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ScienceDirect

Transportation Research Procedia 81 (2024) 35–43

Transportation Research Procedia

www.elsevier.com/locate/procedia

13th International Conference on Air Transport – INAIR 2024, Challenging the Status Quo in Aviation

UAM Passenger Business Model Development: The Effect of Aviation Authorities' Strategies and Technological Advancements

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Abstract

Advancements in technology and requirements of life in metropolitan cities with their suburbs have given rise to the development of new concepts and applications like Advanced Air Mobility (AAM) and Urban Air Mobility (UAM), even if civilian life throughout the world is still getting used to the presence of Unmanned Aerial Vehicles (UAVs). While civil aviation authorities have not yet been able to solve the problems related to the integration of the incredibly increasing number of UAVs into the airspace and their threat to manned aircraft, they are faced with UAM practices that make this situation more complex and inextricable. The fact that the regulations that must be established by aviation authorities are lagging behind cannot prevent the rapid advancement of UAV technologies and UAM practices. This study aims to set forth possible passenger UAM business models and to open a discussion on this subject, unraveling the complex interaction between technology, authorities, and infrastructure although the UAM application is not yet clear. This study is carried out by utilizing present literature on UAM and the regulations of civil aviation authorities. The findings demonstrated the interconnected nature of regulations, technology, infrastructure, and passenger UAM business models. Finally, passenger UAM business models are separated into two main categories as scheduled and nonscheduled. While scheduled UAM business models are proposed as airport shuttles, company shuttles, and air metro; nonscheduled ones are on-demand air taxi, sightseeing, and UAM service providers.

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Peer-review under responsibility of the scientific committee of the 13th International Conference on Air Transport – INAIR 2024, Challenging the Status Quo in Aviation

Keywords: Urban Air Mobility (UAM); Unmanned Aerial Vehicle (UAV); business model; aviation management; strategic management

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10.1016/j.trpro.2024.11.005

1. Introduction

UAM is an emerging concept revolutionizing transportation by introducing innovative aerial solutions within urban environments. This novel, innovative concept has potential to be a fast and reliable alternative for conventional urban transportation. Currently, metropolitan urban areas require such an alternative to reduce the traffic congestion within the cities. Recent researches demonstrated that UAM might meet this need in near future (EASA, 2021; Jonas et al., 2021).

EASA (2024) anticipates that, common presence of electric Vertical Takeoff and Landing aircraft (eVTOLs) above cities will be a reality within the next five to ten years if concerns and regulatory uncertainties are eliminated. Apparently, technology proceeds more rapidly than the regulatory framework, leading to a gap between technological advancements and regulations. If the regulatory structure does not catch up and keep up with technological developments within the next five to ten years, this gap is likely to outgrow. This significant challenge will be one of the main obstacles to the implementation of UAM.

Unmanned Aircraft Systems (UAS) manufacturers and some automobile brands started to boost new products creating innovative VTOLs for UAM operations. Currently, numerous manufacturers have made significant progress in both production and certification processes of electric Vertical Takeoff and Landing (eVTOL) and hybrid Vertical Takeoff and Landing (hVTOL) aircraft taking place in UAM practices. Some of these advances listed below:

- Volocopter conducted crewed test flight with Volocopter 2X in Osaka and Amagasaki on December 2023 in preparation for the 2025 World Exposition, Osaka Kansai EXPO (Volocopter, 2023).
- SkyDrive has started test flights in 2018 and first manned flight test in 2019. Now, accepts pre-orders from private individuals for its eVTOL aircraft SD-05 for personal use (SkyDrive, 2023).
- Joby Aviation's eVTOL air taxi has flown more than 30,000 miles from 2017 on. Their anticipation is to initiate commercial passenger service in the year 2025 (Joby Aviation, 2023).
- Lilium received Design Organization Approval from European Union Aviation Safety Agency (EASA) on November 2023 (Lilium, 2023).
- Pipistrel has air cargo transport vehicle design, Nuuva V300. They signed partnership with Lobo Leasing for 15 Nuuva V300 hybrid hVTOL aircraft (Pipistrel, 2023).
- Wisk Aero has achieved a milestone by successfully conducting the public demonstration flight of a fully autonomous, eVTOL air taxi with fixed wing configuration (Wisk Aero, 2023).
- Hyundai Motor Group's Advanced Air Mobility (AAM) company Supernal debuted SA-2 eVTOL aircraft at CES 2024. The S-A2 is a V-tail aircraft intended to initially meet the usual city operation needs of 25- to 40-mile journeys at a speed of 120 miles per hour at a height of 1,500 feet. Company aims to enter the market in 2028 (Hyundai, 2024).
- E-hang announced that the certified EH216-Spilotless passenger carrying UAS completed commercial flight demonstrations in Guangzhou and Hefei on December 28, 2023 (EHang, 2023).
- Airbus has revealed its eVTOL prototype, CityAirbus NextGen in September 2021. It is fully electric, four-seat VTOL aircraft with Lift + Cruise concept. Capable of 80-km operational range and cruise speed of 120km/h (Airbus, 2024).
- Boeing and Porsche have signed a Memorandum of Understanding to collaborate on the development of eVTOL prototype and participation in the emerging UAM concept (Porsche, 2019).
- Italdesign and Airbus unveiled a passenger eVTOL concept which is the world's first modular ground and air passenger vehicle system (Italdesign, 2017).
- Airbus' Vahana finalize its test flights in November 2019. Vahana is a tilt wing, single seat, self-piloted eVTOL with the specifications of 50km range, 220km/h max speed, 8x45kW electric motors and 38kWh batteries (Airbus, 2019).
- Airbus' on-demand helicopter platform Voom and Audi teamed up to create a door-to-door ground and air passenger transportation service (Airbus, 2018).

Some studies also predict UAM market potential. In the case that the technology and capital formation grow more rapidly than the certification timeline, regulations and infrastructure development, Jonas et al. (2021) estimates that global total addressable market will be around $1tn by 2040 and $9tn by 2050. Another prediction regarding the

market size is that the market size, which includes R&D, manufacture, operations, and infrastructure construction, will be 4,2 billion in 2030. According to this prediction, there will be 90000 jobs created or sustained in construction and operation field (EASA, 2021). Urban air transportation cases as public transportation, emergency services, air rescue, public security, goods delivery, touristic applications, etc. predicted to have potential to be some of the UAM applications (EASA, 2021; Cohen et al., 2021; Straubinger et al., 2021; Porsche Consulting, 2021).

Business models will be determinant in every step for UAM concept to integrate into urban life. Predictions for use cases and market potential, developing technologies and regulations, studies on safety and reliability concerns must be examined for each UAM business model. All facets of developing technologies, regulations and emerging challenges affect UAM business model structures. For this reason, this paper aims to create a frame for passenger UAM business models and to demonstrate the interaction between passenger UAM business models, regulations, technology, and infrastructure.

This study contributes to provide essential strategic frameworks for shaping how UAM services will be launched, operated, and sustained. By showcasing the characteristics of future UAM business models with technological, infrastructural, regulatory, and environmental aspects and challenges, it ultimately contributes to the growth of the UAM industry.

Since UAM business models have not yet been implemented and this sector has not reached a certain maturity, some limitations exist for this study. It does not seem possible to mention or analyze any market environment, competitor analysis, threat analysis, financial plan, and marketing strategy of these business models yet. The benefits for the city or the region will depend on the perception and acceptance of the UAM by society.

2. Methodology

The study employs the content analysis method by searching key words *UAM, business model, eVTOL, UAV, and UAS*. Research articles, news, websites of manufacturers, regulations of aviation authorities like EASA, NASA, FAA, and publications are used as materials to gather relevant data about the evolving business models and the associated concerns. The study identifies the features of UAM business models, strategies, and concepts.

Ultimately, the research concludes by emphasizing the intricate relationship between the development of business models, regulations, technology, and infrastructure within the emerging UAM concept.

3. Business Models

A business model explains the logic behind how a company generates, provides, and acquires value. It outlines the business's strategy for generating revenue and making a profit from its operations (Osterwalder & Pigneur, 2010). Understanding and innovating business models is crucial for companies to stay competitive, adapt to market changes, and meet customer needs effectively. How to generate innovative and visionary business models for a new concept like UAM is really a mystery. However, pilot applications, technological developments, and the developing strategy and concept shed light on what kind of business models can emerge when UAM is actually implemented.

A business has four essential areas: customers, offer, infrastructure, and financial viability. These main areas are covered by the key components of the business model: value propositions, customer segments, customer relationships, channels, cost structure, revenue streams, key activities, key resources, and key partnerships (Osterwalder & Pigneur, 2010).

Until now, discussions surrounding UAM have primarily focused on use cases rather than business models. Although they complement each other, they are not the same. Public transportation, for instance, is more of a use case than a UAM business model, and within that, air taxis can be considered as a sub-use case. Therefore, when addressing business models, the focus should shift to how these use cases are assessed and the strategies that companies employ to deliver services, rather than simply discussing UAM use cases.

Up to now, a comprehensive structure for passenger UAM business models has not been articulated in detail. Therefore, this study contributes to existing literature by defining UAM business models and differentiating them from use cases. Definitions and classification of UAM business models are demonstrated in Table 1.

Table 1. UAM Business Models.

UAM PASSENGER BUSINESS MODELS	**SCHEDULED**	**Airport Shuttles (Straubinger et al., 2021):** Integrating airport shuttle service into UAM will increase accessibility for airline passengers. These eVTOLs might be operated by either airport management or different outsourced company between urban area and the airports.	
		Company Shuttles (Straubinger et al., 2021): It is a collaborative business model, just including participating companies, utilizing a shared infrastructure designed for specific purposes. Its primary objective is to enhance the mobility of the company's employees, clients, and goods which need urgent transportation to save time. Additionally, this model is also applicable for company's business trips. It is anticipated that companies embracing the UAM concept with this business model will experience a positive impact on their image within the industry (Straubinger et al., 2021).	
		Air Metro (Krull et al., 2022; NASA, 2018): The flight path, time, and destinations are predetermined in air metro for scheduled public air transport service. Air metro as a use case of UAM includes some details as predetermined routes, schedules, and stops in high-traffic areas. It also assumes the air metro to be unpiloted and the passenger capacity to be 2-5. Payload capacity is 1000 pounds and trip distance are 10 to 70 miles (NASA, 2018).	
	NON-SCHEDULED	**On-Demand Air Taxi:** On-Demand Air Taxi is a UAM business model where flights are arranged dependent on passenger requests. This model allows passenger to request the departure time, and available take-off and landing locations unlike prescheduled flights. According to NASA (2018), air taxi is one of the use cases of UAM. On-demand air taxi business model might be either exclusive or ride sharing. Destinations, pick-up and drop-off locations are chosen by the passengers. Air taxis are designed as unpiloted flights, 2-5 passenger capacity, 1000-pound payload capacity, 10 to 70 miles trip distance (NASA, 2018). Air taxis might operate either between departure and arrival points, or door-to-door. The collaboration between Airbus and Audi providing door-to-door ground and air transportation. Audi vehicles provide ground transportation services, while Voom's helicopters handle air transportation. This is an example for another original air taxi business model (Airbus, 2018).	**Air Pooling (Cohen et al., 2021) Public:** On-demand air taxi includes a business model where multiple passengers share a single trip. This approach is designed for passengers who seek cost savings through shared trips. For this model to work, passengers must have the same destination, necessitating coordination among passengers to find shared routes and agree on the details. This might be provided via booking applications such that passengers can see other's destinations and communicate with them.
			Exclusive: This model offers service similar to ground taxis for passengers who prefer or require individual trips. Pick-up and drop-off locations are chosen by passenger. Users simply need to call a taxi and specify the destination.
		Sightseeing (EASA, 2021; Straubinger et al., 2021): UAM serves not only as means for reducing the traffic congestion in the metropolitan cities but also for tourism. This concept has given rise to a specific UAM business model known as sightseeing, which involves tourist trips in both metropolitan and tourist-centric cities. Nevertheless, it is also helpful for tourists to escape from traffic congestion and spend more time to touristic activities.	**Hop-On Hop-Off:** Hop-on hop-off type of this business model enables passengers to pause at tourist attractions within the city, disembark at these points, and explore parks, museums, squares or do any other touristic activities of interest in the region.
			Non-Stop: Passengers fly over the city, enjoy the view as the guide provides narration during flight. No breaks or stops until the end of the tour.
		Private UAM Service Provider: This particular business model, which seems suitable for people with high income, arises from the business relationship between private eVTOL owners and the approved service providers. These service providers are responsible for flights and various periodic and non-routine maintenance and controls.	**Privately Owned/ Personal eVTOLs:** Individual vehicle owners make agreements with service provider companies as part of the UAM concept, delegating tasks such as flights, maintenance, and flight planning to these service providers.
			eVTOL Rental Service: Service providers rent their vehicles to the passengers for a specific period. Service provider carries out the entire operational process with the request of renter during that period.

The focus of this section is business models for passenger transportation, which are defined and categorized in Table 1 along with models that have been reviewed in the literature. The identified business models are largely similar to existing land transportation models or adaptations of traditional air transportation models tailored for UAM. The intention is basically to extend models that works on land into the sky, alleviating ground traffic congestion and fostering more liveable cities. This will accelerate acceptability and deployment of UAM business models which underscores the relevance of this study.

While reducing traffic congestion in metropole cities, UAM will develop more environmentally friendly transportation, save time, money, and energy. UAM is the revolution of this century in the field of transportation by utilizing Artificial Intelligence (AI), robotics, and novelest sensor technologies.

As illustrated in Table 1, passenger UAM business models are fundamentally divided into two categories: scheduled and non-scheduled. Making this distinction is crucial for a more accurate understanding of UAM business models and clearer conceptualization. Upon closer examination, the primary characteristic of UAM business models is closely tied to whether they are scheduled or not. As discussed in the following section, UAM business models have requirements regarding regulations, infrastructure, and the advancement of UAS technologies, and these needs largely stem from the scheduling considerations in implementing business models. Hence the distinction between scheduled and non-scheduled stands out as a pivotal factor that sets apart UAM business models.

Scheduled passenger UAM business models are airport shuttles, company shuttles, and air metro while the non-scheduled ones separated into on-demand air taxi, sightseeing, and private UAM service provider. There are different applications of each nonscheduled business model. On-demand air taxis separated into two groups as air pooling public and exclusive according to the option to share the vehicle on the same route or not. Sightseeing eVTOLs are two types by choosing the nonstop or hop-on/hop-off options.

4. Key Aspects of UAM

UAM is an evolving field and is promoted as a sustainable mode of transportation with various key aspects which emerge different challenges:

- Technological Aspect
- Regulatory Aspect and Safety Concerns
- Infrastructure and Air Traffic Management
- Economy and Market Strategy
- Environmental Aspect and Social Impact

Artificial Intelligence (AI) and autonomous flight technologies are critical for navigating complex urban airspaces safely and efficiently. Advances in battery technology and electric propulsion make UAM viable, which impacts range, efficiency, and safety. Strict standards for vehicle design, operation, and maintenance must be established in order to guarantee the safety of UAM operations. From the infrastructure point of view, UAM requires specially designed vertiports, for takeoff, landing, and charging of eVTOLs. Integrating UAM into existing air traffic management systems is a significant challenge, requiring new frameworks and technologies. Societal acceptance, cost of operations, and scalability will determine the market adoption and strategies. Noise pollution in urban areas might also create an environmental concern.

In ICAO's First Advanced Air Mobility Symposium (2024), the challenges and opportunities were put forward to harmonize AAM. Airworthiness of AAM, airspace design/ integration of eVTOLs into airspace, air traffic management, operational rules, infrastructure, holistic and integrated risk management, and AAM security were highlighted as challenges.

5. Interaction of UAM Business Models with Regulations, Technology, and Infrastructure

From a regulatory perspective, distinct considerations arise for each UAM business model. Hence, business models mentioned in the literature necessitate subdivision into subcategories for a comprehensive examination. Scheduled and unscheduled passenger UAM business models are discussed. Flight time, path, battery charge, landing sites infrastructure, regulations are the main determinants of these business models.

Among the various UAM application scenarios, air taxis emerge as the focus for public transportation. Projections for the total earnings generated by intracity air taxis is going to vary significantly ranging from $7 billion to $240 billion during the period of 2025 to 2035 (Porsche Consulting, 2021). Earnings, technology, and regulations developed for air taxis will be shaped in relation with business models. Upon close examination of air taxi business models, distinct characteristics emerge, indicating potential variations in the regulations and technology required for their operations.

Comparing on-demand air taxi and air metro, a crucial distinguishing factor between these two business models is planning. This implies that both models might utilize different take-off and landing locations because of varying frequencies. In addition, the vehicle serves on-demand air taxi service needs to be parked several times during the day when it is not in use unlike air metro. It becomes evident that business models sharing structural similarities might have substantially different requirements. Hence, these different business models might have different operational regulations like flying at different altitudes, utilizing different UAM corridors, or necessitating different take-off and landing locations. For air metro, the requirements include vertical take-off and landing capability, a range of 75 miles, an electric propulsion system suitable for urban environments, autonomous route planning and navigation in the event of signal loss, structural durability for frequent take-off and landings, transportation capacity of four passengers with luggage, and low noise levels (NASA, 2018). It is highly probable that similar requirements are viable to every business model.

Furthermore, diverse aircraft types may be mandated to meet these requirements. For example, variations in cruise altitude or charging frequency may require the deployment of air vehicle with different technologies for each business model. This is a consideration that applies not only to air taxis but also to other business models, as each model comes with its unique set of requirements. These needs encompass factors such as payload capacity, charging frequency, cruising altitude, frequency of using take-off and landing areas (TOLA), as well as parking and maintenance.

A company applying a sightseeing business model may seek to fly at a specific altitude and path to enhance the city view. Alternatively, to achieve the anticipated revenue in alignment with the strategy of this business model, it might require vehicles with greater passenger capacity compared to air taxis or air metros. A similar need might arise for company shuttle and airport shuttle business models, where these aim to decrease the number of trips by increasing passenger capacity to make it more cost-effective. After all, using high capacity eVTOLs doesn't seem to be viable in the near future due to the limited endurance and limited capacity of rechargeable batteries of these vehicles.

As indicated in Table 1, private UAM service providers conduct original operations such as delivering a premium service to high-income passengers. Since, Privately Owned / Personal eVTOL business model operates customer's own vehicles, it is reasonable to say that regulations pertaining to this model will likely limit the selection of the owners' vehicles which means it might not be possible for service providers to operate all types of eVTOLs. Employing licensed pilots and technicians for operations and maintenance is a must for private UAM service providers, as different eVTOL manufacturers design and produce vehicles with varying features. The businesses involved in this venture must also abide by the rules established for this particular business model. These specific needs and preferences lead to design variety, which need categorization. Based on this categorization, authorities will be obliged to impose different operating rules on business models for every design. Similar requirements and categorizations may apply to eVTOL Rental Service. For instance, as the vehicle will be owned by the service provider, it might need to accommodate a wide range of customers.

Table 2. UAS Categorization.

UAS Categorization (EASA, 2021)	Vectored Thrust	Lift + Cruise	Wingless
Specifications	Motors used for both lift and cruise. Lift is created by wings at cruise. Highest cruise speed	Independent motors for take-off and cruise. Faster than rotorcraft due to fixed wings.	Rotors for lift and cruise. Lower maintenance and lightweight.

As seen in the Table 2, technology is advancing faster than formation of business models. Therefore, there is a room for discussion regarding the suitability of the UAS categories presented in the Table 2 for various business models.

Table 3 illustrates the categorization of take-off and landing sites, each category possessing unique characteristics. Considering these features, authorities can establish regulations specifying which business model should operate in which type of take-off and landing site. Such regulations are essential as business models require distinct routes, tools, and planning.

Table 3. TOLA Categorization.

Take-off and Landing Area Categorization (EASA, 2021; Krull et al., 2022)	Vertiport	Vertibase	Vertihub
Specifications	Smallest TOLA. One UAS capability. Short term parking. Suburban area.	Space for up to five UAS. Short term parking. Highly urban areas. Charging available.	More than one UAS capability. Parking, charging, and maintenance is available. Located mostly in significant airports due to the size.

One of the key elements influencing business model design is pricing and cost (Wald et al., 2015, p. 149). Higher infrastructure and technological requirements will absolutely result in higher operating expenses. UAM operations must adapt the right infrastructure and technology for each type of business model since various business models necessitate varying degrees of infrastructure support and technological integration.

6. Results & Discussion

Since each business model possesses unique and different characteristics, regulations should be tailored considering each business model. Currently, UAS technology continues to develop autonomously. When the UAM application is put into practice in metropole cities and mass production is needed, they will adjust their production to fit the emerging market business models, regulations, and strategies.

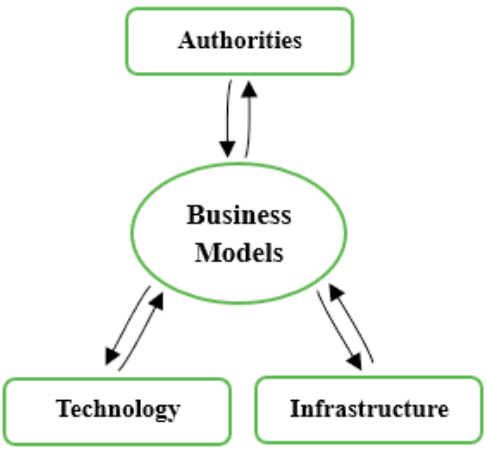

Fig. 1. Interaction between Business Models, Authorities, Technology, and Infrastructure

Business models and applied existing strategies are always in interaction with regulations, technology, and infrastructure (Figure 1). Similar to how authorities impose restrictions, regulations, and expectations on implementing business models, the demands arising from the distinct characteristics of these models will also exert pressure on authorities. The development of technology and infrastructure must align with business models. Imposing incompatible or irrelevant technologies and infrastructures on business models could diminish the performance and efficiency of UAM.

7. Conclusion

UAM is an innovative concept that still requires comprehensive exploration in all its aspects. The focus of this study is to open a discussion on possible passenger UAM business models and to demonstrate the dependencies between authorities, technology, infrastructure, and business models from a strategic management point of view. Possible business models are formed utilizing existing literature and aviation authorities' regulations according to their application natures and characteristics. In addition, this research pays attention to the advancements in UAS technologies evolving faster than regulations, strategies, and concepts. In the face of such major innovative developments, regulations and strategy development activities are always bound to lag behind technology. Once technological developments reach their peak, full concepts and regulations will be settled. Defining business models comprehensively, considering all their relevant aspects and keeping pace with technological advancements are significant to shape business strategies in UAM industry in the future.

The passenger UAM business model formed by the authors is only a proposal to generate new ideas and open discussions on this subject in the academic community and business world. This proposal is important as a starting point to shed light on future studies. The nature and application area of UAM business models are different from those of airline business models.

In future studies, in addition to developing different UAM passenger business models, strategic management studies regarding UAM cargo business models can be conducted. It should consider the interaction between business models, strategic management, regulations, technology and infrastructure. It should always be taken into consideration that UAM is a system that has not yet found its place in practice.

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