ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 8, August 2017

The Air Taxi: A Futuristic Travel System Nearing Reality

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Abstract: This report provides a comprehensive overview of the fast-evolving small air taxi industry and its future scope. This starts by looking at how urban air taxies have developed over the years and providing a snapshot of the current landscape. The study discusses the main application areas, the preliminary timetable when they are likely to be commercialized, and the business models and revenue streams that may emerge from those application areas. It also looks at the different types of air vehicles, their unique features and the areas of use for which they are best suited. In addition, this report analyses the evolving air taxi industry in a comprehensive way. The report aims to clarify the key infrastructure and support resources needed for the smooth operation of air taxis, thereby landscape a representation of the future of the air taxi ecosystem. The present work also discusses legal flight limitations and possible future proposals for air mobility. The goal is to obtain the necessary information for the selection of restricted areas for potential flight routes with the least impact on people. The work aims to capture the evolution of air taxi over the years, up to 2020. The development of air taxi application areas, new business models for air taxi vehicles, and the air taxi industry will grow in the future and main findings and actionable recommendations have been clarified in this research paper.

Keywords: Air Taxis, Least Cost Network; Aerial Space Management, urban air taxi, transportation, 3D geo-fences, Air mobility

INTRODUCTION

Air taxi is a small commercial aircraft that makes short flights on demand. The increase in the number of cars on urban roads and the resulting traffic congestion make it difficult for day-to-day drivers, emergency responders and ambulances to reach their destination on time. An effective alternative would be to use underused urban airspace to make travel in congested areas more secure. Helicopters were the only vehicles available for urban transport to date. Nevertheless, their heavy frame, long propellers and noise levels make them unsuitable for mass urban transport. There is therefore a need for a new vehicle that can be used effectively for urban air transport. Small air taxis have the potential to fill this void, leading to an age of seamless air travel. The introduction of an air taxi poses a number of relevant safety-related issues. The air taxi, the most realistic iteration of a science-fiction car flying dream, could become a possibility in the foreseeable future.

According to the United Nations, 55 per cent of the world's population lives in urban areas, which is expected to increase to 68 per cent by 2050. When traffic congestion continues to rise, so do the associated costs, including travel time and service costs. The air taxi segment is relatively new to the mobility scene, growing in importance across highly-congested urban cities, which find it difficult to handle all traffic on their streets. Although the air taxi niche is not yet commercialized and only a few pilot runs have been reported, the air taxi landscape is exciting with companies such as Uber, Lilium and Kitty Hawk racing to provide people with an urban transport alternative. Volocopter, the German airline taxi company, is a realistic vision of the future of travel [2]. It provides Urban Air Mobility with its lightweight, airborne aircraft, in addition to existing transport options. The start-up is designing an all-electric vertical take-off and landing (eVTOL) air taxi intended to provide an electrical air taxi service in urban areas [1]. At present, the system is limited to a top speed of 100 km/h (62 mph) and a range of approximately 27km (16 miles), but the method of air taxi transport is intended to provide fast point-to-point transport in towns, bypassing traffic. It also looks at the different types of air taxi, their unique features and the application areas that are best suited to them. In addition, this report analyses the evolving air taxi industry in a comprehensive way.

Governments that have favourably introduced air taxi related programmers and their dream. The report aims to clarify the key infrastructure and support resources needed for the smooth operation of air taxis, thereby painting an image of the future of the air taxi ecosystem. The present work discusses the legal restrictions on flights and the principles for possible future air mobility. The goal is to obtain the necessary information for the selection of restricted areas for future flight routes with the least impact on people.

Figure.1: Air taxis

Market Summary:

In 2001, air taxi operations in the United States were supported by a report by NASA and the aerospace industry on the future Small Aircraft Transportation System (SATS) and the growth of light jet aircraft development. Air taxis have resurfaced as part of the emerging sector of passenger drones since 2016. The testing phase of small air taxis in urban areas has recently begun. The German start-up Volocopter has shown that the technical requirements for a small-volume air taxi transport system are already met for an electrical weight shift-air taxi (Volocopter 2018). Competition in the field of electrical air transport, whether manned or unmanned, is growing. Flight rules, however, govern urban areas both now and in the future. Therefore, the futuristic design faces restrictions.

Concepts are being developed by national and international aerial space authorities, such as the DLR (Geister 2018), CAA (2018) or NASA (2018), proposing proposals for future urban aerial space management (Geister 2017). The ideas suggest how the airspace could be separated and restricted by geo-fences [2], in order to prevent flying objects in certain areas. Air taxi operations in Canada are regulated by Transport Canada pursuant to Canadian Aviation Regulation 703. The Canadian concept of air taxi covers all commercial single-engine aircraft, multi-engine helicopters flown by day visual flight rules to one pilot and all multi-engine, non-turbojet aircraft, with a maximum take-off weight of 8,618 kg (18,999 lb.) or less, and nine or less passenger seats used for transporting people or goods or sightseeing. In the US, air taxi and air charter operations are regulated by Part 135 of the Federal Aviation Regulations (FAR) as opposed to larger scheduled air carriers that are subject to more stringent FAR Part 121 requirements. Volocopter raised EUR 50 million in its Series C funding round, with financing led by the Chinese auto giant Zhejiang Geely Holding Group Co., a company that owns Volvo, Lotus and other car manufacturers.

With this round, Volocopter's total investment has increased over the years to € 85 million. They are planning to use the money to bring the aircraft to production and build their urban air taxi service. In the next few years, the air taxi industry will take off, and it can only transform personal and commercial travel to the good of all of us.

RESTRICTIONS FOR AIR-TAXIS IN URBAN AREAS

Flying air taxis are able to ride and can land and start up vertically. Most of them are battery-powered, shift-control aircraft and helicopters. Lilium Aviation (2018) and Volocopter (2018) plan to compete with nearby taxis in urban areas such as New York City. They advertise with a contrast between taxis and air taxis in New York, without acknowledging any aerial restrictions. The goal of this chapter is to stress that aerial space is a scarce resource and that not only Lilium Aviation (2018) and Volocopter (2018) are faced with another challenge: to be allowed to operate in the aerial space of an area where not only commercial and standard air taxi flight regulations operate. However, the high population density of tall buildings and several protected areas limits the city.

Legal Restrictions for the Flight Paths:

Travel limits come from aerial space agencies such as the European Space Agency (ESA) or the Federal Aviation Administration (FAA) in the United States of America. Legislation is strongly dependent on national legislation. The FAA regulation, relating to the example of Lilium Aviation in Manhattan, is soon detailing this research. The requirements vary for different aircraft: Unmanned Aircraft Systems, Ultra-Light-Vehicles, Air taxi with and without communication capabilities, Fixed-wing aircraft and helicopters, including weighted shift-control vehicles (Federal Aviation Administration 2017). The following are the rules for the testing area and the test vehicle.

- In congested areas: 500 feet above the sea, except over open water or sparsely populated areas. Therefore, the air taxi may not be operated within 500 feet of any human, vessel, vehicle or structure.
- Helicopters, electric parachutes and weight-shift control aircraft. If the procedure is carried out without danger to persons or property on the surface: since the electrical air taxi are not as loud and as large as the conventional helicopter, special routes are suggested for this type of aircraft. This optimization is the main objective of the model production.

Concepts for the Future Aerial Space Management:

In the future of urban airspace, Geister (2017) from the German Aerial Space Agency (DLR) suggests the concept of an interconnected urban air space used by numerous aircraft, including autonomous and unmanned aeronautics. Geister (2017) points out the importance of permanent and transient no-fly zones. All air taxi are also given an "Air taxi Safety Bound," which depends on speed and other safety parameters. Taking that idea into account, the following chapter involves the introduction of the restrictions under consideration and the possible solution for the future urban aerial space.

GEOPROCESSING MODEL FOR LEAST COST FLIGHT PATHS AND LEAST COST NETWORK

The methodological process for least cost connections between ports and hubs for air taxis is based on a geo-processing model and built with the ArcGIS Pro Software Model Builder from Esri (2018). Due to the complexity of the model, it is not possible to describe all granular steps for integrity and replication of the solution. The focus is on explaining the most important steps of the model. Nevertheless, it is important to note that the process of obtaining information is necessary for the development of the research. Free and freely accessible data must be collected for the identification of roofs of buildings in a city, the layout of buildings with their elevation characteristics (Open Data NYC 2018) and the economic / social use of urban areas (Open Street Map 2018). It is also important to digitize flight obstruction maps which are freely available in PDF and TIF formats (Federal Aviation Administration 2017). Having worked out the pre-processing tasks, the Model Builder from Arc Map (Esri, 2018) is the chosen method for the design of the geo-processing model.

Generating 3d Geo-Fences:

The first geo-processing model is concerned with extracting the altitude values from the spatial layers coming from the height of the building. They are then used in conjunction with restricted geographic areas such as educational centres, hospitals, embassies and cemeteries to measure 3D buffers. 3D buffers are extruded 2D buffers with z-information extracted from buildings and regions. Height restrictions vary from building limitations, since parks, graveyards and recreation areas are usually large polygons. These have special characteristics in the design of 3D barriers and are given a vertical boundary of 600 meters. A 3D route is intersected in this geo-fencing to simulate a special way to and from airports to create a connection in the vicinity of the airport [3].

Land use	Vertical	Horizontal
Airport	**600**	**Dynamic**
Hospitals	**300**	**300**
Universities	**200**	**300**
Embassies	**300**	**300**
Parks	**300**	**100**
Graveyards	**300**	**100**
Recreational Areas	**300**	**100**
Rooftops	**1524**	**-**

The process begins with the measurement of spatial impedances and the construction of three-dimensional geo-fences that comply with the flight regulations. The impedance has an effect on the cost of transporting electric aerial taxis [4], therefore the intention is to find a route with a minimum cumulative cost. The geo-fences are defined as 3D-buffers, which may overlap.

Figure.2: 3D Geo-fencing feature

In order to obtain a specific geo-restriction layer that serves as input for the second stage of the geo-processing model, it is necessary to apply a dissolving geo-process between all buffers. This cycle must be run sequentially from buffers with higher heights to buffers with lower heights. It means that the biggest gaps exceed the smallest and therefore maintain the spatial integrity of the area of influence. The model also involves the generation of new attributes with respect to the layer of buildings outside the buffer area of influence. This is done to determine the minimum height at which air taxis will travel over buildings in unregulated areas. In this way, the addition of 152.4 m (500 ft.) is applied to each of the roof heights of these buildings, as laid down in the FAA Regulations. The software includes the ability to dynamically add and disable geo-fences.

Generating the Minimal Height:

To create a minimum flight altitude level, the model uses an input layer to eventually transform it into an Inverse Distance Weighting Interpolation Algorithm (IDW) as the cost surface. The first step, therefore, is to take as a point category all polygon-type geometries belonging to the building layer outside the restriction areas, taking into account the amount of the height of the roofs and the additional height of 152.4 meters, which is the 500-foot limit imposed by the Federal Aviation Administration (2017). Since the area of restriction of the current Geo-fences is quite large and needs to be translated to interpolation points, the point mesh is chosen to be no less than 30 meters of distance between the lines. The height of the vertical constraint is inherited by each of the points within the geo-fences. Subsequently, the different point layers of the rooftops and the geo-fences are combined and are the data for the IDW interpolation algorithm. The effect is a raster surface with a spatial resolution of 30 metres, which acts as the least expensive option. Therefore, the first phase of routing for urban air taxis includes converting 3D-Geofences to a low-cost surface.

ANALYSIS OF AIR MOBILITY AND THE EVOLVING AIR TAXI LANDSCAPE

An electric short flight air taxi (aircraft) powered by a traffic management system that makes it cheaper than hire a helicopter. It sounds easy, but there's a big difference between a helicopter-style charter service and a fully operational fleet of flying taxis, whether automated or human-driven. Five years has been very positive. Here are some of the questions that need to be answered before transforming the vision into the reality [5].

1. Where Will We Put All The Landing Pads?

Air taxi models come in a variety of shapes and sizes. Taxi could have four passengers, or just one passenger. It could have been a single or multiple rotor. In any case, the size of the landing pad is likely to be similar to that expected for a small helicopter. A compact two-seater Hughes R22 needs a landing pad of at least 15 meters in diameter. It's hard to imagine a large number of 15-metre-diameter landing pads in an urban environment, close to power lines and houses. The cost of urban land is already prohibitive. The only options available in the urban landscape, if the parks are excluded, are likely to be on the top of the houses. Even then, unless the building is very big, the construction of more than one or two taxi pads on any building seems both impractical and expensive. This means that more than 50 to 100 landing pads in, say, the Sydney CBD may not be feasible.

2. Who will get landing priority?

Drone pads would have to be used sequentially. Even with a very quick five-minute turnaround, the pad could only cope with a maximum of 12 landings and take-offs in an hour. So who determines which taxis should give priority to landing and control usage? If the first to arrive has priority, how are the popular destinations to be served? How, for example, will a large number of people get to and from cricket?

3. How can we ensure they're Safe?

Existing helicopters operate safely, but need turbine or piston engine power to lift the taxi, pilot, fuel and payload. The cost of helicopters is actually prohibitive to the average user. So maybe the tilt-rotor, quad-copter design would be used, but even Bell Boeing has struggled to achieve high reliability for its V22 Osprey. Electric motors could be the solution. Developers are well on the way to creating the right one-person electric motors for rotary propulsion, as the French Volta electric helicopter has shown, but battery technology is a limiting factor. Ensuring the efficiency of the engine power system, electrical system and navigation system is important. The

Washington Post reported 418 significant drone incidents in US military operations worldwide in the 12 years to 2013. Drones were destroyed or damaged in about half of these cases, with a total cost of more than US$ 2 million. The civil air taxi approval system requires extensive testing to promote stability and, in many situations, requires multiple systems to fix system failures. This is going to be a huge obstacle for the manufacturers of flying taxis and for CASA.

4. Where Should Air Taxis Be Able To Fly?

According to CASA, piloted air taxis would be subject to current CASA regulations, but autonomous air taxis or drones are another matter. Drones are currently limited to flights in airspace that are different from manned aircraft. This ensures that they cannot fly above 400 feet (122 meters) above ground level and are not allowed to operate near airports. Such Regulations are designed to reduce the risks to airlines, some of which have more than 500 peoples. But the Sydney tower is about 1,000 feet high (305 meters) and many modern buildings are over 400 feet (122 meters) in height. It means that a number of adjusted height limits will have to be added. Who is going to set these parameters? And how will drone taxis respond when emergency services demand a single use of airspace?

5. How Will We Avoid Mid-Air Collisions?

Managed general aviation taxi depend on "see and be seen" when flying at a lower level in accordance with visual flight rules. Unless the height limit for drone taxis is modified, how would it be detected and avoided? Many drones are now avoiding obstacles to collisions, including the safety of airborne vehicles. The job will be to lay down guidelines that will be consistent and to ensure the safety of a number of drones in close proximity. A protocol must be established for cases where drone taxis are on converging routes with each other or with other light aircraft. For example, should an air taxi make way to the right or to a climbing aircraft? If the dangers of a mid-air crash were to be mitigated by holding drones away from major airports, this could mean banning their use over the Sydney CBD, for example. When should air taxis be grounded because of the weather? Urban environments not only produce physical obstructions for air taxis, but buildings can cause unexpected wakes and eddies in any amount of wind. Convective clouds can also cause thermal instability along with hail, heavy rain and microbursts. Air taxis will need to be able to fly in bad weather conditions, or their use will be severely limited. Who's going to decide if drones need to be grounded due to bad weather? What field and time periods should the grounding take place?

6. How Should Air Taxis Be Regulated?

Air taxis will require extensive regulatory oversight. Australia has a propensity to invent new rules, so this emerging industry is likely to create a large bureaucracy. With a small number of potential users, it is difficult to see the burden of red tape being placed exclusively on users and developers. Will some of the bill be paid by the taxpayer? These and many other questions will have to be answered in a satisfactory manner before a fully automated, safe and reliable fleet of air taxis becomes a reality. Whether or not it can be conquer these barriers, it is possible that any program will be very limited in number. Flying taxis are therefore expected to be very expensive to operate to cover construction and operational costs. In my opinion, the combination of health, technological, commercial and regulatory constraints makes the practicality of air taxis highly unlikely over the next few decades.

CONCLUSIONS

Air taxis are equipped with a semi-automatic tool to help responsible regulatory authorities as well as city and regional planners in the management of urban air space. GIS is used to ensure that this revolutionary technology receives information and is a valuable tool for decision-makers. Visualization is another key factor in contacting the authorities and informing the public of possible routes. The network is diverse and adaptable to meet different needs for different purposes. This finds on-demand transport as well as extension of the network. Potential further steps in the process to make this idea a reality and to develop the built network are also linked to location and therefore GIS plays a key role: optimizing the network topology in multiple layers at times of high demand, designing the site for hubs in central locations and on the rooftops of high-frequented buildings, planning potential emergency stops in congested areas, monitoring of congested areas The idea is to allow on-demand flights without impacting people with additional routes. The vertical dimension is in compliance with the flight rules, which forbid flying above 500 feet above ground height. Second, the reliability of the data needs to be checked. The data is open source and may not be reliable and wrong. Space agencies, airport managers or city authorities may be responsible for authorizing the underlying data. Thirdly, the definitions of the boundary of the geo-fences in all directions are based on existing principles, but without specific restrictions on how much distance should be removed from hospitals, embassies and other structures, areas and points of interest. All the same, these values are parameterized and can be modified easily.

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