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Aerial e-mobility perspective: Anticipated designs and operational capabilities of eVTOL urban air mobility (UAM) aircraft

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Abstract: We collected data about 13 urban air mobility (UAM) electric vertical take-off and landing (eVTOL) aircraft from 12 UAM companies in the world. While none of these models has yet reached a large-scale commercial operation (particularly as air taxis), some of them progressed well in the certification process and may have their UAM models widely operated within a few years. This article focuses on the variability in the configurations of these UAM eVTOL aircraft for aerial e-mobility; such as single-fixed-wing, tandem-tilt-wing, canard wing, fixed-rotor fixed-wing, full tilt-rotor, partial tilt-rotor, V-shaped tail, tailless, twin tail, conventional tail assembly, distributed propulsion, multicopter, rear forward thrust propeller, ducted fans, and a hybrid airplane-helicopter design. The 13 UAM eVTOL aircraft covered here are: (1) EH216-S (by EHang), (2) VoloCity (by Volocopter), (3) Lilium Jet (by Lilium), (4) VoloRegion (by Volocopter), (5) CityAirbus NextGen (by Airbus), (6) Passenger Air Vehicle - PAV (by Boeing), (7) S-A2 (by Hyundai), (8) Joby (by Joby Aviation), (9) VX4 (by Vertical Aerospace Group), (10) Midnight (by Archer Aviation), (11) Eve (by Eve Air Mobility), (12) Jaunt (by Jaunt Air Mobility), and (13) Generation 6 (by Wisk Aero). Out of these 13 UAM eVTOL aircraft models for aerial e-mobility and/or air taxis, we found that 11 models utilize a wing configuration, while only two use a wingless multirotor concept (as in hobbyist drones). A fixed-wing design is associated with a faster travel speed, at the expense of added restrictions on maneuvering and low-speed travel (or hovering). Six models are intended to have an onboard human pilot, while the remaining seven models are designed to be pilotless. One model demonstrated the ability to use hydrogen as a clean source of energy through a fuel cell system.
Keywords: *Aerial, Air taxi, Aircraft, E-mobility, eVTOL, UAM, Urban air mobility.*

1. Introduction

According to a released Tracking Clean Energy Progress (TCEP) report in July 2023 by the International Energy Agency (IEA), only the "Electric Vehicles" component within the "Transport" sector was progressing satisfactorily toward a 2030 target that is aligned with a longer-term scenario for reaching net zero carbon dioxide (CO_2) emissions by 2050 globally. On the other hand, the "Aviation" component was not on track with such a decarbonization pathway [1,2]. Electrification of the transport sector can be achieved through electric road vehicles, which represent a technological transformation but without introducing a new mode of transport [3–8]. Such electrification not only helps in reducing the combustion-based emissions of greenhouse gases (GHGs) that cause global warming and climate change, but also improves the outdoor air quality within a low-carbon built environment, making electric mobility (e-mobility) a preferred clean transport option in smart cities and sustainable (green) communities [9–34]. Compared to some other GHG abatement technologies applied to combustion processes or industrial activities; like carbon capture and storage (CCS), unconventional combustion, and advanced power generation; electrification eliminates the direct release of CO_2 and other GHGs, rather than attempting to control their release to the atmosphere with the presence of worries regarding leaks [35–53]. The potential emergence of urban air mobility (UAM)

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as a novel transportation mode within a city (intra-city UAM) and between cities (inter-city UAM) not only can boost the replacement of conventional fossil-fuel-based mobility with clean zero-direct-emissions e-mobility, but also may bring several advantages such as less congestion, faster travel, expanded aerial tourism, better cargo movement, and effective delivery of medical emergency aids [54–71]. In the current study, the term urban air mobility (UAM) refers specifically to commercial or institutionally-managed domestic aerial trips, located well below the altitude of airliners for regular air flights, thus located normally within the uncontrolled part of airspace closest to the surface (International Civil Aviation Organization – ICAO – Class G), with the altitude typically limited to 1,200 ft (366 m) and with the travel range confined within the same city or between neighbor cities using electric vertical take-off and landing (eVTOL) aircraft to transport passengers, goods, or both [72–77]. When the main purpose is to transport passengers, this UAM service can also be called "air taxi". Several studies have been conducted to identify or optimize the operation eVTOL aircraft along with advantages and disadvantages using simulation modelling, analytical methods, or experimental work [78–97]. The optimum altitude of UAM cruising depends on the cityscape; it should be high enough to not interfere with existing buildings and other structures; while also should be low enough to avoid wasted time and energy in unnecessary climb and descent. The vertical take-off and landing (VTOL) concept is important in UAM to eliminate the need for a runway at take-off and landing as well as to relax restrictions on buildings' height near that runway, and this strengthens the applicability of this transport mode in urban settings where unoccupied land spaces can be very limited. Using only electric power and electric motors is also important in UAM (when compared to an engine-powered helicopter for example), to avoid air pollution, eliminate acoustic noise from the combustion engine, reduce the number of auxiliary components, simplify the speed control, and suppress engine's mechanical vibrations and oscillatory forces [98–128]. While eVTOL aircraft, like all-electric (battery electric) road vehicles, do not release direct (scope 1) GHG emissions; such as those released due to the combustion of a hydrocarbon fossil fuel; they may cause indirect (scope 2) GHG emissions through purchased electricity for recharging their batteries [129–143]. However, if this electricity is generated using a renewable source (such as solar energy, wind energy, or a plant-based biofuel), then the UAM aircraft allow zero GHG emissions for both scopes, which allows achieving a national or global net-zero GHG emission target by being a zero-carbon-ready (ZCR) transport mode [144–161]. Also, since UAM aircraft can be equipped with multiple smaller and independent lift or thrust rotors (rather than one large rotor as in a helicopter), such enabled propulsion redundancy in UAM aircraft improves its safety and reduces the probability of accidents [162–164]. Electric aircraft have a limitation on their range, imposed by the onboard battery charge. However, since UAM trips are local with relatively small distances, this limitation should not restrict UAM operation, especially with the existence of fast charging technology or with the possibility of using onboard hydrogen and fuel cells rather than batteries [165–174].

2. Objective and Related Studies

The objective of this article is to report a focused technology review of the technical and operational features of various urban air mobility (UAM) aircraft as proposed by their manufacturers. This helps answer some questions like:

- Is there a common optimum UAM aircraft design?
- Are the first-generation UAM aircraft expected to be autonomous, artificially intelligent or piloted, traditional [175–179]?
- Are UAM aircraft simply a large-scale version of personal (consumer) drones, or do they need to have their different configurations [180,181]?
- How many passengers can a UAM aircraft carry?
- Are helicopters suitable for used as UAM aircraft [182,183]?
- What are the leading companies in UAM?

It is admitted that there have been previous review studies about UAM. However, the current study is considered different, contributing more information regarding this emerging and evolving transport concept.

For example, Cohen et al. [184] provided an overview of the history, market potential, challenges, and ecosystem of urban air mobility (or urban aerial transportation), which is one of two concepts envisioned since the early 20th century (the other being flying cars or plane cars). For them, UAM is viewed as a sustainable, safe, accessible, and affordable system of air transportation for passenger mobility, delivery of goods, and emergency services; and can cover metropolitan areas and also can extend geographically beyond them. Their research utilized a multi-method approach with 106 interviews and two stakeholder workshops. They consider that early UAM operations started in the 1950s in the form of scheduled helicopter services, with re-emergence of interest as an on-demand service in the 2010s, and with the vertical take-off and landing (VTOL) concept of UAM envisioned for the 2020s. As possible barriers against rapid expansion of UAM, they listed for example the regulatory environment, public acceptance, safety, noise, and concerns about social equity [185–193].

Schweiger and Preis [194] conducted a systematic review of scientific publications or regulatory documents concerning the vertiport (the ground pad vertical landing and take-off) design and operation for UAM aircraft. They were able to identify 49 Scopus-listed scientific publications (within the period 2016–2021) that deal with UAM ground infrastructure and airspace operation. They also presented regional and international regulatory considerations, and introduced additional industry contributions about that topic. Among their findings, they reported that vertiports were not yet clearly understood and that there was scatter in the research. Also, they commented that the investigated vertiport designs (with the exception of some preliminary prototypes) were more descriptive of a vision rather than giving a realistic achievable structure.

Mavraj et al. [195] conducted another systematic review of urban air mobility, but dealing particularly with ground-based infrastructure. This UAM infrastructure includes networks of take-off and landing locations, maintenance facilities, electricity supply stations, and navigation services. Their final analysis contained 64 articles, showing a strong focus on simulations and vertiport networks, and less frequent appearance of case studies and urban planning.

Long et al. [196] conducted a literature review focusing on the demand analysis for urban air mobility. They pointed out that the success of UAM is highly contingent upon the market demand. In their work, they identified various types of on-demand applications for urban air mobility, such as moving passengers and cargo. Also, they discussed factors influencing the market demand in urban air mobility; including cost, duration, distance, safety, congestion, and privacy. They also highlighted multiple opportunities for future research regarding UAM demand analysis, such as the feasibility of air shuttle services, and the integration of UAM with existing transportation systems.

Brunelli et al. [197] conducted a systematic review of studies related to the location and capacity of UAM vertiport (as ground infrastructure elements used as interchange nodes between a ground transport mode and the aerial transport mode). They found that the number of pads and gates, and the weather conditions have a major impact on the vertiport capacity. They add a remark that while existing heliports in urban areas can be used as vertiports at a first attempt, their numbers are too small to support an expected level of UAM operations.

While the mentioned reviews provide useful information about UAM; our study is different in multiple aspects. We are not conducting a review based on academic research articles, but based on technical and operational designs of urban air mobility aircraft as made by their manufacturers. Thus, our review is more industry-focused. Also, it is more recent, making it more updated, especially that quick changes and continuous progress are expected in the UAM field. In addition, the main results of our focus article are semi-structured in a standardized comparative form, making them concise and easy to understand. Through our study, readers interested in UAM can quickly obtain a good idea about how the first-generation UAM aircraft may look like, the variability in their various models, and the operational capacity.

3. Research Method (Selection Criteria)

3.1. Inclusion Criteria

The inclusion criteria adopted here for UAM models are divided into two steps. In the first step, UAM companies (those with a program to develop and manufacture a UAM aircraft, not those intending to use UAM aircraft as a fleet operator) were searched for, and 12 companies were identified. In the second step, the active UAM model (or models in the case of developing more than one design simultaneously) was then identified. For 11 companies out of the identified 12 UAM companies, a single UAM model was found. For another UAM company, there were two UAM models. Thus, a total of 13 UAM models were included in the current focused technology review.

3.2. Exclusion Criteria

Because the current study is about UAM aircraft, the flying cars concept was excluded. Flying cars represent another future transportation concept where a convertible road vehicle has also the capability of performing a near-surface flight (NSF). The Alef flying car (USA), ASKA flying car (USA), PAL-V Liberty (Netherlands), and AirCar (Slovakia) are examples of such a concept [198–211]. UAM aircraft are designed and optimized solely for an airborne mode of travel, rather than both on-road and aerial modes of travel. Also, flying cars may be available for ownership by individuals, rather than being used according to the (mobility as a service: MaaS) business model [212–219]. In addition, the licensing, design, and energy source for flying cars may differ largely from those of UAM aircraft. Thus, it is appropriate to exclude flying cars in our review.

In addition, when a UAM company has an old aircraft design that was replaced by a new one, we only included the new (active) design here, and excluded earlier versions. For example, the

Vahana UAM-eVTOL aircraft (with a tandem tilted wing configuration) of Airbus was excluded, since the work on it came to an end on 14/November/2019 when the aircraft made its final test flight [220]. Its total battery storage charge was 38 kWh. For benchmarking, this battery size is comparable to that of an all-electric (battery electric) car [221–229]. Similarly, the Airbus CityAirbus multirotor demonstrator UAM-eVTOL aircraft that ended in summer 2021 was excluded [230]. It was equipped with eight 100 kW motors (total power 800 kW) and a total battery storage charge of 110 kWh. This power is nearly 1,070 hp (1 mechanical horsepower is equivalent to 0.7457 kW), making that CityAirbus UAM-eVTOL slightly less powerful than either the Tesla Model S Plaid or the Tesla Model X Plaid all-electric car, with either car model has a peak power of 1,020 hp (approximately 760 kW) [231–235].

4. Results (Selected UAM Models)

The data provided in this section about the urban air mobility (UAM) aircraft were almost obtained directly from the public web data of the manufacturer/developer UAM company. This helps in ensuring the accuracy of the data. No artificial intelligence (AI) tools were used in collecting or organizing the data.

The review results are presented as subsections. The first two subsections correspond to the two multirotor (multicopter) UAM designs, where no wings are used, and thus a set of rotors (or propellers) are responsible for the upward lifting force as well as the forward and lateral motion, resembling a hobbyist drone. The remaining 11 subsections correspond to the 11 wing-based UAM designs, where a lifting force during the cruising flight comes from the net upward aerodynamic force exerted on a wing (or wings), as in typical fixed-wing airplanes [236–249]. In either subsection, 10 collected features of each UAM aircraft are listed in a standardized style that facilitates comparing different UAM designs. These features include technical data (such as the propulsion system and the travel range) and non-technical data (such as the manufacturer's name and country). One or more additional remarks that we felt useful are also listed for each UAM aircraft, such as an update about the progress in the UAM aircraft toward certification or commercial production. The results are systematic and unified such that they can be efficiently presented in a single table. However, because such a table would be too large to fit in this article, the features are listed as bulleted lists for each of the 13 UAM aircraft models.

4.1. EH216-S **[250]**

- Manufacturer: EHang Holdings Limited
- Base country: China
- Lift/Thrust method: multirotor (multicopter)
- Tail shape: None
- Propellers' count: 16
- Propellers' mount: 8 pairs of coaxial propellers attached to 8 foldable arms from the cabin's bottom (powered by 8 brushless direct current "BLDC" motors [251–253])
- Number of non-pilot passengers: 2
- Piloting: autonomous
- Speed: 130 km/h (maximum design speed)
- Range: 30 km (maximum range)
- Remarks:

(1) On 31/December/2023, EHang announced that EH216-S has obtained the standard Airworthiness Certificate (AC) from the Civil Aviation Administration of China (CAAC), making it the first pilotless passenger-carrying UAM-eVTOL aircraft to achieve this regulatory milestone. This Airworthiness Certificate (AC) confirms that the aircraft (as certified) complies with the approved type design and meets the necessary safety and quality requirements for commercial operations.

(2) On 31/December/2023 also, EHang announced the start of commercial delivery of the certified EH216-S to a customer (ETON, a subsidiary of Guangzhou Development District Communications Investment Group Co., Ltd.; managed by the local government of Huangpu District in Guangzhou, China), for use in aerial tourism in the Guangzhou city (China).

(3) Maximum take-off weight (MTOW) [254–256]: 620 kg

(4) A photograph illustrating the operation of EH216-S can be found in Figure 1.

Figure 1.
A real view of the EH216-S UAM-eVTOL aircraft while flying at Hang's UAM Center in Europe, inside Lleida–Alguaire International Airport (LEDA) in Spain (displayed with courteous permission from EHang Holdings Limited.
Source: https://www.ehang.com/ueditor/php/upload/image/20240620/1718894681167399.jpg).

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4.2. VoloCity [**257**]

- Manufacturer: Volocopter GmbH
- Base country: Germany
- Lift/Thrust method: multirotor (multicopter)
- Tail shape: None
- Propellers' count: 18
- Propellers' mount: 18 rotors with 18 BLDC motors (12 rotors mounted to a large rim above the cabin, and 6 rotors mounted to connecting arms to that rim)
- Number of non-pilot passengers: 2
- Piloting: autonomous (but initially piloted by an onboard human pilot)
- Speed: 110 km/h (maximum airspeed)
- Range: 35 km
- Remarks:

(1) On 29/February/2024 - Volocopter announced that it received the German Federal Aviation Office's Production Organization Approval (POA) extension, which permits the production of the VoloCity aircraft.
(2) The 18 electric motors are powered by nine rechargeable batteries.
(3) VoloCity battery swapping system reduces gap periods during operations (battery swapping time: 5 minutes).
(4) Maximum take-off weight (MTOW): 900 kg
(5) Maximum payload: 200 kg
(6) Operating weight empty (OWE): 700 kg
(7) A photograph illustrating the operation of VoloCity can be found in Figure 2.

Figure 2.
A real view of the VoloCity UAM-eVTOL aircraft during a crewed flight at the aerodrome of Saint-Cyr-l'École in France (displayed with courteous permission from Volocopter GmbH.
Source: https://mediahub-volocopter.pixxio.media/collections/37/media/731340272).

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4.3. Lilium Jet **[258]**

- Manufacturer: Lilium GmbH
- Base country: Germany
- Lift/Thrust method: tilt-wing and tilt-canard; electric jet propulsion units (for lift and forward thrust) attached to the wing and the canard. A canard is a forward horizontal stabilizer (unlike the conventional case of a rear stabilizer within a tail assemble) [259–263]
- Tail shape: front canard (no vertical stabilizer)
- Propellers' count: 30 motors within the main wing and the canard wing
- Propellers' mount: ducted DEP (distributed electric propulsion) [264–269]
- Number of non-pilot passengers: configurable (up to 6)
- Piloting: onboard human pilot
- Speed: 248 km/h (cruising)
- Range: 175 km (maximum)
- Remarks:

(1) The Lilium Jet UAM-eVTOL uses a standard CCS charger (combined charging system for battery electric vehicles "BEVs" fast DC charger) [270–274].
(2) Typical charging session: about 45 minutes
(3) On 18/July/2024, Lilium GmbH announced a firm order from "Saudia" (Saudi Arabian Airlines, the national flag carrier of Saudi Arabia) to acquire 50 Lilium Jets, with an option for additional 50 units of that UAM-eVTOL aircraft [275].
(4) A photograph illustrating the structure of Lilium Jet can be found in Figure 3.

Figure 3.
A real view of the Lilium Jet UAM-eVTOL aircraft while standing on a vertiport, cropped version of the original image (displayed with courteous permission from Lilium GmbH.
Source: https://lilium.com/files/redaktion/newsroom/news/releases/Groupe%20ADP/3000x2000_LLM_GroupeADP-min.jpg)

4.4. Volo Region **[276]**

- Manufacturer: Volocopter GmbH
- Base country: Germany
- Lift/Thrust method: separate thrust and lift sources; fixed-tandem-wing
- Tail shape: tailless

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- Propellers' count: 6 (plus 2 side ducted fans for forward thrust)
- Propellers' mount: 3 propellers mounted to each of a left and right bar (and a ducted fan is attached to either side of the fuselage “the main aircraft body”)
- Number of non-pilot passengers: 4
- Piloting: autonomous
- Speed: 250 km/h (maximum airspeed); 180 km/h (cruise speed)
- Range: as much as 100 km
- Remarks:

(1) This fixed-wing UAM-eVTOL passenger aircraft allows a larger range than the VoloCity UAM-eVTOL model (also by Volocopter), with two propulsion fans, and six electric motors powering six rotors.
(2) A photograph illustrating the operation of VoloRegion can be found in Figure 4.

Figure 4.
A real view of the VoloRegion UAM-eVTOL aircraft during a test flight (displayed with courteous permission from Volocopter GmbH.
Source: https://mediahub-volocopter.pixxio.media/collections/45/media/1150).

4.5. CityAirbus NextGen **[277]**

- Manufacturer: Airbus SAS
- Base country: France
- Lift/Thrust method: fixed (not tilting) rotors and fixed (not tilting) wing; propulsion concept resembling the one used in a consumer drone
- Tail shape: V-shaped [278–282]
- Propellers' count: 8
- Propellers' mount: 6 propellers mounted to the wing; 2 other propellers mounted to the tail
- Number of non-pilot passengers: 4
- Piloting: autonomous (but initially to be piloted)
- Speed: 120 km/h (cruise speed)
- Range: 80 km (operational range)

- Remarks:

(1) The single wing is swept forward (or reverse-swept, that is inclined forward), which is not a conventional style [283–288].

4.6. Passenger Air Vehicle (PAV) **[289]**

- Manufacturer: The Boeing Company
- Base country: USA
- Lift/Thrust method: separate thrust and lift sources; fixed single wing
- Tail shape: twin tail [290–294]
- Propellers' count: 9 (including a rear propeller for forward thrust)
- Propellers' mount: 8 lift propellers in a bottom base frame (below the cabin); and one rear pusher-type cruise propeller (for forward thrust) mounted to the fuselage [295–299]
- Number of non-pilot passengers: 2 or 4
- Piloting: autonomous
- Speed: unknown
- Range: up to 80 km (50 miles)
- Remarks:

(1) Design and developed by Boeing subsidiary: Aurora Flight Sciences (USA)

4.7. S-A2 **[300]**

- Manufacturer: Hyundai Motor Group (HMG)
- Base country: South Korea
- Lift/Thrust method: full tilt-rotor (all rotors can tilt to provide lift or forward thrust); fixed single wing
- Tail shape: V-shaped
- Propellers' count: 8
- Propellers' mount: all 8 propellers mounted to the wing
- Number of non-pilot passengers: 4
- Piloting: onboard human pilot
- Speed: 193 km/h, 120 mph (cruise)
- Range: 64-km, 40-mile trips possible (exact maximum range not known)
- Remarks:

(1) Development through Hyundai's owned subsidiary: Supernal (USA)

4.8. Joby **[301]**

- Manufacturer: Joby Aviation, Inc.
- Base country: USA
- Lift/Thrust method: full tilt-rotor; fixed single wing
- Tail shape: V-shaped
- Propellers' count: 6
- Propellers' mount: 4 propellers mounted to the wing; 2 propellers mounted to the tail
- Number of non-pilot passengers: 4
- Piloting: onboard human pilot
- Speed: up to 322 km/h, 200 mph

- Range: not known
- Remarks:

(1) On 24/June/2024, a Joby's hydrogen-electric technology demonstrator UAM-eVTOL aircraft completed an 842-km (523-mile) flight. This hydrogen-powered UAM initiative was developed by the Joby subsidiary (H2FLY), which was acquired in 2021 [302]. A hydrogen-electric power is also used in fuel-cell electric vehicles (FCEVs), where oxygen (from the ambient air) reacts with onboard hydrogen to generate electricity; and this reaction produces emissions-free water vapor, with no carbon dioxide or other greenhouse gases [303–310]. Unlike FCEVs, where the onboard hydrogen is stored as a compressed gas "superheated vapor" above the ambient pressure (at a high pressure, such as 70 MPa, which is equal to 700 bar, or approximately 700 times the normal atmospheric pressures), the hydrogen in the case of the Joby flight was in a liquid state [311–322].

4.9. VX4 **[323]**

- Manufacturer: Vertical Aerospace Group Ltd
- Base country: UK
- Lift/Thrust method: partial tilt-rotor (only the 4 front lift propellers can tilt); fixed single wing
- Tail shape: V-shaped
- Propellers' count: 8
- Propellers' mount: all 8 propellers mounted to the wing
- Number of non-pilot passengers: 4
- Piloting: onboard human pilot
- Speed: 241 km/h, 150 mph (cruise)
- Range: up to 161 km, 100 miles
- Remarks:

(1) Vertical Aerospace Group announced that they are on track to certify their aircraft by the end of 2026 [324].

4.10. Midnight **[325]**

- Manufacturer: Archer Aviation Inc.
- Base country: USA
- Lift/Thrust method: partial tilt-rotor (only the 6 front lift propellers can tilt); fixed single wing
- Tail shape: V-shaped
- Propellers' count: 12
- Propellers' mount: all 12 propellers mounted to the wing
- Number of non-pilot passengers: 4
- Piloting: onboard human pilot
- Speed: up to 241 km/h, 150 mph
- Range: 161 km, 100 miles (and optimized for back-to-back trips of 32-km, 20-mile distance; thus the optimum range is 64 km or 40 miles)
- Remarks:

(1) The Midnight UAM-eVTOL aircraft is powered by 6 independent proprietary battery packs, and each pack supports a pair of the electric motors.
(2) Payload can exceed 454 kg (1,000 pounds).
(3) Cruising altitude 610 m (2,000 feet)

(4) As of August 2024, Archer Aviation Inc. is working through certification with the United States Federal Aviation Administration (FAA) and other global aviation authorities.
(5) Archer Aviation Inc. goals include transporting passengers using their Midnight UAM-eVTOL aircraft in the largest cities in different parts of the world.

4.11. Eve **[326]**

- Manufacturer: Eve Air Mobility
- Base country: USA
- Lift/Thrust method: separate thrust and lift sources; fixed single wing
- Tail shape: twin tail
- Propellers' count: 9
- Propellers' mount: 8 lift propellers mounted to the wing; and one rear pusher-type cruise propeller (for forward thrust) mounted to the fuselage
- Number of non-pilot passengers: 6 (but expected to be 4 at the beginning: EIS "Entry Into Service")
- Piloting: autonomous (but expected to have an onboard human pilot at the beginning)
- Speed: not known
- Range: 100 km, 60 miles
- Remarks:

(1) Eve Air Mobility is backed by Embraer S.A. (a Brazilian manufacturer of commercial jet aircraft). Eve Air Mobility has spun out of Embraer-X (the business and innovation accelerator of Embraer).
(2) This described design of the Eve UAM-eVTOL aircraft is under development (subject to change later).
(3) A rendered image illustrating the structure of Eve can be found in Figure 5.
(4) A rendered image illustrating the operation of Eve can be found in Figure 6.

Figure 5.
An imagined view of the Eve UAM-eVTOL aircraft on a vertiport "for take-off and landing" (displayed with courteous permission from Eve Air Mobility.
Source: https://www.eveairmobility.com/storage/2024/02/Eve_PR_Suppliers.png).

Figure 6.
An imagined view of the Eve UAM-eVTOL aircraft during operation (displayed with courteous permission from Eve Air Mobility.
Source: https://www.eveairmobility.com/storage/2024/02/Eve_Singapore_2024-1.png).

4.12. Jaunt [**327**]

- Manufacturer: Jaunt Air Mobility LLC.
- Base country: USA and Canada
- Lift/Thrust method: separate thrust and lift sources; fixed single wing
- Tail shape: conventional (horizontal stabilizer and vertical stabilizer)
- Propellers' count: 4 propellers (and one main rotor)
- Propellers' mount: 4 propellers for forward thrust mounted to the wing; one main central rotor (as in a helicopter) with a tilting mast
- Number of non-pilot passengers: 4
- Piloting: onboard human pilot
- Speed: 280 km/h, 175 mph (estimated)
- Range: 130-190 km, 80-120 miles (estimated)
- Remarks:

(1) Jaunt Air Mobility LLC. is headquartered in Texas (USA), with design and manufacturing taking place in Montreal (Canada). It specializes in transformative aerospace.

4.13. Generation 6 [**328**]

- Manufacturer: Wisk Aero LLC.
- Base country: USA
- Lift/Thrust method: partial tilt-rotor (only the 6 front lift propellers can tilt); fixed single wing
- Tail shape: conventional (horizontal stabilizer and vertical stabilizer)
- Propellers' count: 12
- Propellers' mount: all 12 propellers mounted to the wing
- Number of non-pilot passengers: 4

- Piloting: autonomous
- Speed: 204-222 km/h, 110-120 knots (cruising speed)
- Range: 144 km, 90 miles (with battery reserves [329,330])
- Remarks:

(1) For better aerodynamic performance, the 6 rear lift propellers stop "lock into position" during cruise.
(2) Charge time: 15 minutes

5. Conclusions

In the current study, we presented selected features of 13 different designs of urban air mobility electric vertical take-off and landing (UAM-eVTOL) aircraft from 12 different UAM developers worldwide. Our study is a focused review regarding the industry technology options for UAM-eVTOL aircraft (which can have multiple applications, such as air taxis). The following findings can be stated:

- There is no one optimum or universal design for urban air mobility aircraft. Instead, no two UAM designs among the 13 discussed here are the same.
- Most of the UAM-eVTOL designs covered here use a wing configuration, while only two designs use a pure multirotor configuration.
- A representative cruising speed of multirotor UAM-eVTOL aircraft is 120 km/h, and a representative range is 30 km.
- A representative cruising speed of wing-based UAM-eVTOL aircraft is 240 km/h (roughly twice the speed of a multirotor design), and a representative range is 120 km (roughly four times the range of a multirotor design).
- About half of the UAM-eVTOL models are designed for autonomous operation, while the other half are designed for operation by an onboard human pilot.
- Hydrogen fuel cells can be used to operate UAM-eVTOL aircraft, where the electric energy is generated during the flight from onboard stored hydrogen (rather than being stored in battery packs).
- As an air taxi, a first-generation UAM-eVTOL aircraft may carry between 2 and 6 passengers.

Table 1 below summarizes three selected key features of the 13 UAM-eVTOL aircraft covered in this study, and these key features are (1) the overall flight concept, (2) the travel speed, and (3) the flight range. For consistent comparison, unit conversion was applied if needed, such that a uniform unit of km/h is displayed for all speeds and a uniform unit of km is displayed for all ranges.

Table 1.
Characteristics of the photovoltaic system (PVF) with fixed panels.

Index	UAM eVTOL model	Flight concept	Speed	Range
1	EH216-S	Multirotor	130 km/h (max. design speed)	30 km (max.)
2	VoloCity	Multirotor	110 km/h (max. airspeed)	35 km
3	Lilium Jet	Wing	248 km/h (cruise speed)	175 km (max.)
4	VoloRegion	Wing	250 km/h (max. airspeed) 180 km/h (cruise speed)	up to 100 km
5	CityAirbus NextGen	Wing	120 km/h (cruise speed)	80 km (operational range)
6	Passenger Air Vehicle (PAV)	Wing	-	up to 80 km
7	S-A2	Wing	193 km/h (cruise speed)	can perform 64-km trips
8	Joby	Wing	up to 322 km/h	-
9	VX4	Wing	241 km/h (cruise speed)	up to 161 km
10	Midnight	Wing	up to 241 km/h	161 km (optimized for 64 km)
11	Eve	Wing	-	100 km
12	Jaunt	Wing	280 km/h (estimated)	130-190 km (estimated)
13	Generation 6	Wing	204-222 km/h (cruise speed)	144 km (with battery reserves)

Finally, this work may be extended in multiple directions; such as investigating specialized technical requirements for the UAM-eVTOL aircraft and that novel mobility concept (including precise control for autonomous flight, low-weight onboard electric storage, limited acoustic pollution, and integration with distributed clean power units), assessing the impact UAM-eVTOL on the environment and its contribution to mitigating harmful emissions, forecasting new higher-education specializations or academic subjects that the workforce in that area may need, proposing safety standards and regulatory procedures to suppress chances of accidents in inhabited communities, establishing accessible databases for UAM-eVTOL utilization data such that statistical analysis can be made by a wide range of interested stakeholders, building simulation models for designing and optimizing the trajectories and configuration of aircraft and their routes, and performing economic study about the feasibility of the UAM-eVTOL mode of transport at different presumed scales [331–342].

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