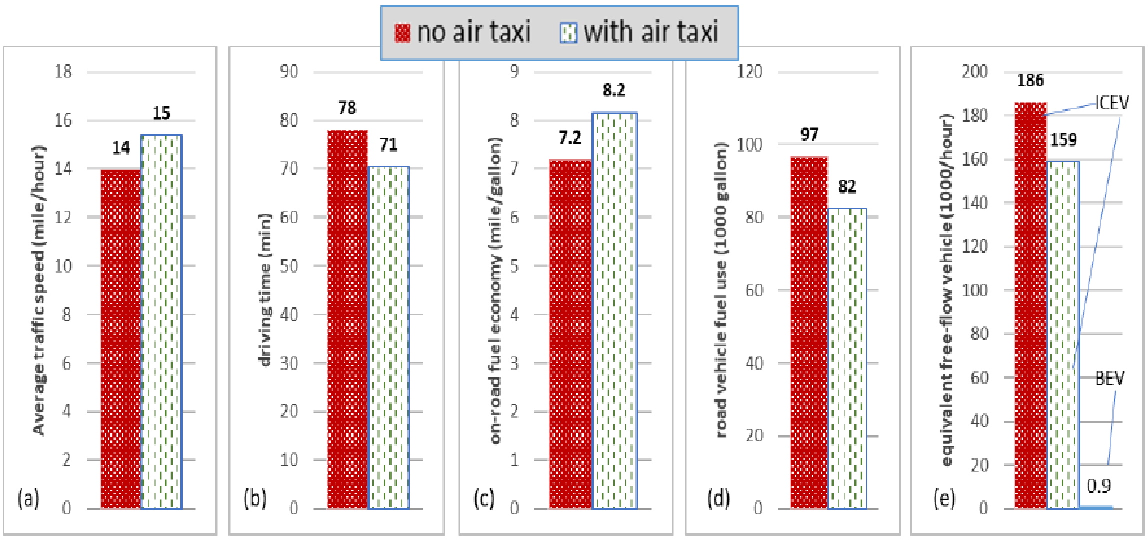
Results show a willingness to pay for UAM services from/to greater airports (in a range of 44%–57%) than for traveling within the metropolitan area, and greater (in a range of 31%–44%) for business travel than for other purposes, indicating that the most financially sustainable UAM services will potentially be available for airport-shuttle connections from/to central business districts(Coppola et al., 2024). External benefits include reductions in road congestion, emissions, and energy. Compare total vehicle and aircraft energy vs air taxi flights are given in Fig.3 and air taxi impact on traffic-related energy use with conservative scenario and optimistic scenario respectively are given in Fig.4 and Fig.5.

Figure 3: Total vehicle and aircraft energy vs air taxi flights



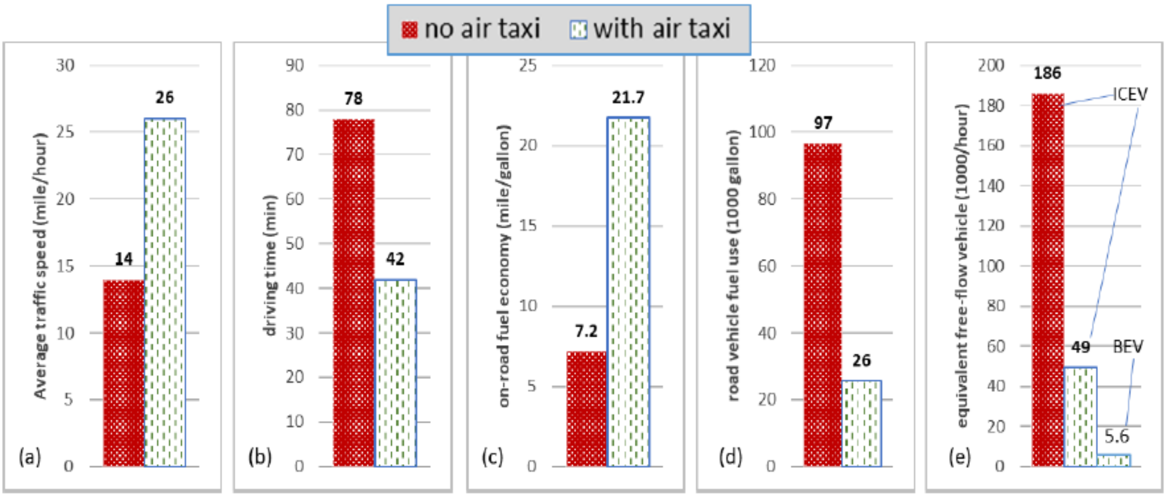
Source: (Lin et al., 2020)

Figure 4: Air taxi impact on traffic-related energy use-conservative scenario



Source: (Lin et al., 2020)

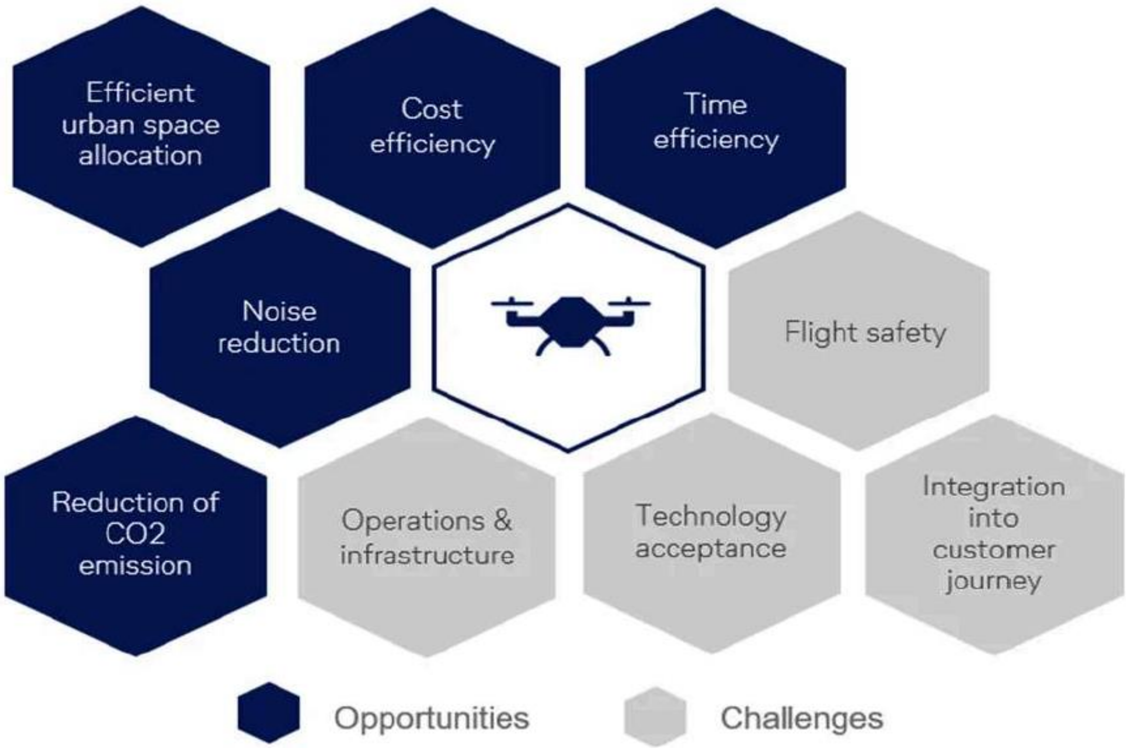
Figure 5: Air taxi impact on traffic-related energy use-optimistic scenario



Source: (Lin et al., 2020)

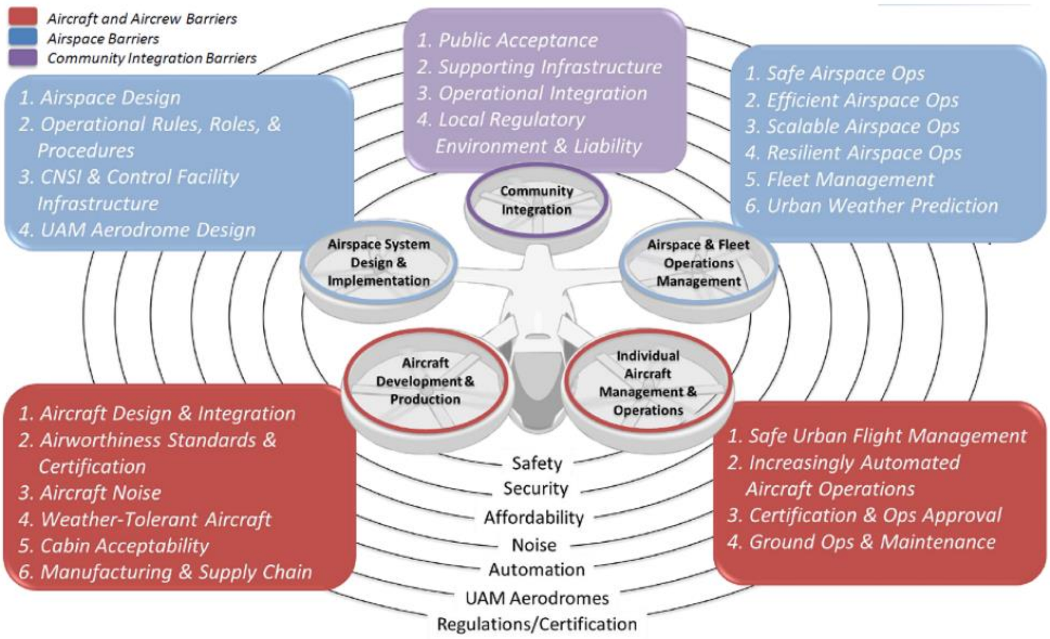
Barriers to commercialization and implementation include high cost, energy storage and density, technological reliability, perceived safety, infrastructure, noise, air traffic management, and adverse weather(Lin et al., 2020). Respectively in Fig.6 and Fig.7, Some of the main challenges and opportunities of AAM and NASA's UAM framework barriers are given.

Figure 6: Main challenges and opportunities of AAM



Source: https://www.lufthansa.com/, 2024

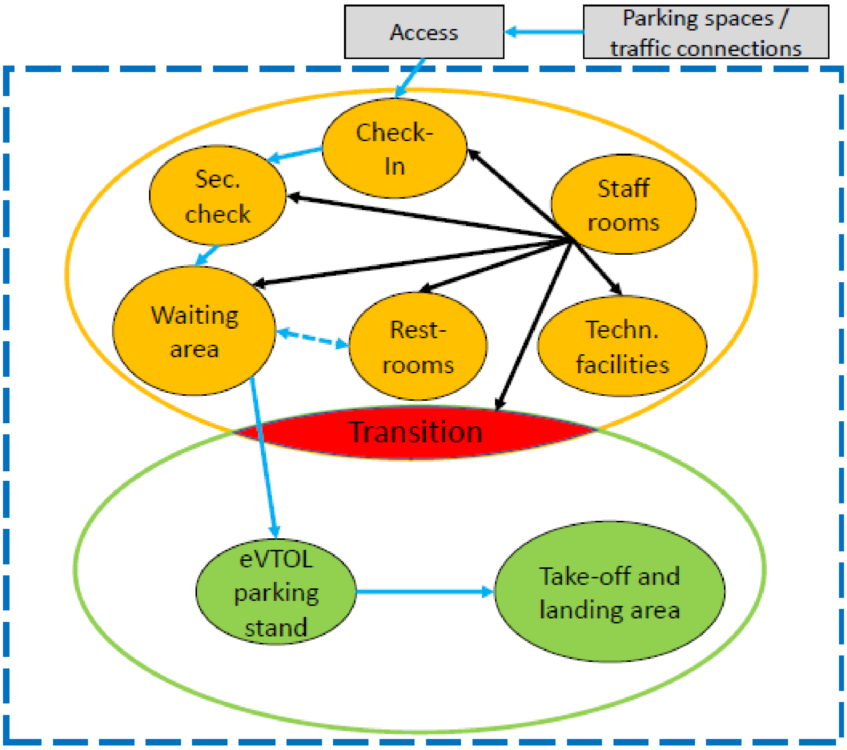
Figure 7: NASA's UAM framework barriers



Source: (Hill et al., 2020)

Urban mobility has reached a critical saturation point in terms of infrastructure use, as many metropolitan areas around the world are experiencing high levels of congestion daily(Alam & Georgakis, 2022). With the rise of the new business case of Urban and Regional Air Mobility (UAM/RAM) using electric vertical take-off and landing (eVTOL) vehicles in inter-urban transport, new challenges for a corresponding air transport infrastructure appear, which differs significantly from today's airports (Brühl et al., 2022). To foster the rising urban and regional air mobility, suitable ground infrastructure is required in urban and regional areas. This takeoff and landing infrastructure can be described as "vertiplace", which is categorized into three types (vertihub, vertiport, and vertistation). Each type is expected to fulfill anticipated certification standards for air taxi operations, further consisting of the turnaround of the vehicle and passenger handling. We assume electric vertical take-off and landing (EVTOL) aircraft configuration will become dominant. Each type of vertiplace has a different scope of anticipated services, resulting in distinct equipment levels and space requirements. In this contribution, we evaluated 70+ candidate locations in Saxony representing existing mobility infrastructures (airfields, parking lots, and parking garages) by conducting an operational location assessment. Various factors (e.g., space availability, catchment area, links to other transport modes (intermodality), infrastructure installation costs, environment) are considered to figure out which locations meet the best operational requirements. Selecting high-ranked locations, we design a hub-and-spoke network by simultaneously considering operational vehicle characteristics such as maximum range and passenger capacity of eVTOL aircraft to serve the demand. This results in a generalized hub location problem (HLP) methodology designing an air taxi network using demand data, cost estimates for infrastructure installation, distances, and ticket prices for passengers (Brühl et al., 2022).
Fig.8 Vertiplace functions required for passenger and flight processing are given.

Figure 8: Vertiplace functions required for passenger and flight processing



Source: (Brühl et al., 2022).

3 Infrastructures

The ground infrastructure shall provide safe and secure touchdown and lift-off areas, as well as aircraft and passenger handling facilities. Since UAM and RAM are intended to operate within a city (intra-city) or between regional and metropolitan areas (inter-city), proper ground infrastructures must be established at strategic locations The objective is to construct a hybrid hub-and-spoke network for air taxis, where hybrid indicates that there are central hubs, as well as a point-to-point factor that allows direct connections between non-hub nodes to a certain extent. This should cut future travel expenses (costs and duration) for passengers by avoiding detours over hubs (Brühl et al., 2022).

To initially adopt and later scale down these opportunities, three categories of enablers are vital: social acceptance, operational feasibility, and financial viability. The degree of importance of each category of enablers depends on the use case. For the development of passenger-related use cases, social acceptance is most crucial. Non-passenger applications will thrive through financial viability best achieved by increased levels of automation. AAM adoption is expected to benefit various industries (e.g. healthcare: high speed, better coverage, and accessibility); different geographies (e.g. remote areas: better accessibility and lower risk in dangerous surroundings); and people (e.g. (sub)urban transit: faster, increased convenience and more pedestrian space). Some use cases are already being piloted in confined regulatory sandboxes designed to test and derive best practices for the midterm (https://www.weforum.org/, 2024).

Nevertheless, the ecosystem is not yet ready for large-scale adoption. More cohesive regulations must be implemented to certify vehicles and autonomous operations. Digital infrastructure needs to be developed to orchestrate seamless airspace operations, while wider physical infrastructure buildup is required to integrate AAM into the existing transport infrastructure (https://www.weforum.org/, 2024).

4 Literature review

Most of these studies explore the UAM demand by examining disaggregated data from surveys. Some of them provide insights and structure their discussions around the various factors that can influence the demand for UAM services. Specifically, several studies have extensively analyzed the impact of various levels of service attributes, such as travel times and monetary costs, as well as socio-economic variables, personal attitudes and expectations, along with respondents' travel habits, on the demand for UAM services (Cho & Kim, 2022; Ilahi et al., 2021; Ahmed et al., 2021; Boddupalli, 2019; Fu et al., 2019; Brunelli et al., 2023; Al

Haddad et al., 2020). Moreover, some researchers (Cho & Kim, 2022; Rimjha et al., 2021, A;Rimjha et al., 2021,B; Hae Choi & Park, 2022) have focused their attention on travel demand forecasts for UAM services, examining and drawing conclusions from real-world case studies. In a related vein, other studies (Ilahi et al., 2021; Ahmed et al., 2021; Fu et al., 2019) have delved into the analysis of the willingness to pay for air taxi services, without considering that for UAM airport shuttles.
In the following, some papers written in the fields of Intention to use air taxis, Societal acceptance, and Willingness to pay will be reviewed. In Tab.1, examples of announced UAM services, and in Tab.2, Main UAM demand studies, which are divided by service type, are discussed.

Table 1: Examples of announced UAM services, by service type.

Service type	Continent	State	City	Announced year for starting UAM operations	Companies involved	Reference
Air taxi	North America (USA)	Florida	Miami	2024	Archer Aviation	(Archer, 2021)
Air taxi	North America (USA)	California	Los Angeles	2024	Archer Aviation	(Fox, 2021)
Air taxi	Europe	France	Paris	2024	Groupe ADP, Volocopter GmbH, RATP Group	(ADP,2021)
Air taxi	Europe	Spain	Algeciras, Ceuta, M´alaga	-	Lilium GmbH, Helity Copter Airlines	(Lilium, 2022)
Air taxi	Asia	South Korea	-	2024	Volocopter GmbH, Kakao Mobility Co.	(Volocopter, 2021, A)
Airport shuttle	North America (USA)	New York State	New York	2025	Archer Aviation, United Airlines Inc.	(Archer, 2022)
Airport shuttle	North America (USA)	Illinois	Chicago	2025	Archer Aviation, United Airlines Inc.	(Archer, 2023)
Airport shuttle	Europe	Italy	Rome	2025	AdR S.p.A., Atlantia S.p.A., Volocopter GmbH	(Volocopter, 2021, B)
Airport shuttle	Europe	Italy	Milan	2026	S.E.A. S.p.A., F2i S.p.A., Skyports	(SEA, 2022)
Airport shuttle	Asia	Japan	Osaka	2025	ANA Holdings Inc., Joby Avia	(Aviation ,2022)

Source: (Archer, 2021; Fox, 2021; ADP,2021; Lilium, 2022; Volocopter, 2021, A; Archer, 2022; Archer, 2023; Volocopter, 2021, B; SEA, 2022; Aviation ,2022)

Table 2: Main UAM demand studies, by service type.

Service type	Continent	Country/ Nation	City	Year	Modeling specification	Reference

Air taxi	Asia	Indonesia	Greater Jakarta	2018	Multinomial logit and mixed logit	(Ilahi et al., 2021)
Air taxi	Worldwide	-	-	2017	Correlated grouped random parameters, bivariate probit models	(Ahmed et al., 2021)
Air taxi	North America	U.S.A. (different States)	Atlanta, Boston, Dallas-Ft. Worth, San Francisco, and Los Angeles	2018	Multinomial logit, mixed logit and latent class models	(Boddupalli, 2019)
Air taxi	Europe	Germany	Munich	2018	Multinomial logit and mixed logit	(Fu et al., 2019)
Air taxi	North America	U.S.A., California	Northern California cities	2019	Mixed logit	(Rimjha et al., 2021, B)
Airport shuttle	Europe	Italy	Bologna	2022	Multinomial logit and mixed logit	(Brunelli et al, 2023)
Airport shuttle	Asia	South Korea	Seoul	2019	Multinomial logit and mixed logit	(Hae Choi and Park, 2022)
Airport shuttle	North America	U.S.A., California	Los Angeles	2019	Mixed logit	(Rimjha et al. ,2021, A)
Air taxi/ Airport shuttle	Europe	Germany	Munich	2018	Exploratory factor analysis, multinomial logit, and ordered logit model	(Al Haddad et al., 2020)
Air taxi/ Airport shuttle	Asia	South Korea	Seoul	2020	Multinomial logit and mixed logit	(Cho and Kim, 2022)

Source: (Ilahi et al., 2021; Ahmed et al., 2021; Boddupalli, 2019; Fu et al., 2019; Rimjha et al., 2021, B; Brunelli et al, 2023; Hae Choi and Park, 2022; Rimjha et al. ,2021, A; Al Haddad et al., 2020; Cho and Kim, 2022)

1.1.1 Intention to use air taxis

Intention to use air taxis Established theories in predicting human behavior, such as the theory of planned behavior, state that behavioral intentions immediately determine behavior (Ajzen, 1985). Thus far, results of previous research on attitudes and intentions toward air taxis have been inconclusive. In a telephone survey (Dannenberger et al., 2020), only 18 % of the participants reported an intention to use air taxis in the future. By contrast, in a survey on the initial reaction of respondents toward air taxis (Yedavalli et al., 2018), 44.5 % of the respondents expressed support or even strong support for air taxis. Similarly, a quantitative survey conducted by the U.S. National Aeronautics and Space Administration (NASA), investigating 2,000 participants from five urban areas, found that approximately half of the respondents would be comfortable adopting air taxis (Hasan S, 2019). This is supported by a virtual reality simulation conducted (Janotta & Hogreve 2021), in which 65% of the participants reported an intention to use air taxis in the future.

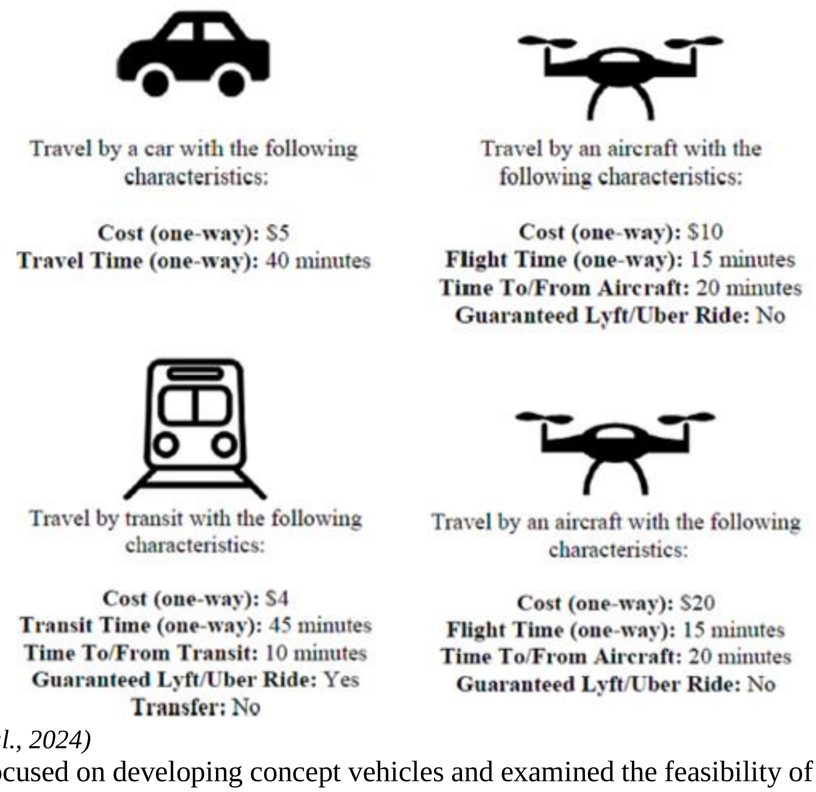
1.1.2 Societal acceptance

An essential factor in the integration of air taxis into a city's public transport system is the impact it has on the city's inhabitants, for example, by installing landing sites close to their homes. This should be desirable, as trip times would be reduced and comfort and attractiveness would be improved. According to research, public acceptance of drones is restricted by worries about visual and acoustic pollution (Boucher, 2016; Eißfeldt et al., 2020). A study conducted arrived at similar findings, with around half of the participants expressing concerns about the noise generated by drones and the visual pollution caused by their presence in the skyline (Yedavalli & Mooberry, 2018). Studies on the acceptance of air taxis have also indicated that residents are concerned about factors on a societal level, such as noise levels and visual impact disturbance of the cityscape, regardless of whether manufacturers guarantee low noise levels (Boelens, 2019). Noise levels have been identified in many studies as a fundamental concern of residents (al Haddad et al., 2020; Goyal et al., 2021; Hasan S, 2019; Straubinger et al., 2020). Furthermore, the disturbance of the cityscape by visual pollution is also considered a severe problem, as well as the impact that air taxis may have on the environment (al Haddad et al., 2020; Goyal et al., 2021; Hasan S, 2019). However, contrary to the restricted societal acceptance in aforementioned studies, a field study conducted by Planing and Pinar allows for a more positive perspective, with 84 % of the respondents indicating that they would support the offering of an air taxi service in a German metropolitan area (Planing & Pinar, 2019). These rather contradictory results may be explained by the fact that the study by Planing and Pinar was conducted as part of a field study following a demonstration flight of an air taxi prototype. This consideration is supported by a study by Stolz and Laudien, who found that acceptance and attitudes toward drone flights turned more positive after participants experienced a drone flight (Stolz & Laudien, 2022). The mode of representation of a new technology might influence societal acceptance and the potential use case. In a study on autonomous driving, acceptance was higher for a public transport use case than for individual use (Pakusch & Bossauer, 2017). How the potential acceptance of air taxis differs in potential future scenarios has yet to be investigated.

1.1.3 Willingness to pay

Next to the intention to use air taxis, the present study investigates the consumer's willingness to pay for this technology. Unlike the expected price of a technology, which is more about external perceptions, the willingness to pay denotes an intrinsic valuation of the product/ service (Thaler, 1985). Willingness to pay is utilized in various areas, such as pricing strategy, welfare economics, and cost-benefit analysis (Carson & Groves, 2007). The users' willingness to pay for air taxi service will be crucial to the success or failure of its integration into today's public transportation network. Thus far, this aspect has been addressed in only a few studies, and a NASA study identified the limited willingness to pay as a major barrier to UAM (Hasan S, 2019). An analysis (Goyal et al., 2021) demonstrated that the demand for UAM is limited by the user's willingness to pay for routes with a journey time of less than 45 min compared to longer journeys. Moreover, (Kreimeier et al., 2018) conducted an economic assessment of UAM on-demand concepts in Germany and found that air taxi demand is susceptible to price aspects. In particular, the study found a willingness to pay only €0.50– €0.80 per kilometer traveled, which presents a rather unrealistic price point. In 2018 and another study, the cost and time of travel by air taxi compared to car and transit were investigated and estimated, and the result of this estimate is given in the Fig.9 (Kaito, 2018)

Figure 9: Estimating the cost and travel time of an auto versus an air taxi and transit versus an air taxi.



Source: (Boddupalli et al., 2024)

Recent studies have focused on developing concept vehicles and examined the feasibility of implementation of UAM by analyzing the performance parameters (Al Haddad et al., 2020; Johnson et al., 2018; Silva et al., 2018; Vascik & Hansman, 2018). The efficiency of three different VTOL types, electric quadrotor, hybrid side by side helicopter, and turbo electric-powered tilt-wing, were discussed (Johnson et al., 2018). They considered several factors, such as aircraft optimization, drag minimization, propulsion efficiency, and operational effectiveness. (Silva et al., 2018) extended this research by investigating another type of vehicle called lift plus cruise. The authors concluded that lift plus cruise type is a superior alternative for turbo-electric propulsion than tilt-wing. Several criteria impacting customers' opinion, such as service reliability, percentage time savings, and cost of availing the facility, were identified by (Al Haddad et al., 2020) through an online survey of residents in Munich. Similarly, (Vascik & Hansman, 2018) established three additional

constraints in aircraft noise, a control system for air traffic, and ground infrastructure availability that potentially affects the market growth of UAM. The literature on infrastructure location for air taxis is still in the evolutionary stage. Multiple tools, such as clustering algorithms (Lim & Hwang, 2019; Rajendran & Zack, 2019), mathematical models (Rath & Chow, 2019), and simulation (Balac et al., 2019), have been utilized to estimate demand and determine optimal vertiport and vertistop locations. (Rajendran & Zack, 2019) proposed integrating a multimodal warm start approach with k-means clustering algorithm to determine 21 potential air taxi stations in New York City (NYC). Demand estimation for this soaring service was made by employing publicly available regular taxi data and parameters provided (Holden & Goel, 2016). They also examined the effect of various parameters, such as customer satisfaction and percentage time savings on prospective sites. Similarly, (Lim & Hwang, 2019) suggested a k-means algorithm for selecting skyport stations based on three heavily used routes in the Seoul metro area. However, cluster centroids generated from k-means approach are highly dependent on the initial value selected, and it produces a different result with every run (Zahra et al., 2015).
At the end, in Tab.3, a Summary of papers on air taxi operational site selection is given.

Table 3: Summary of papers on air taxi operational site selection.

Reference	Methodology	Key findings
(Fadhil, 2018)	Geographic Information System (GIS)	City centers, airport terminals, and inter-city train stations are ideal locations for air taxi station establishment.
(Rajendran & Zack, 2019)	Constrained clustering approach ,with multimodal transportation-based warm start technique	Parameters such as the "willingness to fly "rate did not have a significant influence on the air taxi site selection.
(Rath & Chow, 2019)	Integer linear programming model	Minimum of nine operating stations has to be located in three NYC boroughs -Manhattan ,Queens and Brooklyn ,to accommodate passenger demand traveling specifically to airports .
(Chen et al, 2021)	Novel variable neighborhood search heuristic	The variable neighborhood search heuristic developed by the authors solves towards optimality for almost all problem instances
(Sinha & Rajendran, 2022)	Multi -criteria warm start technique with an iterative k -means clustering algorithm	The proposed two -phased approach performs better than the algorithm discussed by Rajendran and Zack (2019)with respect to metrics ,such as Davies Bouldin index and number of clusters .
(Willey & Salmon, 2021)	Five heuristic algorithms	The best of the proposed methods was able to provide a solution that is within 10%of the optimal solution on average.

Source: (Fadhil, 2018; Rajendran & Zack, 2019; Rath & Chow, 2019; Chen et al, 2021; Sinha & Rajendran, 2022; Willey & Salmon, 2021)

2. Methods

To analyze and review, the data archive of Tehran municipality (https://amar.thmporg.ir/, 1403) in the years 1387 SH[1] to 1402, the post office(https://www.post.ir/, 1403) in the years 1395 to 1402, the air quality control company of the city of Tehran (https://airnow.tehran.ir/, 1403) , the budget bill of the transportation department(https://www.mporg.ir/, 1403) in the years 1397 to 1402, the energy balance published by the Ministry of Energy (https://iies.mop.ir/, 1403) , and the traffic police organization (https://rahvar120.ir/, 1403) for the year 1395 to 1402 have been used. In section 1-2 and especially in Fig.6, the opportunities and challenges of AAMs are given. In this section, based on these opportunities and challenges, the conditions of the city of Tehran have been examined to determine whether the use of UAMs in Tehran is cost-effective or not.

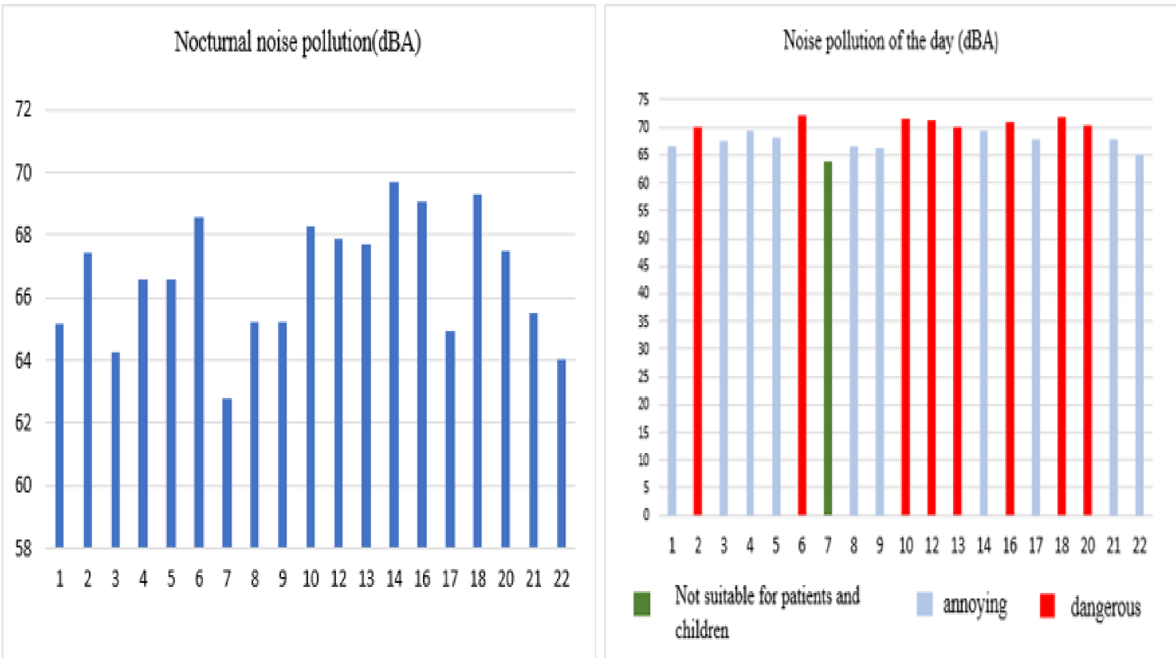
All the years in this section are based on solar hijri(SH) date.[1]

2.1 Noise reduction

36 sound measuring stations are located in different districts of Tehran, and the sound level measured in each station does not indicate the sound level of that area, but the sound level in a radius of about 100 to 200 meters of the open environment around the station. However because the stations location is in the points with the average sound level of the districts, it can be used as a measure to measure the average sound level of the districts. According to the studies, the biggest source of noise in urban areas is traffic noise, which constitutes 80% of the total sources of public noise pollution and is the most common type of noise in urban areas (Amundsen & Klæboe, 2005).

In order to divide the ambient noise index per day, the standards of the Environmental Protection Organization and the Air Quality Control Company have been used. Accordingly, more than 70 dB is in the dangerous range, between 60 and 70 dB in the annoying range, and between 50 and 60 dB for children and patients. According to Fig.10, based on the average annual noise level during the day, eight of the 22 districts of Tehran are in a dangerous situation and the rest of the areas are in a disturbing or unsuitable condition for children and patients. According to the standard provided for the night, more than 60 dB is placed in the dangerous zone, and according to Fig.10, all areas of Tehran are in a dangerous situation during the night. While the traffic of cars and the number of trips during the night is much less than during the day, the decrease in the noise level is not enough to put the city in a more suitable situation. This point indicates the significant role of factors other than the car in creating noise pollution.

Figure 10: Annual average level of noise pollution in Tehran city districts in 1400.

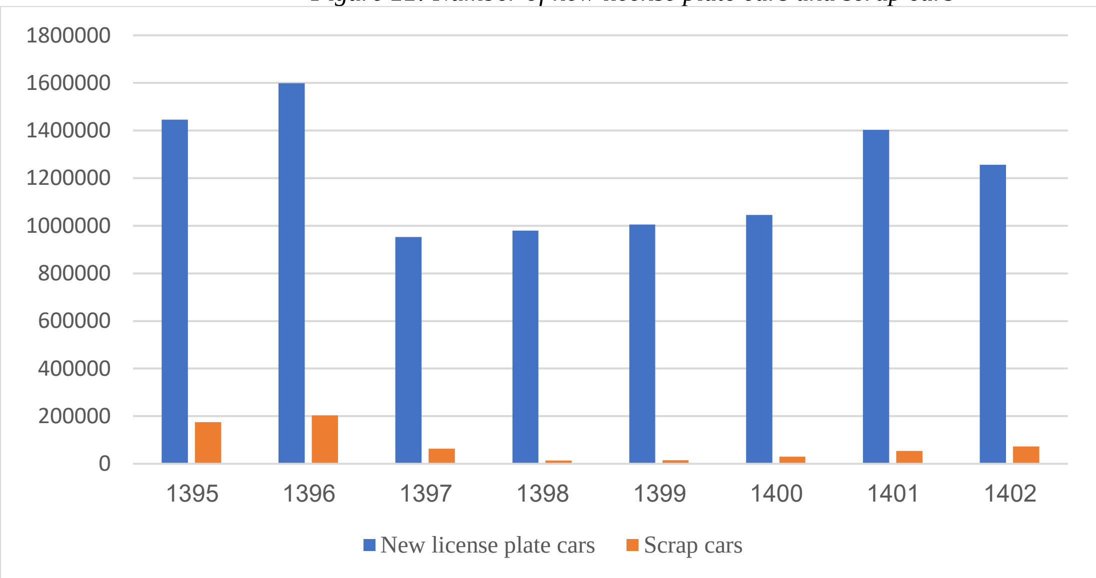


Source: (https://airnow.tehran.ir/, 1403)

Each of the areas of Tehran is exposed to noise pollution for various reasons, including the high number of trips in the region, its location in the airport area, the lack of noise level reducers such as acoustic retaining walls, and especially the confinement between the highways of Tehran. Since highways produce more noise in the inner-city thoroughfares, increasing the number of cars and the number of roads not only does not help reduce noise pollution, but also increases. By examining the number of new and scrapped cars from 1395 to 1401 shown in Fig.11 from 1397, we have been faced with an increase in the amount of private car purchases every year, which is one of the main reasons for the increase in dependence on private vehicles, the decrease in the use of public transportation and the increase in road traffic, as well as the very low percentage of scrapped cars in each year and the decommissioning of a few cars The number of cars in Tehran is increasing. This increase, in addition to creating traffic on the roads, also raises the level of noise pollution.

According to the statistics stated in this section, increasing the number of cars and roads within the city in addition to creating traffic, also leads to an increase in noise pollution, so there is a need for a mode of transportation that helps reduce traffic and reduce noise pollution, and creating UAM in Tehran can be one of the appropriate options to do this.

Figure 11: Number of new license plate cars and scrap cars



Source: (https://rahvar120.ir/, 1403)

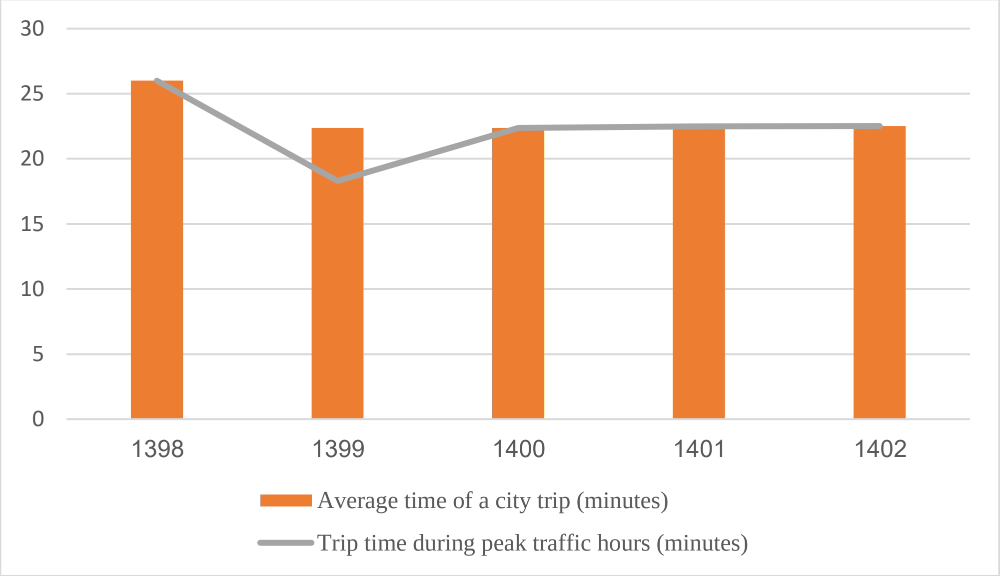
2.2 Energy and air pollution

According to the energy balance sheet published by the Ministry of Energy (https://iies.mop.ir/, 1403) , the transportation sector, except for CO_2 and SO_2, had the largest share in the production of other pollutants and greenhouse gases. Meanwhile, the power plant, household, commercial, and transportation sectors had 31.7, 22.4, and 21.7 percent of carbon dioxide emissions among energy-consuming and producing sectors, respectively. Also, the power plant and transportation sectors have a total of 81.5% with 42.8% and 38.7% respectively of sulfur dioxide emissions. The transportation sector mainly consumes two products, gasoline and oil and gas. The sub-sector of road and sea transportation has the largest share in the emission of pollutants and greenhouse gases compared to other sub-sectors of transportation. Gasoline and oil gas fuels in the sub-section of sea and railroad transport have the highest emission of polluting gases and ATK fuel in the sub-section of air transport has the highest emission of greenhouse gases this year. One of the main advantages of UAMs is reducing energy consumption and reducing air pollution, especially carbon dioxide. The annual increase in the number of cars in Tehran (according to Fig.11) has also led to an increase in the concentration of carbon dioxide. to reduce this concentration, modes that produce less air pollution can be used, of which UAM is one of them.

2.3 Reducing road traffic

Today, most people in Tehran suffer from traffic and crowding of streets, passages, and public transportation. In Fig.12, the duration of an intra-city trip and the duration of travel during peak traffic hours in the years 1398 to 1402 in Tehran are given. According to Fig.12, the duration of an intra-city trip is equal to or greater than the duration of travel during peak traffic hours in Tehran, which indicates the daily traffic in Tehran during these years. Non-peak traffic hours are higher than peak traffic hours! The same traffic time in the non-peak hour of traffic compared to the peak hour of traffic also indicates permanent traffic in Tehran.

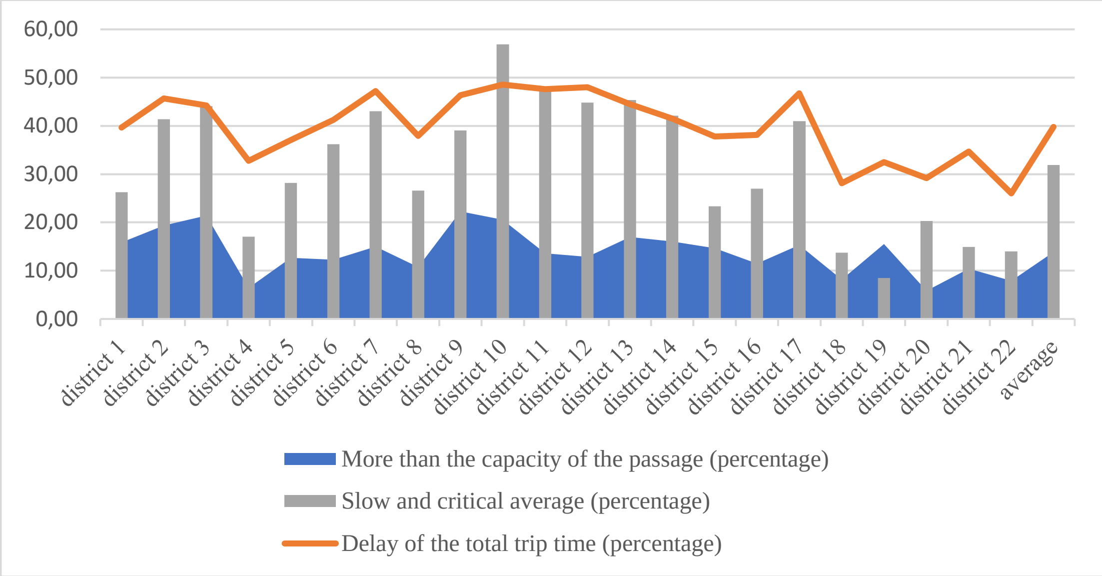
Figure 12: Number of new license plate cars and scrap cars



Source: (https://amar.thmporg.ir/, 1403)

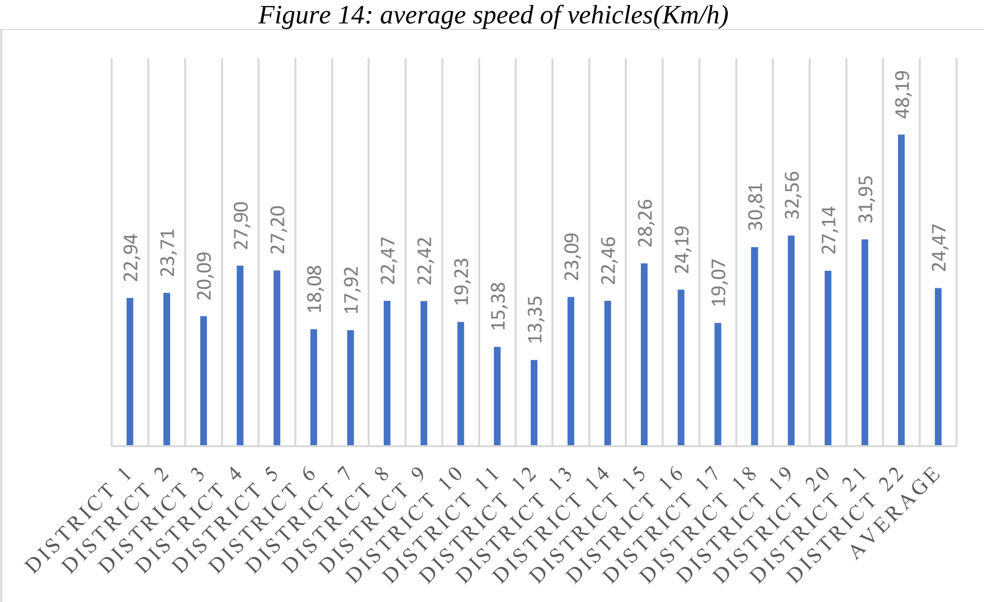
In Fig.13, three variables in the regions of Tehran in 1402 have been investigated simultaneously, including more than the capacity of the passage (percentage), delay of the total trip time (percentage), and slow and critical average (percentage). According to Fig.13, on average, about 40 percent of trips in Tehran are delayed, which indicates high traffic in the regions. On the other hand, in most areas, many vehicles, which are about 32 percent on average, move slowly and in a slow and critical network. This statistic for District 10 is about 57%, which is a high percentage of network slowness. It is also observed that on average, about 14 percent of trips are made in all regions when the capacity of the roads is filled and more vehicles want to enter the crossing than the capacity of the passageway, and queues are created. In Fig.14, the average speed of vehicles in the areas of Tehran in 1402 is shown, and the average speed of 24.47 km/h indicates a low speed in Tehran's road transportation network. All these data indicate heavy traffic in the streets of Tehran and measures should be taken to reduce this traffic. One of the ways to reduce traffic is to improve public transportation fleets such as subways and buses, but in recent years, public transportation improvement plans have not had much effect on reducing traffic in Tehran. In the next subsection, the reasons for the insufficient impact of public transportation on Tehran's traffic will be discussed. One of the effective solutions to solve road traffic is the use of UAMs.

Figure 13: more than the capacity of the passage (percentage), delay of the total trip time (percentage), and slow and critical average (percentage).



Source: (https://amar.thmporg.ir/, 1403)

Figure 14: average speed of vehicles(Km/h)



Source: (https://amar.thmporg.ir/, 1403)

2.3.1 Insufficient impact of public transportation on Tehran's traffic

In the city of Tehran and in 1403, more than two million trips by subway and more than 9 million trips are made by public transportation during the day, which according to the number of public transportation fleets, indicates a lot of crowding in the subway and congestion in public transportation. Until 1395, very good measures were taken to increase the percentage of trips using public transportation, so that in this year, more than 60% of trips were made by public transportation. But during these years, with the decrease in the use of public transportation, it has reached about 45%. One of the main reasons for the decrease in the share of public transportation and the failure of data plans To increase this share of travel, the outbreak of the Corona virus has been since the end of 1398 and the beginning of the first peak of the disease. Due to the greater spread of the Corona virus, especially at the beginning of 1399 and the peaks of the disease during the years 1399 and 1400, and the increase in the rate of human deaths, more severe road and intra-city travel restrictions were imposed throughout the country, especially in the red zones, and Tehran is one of these areas and this reduced the share of travel by public transportation in Tehran. Among these restrictions, we can mention social distancing, which includes activities such as marking subway and bus seats, stopping places and queues to buy subway and bus tickets, and limiting the picking up of passengers by taxis. Closure or semi-closure of public and private offices and organizations, as well as schools and universities, increase in telework and virtualization of national activities such as e-government, and closure Recreational places and gathering places have also caused a huge decrease in the share of public transportation travel, so that compared to 1398, the use of the subway has decreased by more than 75% and the use of buses has decreased by more than 65%

in 1399.

By comparing the amount of travel absorption and production in different areas of Tehran Municipality and the amount of trips made by public transportation in these areas, we conclude that a high share of public transportation trips are made in areas where the traffic plan and the air pollution reduction plan have been implemented. After the outbreak of the Corona virus and the removal of the traffic plan and the air pollution reduction plan, a large part of the share of trips to these areas was replaced by private transportation, and this rate of entry to the areas of the traffic plan by private vehicles was so high that the rate of entry to areas with a registered traffic plan in 1399 was almost compared to 1401, when the public transportation system returned to normal. The return and also the traffic plan was re-imposed, and the number of trips increased by a lot, almost equally.

The increase in dependence on personal transportation or the reduction of dependence on public transportation is such as the increase in road and personal transportation development plans in 2019 and the imposition of social distancing restrictions due to Corona in 1399, which reduced the desirability of public transportation and increased the use of private transportation. After a society's dependence on the use of a mode of transportation, changing that dependence takes time, and since 1400, the creation of incentive plans as well as efforts to increase the desirability of public transportation have increased the use of this type of transportation by only about one percent.

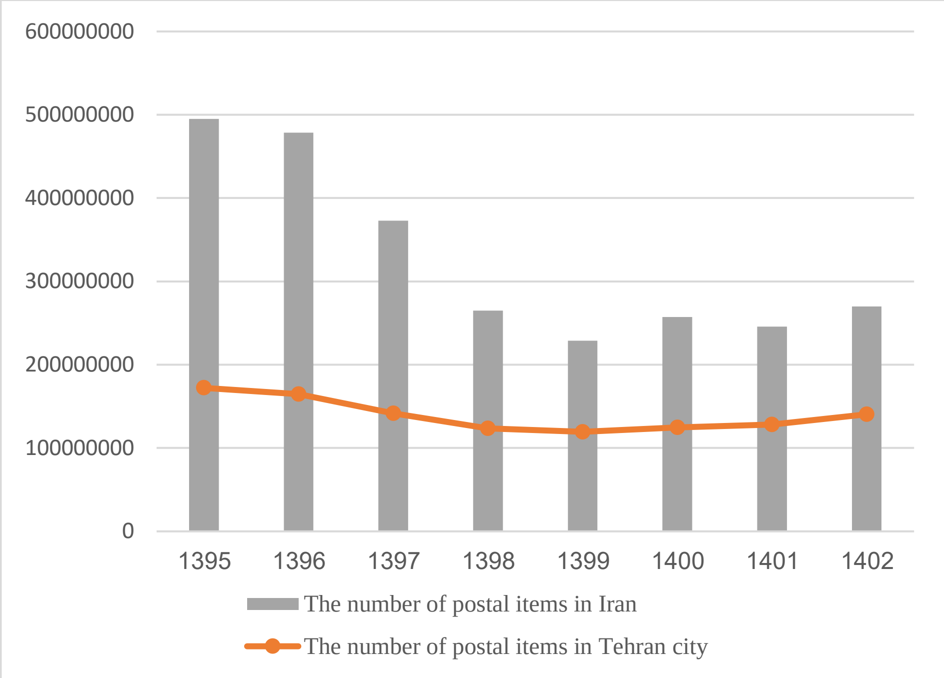
In 2019, the use of public transportation decreased by more than 7%, and the main reason for this decrease in the share of public transportation trips was the application of 80% of the plans of this year's transportation budget bill to the development of road transportation (https://www.mporg.ir/, 1403) . Although after the increase in the price of gasoline in November 1398, we witnessed an increase in the use of public transportation, but this price increase also compensated for this The decline in the share was not severe, and this percentage difference was between 1397 and 1398.

According to these statistics, it can be concluded that the proposed and applied plans to improve public transportation and reduce the amount of traffic are not as efficient as they should be and other methods should be adopted. The use of UAMs can be one of the efficient methods to reduce traffic and travel time.

2.3.2 The number of postal items

The high number of postal shipments and how to send them has always been one of the main challenges of countries. Iran is also one of the countries with a high number of postal shipments and the management of the system for sending these items can be very complicated. In most cases, because the shipments have to reach the customers during working hours, sending these shipments causes traffic in the city. The city of Tehran has the highest number of postal shipments by a large margin compared to other cities. It has. In Fig.15, the number of postal parcels in Iran and the number of postal parcels in Tehran are shown, which shows the high rate of national postal parcels and also the high percentage of postal parcels in Tehran compared to the total postal parcels of Iran. One of the applications of UAMs is to send postal shipments. Putting UAMs on the agenda and using them to send postal shipments can also reduce the traffic load in Tehran.

Figure 14: The number of postal items in Iran and Tehran city



Source: (https://www.post.ir/, 1403)

In this section, we have examined the need of the city of Tehran for UAMs, and according to the studies conducted in the fields of noise pollution, energy, air pollution and traffic, we conclude that the city of Tehran is in dire need of creating a new mode of transportation that improves the situation of noise pollution, energy and fuel consumption, air pollution and traffic. At present, the use of UAMs can be used as the best solution to improve the level of transportation and the reduction of the issues mentioned above, and it can be said that Tehran needs the use of UAMs.

3. Conclusion

In this study, first, advanced air mobility was investigated and definitions of this mode of transportation were made. Then, urban air mobility was investigated and in addition to defining and examining this type of vehicle, its opportunities and challenges were also examined. Through these opportunities and advantages of using urban air mobility, the challenges in transportation in Tehran were investigated were discussed to examine whether the city of Tehran needs this mode of transportation or not.

In order to conduct this study, data were collected in the fields of transportation and traffic, noise pollution, air pollution, energy and fuel consumption, and the number of postal parcels. After examining the challenges of each of these fields, we concluded that many of the challenges in these areas can be solved or improved to a good extent by using UAMs. From examining the noise level of Tehran and the failure to control the increase in the noise level, as well as the increasing number of private vehicles, the use of UAMs that help reduce this noise level is a good solution. In the field of energy, fuel and air pollution, we have come to the conclusion that transportation plays a significant role in energy and fuel consumption and the creation of pollutants, which can be used to improve fuel and energy consumption and reduce air pollution, which both improve fuel and energy consumption and reduce air pollution.

In the field of traffic control, after reviewing the traffic data including the average travel time within the city, the duration of travel during peak hours, the average speed of vehicles in the areas of Tehran, the percentage of delay in the total travel time, the percentage of demand more than the capacity of the passageway, and the average percentage of the slow and critical network, we concluded that there is traffic at all hours of the day in the city of Tehran and the measures taken to improve the traffic situation are not have been successful. Then, one of these measures, which is the improvement of public transportation, was investigated, and by examining the data of public transportation and examining the reasons for its reduction, we reached the failure of the presented plans. In this section, it can be concluded that the use of UAMs can have a significant impact on improving the traffic situation and improving travel time. Finally, by examining the data of Tehran Post and the number of postal parcels in Iran and Tehran, we concluded that a part of the traffic that includes sending postal parcels can be eliminated or even reduced by using UAMs, which due to the high number of parcels in Tehran, can play a significant role in improving the traffic situation and accelerating the time of sending postal parcels.

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