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Air-mobility solutions: What they'll need to take off

Innovators are designing air taxis and delivery drones. But these won't take flight unless stakeholders accelerate investment in air-mobility infrastructure.

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Traffic congestion forces US drivers to waste more than three billion gallons of fuel and keeps them trapped in their cars for almost seven billion extra hours each year.[1] Much of that time might involve dreaming of a trip to work that does not involve staring at taillights on the expressway. Could we reduce long drives by transporting people with large drones tailored for passenger transport? Air-mobility solutions could also improve the transportation of goods. Can we deliver prescription drugs within 20 minutes to elderly people who lack transportation or provide medevac services to remote locations? And what about sending groceries or food to areas with few stores?

Start-ups, high-tech giants, and others have already begun investing in the innovative technologies needed to make such delivery and transport drones a reality. But the wider use of air-mobility solutions also requires other enablers. Potential drone operators need to develop strong business cases that attract investors. Regulators will play a critical role in setting comprehensive guidelines for everything from vehicle requirements to airspace management. Industry stakeholders must educate the public to address core concerns about air mobility, including safety. Another important enabler—one that is often overlooked—involves infrastructure, a broad category that includes places where drones take off and land.

It's easy to understand why infrastructure has received minimal attention. Air-mobility solutions themselves are so technically complex, and their potential use cases so fascinating, that they tend to command the most attention. But now, many companies and private investors have begun exploring the infrastructure assets required to make air mobility a reality. Companies that have engaged stakeholders in a dialogue about infrastructure include Amazon, which recently patented a flight-management system, and Uber Technologies, which has tried to determine the costs and requirements for various infrastructure assets—including the vertiports that will serve electric vertical takeoff and landing (eVTOL) aircraft. On the government side, it seems that interest in infrastructure is also growing, with some public agencies investing in the development of air-mobility infrastructure for drone use cases. They're also investigating how these systems can be integrated with the existing air-traffic-management system.

When companies and other stakeholders invest in infrastructure assets, they often face questions about their necessity, since air-mobility solutions still have many other hurdles to overcome. Wide availability of delivery drones is not expected for three to ten years, and it may be even longer before passenger-transport drones are deployed at scale. But the timelines for designing, constructing, and obtaining space for infrastructure, including vertiports, are also long, such that companies should begin planning now. If they hold back until air-mobility solutions are ready to hit the skies, their drones will be the aerial equivalent of a bridge to nowhere: expensive technologic marvels that serve no purpose.

To help investors, private companies, and the public sector avoid this outcome and quickly capture potential benefits once the technologies are ready, we identified infrastructure requirements in the critical US market. These include traffic-management infrastructure, physical infrastructure for receiving packages or landing vehicles, and supporting technology infrastructure, such as automatic doors for admitting drones into warehouses.

The role of unmanned traffic management

The most mature unmanned-aerial-systems (UAS) applications—and the only ones where drones are widely used in either the corporate or the consumer sector—involve short-range surveillance and associated photographs or videos. During these flights, drone operators can identify obstacles and redirect the flight path as needed, since the vehicles always remain within their visual line of sight. All drones that travel further distances require unmanned traffic management (UTM), a system of radar, beacons, flight-management services, communication systems, and servers that coordinate, organize, and manage all UAS traffic in the airspace. Within the private sector, companies had attracted more than $350 million in funding to create UTM and associated navigation systems by 2017, but these are still in the pilot phase.

For UAS that do not fly more than 400 feet above ground level, UTM serves a purpose similar to the air-traffic-management system for traditional aviation. It directs flight paths and prevents collisions between UAS and obstacles, such as buildings, other drones, and aircraft (exhibit). Other important capabilities involve providing information in real time (or close to it) to help air-mobility solutions avoid severe weather, congestion, and prohibited airspace.

UTM requirements will vary by altitude and location. Consider air-mobility solutions that typically fly at relatively low altitudes.[2] In rural areas, UTM can be relatively simple because air-mobility solutions will encounter few stationary obstacles or air traffic. However, in urban areas, UTM systems must be programmed to conduct more frequent checks for obstacles and handle more complicated flight paths.

UTM-development and airspace-management challenges

For UTM to function, air-mobility solutions must be equipped with critical technologies, such as detect-and-avoid systems and navigational tools for environments where GPS does not function—all of which will require significant investment and testing. Regulatory compliance will also present hurdles because, understandably, the industry must be prepared to address safety concerns for both passengers and people under the path of drone flights.

Some air-mobility solutions, including freight-delivery drones and passenger-transport eVTOLs, must fly in the airspace commonly used by manned commercial flights and general aviation aircraft. That means stakeholders cannot create UTM in isolation; instead, they must develop an integrated airspace-management system—one that can help air-mobility solutions avoid obstacles in any airspace and that can comply with multiple systems that govern flight rules. Such connections may be technically challenging, since today's airspace relies on robust traffic-management systems, as well as highly trained pilots and air-traffic controllers who navigate within different levels of the national airspace and eliminate any conflicts within these zones. By contrast, most future UTM solutions will automate many tasks, with human intervention limited to emergencies.

To date, UTM development has been a joint public- and private-sector endeavor. For instance, the Federal Aviation Administration (FAA) formed a partnership with UAS stakeholders to create the Low Altitude Authorization and Notification Capability program, which provides UAS with access to controlled airspace near airports by processing airspace authorizations at low altitudes in near real time. In the future, however, some private companies may try to gain an edge by creating UTM solutions for specific geographic areas. If that materializes, air-mobility solutions, including small UAS and eVTOLs, would have to interact with a variety of competing UTM solutions as they travel to different areas, rather than a single system. Stakeholders would have to ensure that all UTM systems were interoperable and could communicate with each other, as well as with the air-traffic-management system.

Exhibit

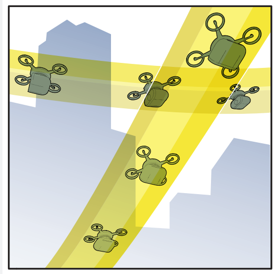
The challenge of building roads in the sky.

Requirements for unmanned-traffic-management (UTM) systems that direct drone flights

1 Compliance with airspace regulation

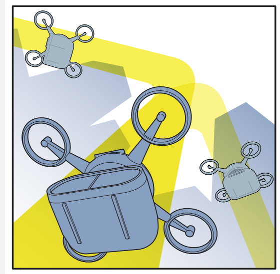
The rules of flight vary depending on altitude and proximity to people, places, and objects. UTM systems must be programmed to understand these requirements.

2 Separation management



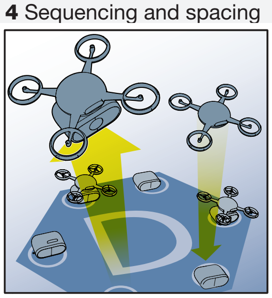
Drones can’t tailgate. UTM systems must ensure a safe distance between them as they fly.

3 Route planning and rerouting



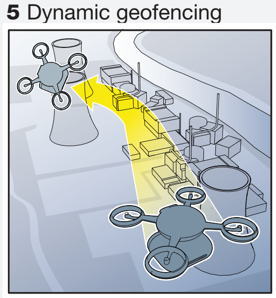
The shortest flight path may not always be the best one. UTM systems find routes that get drones to their desired locations most quickly based on their size, weather conditions, and other factors that affect flight.

4 Sequencing and spacing



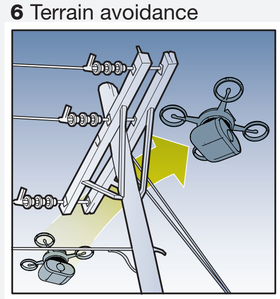
Takeoff and landing are often the most complicated parts of any flight. UTM systems help direct takeoffs and landings to maintain safe and smooth operations.

5 Dynamic geofencing



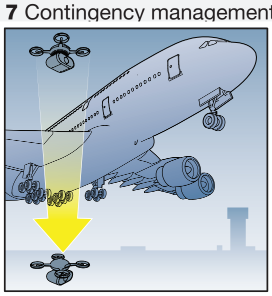
Drones can’t get too close to certain government buildings, nuclear plants, and other facilities where a crash could be disastrous. There might even be restrictions for flying over outdoor concerts or other large one-off events.

6 Terrain avoidance



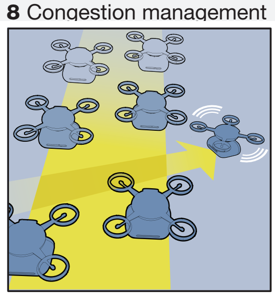
Just like airplanes, UTM systems must inform drones of all obstacles—mountains, tall trees, electrical pylons, or buildings, just to name a few.

7 Contingency management



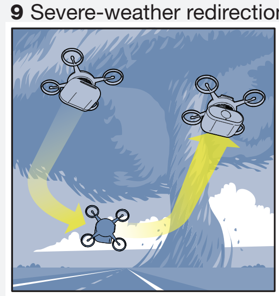
If drones accidentally enter restricted airspace, or encounter conditions that threaten their mission (eg, internal failure or foreign objects), UTM systems will redirect them or provide emergency-landing guidance.

8 Congestion management



Commuters change their route if they know traffic is ahead, and the same should hold true for drones. UTM systems must be able to monitor traffic and suggest alternative routes.

9 Severe-weather redirection



If there’s bad weather ahead, drones need to know. UTM systems monitor developing weather situations and send relevant information to unmanned aerial systems.

Physical assets and supporting technologies for air-mobility infrastructure

Beyond UTM, air-mobility solutions require three core physical infrastructure assets:

- vertiports and vertistops—sophisticated helipads that facilitate UAS landings and takeoffs; with passenger transport, these will also serve as sites for embarking and disembarking[3]

- receiving vessels, such as lockers or other storage facilities, for package deliveries

- charging stations, which could be in vertiports, vertistops, or low-cost docks

With all infrastructure assets, companies can pursue multiple design options. For instance, they could build vertiports with capacity for three to six eVTOLs or opt for additional space. In areas with limited demand, a vertistop accommodating one or two vehicles might suffice. There will be some common elements in each asset class, however. With vertiports, essential features will include charging stations and security-screening areas. Some may also include storage space for additional batteries to assist eVTOLs that have lost charge and can't afford downtime. Developers must also ensure that their vertiport designs comply with regulatory requirements and state or local zoning guidelines.

The makeup, density, and distribution of air-mobility infrastructure assets will vary by location. As with UTM, urban areas with tall buildings and dense populations will have the most complex and expensive infrastructure needs. Consider drone deliveries. In rural or suburban areas, UAS could likely drop off packages on doorsteps, in backyards, or on driveways. In urban areas, by contrast, companies will need to place receiving vessels on rooftops or other locations for deliveries to apartment buildings that lack a clear drop-off point. These areas would also require robots or delivery people to transport packages the short distance to their destination.

When budgeting for their infrastructure needs, companies should remember that the big-ticket items won't be their only expense. They'll also need to invest in supporting technologies, such as automated systems for loading packages onto delivery drones at distribution hubs. Finally, they will need funding for relevant infrastructure-operating technologies, such as automated systems for swapping eVTOL batteries for greater efficiency.

Next steps for air-mobility stakeholders

With air taxis and delivery drones still in early development, many air-mobility stakeholders have not begun to think about the associated infrastructure needs. But they must soon shift some attention to the creation of vertiports and other assets to prepare for the future. Here are some of the critical considerations for owners, investors, and public officials.

Owners

For physical asset owners, one major question looms: Should they build new infrastructure or try to retrofit existing structures to accommodate their air-mobility needs? Stakeholders must also decide how they'll profit from their infrastructure investments. Some, for instance, might decide to charge other companies a fee to use their vertiports, while others might see value in restricting access because that could limit competition among air-mobility solution operators.

With airspace management, stakeholders must think about regulatory requirements. Consider iterative route planning. Should UTM systems be able to alter routes based on new information, or must air-mobility solutions always stick with the path specified at the outset? On the technical side, the issue of integrating UTM with current airspace-management systems also deserves attention now.

Investors

Air-mobility infrastructure will open opportunities for investors who are willing to explore a new asset class, provided that they're willing to enter uncharted waters. The sums in play will be high, once the costs of all essential assets are considered. For instance, vertiport costs could range from $2 million to $200 million based on various features, including size, the number of vehicles accommodated, location, and building structure (for instance, whether it is located on a rooftop or a stand-alone building). In most metropolitan areas, the number of required vertiports could be on the same order as the number of subway stops, so there could easily be 100 or more of varying size. And that means the investment requirements for each city could be significant. As private-equity-style funds and institutional investors seek to invest ever-larger amounts in the infrastructure sector, the air-mobility segment could present interesting opportunities.

Public officials

Government officials might get the best picture of infrastructure requirements by collaborating with private companies interested in air-mobility solutions, developers creating UTM systems and other infrastructure, and community-interest groups (mostly consisting of concerned citizens in specific locations). Consider how the US federal government could work with private players on UTM, for example. Because many companies are now developing different technologies and approaches, the government could collaborate with them to define the design and create technical standards that allow safe, reliable performance while ensuring interoperability of UTM systems. Some initiatives are already under way to explore these topics.

If government agencies were to invest in air-mobility infrastructure, they would likely be very selective. For instance, agencies might prioritize funding for vertiports in a transport system that serves many residents in a highly populated metropolitan area. Their involvement might also give them a say in important decisions, such as the locations of transport lines. But government agencies might restrict or deny public funding for vertiports that serve only a few businesses.

Even if they don't provide funding, government agencies might still assist with air-mobility infrastructure planning and investment. The requirements for vertiports, UTM, and other systems will vary based on population density, open space, transportation patterns, and many other factors. State, local, and federal authorities could work with communities as they initiate infrastructure planning and investment. These authorities could also quantify the potential impact of air mobility on their regions to understand how it integrates with their broader mobility strategies and objectives, such as cutting commute times for citizens and reducing air pollution. They could then determine the infrastructure required to prioritize investments and support the desired outcomes.

Air-mobility solutions could transform commutes, package delivery, and other mundane tasks in ways that would have seemed impossible only a few years ago, producing repercussions that go far beyond transport. eVTOLs could help reduce pollution and alleviate the housing crunch in urban areas by making distant suburbs a viable option for city workers. Rapid drone delivery could accelerate the already steep uptick in e-commerce and increase the bottom line at many companies. And the overall economic benefits of air mobility could be immense as new applications increase efficiency and productivity. First, however, companies, governments, and other stakeholders must take thoughtful steps toward creating an environment that enables these societal benefits. Much is uncertain, as with any new industry, but the potential for gains is also great. ■

[1] *2015 Urban Mobility Scorecard*, a joint report from Texas A&M Transportation Institute and INRIX, August 2015, mobility.tamu.edu.

[2] Drones mostly fly at or below 400 feet above mean ground level; some may fly at higher altitudes because of skyscrapers or other obstacles.

[3] Vertistops typically handle takeoffs and landings for one vehicle, while vertiports simultaneously handle multiple vehicles.

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