McKinsey & Company: Perspectives on advanced air mobility (Summary)

This issue of Perspectives on advanced air mobility consolidates some of our most interesting research from the past few years (McKinsey´s research and third party’s researches)

**About the potential market:**

The low prices of eVTOL´s vs a flying trip in helicopter is a key variable to fully understand traffic within major cities ($150 estimates by eVTOL vs $ 500-1500 Helicopter). This applies to massive cities.

Business model: A great question. Exhibit 1 provides a conservative estimate of the “base case” flying taxi market, revealing a pathway to an operator market of approximately $1.5 billion by 2040. In this scenario, flying vehicles will still be a luxury option and does not achieve scale. It’s a big market but not a **really big market**.

A key to get an annually market of $500 billion to $600 billion: an ecosystem of players including OEMs, suppliers, maintenance and charging companies, infrastructure players, investors, regulators, and policy makers coming together and overcome all challenges.

**Energy density:** A major point on eVTOLs. Batteries technology most improve performance to obtain approximately 200 watt-hours per kilogram with its respective aviation-grade safety standards.

**Regulatory support:** Regulators will have to certify the new batteries. To address addresses noise and safety issues in a manner acceptable to all

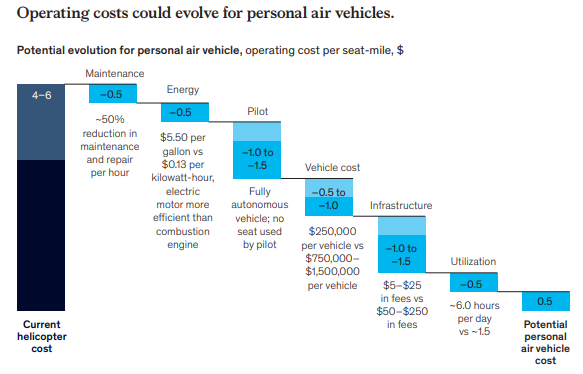
**Air traffic control system:** Implement a safety UTM (Unmanned traffic management) to each eVTOL.

**Autonomous flight:** Technology and regulation must allow full autonomy for flying taxis. Again, the UTM is vital to eVTOLS.

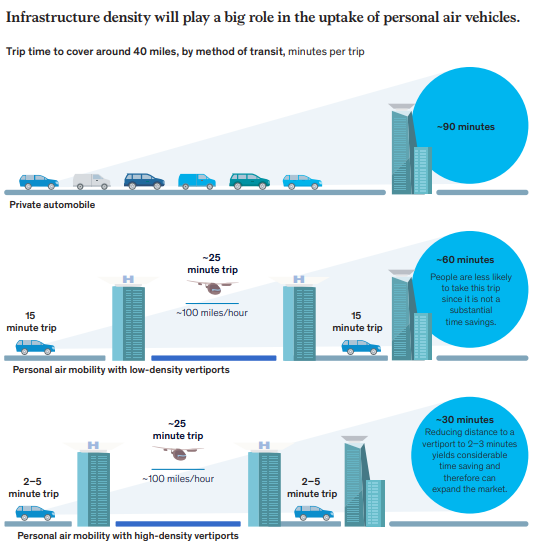
**Physical infrastructure:** The concept of vertiport is a newborn term of the industry. A platform where eVTOLs will recharge, land and take off.

**Customer acceptance:** Customer need a quiet interior, comfortable temperature. This, to eventually improve the customer acceptance. The scale of the market will hinge on customer acceptance.

The last items are key values to implement and make profits of eVTOLs market in the AAM industry. This effort will ultimately be limited by technologies developments. In the other hand, this will be a challenging process but most important; a one with a high potential income when it is compared with helicopter market. The next chart will show a comparison of the two markets.



infrastructure density will likely play the biggest role in driving scale once the technology is ready and regulatory reform passes. More vertiports implies more trips and eventually, a bigger market size.



To make the flying taxis reals, it is needing the participation of different players to get it happen.

Some of the key points:

Regulators: They will have the next route map: First, develop aircraft certification standards, second, implement UTM systems with traditional air traffic control networks, third; enable test-flight programs, fourth, create standards certification to autonomous flight and finally, provides incentives and subsides for personal air mobility

Aerospace: traditional aerospace incumbents have a head start in developing vehicle platforms due their expertise in the field.

Software and technology: A robust UTM system will require will require onboard software (detect and avoid), mapping and route-optimization tools, and external inputs such as real-time weather reports

Physical infrastructure companies: Who will pay maintenance of vertiports? The collaborators must create high-throughput vertiports in dense urban environments, designing their networks and pricing access to pay off capital investments. These investments could range anywhere from $2 million for a small single-spot vertiport on an existing building to $200 million for a mega hub with ten to 20 spots, retail, services built.

**CUSTOMER TAKING TO THE AIR**

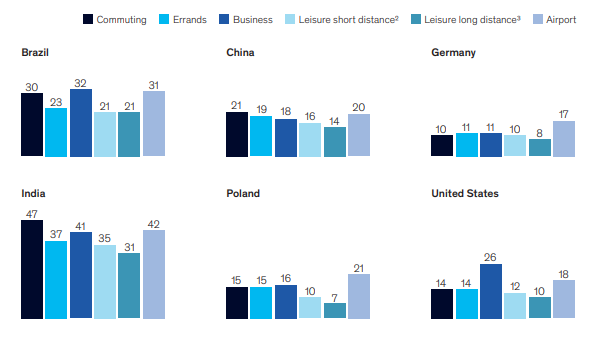
Regarding the AAM industry investment; The uptick has been so rapid, in fact, that total disclosed investments exceeded $8 billion at the end of March 2021.

McKinsey made a survey to 4,800 persons in Brazil, China, Germany, India, Poland and UK.

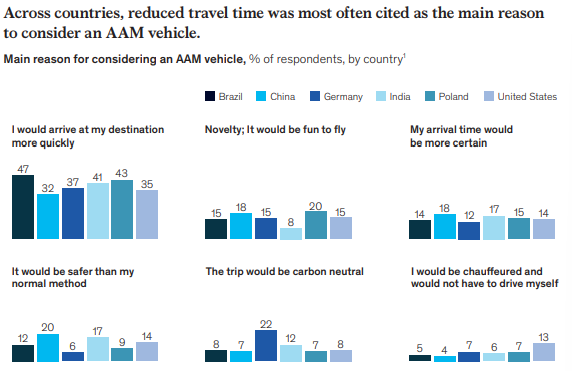
**Consumer insight on flying taxis:** Use cases of potential consumer

Commuting to and from work, errands, business travel, short-distance leisure travel (such a cinema), long distance leisure travel, such as visits to family member in other cities, trip to and from airport as part of a longer journey.

1. Willingness to adopt passenger AAM and preferred use cases vary by country.  
   India and Brazil were the country where the AAM would likely receive approbation from the costumers. 31 to 47 percent of India and 21-32 percent of Brazilian would definitely use AAM vehicle.

  
  
So far, no clear winning use case for people moving has emerged; in each country, most use cases attracted somewhat similar levels of interest. According to the country, the AAM market will have to adapt to the consumer interest.

1. Consumer´s motivation for the manned services: The main interest of the respondents was the desire of shorter travel times. In particular, with countries with high congestion levels and time lost in traffic. The chart:



India and Brazil show the most willingness to pay for future flying-taxi offerings. Thirty-six percent of Indian consumers said they would definitely pay five times the price of their current transport mode to hop on an AAM vehicle for a trip to or from an airport, as did 30 percent of Brazilian respondents—the highest rates reported in our survey  
  
The survey suggests that consumers are willing to pay a premium for AAM service even for traveling very short distances.

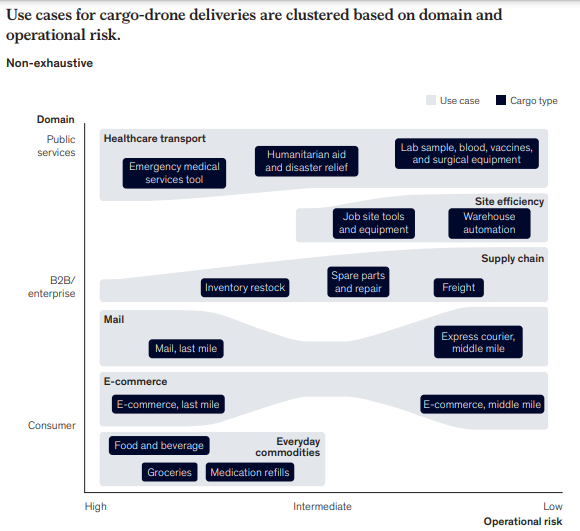
Germany ranked lowest in willingness to pay  

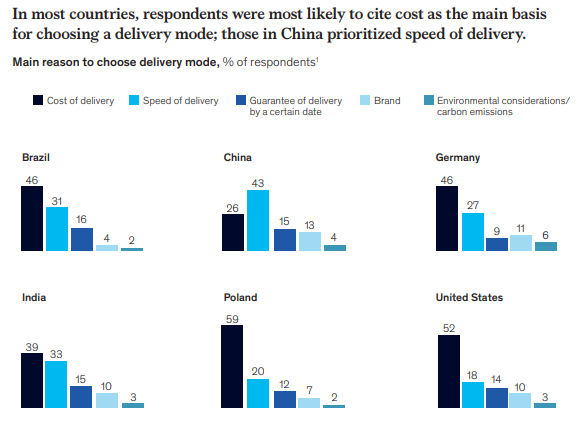

Today’s limousine and ride-hailing users might be first adopters.

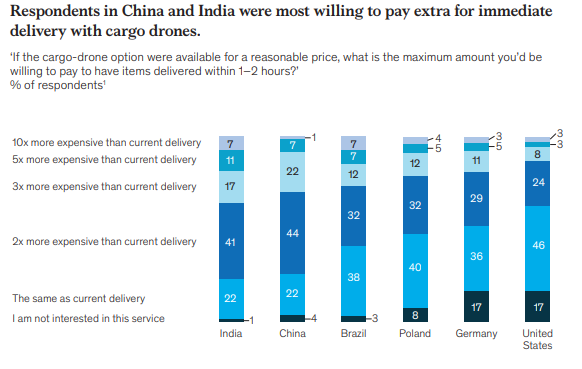
The main consumer concerns about passenger AAM relate to safety and price. Across countries, more than 60 percent of respondents said safety was their top concern about AAM vehicles, making it the most important issue by far.

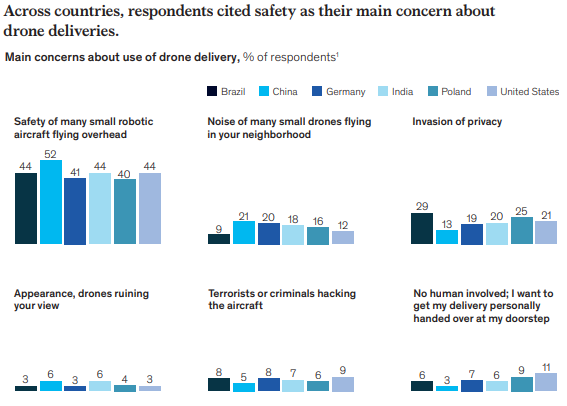
About 10 to 20 percent of respondents across countries reported concerns about ticket prices. These findings are in line with the fact that many respondents expressed willingness to pay a higher rate for AAM services.

Demographic trends provide hints about demand: only 8 percent of respondents in single-member households would consider a shift, compared with 22 percent of those in households with more than four people. This suggests that the most likely AAM adopter is between the ages of 18 and 29

1. Consumer insights on cargo-drone delivery: The survey have divided the main use cases, such as inner-city and last-mile deliveries, into clusters, based on domain—public services, B2B, or B2C—and level of operational risk  
   
2. Pricing is the main lever for winning market share. Across most countries, our survey showed that cost would be the major consideration when respondents select a dedicated delivery mode. The share of respondents in most countries citing this as their top concern ranged from 39 to 59 percent. The only exception is China, where the largest share of respondents (43 percent) said their main consideration would be speed of delivery, compared with 26 percent selecting price.  
     
   The cargo market is wide open for new entrants. In each country, delivery is relatively unimportant. less than 14 percent of respondents identified it as the main decision driver.  
     
   Stated interest in instant delivery varies widely across countries. About 76 percent of Indian respondents said they would be willing to pay extra to have items delivered within one to two hours by cargo drone, as did 74 percent of Chinese respondents.





1. Convenience products, such as groceries and prepared food, could become the most promising use case for instant drone delivery  
     
   Safety is key for public acceptance, just as it is with people transport. In all countries, 40 percent or more of survey respondents had reservations about the safety of many small robotic aircraft flying overhead to make deliveries
2. 

**PUTTING THE COSTUMER AT THE CENTER OF ADVANCED AIR MOBILITY**

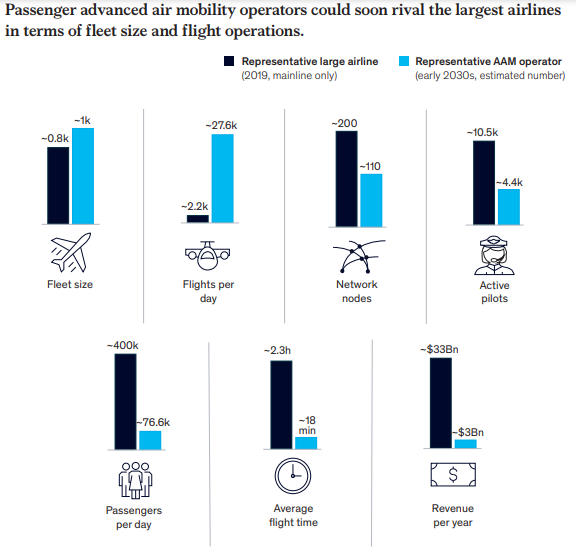
The industry has focused on safely getting new types of electric aircraft in the air, but winners in this market will differentiate themselves based on customer experience. Much of the public attention around manned advanced air mobility (AAM) has focused on the development of electric vertical takeoff and landing vehicles (eVTOLs). As AAM operators think through the customer experience, five elements are worth considering.

1. Time saved could be less important than how people spend their time. Operators will need to determine the threshold at which time savings become more important to key customer segments.
2. Inter-modal connection and integration could be critical for a seamless customer experience. AAM flights will require coordination across different modes of transportation, including time buffers between legs of the trip to avoid missed connections. Mobility platforms will need to decide whether to build an open ecosystem with connections to a broad range of operators or a closed ecosystem with exclusive relationships.
3. Vertiports may become havens for omnichannel e-commerce. The classic definition to heliport does not apply to a vertiport. operators may explore hybrid models that rely more heavily on e-commerce, like ordering food or product via a mobility app and have those products waiting in a “click-and-collect” area when they land.
4. Pilots could become frontline customer reps (assuming they are not in remotely operated or autonomous vehicles). This could turn pilots into important brand and experience ambassadors, and they may require training in how to handle customer interactions.
5. Issue resolution could play an outsized role in the early days of AAM. As operators and OEMs start thinking about how they will operate AAM aircraft, customer-experience considerations will emerge; these will evolve as the industry shifts from few flights in its infancy to higher passenger volume and more complexity. in the long term, companies that have the closest relationship with customers will be in the best position to capture value, drive retention, and build sustainable businesses.

**OPERATIONALAING ADVANCED AIR MOBILITY**

What’s required for AAM players to become some of the largest airlines in the world?

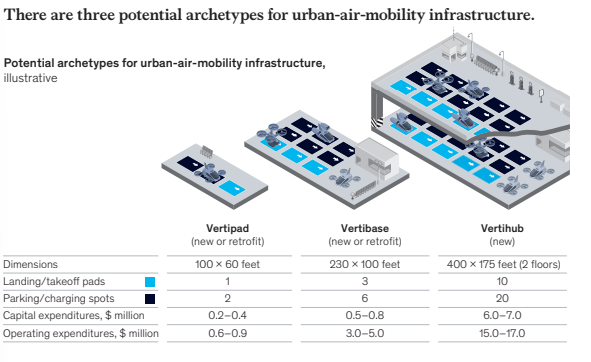
With investment: growing and prototypes in development, advanced air mobility (AAM) players have great ambitions. By 2030, they could be similar in size across some dimensions to the largest airlines in the world. Yet, operations could be a limiting factor to the industry’s growth, and stakeholders must overcome hurdles in the following areas.

1. High-throughput vertiports: the industry will need takeoff and landing sites capable of supporting a large volume of takeoffs and landings each day
2. Network planning and optimization: Unlike commercial air travel, AAM passengers won’t book months in advance. For that reason, operators need to be far more agile and responsive to short-term changes in demand.
3. Ground operations: Even with increased automation, manual labor will still be required, even at small vertiports. (Cleaning, recharging, maintenance)
4. Passenger experience: Because the flights are short, passengers will want to spend far less time in terminals, so its experience has to be short, safe and efficient.
5. Maintenance repair and overhaul: Some vertiports should be prepared to receive eVTOLs to scheduled and unscheduled maintenance.
6. Pilot training: McKinsey´s model suggests that the AAM industry could require about 60,000 pilots by 2028. Longer term, some pilots can advance to remote supervisors capable of overseeing multiple flights from the ground  
     
     
   

**INFRASTRUCTURE OF UAM AND POSIBLE EVOLVING:** To offer sustainable service, flying vehicles need places to take off, land, receive maintenance, charge their batteries and/or refuel their tanks, and park. The physical infrastructure will be an important determinant for the size of the addressable market, since the only trips possible are between VTOL ports

The location of the infrastructure will determine market-conversion levels. The closer a passenger is to a takeoff or landing spot, the greater the potential for time savings. If a landing spot is too far away from the origin or destination, the customer might not save enough time for a UAM trip to make sense.

Envisioning an infrastructure network: This section defines three potential UAM-infrastructure archetypes that could emerge



1. Vertihubs: Envisioned as stand-alone buildings constructed in central, high-traffic areas, they will have around ten active takeoff and landing areas, plus 20 additional spaces for parking or maintenance
2. Vertibase: Vertibases are medium-size structures. Located in medium-traffic areas, such as suburbs, or at major work or retail locations, vertibases would have around three active takeoff and landing spaces, plus six additional spaces for parking or vehicle maintenance
3. Vertipad: Vertipads represent the smallest structures and would function as the spokes in the hub-and-spoke network

**Cost remains the critical element in assessing the viability of any proposed VTOL-port strategy.**

The amount of these structures depends of the density of the population of the cities.

**For large, densely populated cities**: there could be roughly 85 to 100 takeoff and landing pads, including the following:

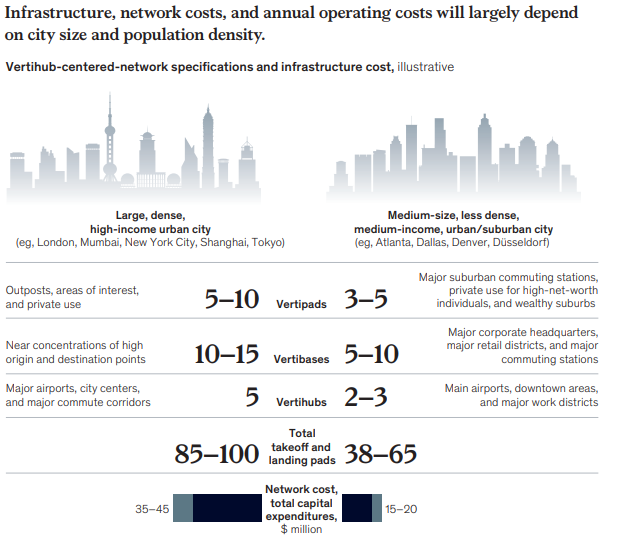
* vertihubs located at one or two major airports, as well as two or three city locations around major commute corridors
* ten to 15 vertibases around commuting-origin and destination areas
* five to ten vertipads at targeted areas of interest or for private use

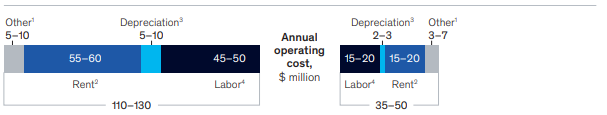
Building this infrastructure network would cost approximately $35 million to $45 million,5 with annual operating costs of around $110 million to $130 million per year.

**In medium-size cities:** less densely populated cities, there would be around 38 to 65 takeoff and landing pads, including the following:

* vertihubs at one major airport and one or two city locations
* five to ten vertibases to handle workplace commutes and retail districts
* three to five vertipads near suburban commuter stations

Building this infrastructure network would cost between $15 million and $20 million,7 and annual operating costs would range from $35 million to $50 million per year.





**Assessing the economics of flying-vehicle networks:**

The following four selected insights on the economics of such infrastructure networks provide some clarity about the costs associated with a flying taxi network.

**Insight 1**: The infrastructure network can break even in a small, premium market.

Assumptions : Infrastructure charges $150 per trip.

* Large, densely populated cities. The network would require approximately 2,200 trips per day
* Medium-size, less dense cities. The network would require 750 trips per day (one every 100 minutes when averaged over 24 hours). During peak travel times, this would increase to one trip per pad every 30 minutes.

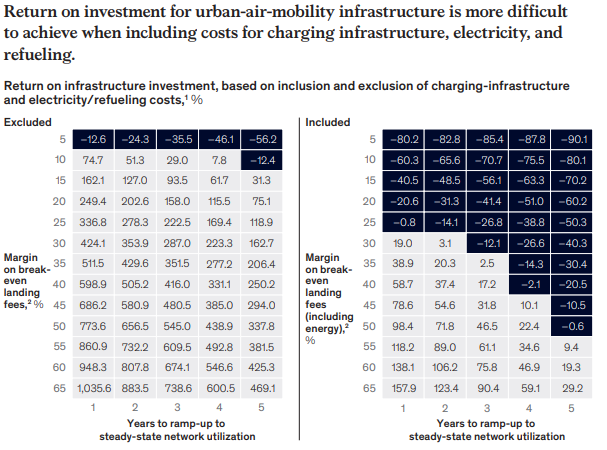
At this price level, the per-passenger charges would be in the $50 to $75 range, depending on the number of passengers per trip. Essentially, UAM in this type of small, premium market would work

**Insight 2:** To achieve very low trip costs, the network needs to accommodate very rapid turnaround times.

To get to per-passenger charges of $25 per trip–in line with mass-market travel today–the network must generate 10,000 trips per day in a large, dense, high-income city and approximately 3,500 trips per day in a medium-size, less dense city. Challenging, not impossible.

**Insight 3:** Achieving a return on invested capital, excluding charging and refueling costs, could be feasible

Consider the following scenario: infrastructure gets built, and the desired number of trips ramps up over five years, which is likely a realistic time frame. In this case, the infrastructure owners would have to charge a 15 to 20 percent margin on landing fees to achieve a reasonable return on their capital investment. If passenger traffic continues to rise, network operations will increase in scale, resulting in further cost reductions and a larger addressable customer base.



**Insight 4:** The cost of charging or refueling, both initially and ongoing, is significant and will affect the business case.

The infrastructure required for superfast charging of UAM vehicles does not yet exist. To create it, networks would need to install the necessary physical hardware and then pay utilities for electricity drawn at very fast rates. In such cases, the cost of the charging infrastructure could be between 65 and 75 percent of the total initial capital expense, unlike the cost of fueling infrastructure today

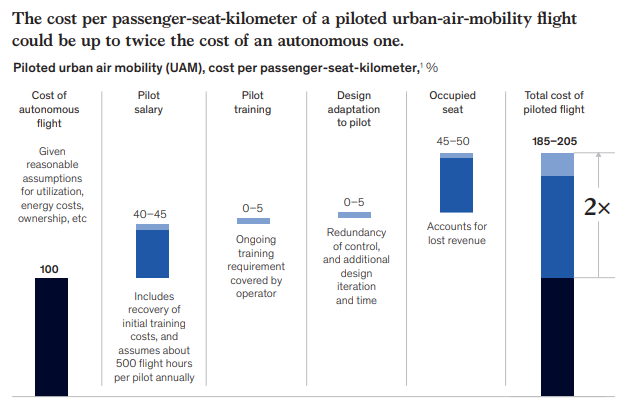
**HOW WILL IT HAPPEN?**

* Ancillary sources of revenues. Infrastructure operators could leverage ancillary sources of revenue beyond landing fees
* Private companies or individuals could invest in ports at large corporate headquarters or personal estates to help support the initial market
* Cities and states could consider subsidizing network construction to enhance public welfare.
* Small-scale and retrofit projects first: stakeholders should initially focus on encouraging trips that use existing helipads or undertaking small-scale projects to retrofit pads and bases. As the market takes root and demand starts to grow, stakeholders can invest in the larger new builds.
* Innovative power solutions: Infrastructure operators should work with utilities and/or fuel providers to streamline this part of the solution.
* Modular infrastructure solutions: In addition to using existing helipads, the early market will benefit from “infrastructure in a box” solutions that can quickly convert the top of a parking garage or building into a functional vertipad or vertihub through a lease, subscription, or revenue-share model.

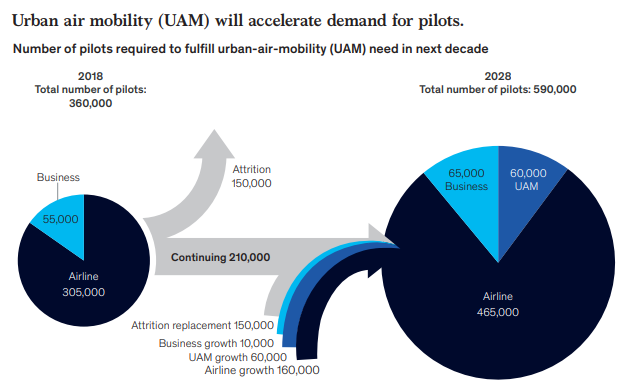
**ABOUT THE FLYING-CAB DRIVERS**

Pilots will help the public recognize the value proposition for UAM

The cost challenge Pilots increase costs and the complexity of operation. Our models (using reasonable assumptions about key inputs, such as energy prices, the cost and utilization of vehicles, landing fees, and pilots’ salaries) suggest that the cost per passenger-seatkilometer of a piloted UAM flight could be up to twice the cost of an autonomous one

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Finding, training, and retaining enough pilots will be another big challenge.

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Given current training costs, it will take about $4 billion to $6 billion to train 60,000 new UAM pilots. If these aspiring aviators, like the majority today, pay for the training themselves, financial institutions must step in to overcome the tight supply of financing.

**About the customer´s experience:**

A pilot’s presence in a small capsule without a separate flight deck will surely affect the customer’s experience of the ride and perceptions of its safety— potentially both positively and negatively—much as experiences with taxi or rideshare drivers do today

**To ensure an ample supply of pilots, operators must offer them an attractive career path. Otherwise, high pilot churn might break their business case.**

In any case, pilots on board will gradually promote public acceptance of UAM itself. Our research shows that while most people are neutral or positive about the basic idea, they prefer flying in piloted vehicles, and the very notion of a remotely piloted one will deter some potential customers, at least for now. As the need for human controls progressively declines, the market will gradually come to accept full autonomy.

**THE EMERGYNG AAM ECOSYSTEM:**

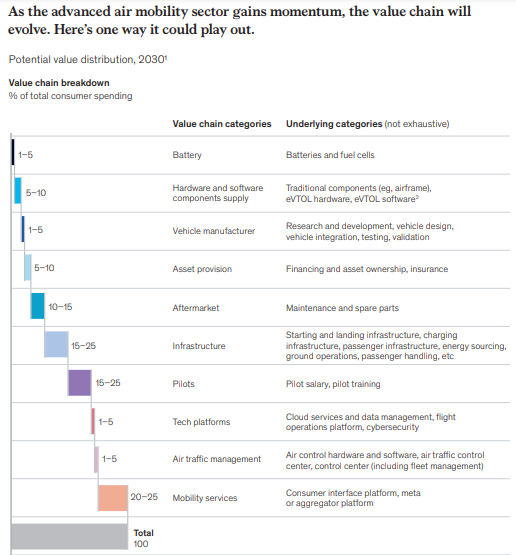
Here are three insights that can help leaders prepare for the shifts ahead.

**Insight 1: Automation has the potential to substantially reduce costs and unlock a larger market**

Pilots are one of the most significant drivers of value and cost for the AAM sector. One way to reduce costs, once regulation and technology allow for it, is to move the pilot from the vehicle to a control center on the ground in 1:1 pilot-to-vehicle operations. However, we estimate that 60,000 new electric vertical takeoff and landing (eVTOL) pilots may be required by 2028, which may create a challenge for operators.

**Insight 2: Mobility services may become a control point, charging fees that are comparable to today’s ridehailing platforms**

Connecting vehicle operators with consumers via a mobility platform may be a future control point. if platforms can acquire a sufficiently large customer base to achieve network effects and offer intermodal integration. In this case, our estimate of 20 to 25 percent value creation is comparable with today’s e-hailing services, which generate value of more than 20 percent. This value varies from city to city, which might be also the case for future AAM offerings.



**Insight 3: Infrastructure (including charging) may account for a major percentage of the value chain**

We estimate that the necessary ground infrastructure in a city such as London or New York could require capital expenditures of $35 million to $45 million, with $110 million to $130 million in annual running costs.

It is recommended that the operator makes profit attracting retails stores and restaurants as tenants.

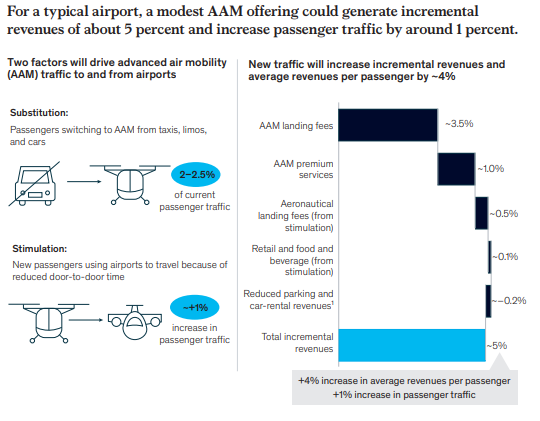
**FINAL APPROACH: HOW AIRPOTS CAN PREPARE FOR ADVANCED AIR MOBILITY**

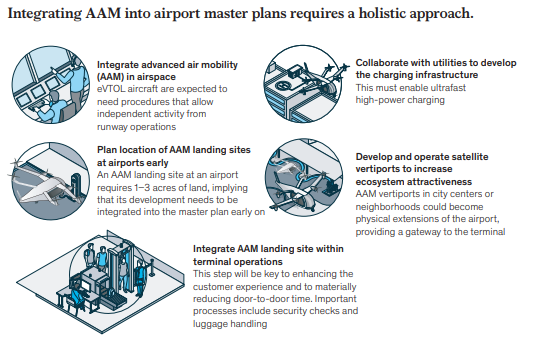
Advanced air mobility is becoming a reality. Airport operators need to assess the opportunity and integrate it into their planning. It is likely only a matter of years before AAM innovations truly take off. McKinsey’s AAM database lists more than 250 active AAM projects across the globe with more than $11 billion in disclosed investment over the past five years and more than 5,000 employees globally as of August 2021. The speed and scope of these developments make integrating AAM an issue of high relevance for airports.

**Airports are uniquely positioned to benefit from early AAM growth**

Airports are likely to be at the center of the AAM revolution, at least in the beginning. First, the economics are attractive because of high, bundled demand for last-mile connections—the vital and currently congested links between airports and the urban areas they serve. Second, some of the basic infrastructure is already in place, both on the ground and in the air, and airport operators have the relevant skills and experience needed to manage facilities. Third, there are obvious customer benefits. AAM flights could save 40 to 60 percent of the time spent traveling to airports on ground transportation within and beyond the city limits. Business passengers would be natural early adopters.

The main use cases for AAM flights involve transport between a hub airport and vertiports in city centers or the broader catchment area, or between a hub airport and AAM landing sites at smaller regional airports. All use cases will require airports to integrate AAM connections into their infrastructure, investment, and business planning. And each use case will involve distinct challenges, making a “one size fits all” approach impossible.





**ECONOMICS OF ADVANCED AIR MOBILITY**

An important building block of business plans is unit metrics for cost and revenue. To fully understand the economics, we need to clearly define unit metrics. The following discussion aims to provide some clarity about how to properly adjust unit metrics. It does not mean to endorse any absolute price points—that requires a longer and deeper discussion.

**Defining unit cost and revenue**

Unit cost for transportation is usually seen as cost per unit of distance. There are also three ways to think about distance: the direct (great circle) distance, which is the most direct path between two points; the road distance, which reflects the indirect nature of road travel; and the air distance, which is the aircraft’s flight path. Air distance tends to be shorter than road distance but longer than direct distance because the aircraft needs to maneuver for takeoff and landing and around other traffic and geography.

**INDUSTRY PERSPECTIVES:**