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Air Taxis: A Technological Breakthrough to Beat the Traffic Woes

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Abstract:

Traffic problems across the major cities around the world and the ever-growing population have put immense stress on countries' smart infrastructure needs and requirements, particularly in emerging economies such as India. In such countries, existing urban transport modes have failed to accommodate the rising travel demand, which means traffic congestion will likely multiply further in the coming years. This distressing situation creates opportunities for automobile and aircraft makers to develop state-of-the-art urban air mobility (UAM) solutions. The electric vertical take-off and landing (eVTOL) vehicles seem to represent the future of urban mobility. Commercialized air taxis have the potential to completely disrupt the urban transportation system and relieve the urban streets from congestion. The case discusses the factors facilitating a speedy drift towards adopting air taxis and the recent developments in the UAM industry. To explore the air taxi market opportunities and business feasibility, the case examines the UAM ecosystem, the related cost and technology components, the industry's latest competitive landscape, and anticipated barriers to the successful implementation of the air taxi business. The case outlines allied businesses and complementary revenue streams that the UAM sector would encourage and, thus, help developing nations to grow technologically and economically.

Keywords: Traffic Congestion, Urban Air Mobility (UAM), eVTOL, Air Taxis, Commercialization, Technology.

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1 Background

While traveling on a business trip in Bengaluru, Yash Raikar, the managing director and chairman of the Raikar group, got stuck in traffic on his way to the airport. He took out his smartphone and browsed the latest trends in urban transportation and mobility. While glancing at various articles online, he came across an announcement from Hyundai and Uber about their plans to develop drone taxi services in the US by 2023 (Alcock, 2020). He also found reports suggesting Dubai has already conducted successful drone-based autonomous air taxi tests in early 2020 (Blau, 2020; Caughill, 2017; Wakefield, 2017). Additionally, he discovered Morgan Stanley research (Figure A1) that predicted air taxis would create a US$1.5 trillion market by 2040 and, thus, huge investment opportunities that would benefit multiple sectors along the way.

Going through these articles made Raikar filled with sudden excitement on realizing the flying taxi business's potential. A few days later, he invited a group of his trusted advisories to the Mumbai head office to have an insightful discussion on new business avenues around air taxis. After a productive brainstorming session, they decided to initiate feasibility research and explore air taxis' market potential in India. Eventually, Raikar structured a dedicated project team that comprised a robotics engineers, computer scientists, aviation field experts, and other specialists to commence concept testing and probe the market readiness for air taxis. He entrusted the project team with developing a business feasibility report that analyzed the air taxi market opportunity, various factors that affect its functioning, a potential market estimate, different input costs, and prospective revenue streams.

Fast-forwarding a month, Raikar's team unearthed a bountiful set of knowledge on air taxis, which they were ready to present to the board. They have studied the evolving urban air mobility (UAM) market to explore the air taxi business potential. They were all set to discuss the business scope of air taxis in detail, outlining the latest developments in the air taxi services around the globe, the air taxi ecosystem, challenges of the business, and potential market analysis. This information will help Raikar and the board make a go, no-go, or hold decision about entering the air taxi business arena. The decision will be made through intense deliberation. Is the business viable? If the business is viable, is this the right time? Or should they keep a watch on the development in the mobility space in terms of technology, regulations etc., and time the market when the moment is right?

2 The Raikar Group

An Indian multinational conglomerate with its headquarters in Mumbai, Raikar group had a net worth of more than US$110 billion in 2019. Jatin Raikar founded Raikar Sons, a trading entity, in 1865 to become one of the oldest and largest industrial groups in contemporary India. It gained international recognition after acquiring numerous global companies. The Raikar group contained many significant affiliates that expand across sectors, such as Raikar Chemicals, Raikar Steel, Raikar Motors, Raikar Communications, Raikar Powers, Raikar Consulting Services, Raikar Consumer Products, Raikar Hotels Company Limited, Raikar Airlines Limited, Raikar Retail, and others. In 2019, the Raikar brand featured 83rd among 100 most valuable global brands.

Taking over the Raikar group, Yash Raikar became the chairperson in 2002. He emphasized revamping the existing businesses by pioneering research and product development in several operational areas. He prioritized innovation and infused younger talent into the organization. Under his leadership, the Raikar group transformed from a domestic player to a multinational brand via an aggressive acquisition strategy. His business interests spanned from tea estates to steel plants. A visionary leader, he has a knack for identifying and seizing business opportunities and building large-scale systems. He has also vigorously invested in startups that ranged from e-commerce firms to cab aggregators and Bitcoin ventures.

Raikar Motors represented a crown jewel in the Raiker group. Raikar Motors has functioned efficiently as a multinational automotive manufacturing company for almost 75 years. Its product range includes passenger cars, trucks, vans, coaches, buses, sports cars, construction equipment, military vehicles, and so on. It had auto manufacturing and vehicle plants along with research and development centers in different parts of India and various foreign locations, such as East Asia, South America, South Africa, Great Britain, and Spain. By 2020, Raikar Motors had introduced electric versions of their passenger cars, commercial vehicles, and sport utility vehicles (SUV). Raikar's electric SUV Phoenix ran on a lithium-ion battery for a consistent range of 312 km on a single charge. It also adopted fast charging technology that charged the vehicle from 0 to 80 percent in 60 minutes.

A decade ago, Raikar Motors ventured into the aviation, defense, and aerospace industries. In 2008, Raikar Advanced Systems Limited (RASL) was founded as a wholly owned subsidiary of Raikar Sons to support the Indian security forces. RASL manufactured Secursky S-95 helicopters for the domestic civil and military market. RASL partnered with Airbus Defence and Space in 2016 to manufacture aircraft for Indian Air Force. In 2018, Boeing ventured with RASL to produce fuselages for Apache helicopters to meet global demand. Further, in a joint venture with a Malaysian company, Raikar sons founded Hawk India Airline in 2014 (51% stake). As of January 2020, it constituted the third largest carrier in India.

The Raikar group occupied a huge proportion of the Indian Mobility market. The air taxi business presented an unparalleled opportunity to enter into a disruptive mobility space and further extend its contribution to the mobility sector. The group has displayed its cutting edge technology and knowledge by unveiling its electric vehicles and carriers. The flying taxi business would seemingly represent an organic extension of the Raikar group's portfolio. Moreover, the Raikar group has worked its way around Indian governments and bureaucracy for decades and, with its long earned experience and expertise, had the potential to kick-start a futuristic large-investment project such as air taxis. Via repeatedly delivering products and services (with tea leaves or fuselages) in an efficient manner, the Raikar brand has become a symbol for "trust" worldwide. With great zeal, technological know-how, and abundant financial resources, Raikar had the suitable ingredients to enter the air taxi space. However, having resources and capabilities did not imply success as air taxis represent new and uncharted territory with many unknown variables and complexities related to technology, logistics, and regulations. Plus, determining consumer acceptability for an unprecedented service would be tricky. So, choosing the best course of action required Raikar to consider plethora factors and due diligence.

3 Need Gap Analysis

A professor of technology and digital business at the University of Pennsylvania's Wharton School, Kartik Hosanagar, once said: "The ideal launch city for an urban air taxi is a dense metropolitan area where traffic congestion can mean that even distances of 10-15 kilometers (km) can take an hour. Indian cities qualify quite well" (Bhattacharya, 2018).

3.1 Current Congestion Situation and Rising Need

According to the TomTom Traffic Index, which the Netherlands-based global location technology specialist TomTom publishes, four Indian cities featured in the top ten highest traffic-congested cities in the world in 2019 (Tomtom, 2019). Bengaluru topped the chart with 71 percent congestion (Figure A2), while Mumbai (65%), Pune (59%), and Delhi (56%) occupied the fourth, fifth, and eighth positions, respectively. Bengaluru drivers spent approximately 243 hours or 10 days and three hours extra travel time on roads due to congestion during peak hours. The report indicated 291 traffic jams during peak hours in Bengaluru that extended to 145.7 km. The traffic congestion in three major cities (Delhi, Bengaluru, Mumbai) costs India's economy around US$20 billion each year (Chin et al., 2018). Delhi contributed the most to India's cost of congestion figure—around US$9.6 billion (Figure A3) annually through diminished productivity, fuel wastage, accidents, air, and noise pollution. The increasing congestion makes it difficult for the daily urban commuters and emergency responders such as ambulances and firefighters to reach their destination in time. The traffic congestion will likely multiply further in the coming years due to rising population, growing rural-to-urban migration, increased disposable income, and an increase in on-road vehicles.

Figure A4 graphically represents the estimated growth in travel demand in several countries in the last four decades. The graph shows a steep upsurge in India's travel demand since 2002 and that it had far surpassed all the other countries in consideration by 2016. This demand has put significant strain on India's urban transportation infrastructure during recent years. The existing urban transport modes have failed to provide faster and neater travel solutions. In this situation, air taxis seem to represent mobility's future in the country. It has the potential to completely transform the urban transportation system by providing short-haul flights on-demand and relieve the urban streets from congestion.

3.2 Issues with the Current Transportation Modes and Gap Analysis

Currently, in a typical Indian metropolitan city such as Bengaluru, which has 12.3 million people (PopulationU, 2020) and eight million vehicles (Kulkarni, 2019), buses and two-wheelers meet around 67 percent of the travel demand (Figure A5) (Nayka & Sridhar, 2019. Figure A6 analyzes the existing transportation modes for long and short distances based on their relative travel cost versus time.

Airplanes, trains, buses, and cars represent travel modes for long-distance travel. For short distances, buses, auto-rickshaws, two-wheelers, carpools, private cars, metropolitan trains, and helicopters represent available options. However, for short-distance travel, a huge gap for a transportation mode that would allow swift movement in a metropolitan city or a satellite city without the need for individuals to waste considerable time stuck in congestion, waiting time, multiple stops, and transfers exists. Helicopters travel short distances the quickest, but their bulk, noise, and cost makes them unfit for mass urban aerial transportation. Companies such as Pawan Hans Ltd. (Business Today, 2018b) and Thumby Aviation (Chowdhury, 2018) actually already operate some helicopter-based taxi services in India; however, they offer limited and expensive services (Sinha, 2019). Hence, the country requires a contemporary aerial vehicle that can be effectively commercialized for urban aerial transport. With the advent of electric vehicles and advanced battery technology, air taxis seem to be a viable alternate. In the coming decades, electric air taxis might just completely replace helicopters to become faster, cheaper, quieter, cleaner, and safer solution for short distance intracity travel (Garrett-Glaser, 2020a).

Rajeev Lalwani, a Morgan Stanley analyst, has conjectured that one could introduce a flying taxi business as "an ultra-niche addition to the existing urban transport infrastructure, similar to the helicopter market today" (Morgan Stanley, 2019). Nevertheless, he also speculated that, with enhanced automation and commercialization, one could bring the cost to operate air taxis down, which would democratize intracity mobility. Thus, in the initial phase, the target segment for air taxis would be people such as businessmen, C-level executives, top-level government bureaucrats, consultants, and foreign delegates for whom time poses a more critical concern than affordability. As air taxis become broadly commercialized, their price would reduce to accommodate the ever-expanding travel demand from different urban population segments and ease city roads from traffic burden. If air taxi travel becomes cheaper than owning a car, then many people would definitely stop traveling by private cars, which would likely result in a fall in on-road fuel consumption and congestion in urban streets—a win-win situation. In their study, Lin et al. (2020) considered the Los Angeles downtown-airport route (which has 38,200 vehicles during peak hours). Based on conservative estimates and near-future technologies, they found that one could reduce traffic-induced fuel consumption on the route by 15 percent if one diverted 3.2 percent of the traffic to air taxis (Lin et al., 2020). Likewise, based on more optimistic estimates and mature technologies, they found that one could reduce traffic-induced fuel consumption on the route by 74 percent if one diverted 20 percent of the traffic to air taxis. Thus, their study suggests that commercializing air taxis could play a significant role in reducing the costs of congestion.

4 Recent Developments in Urban Air Mobility

Many companies worldwide have begun participating in the race to conquer the UAM market. Among the most vital players in the global market to delve into developing air taxis includes Uber. Under its flying taxi project, Uber Elevate, Uber has begun working in collaboration with experienced aerospace giants such as Pipistrel Aircraft, Embraer, Boeing subsidiary Aurora Flight Sciences, and Bell Helicopter and startups such as Karem Aircraft, Jaunt Air Mobility, and Joby Aviation to manufacture the flying taxi for a scheduled launch in 2023 (Hawkins, 2018; Mishra, 2018). Though, Uber believes that Hyundai, a South Korean carmaker, will be able to manufacture high-quality eVTOL at a more cost-effective and larger scale than its other partners. The partnership between Hyundai's manufacturing muscle and Uber's technology platform will result in a vigorous air taxi network. At the same time, Uber is also developing its air traffic control systems in conjunction with the U.S. space agency NASA. Uber expects its air taxi to carry one pilot and four passengers, to cruise at 1,000 to 2,000 feet altitude, and to cover a 50-mile (approximately 80 kilometers) trip in just 15 minutes. The same trip can take more than two hours by car depending on the road congestion (Hornyak, 2020).

Other players in the area include the European multinational aerospace corporation Airbus (Vahana), the American truck manufacturer Workhorse (Surefly), the German company Volocopter, China's EHang, the Munich-based Lilium. They have all made considerable success in testing their eVTOL prototypes. As such, we can project tough competition in the UAM market. EHang has successfully tested its VTOL craft in different weather conditions such as heavy fog, high winds, and night trips based on which it received an Experimental Airworthiness Certificate from the Federation Aviation Administration in the USA. According to a UAM study that Frost & Sullivan conducted, Dubai will become the first city across the globe to commercialize flying taxis in alliance with Volocopter and EHang (Frost & Sullivan, 2019; Valente, 2019). The air taxi services will commence in Dubai by 2022 and expand at a compound annual growth rate (CAGR) of 46 percent to reach global operations with more than 430,000 units by 2040. The study

also suggests that Singapore, The United Arab Emirates (UAE), and New Zealand as among the first countries to adopt flying taxi services, while Brazil and Mexico will be next in line by leveraging their helicopter taxi expertise.

India has also begun participating in the UAM market. Navi Mumbai's VTOL Aviation Pvt. Ltd. began indigenously developing an air taxi model in collaboration with technocrats from IIT Kanpur (Urban Transport News, 2019)—a pilot-optional, battery-powered hybrid eVTOL aircraft. Making safety concern its priority, VTOL Aviation India has focused on building a robust battery management system and propulsion technology for its aircraft. It has successfully completed its initial aircraft tests and made attempts to develop the autopilot facilities. VTOL Aviation has planned to invest US$2 billion in an initial phase to manufacture these facilities (Kautilya, 2019). The company projects that it will commercialize and deploy its air taxis into service by 2025. In addition to these advancements, McFly.aero has begun constructing landing pads by collaborating with various companies. With help from McFly.aero, Bengaluru has started building a lab for air taxi infrastructure (McFly.Aero, 2019).

5 Working Model of a Smart Air Mobility Solution

Figure 1 provides a typical smart air mobility solution to vitalize metropolitan cities. It has three main components: 1) urban air mobility (UAM), 2) the hub, and 3) the purpose built vehicle (PBV). The UAM combines personal air vehicle (PAV) with air mobility services to make the airspace available for transportation. PAV with eVTOL capability enables the vehicles to take off or land vertically on the vertiports, which makes travel completely runway free. The UAM connects to the hub via vertiports on the top of the hub. The hubs connect the air-based UAM to the ground-based purpose built vehicles (PBC)—eco-friendly vehicles that offer customized services, such as a coffee shop, medical clinic, and so on. The hubs can support multiple such PBVs. The PBV connects to the hub through docking stations on the hub's ground floor. Thus, the three components will conveniently allow mobility even in the busiest and densest urban areas.

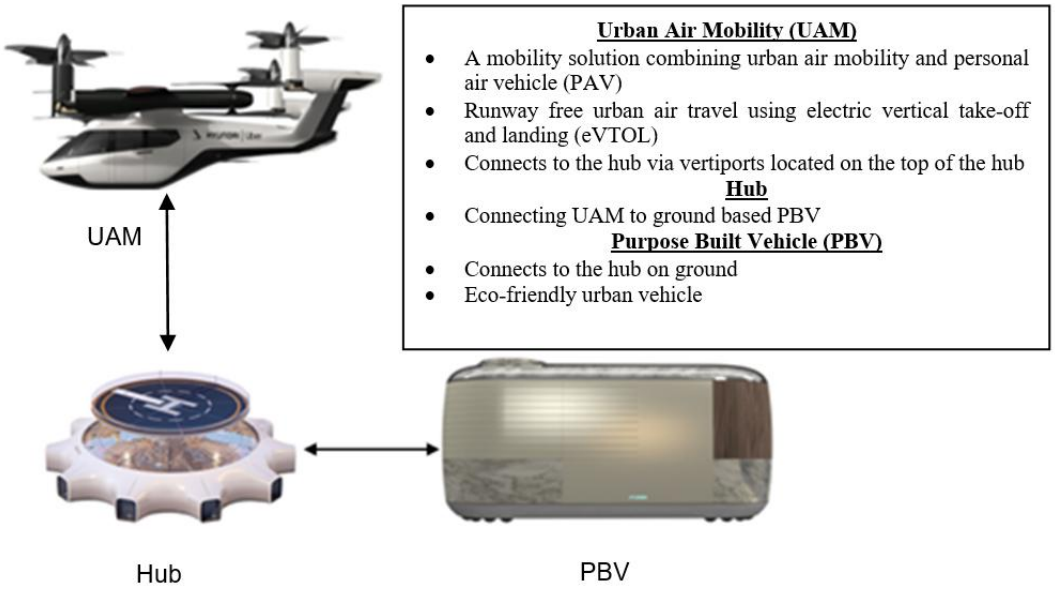

Figure 1. An Urban Air Mobility Solution (Hyundai, 2020)

6 The Ecosystem of an Air Taxi Business

An ideal business model for air taxi operations should depict both an operation's cost effectiveness and flexibility. Such understanding will help a business create an optimized air taxi network, flexible time windows for flight schedules, a sturdy booking management system, and efficient channels for marketing the air taxi services. Hence, to enter the novel UAM market, one needs to study the entire air taxi business ecosystem, which Raikar's team attempted to do.

6.1 Air Taxi Carriers

Air taxi carriers will play a vital role in the path to UAM commercialization. Becoming a potential air taxi carrier seems to be an obvious move for two kinds of companies: 1) companies that already operate in the auto and aviation sector (e.g., SpiceJet, Indigo, Raikar Airlines, and GoAir) and 2) new-generation transport aggregators such as Uber and Ola. The first companies can use their experience in the aviation domain to take the first-mover advantage in the UAM market. Their expertise and know-how will enable them to enhance aerial navigation and route optimization for flying taxis. In contrast, the second companies can leverage their technological capabilities, data, and distribution strength to their relative advantage while exploring the UAM space. Nonetheless, both kinds of players have deep pockets to bear the initial capital expenditure and cash burn. To successfully commercialize air taxis, the air taxi carriers must use the pay-per-ride business model.

6.2 Manufacturers and Technocrats

Today, around 60 firms across the world test and develop eVTOL passenger vehicles. All the major original equipment manufacturers (OEMs) plan to enter the UAM vehicle market soon. The manufacturers such as Airbus, Boeing, Embraer, Hyundai, and Toyota have already designed eVTOL vehicles that vary in their shape and size (see Figure A7). They look quite different from the traditional winged aircraft. OEMs will invest in hybrid fuel systems, high capacity battery cells, alternate energy sources such as hydrogen fuel cells or solar, and lightweight high-strength composite materials for fuselages. To reduce propulsion noise levels, the OEMs will collaborate with firms that provide innovative next-generation rotors and propellers with sound-muzzling ability.

In India, automobile companies such as Raikar Motors, Maruti, and Honda may participate in manufacturing air taxis. The air taxi manufacturing companies can obtain battery technology from giants such as GE, Rolls Royce, and Lockheed, and they can explore companies such as Tesla, Chargepoint, ABB, and Shell to acquire powerful engines. Data will drive autonomous air vehicles (AAVs); therefore, all the technology companies such as Google, Microsoft, and Apple may provide their data analytics expertise.

6.3 Investors and Partners

Air taxis represent a new and dynamic venture—a high-risk, high-return business—which makes it impossible for a company to enter it alone without investors. Hence, venture capitalists and private equities will substantially fund air taxi operations to bring the business to a viable stage. Excited investors will pour millions into the commercialization effort based on the realization that air taxis can completely disrupt the urban mobility landscape. They express excitement about the potential for eVTOL vehicles to dramatically lower operating and maintenance costs (Hornyak, 2020). Nonetheless, some investors remain skeptical about investment opportunities in the UAM market given the complex regulatory framework, the technology's opaqueness, and the market's dynamic nature in terms of costs and operations.

We have seen some significant investments, partnerships, and acquisitions in the UAM market in recent years. For example, Daimler invested US$30 million in the German flying taxi startup Volocopter, and Geely (Volvo's Chinese parent company) acquired U.S.-based Terrafugia. Several VTOL vehicle manufacturers, technology experts, real estate giants, and government agencies have partnered to make air taxis commercially operational by 2023 under the Uber Elevate program.

6.4 Infrastructure

Establishing air taxi infrastructure would require base hubs, landing and take-off vertiports, eVTOL vehicle charging stations, air taxi terminals and hangars, air navigation control centers, passenger waiting lounges, and other support infrastructure. It would require government initiative to issue tenders on a build-operate-transfer model to real estate firms and infrastructure companies with experience in building and maintaining airways facilities. Government agencies would have to issue clear guidelines on licensing carriers, land-acquisition processes, lease costs, the allocation of construction and maintenance contracts to the construction companies, and so on. To encourage participation, regulatory bodies should consider providing temporary subsidies in the preliminary phases. Initial efforts to develop infrastructure for the passenger-carrying air taxis may start around the activity centers where existing transportation options

function. Such infrastructure would facilitate access, interconnections, and transfers to multiple urban mobility options.

6.5 Regulatory Authorities and Air Navigation Service Providers

Regulatory bodies play a crucial role in triggering a paradigm shift towards operationalizing and commercializing air taxis. They need to formulate a UAM framework that would address concerns such as airworthiness criteria, carrier certification, navigation cost, traffic command-and-control, vehicle safety standards, software security, noise level norms, and emission regulations. Authorities should outline procedures and measures as a guiding principle for the whole UAM industry. In case a mishap occurs, such as a mid-air collision or property damage, responsibilities and liabilities must be clearly assigned to the concerned parties by regulatory authorities.

The European Union Aviation Safety Agency (EASA) is the regulatory authority entrusted with providing airworthiness certifications. The Federal Aviation Administration (FAA) is the U.S. regulatory body for aviation safety and efficiency (Xu, 2020). In India, the governmental regulatory body called The Directorate General of Civil Aviation (DGCA) will likely take charge of formulating the UAM framework and compliance guidelines. The Indian air-traffic control (ATC) center will most likely be entrusted with the task of doing efficient route analysis and air navigation management for air taxis in India.

6.6 Distribution

Distribution agents will contribute immensely to realizing air taxi operations by creating distribution for mass audiences. They will engage in significant activities related to inventory discovery, ticket booking and payment services, special offers, demand creation (e.g., through schemes and corporate tie-ups). Online platform providers such as Uber, Ola, GooglePay, PayTM, and PhonePay could revolutionize India's aerial ride-sharing industry. These platforms have collected massive user-data based on consumption patterns, demographics, income segmentation, and various other relevant parameters over the years. These online platforms can capitalize on this data to develop AI-enabled demand prediction models for air taxi rides (Suh & Ryerson, 2019). They can enable air taxi carriers to seamlessly reach out to the exact targeted segment through accentuated targeting, reducing their marketing, and distribution costs.

7 Costs and Revenue Streams

To understand business economics, Raikar's team deliberated on the operating cost estimates for the air taxi carrier. Based on current information, the team expected a typical eVTOL to carry one pilot and four passengers and travel approximately 290 to 300 km per hour. However, a gap between the claimed and achieved mileage in an automobile always exists due to efficiency loss. Assuming a 33 percent efficiency loss due to multiple stops, the air taxi would cover 200 km per hour. Supposing the VTOL vehicle runs on conventional fuel in immediate years, it would consume 15 gallons (approximately 68 liters) per hour (VTOL vehicles that used battery power would definitely bring down energy consumption). Benchmarked against the existing Indian airline, we can assume the air taxi navigation per trip to cost five percent of the total trip fare. Furthermore, an air taxi carrier will incur vertiport usage rents on a slot-wise basis with peak hours costing more. The carrier will have to pay a five percent per passenger commission to its distributors. Additionally, the carrier will incur some fixed costs every month, such as pilot salaries, insurance costs, maintenance costs, ground staff costs, hangar rent, and vehicle-leasing costs. Table A2 lists the cost particulars. With higher customer adoption and economies of scale, the overall air taxi occupancy will tremendously improve, which will allow carriers to reduce fares further and still earn a profit.

As companies commercialize air taxis, an allied business network will evolve gradually around UAM. This network will require support service providers that can clean, service, repair, maintain, and routinely inspect the eVTOL vehicles. Pilot training schools would also receive a boost due to the need for more trained pilots. Air taxis also promise various growth opportunities for other businesses, such as shopping complexes and cultural centers around their hubs.

Further, air taxi carriers can generate complementary revenue streams over and above the pay-per-ride model. Figure A8 and Table A1 depict various novel aerial business models that apply in the UAM market. Examples include air taxi corporate subscriptions, corporate leasing, shuttle services between airports and city centers, aerial sight-seeing tourism, aerial surveillance and policing services, emergency responder

services (e.g., critical care delivery), and aerial support for road accidents. Piloted eVTOLs or AAVs could even find use in the medical domain, such as to transport patients or biological samples (e.g., blood and organs). AAVs and eVTOLs have also begun gaining traction in the military for border reinforcement and other sensitive defense exercises due to their speed, quietness, and precision as compared to traditional aerial services.

8 Is This the Right Time for Flying Taxis?

Latest technological advancements and recent government initiatives have encouraged significant reputable aerospace, automotive, and technology firms to take a keen interest in the nascent UAM market (Gipson, 2019). Experts believe that some emerging factors have facilitated a speedy drift towards air taxi adoption. A decade ago, air taxis appeared only in fiction or as failed experiments, but they do not seem a distant dream anymore. Today, companies can demonstrate successful working aircraft taxi models. The facilitators have motivated and equipped these firms to design and develop flying taxi models.

8.1 Facilitators of UAM

8.1.1 Rising Demand

Since India adopted the liberalization, privatization, and globalization (LPG) model in in 1991, its metropolitan cities have become monumental trade and economic activity centers that offer multidimensional opportunities. They have attracted people and organizations from different segments and backgrounds and, thus, burgeoned in population in recent decades. This population increase has put immense pressure on the urban infrastructure and, thus, created severe mobility bottlenecks. Because the current infrastructure cannot keep up with the increasing population and swelling congestion, Indian cities urgently need alternate urban mobility solutions.

8.1.2 eVTOL Technology

Electric vertical take-off and landing (eVTOL) or fuel-based VTOL technologies may prove to be game changers in the transportation field. eVTOL enables one to operate aerial vehicles from runway-free vertiports, which means eVTOL vehicles can touch down and take off from locations inside cities rather than airports since they do not require much space. eVTOL technology will not just significantly reduce port infrastructure development costs but also reduce congestion-induced energy consumption. eVTOL aircraft can travel directly from point A to point B and, thus, reduce journey times by over 80 percent without facing roadway barriers such as traffic congestion or diversions for closed roads (TransportUP, 2020). With advancements in electric propulsion technology and next-generation rotors, manufacturers such as Boeing currently focus on developing silent VTOL vehicles. These companies expect the VTOL vehicles to go up to 60 miles (approximately 96 km) before requiring a recharge, which ensures faster, quieter, and eco-friendly rides in and around the city (Nitinlahoti, 2019).

8.1.3 Improved Battery and Fuel Technology

With electric vehicles making revolutionary technological leaps, most emerging UAM industry players have decided to make their VTOL aircrafts fully electric through lithium-ion batteries. A few startups have begun to aggressively focus on creating innovative aircraft that emit no carbon using electric power (YourStory, 2019). However, some firms such as Rolls-Royce may adopt hybrid-electric VTOL to better fuel economy and performance for longer distances (Rolls-Royce, 2020). A hybrid-electric VTOL variant may use, for example, a conventional internal combustion engine with an electric propulsion system. A vehicle that uses both the electric and hybrid-electric powertrain can considerably reduce energy consumption, emissions, and operational noise compared with traditional helicopters (Lin et al., 2020). Furthermore, some companies have advocated for and begun developing hydrogen fuel cells for VTOL aircraft. They claim these hydrogen fuel cells to be more efficient, powerful, and longer lasting than lithium-ion batteries. A U.S.-based startup, Alaka'i Technology, has developed a hydrogen fuel-based VTOL prototype that can cover 400 miles (approximately 647 km) in a four-hour flight on a single load of fuel (Garrett-Glaser, 2020b). The hydrogen fuel cells can be replenished at a hydrogen fueling system in just 10 minutes. Due to such innovations, the UAM industry feels more confident about commercializing flying taxis and entering the flying taxi industry.

8.1.4 Uberization

After 4G appeared in 2009, the on-demand economy (or "uberization") became popular in several sectors. By minimizing the client-service provider distance using digitized platforms, uberization has completely disrupted how businesses traditionally used to run. It has made demand assessment, supply provisioning, and delivery more efficient and instantaneous through online applications. Uberization allows real-time inventory discovery and reduces idle time through network effect (peer-to-peer transaction). Uberization will find applications in streamlining the ride-hailing concept in the air taxi business as well. Moreover, since existing urban mobility players such as Uber and Ola already have aggregated demographic data for many metropolitan cities, they could easily identify their potential customers for the air taxi market. They can reach out to the target audience and provide air taxi service information with a mere push notification in seconds. Many people have already become quite familiar with the ride-hailing platforms, which would make air taxi adoption easier. Overall, uberization will lead to a reduction in the marketing and distribution costs of the distributors.

8.1.5 5G Communication Network

To successfully implement air taxis, companies must have access to a 5G network. A 5G network will enable precise navigation, enable predictive air traffic management, and help air taxi players to optimally utilize the entire UAM network. Furthermore, since air taxis will fly in urban centers with high-rise buildings, a 5G network will provide necessary GPS-based satellite reception to ensure air taxis function smoothly. Hence, a robust 5G cellular network becomes imperative to allow communication between eVTOL vehicles and control centers (Roland Berger, 2018).

8.1.6 IoT and Blockchain Technology

Since thousands of individual components contribute to creating and maintaining an aircraft over its lifecycle, one cannot easily track and maintain a record for each one. This difficulty results in hurdles related to operating, maintaining, and disposing aircraft. Some companies such as Boeing deal with this challenge by using blockchain technology. Internet of things (IoT)-driven blockchain technology enables Boeing to maintain provenance details about every component. Boeing shares the information with every manufacturer in the production process, government regulators, and aircraft owners and maintainers. Boeing uses AI and blockchain technologies to develop tracking solutions for unmanned air vehicles in flight in collaboration with SparkCognition (Daily, 2018). Boeing has already used blockchain-based platforms to track and sell US$1 billion worth of airplane parts (Haig, 2020). The aircraft manufacturing giants have started using blockchain technology in their operations and have recorded significant improvements. The IoT will give the companies relevant and deeper insights into VTOL vehicles' various parts and components. With this detailed data in hand, these companies can apply predictive analytics to anticipate defects and prevent them from occurring. IoT can also help improve aircrafts' navigation systems.

8.1.7 Government Initiatives

Realizing the potential in the UAM market, government authorities all over the world have encouraged companies to develop and manufacture VTOL vehicles. In India, VTOL Aviation India Pvt. Ltd. has promoted efforts to manufacture advanced technology products under the "make In India" initiative (a government-launched initiative to encourage firms to manufacture products domestically) (VTOL Aviation India, 2020). Additionally, VTOL Aviation India has launched a project named "VTOL Air Taxi-Abhiyaan" under which the company intends to commercialize these new-age VTOL aircraft as the most economical and fastest transportation mode (Business Today, 2018a). Furthermore, the Indian Government has committed to formulating an encouraging and responsive regulatory framework to support air taxi service solutions. The New Aviation Policy will align with India's goal to launch air taxi services by 2025 (Agarwal, 2019).

The above-mentioned progress made in the last few years has accelerated the potential for the air taxi business to emerge. Although potential industry players have more clarity about the UAM ecosystem now, some pertinent challenges remain.

8.2 UAM Inhibitors

8.2.1 Air Traffic Management Systems

First, air taxis require a dedicated air traffic management system to manage all the traffic-related issues and ensure the different players in the air taxi ecosystem operate in a safe and efficient manner. All the stakeholders should agree on a universal air traffic management framework that integrates well with other transport modes in urban areas. The real challenge will lie in allocating air space (from lower altitudes to higher altitudes) to the air taxi service providers.

8.2.2 Regulations

Another significant barrier concerns insufficient or nonexistent UAM regulations across the world. Currently, no dedicated authority provides certification standards and administers flying taxi operations. Thus, the current situation calls for a committed worldwide regulatory body that can draft the guiding framework for the UAM industry and clearly define accountability and insurance liability. The framework will be essential in interpreting safety and security concerns. Four key safety and security issues exist: 1) rules to avoid possible mid-air collisions, 2) preventive measures on damage to life and property, 3) preparedness to disaster management, and 4) processes to evade privacy breaches. Regulatory bodies can provide norms related to operating piloted and autonomous air taxis. Formulating such complicated policies that accommodate all stakeholders' needs will no doubt be tedious.

8.2.3 Technological Barriers

Piloted eVTOLs and AAVs also require reliable and robust technology. Technologies such as electric propulsion, on-board sensors, and collision detection remain in their nascent stages and require maturation for flawless functioning. Geolocation sensors, radar systems, cellular networks, and GPS technology have to be upgraded to provide long-range sensing and recognition capabilities. Such technology will help deal with convergence and multidirectional speeds, especially for autonomous air taxis. For example, EHang uses an intelligent navigation system and accurate global navigation satellite system (GNSS) positioning to ensure flight vehicles can reliably communicate with airports to avoid any conflict in their trips (Reichmann, 2020). Furthermore, air taxi operators may need to use AI and machine learning techniques to fruitfully operate air taxis since they can help develop robust "detect and avoid" capabilities during flights. Machine learning will be instrumental in predicting demand for air taxis using ride-related factors (busy routes, peak hours, weekend rush) and environment-related factors (extreme weather, heavy rains, low clouds, and harsh winds). For example, low clouds often affect Heathrow airport's control tower. AI-based monitoring systems can help the Heathrow airport reclaim up to 20 percent of lost capacity due to low cloud situations (Caswell, 2019). Besides, eVTOL vehicles require efficient energy management through better battery technology or alternate energy sources such as hydrogen cells or solar cells. Technology will play a massive role in making these vehicles almost silent during propulsion, more resistant to extreme weather, and more cost effective.

8.2.4 Safety Issues

The companies that operate air taxis (especially autonomous air taxis) will have to demonstrate near-flawless operations. Otherwise, any mishap will pose a threat to the urban area beneath and, in the long run, might eventually slow down the customer adoption rate. Aside from risks to passengers and people on the ground, air taxis could pose hazards for other aircraft as well. A centralized system to command and control air traffic and navigation would ensure safe operations. To reduce casualties due to accidents or malfunctioning, a possible precautionary measure would be to fly over water bodies in and around the cities wherever possible. Advanced technology can enable design innovations to add more safety features. Companies could also supplement the vehicles with extra batteries, rotors, and sufficient parachutes to ensure passenger safety in case malfunctions occur. Efficient air traffic management systems could play an important role in ensuring safety standards. Another challenge would be to fly an air vehicle in tropospheric altitudes without endangering birds or sometimes amidst adverse weather conditions. Air taxis could also become vulnerable to hacking and miscreants taking control of the eVTOL vehicles. So, a UAM network would require robust cybersecurity to function smoothly. Also, since eVTOL vehicles will fly close to the ground, privacy breach cases may arise. Hence, regulatory authorities must formulate some norms to protect personal privacy. These safety issues remain key hurdles in commercializing air taxis.

8.2.5 Political Ramifications

To make air taxis an integral part of the urban public transportation system, a nation would require strong political will and proactiveness. In developing countries such as India, center-state conflicts and resource sharing issues may derail lawmakers from legislating UAM policies. Additionally, political steering tasks related to UAM policies may experience political backlash from the opposition. It could bring reduce the extent to which the public accepts air taxi travel and shake investor confidence. Moreover, any rigid policy that makes it more difficult to conduct an air taxi business may further discourage investments.

8.2.6 Bureaucratic Tardiness

Emerging nations such as India have a large hierarchical organization that often experiences “red tape”. Red tape hinders action or decision making through unnecessary paperwork, approvals, and licensing mandates. It increases how much it costs to do business (e.g., time and money) and reduces productivity and innovation. In order to implement something as complex and unprecedented as an air taxi business, bureaucratic roadblocks have to be overcome. Through simplifying administrative processes and training bureaucrats, a nation can create a more conducive environment for the UAM industry.

8.2.7 Psychological Challenges

People’s fear about flying in pilotless autonomous air taxis would pose one potential challenge to whether they would adopt air taxis. Regulatory authorities and manufacturers can overcome this fear if they ensure that they incorporate fail-safe mechanism features in eVTOL vehicles and provide well-documented safety records. They would also need to demonstrate and repeatedly high air taxis’ prominent advantages, such as their speed, advanced technology, and benefit to the economy and the environment. UAM solutions will realize their full potential only if relevant bodies can instill public confidence in flying taxis.

9 Roadmap

After the team’s analysis, the board members entered into a discussion. While some felt excited about entering into the air taxi business, others had grave concerns about it. The Raikar group’s chief financial officer (CFO), Rajesh Shah, opined that the air taxi business entailed considerable risks. He worried that, because the air taxi business represented an unknown terrain with no tangible precedents, one would encounter many problems only after entering into it. He cautioned the board that the Raikar group is a listed conglomerate company and the shareholders would face the brunt of failure if the flying taxi execution did not succeed. He further suggested waiting for a startup firm to build a proof of concept and acquire it early, much like Elon Musk acquired Tesla. It would indeed reduce the financial risk. Another prominent board member pointed out that the air taxi business would entail liaising with the government. He expressed that the company should not make efforts in that direction given upcoming central elections. A change in government raises doubts about whether the government would support an air taxi project. It might adversely impact its progress and undermine investors’ opportunity cost. However, Raikar Motor’s Chief Executive Officer (CEO), Ramesh Satlani, who staunchly believed in being the first mover, confidently believed in air taxis as the solution to beat the traffic woes in the near future and believed that, due to international developments in the area, the company had reached the right time to enter a new mobility era. He wanted the Raikar group to pioneer this segment in India and showcase to its shareholders that the group meant being a step ahead in the game.

Raikar and the board must reflect on these concerns and contemplate debuting in the nascent Indian UAM market. Should the team go forward with a more in-depth feasibility study and develop a more detailed business plan? Should Raikar start the groundwork for a pilot project? Or should they wait for the market to mature further? If Raikar and the board members decided to go ahead with the business idea, how should they proceed? Should Raikar venture into joining hands with companies such as Boeing, Tesla, and Uber, which have developed a strong base in this field, to garner technological exchange and share the risk, or should he deploy Raikar group’s existing capabilities and abundant resources to go solo?

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Appendix

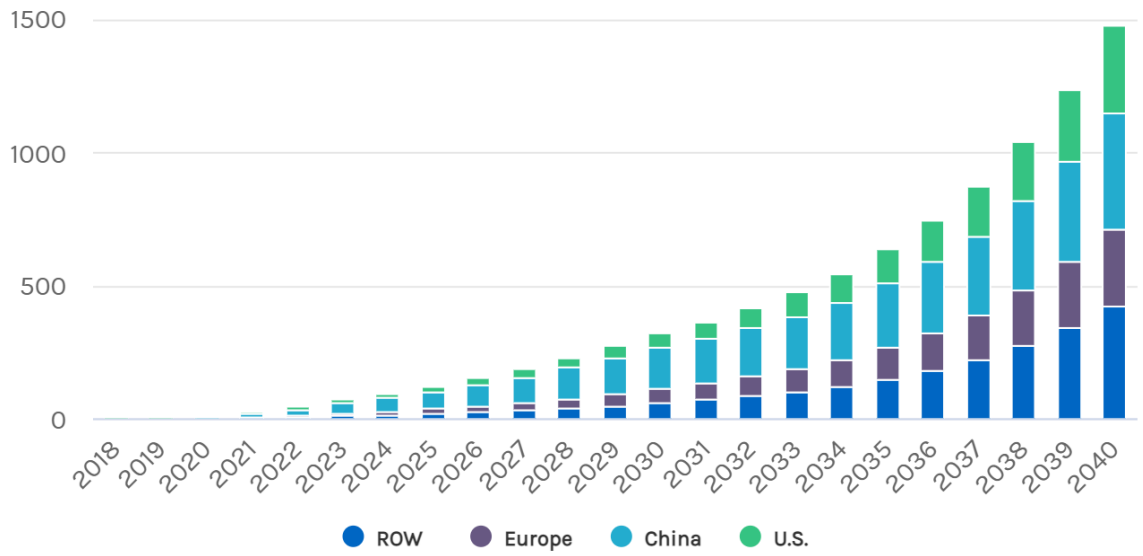

Figure A1. Urban air Mobility Global Total Addressable Market (in Billion USD) (Morgan Stanley, 2019)

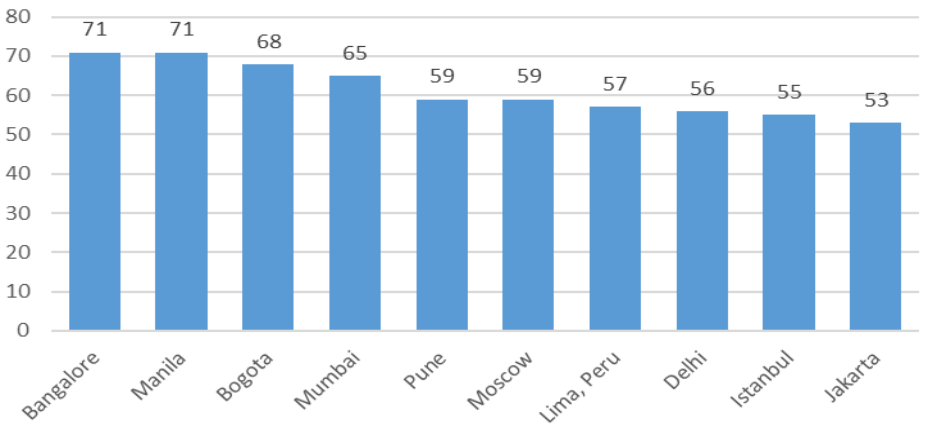

Figure A2. Congestion (%) in 2019 Congestion (%): Percentage Increase over Normal Travel Time (Dash, 2020)

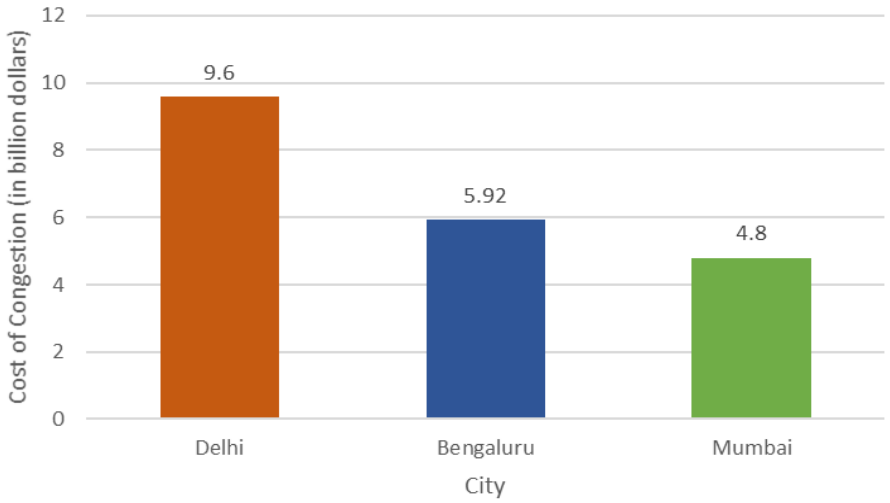

Figure A3. Cost of Congestion in INDIA (in Billion USD) (Chin et al., 2018)

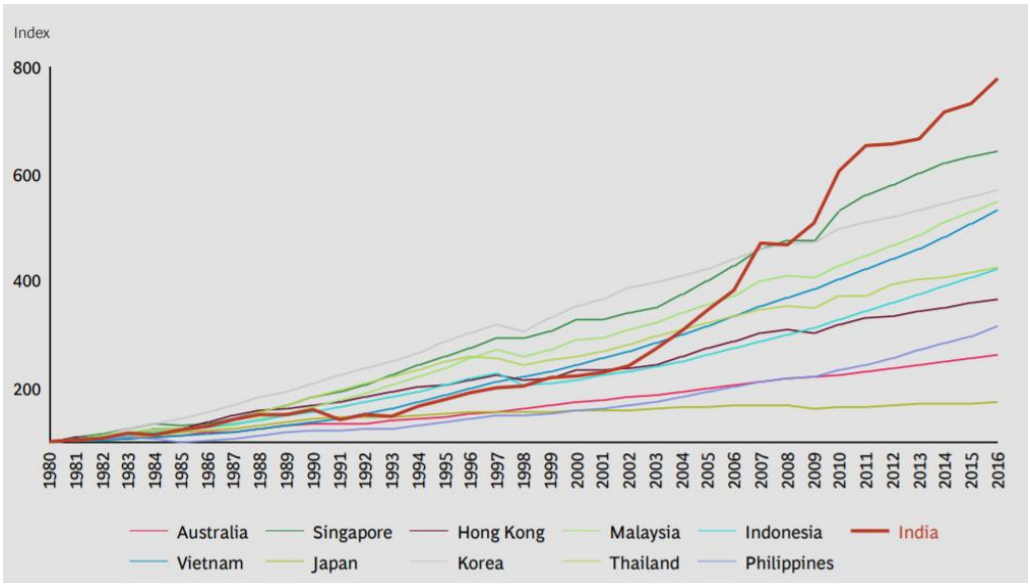

Figure A4. Indexed Estimated Growth in Travel Demand (1980 = 100) (Chin et al., 2018)

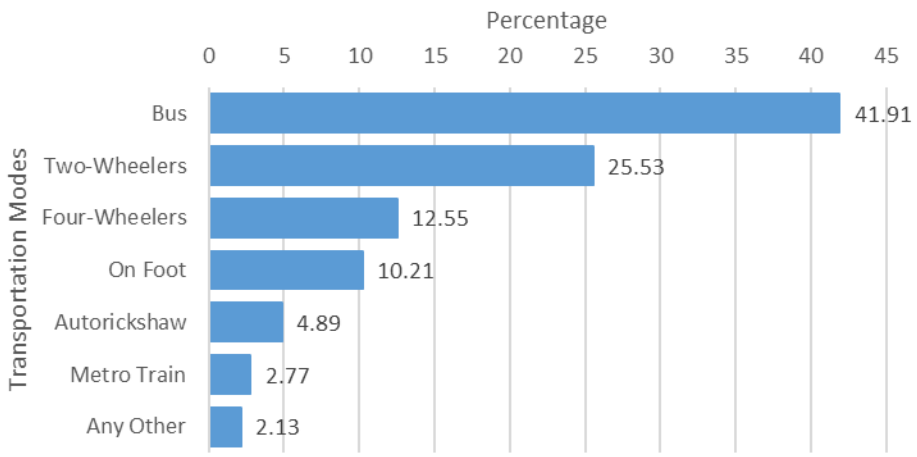

Figure A5. Percentage of Commuters for Various Modes of Transports in Bengaluru (Nayka & Sridhar, 2019))

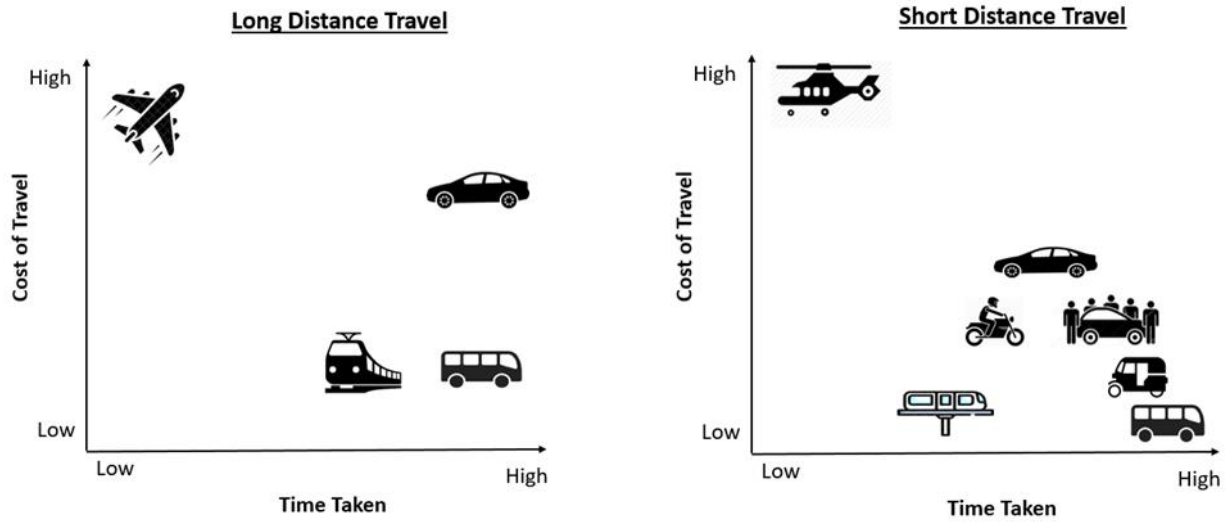

Figure A6. Existing Transportation Modes for Long and Short Distances

Figure A7. Different Types of Aircrafts

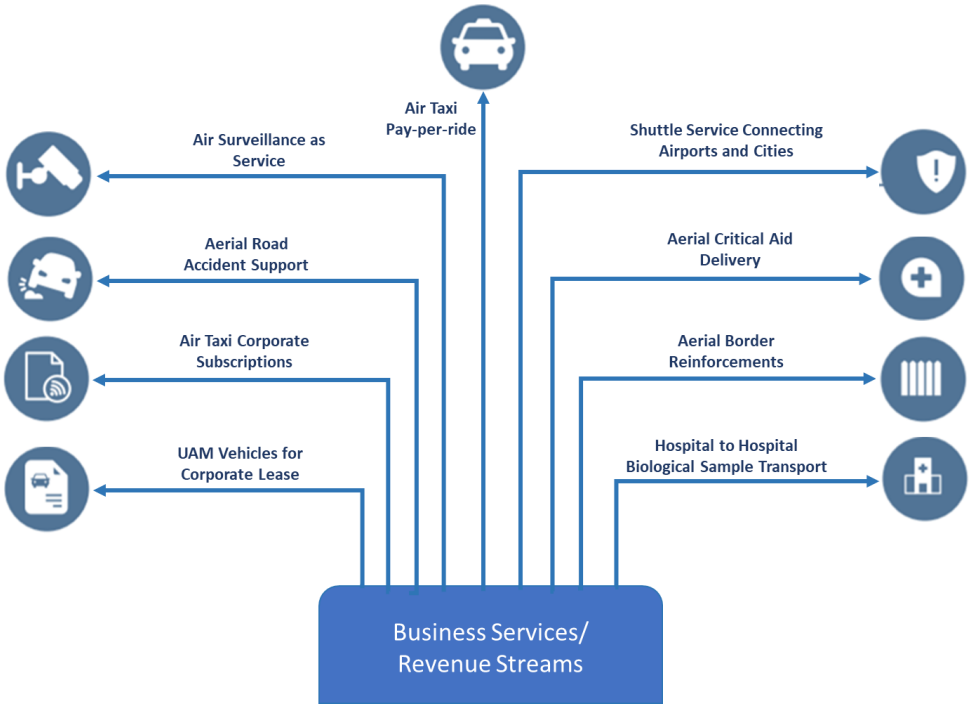

Figure A8. Business Services and Revenue Streams (Frost & Sullivan, 2019)

Table A1. Proposed Applications for eVTOL Vehicles

Vehicles	Purposes	Location
Hoversurf S3 hoverbikes	Police department will use it for surveillance and emergency response	Dubai
The CityHawk	Air ambulance	Israel
Ehang	Transporting transplantable human organs	China
Kitty Hawk Flyer	Compact personal vehicle for recreational purposes	USA
Alauda Racing	Air racing cars	Australia

Table A2. Cost Estimates

Variable costs	Particulars	Amount per hour (in INR)	Amount per trip (in INR)
Fuel cost	For covering five trips of 40 km each in an hour	2271	454.20
Air navigation cost	5% of the total trip fare	1500	300
Distribution cost	5% per passenger fare	1500	300
Vertiport rent	5% of total trip fare	1500	300
Total variable cost	Cost of the trip at 100% occupancy		1354.20
Fixed costs	**Particulars**	**Amount per month (in INR)**	
Pilot salary	Two pilots @ INR 2,00,000 per month	400,000	
Lease cost	1% of the vehicle cost	400,000	
Insurance cost	US$2560 per month	192,000	
Maintenance cost	Equipment and salaries	200,000	
Ground staff cost	Operational staff	150,000	
Hangar rent	Parking area for air taxis	200,000	
Total fixed cost		1542,000	

Assumptions:

- The Raikar group's project team conducted benchmarking against a four-seat R44 helicopter
- Air taxi carries one pilot and four passengers and covers 200 km per hour (considering efficiency loss)
- Air taxi takes five trips of 40 km in an hour to account for turnarounds and maintenance
- Air taxi takes 20 trips 40 km in a day, which amounts to five flying hours per day
- Air taxi fare: INR 1500 per passenger per trip
- Fuel cost: INR 40 per liter
- Fuel consumption: 15 gallons per hour
- We benchmarked air navigation cost against figures from the Airport Authority of India (AAI
- We calculated air navigation cost based on revenue from air taxi per trips at 100 percent occupancy
- Air navigation cost can vary based on government inclination towards the sector
- All bookings come through channel partners
- We calculated the distribution fee based on actual occupancy
- An air taxi carrier will incur vertiport usage rents on a slot-wise basis with peak hours costing more.
- For calculation purposes, we considered it as five percent of the total trip fare
- A vehicle costs INR 40,000,000
- We benchmarked the insurance cost against cost figures available in R44 manual

Conversion:
1 gallon = 3.785 liters
1 USD = INR 75

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