Urban Air Mobility Landscape Report

Initial Examination of a New Air Transportation System

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April 2018

Approved for Public Release
Distribution Unlimited - Case: 18-0154-4

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PURPOSE

This report provides an overview and initial examination of Urban Air Mobility, an emerging form of air transportation service in low-altitude airspace. It addresses six main questions: What is Urban Air Mobility (UAM)? What is enabling this new industry? Who are some major participants in UAM? What are the challenges to enabling UAM operations? When will we see UAM operations? Why does this matter? We expect the industry vision to evolve as technologies are matured and policies are enacted.

INTRODUCTION

The low-altitude landscape is quickly evolving. Ten years ago, it was rare to see a Remote Control (RC) helicopter operated by a hobbyist in a park. Fast forward a few years and the development of small Unmanned Aircraft Systems (UAS) has enabled a variety of new applications, from inspection services and photography, to cargo delivery and search and rescue. The FAA recently reported that over 1 million operators in the United States have registered to fly a UAS [1]. As the technology is improving, the applications for operating an unmanned aircraft are growing. Many companies now see an opportunity for passenger-carrying applications with small self-piloted [1] aircraft. These technology advances have altered and continue to change the low-altitude urban air transportation environment.

WHAT IS URBAN AIR MOBILITY?

As part of this future urban landscape, Urban Air Mobility (UAM) is an industry term used to describe the system that enables on-demand, highly automated, passenger[2] or cargo-carrying air transportation services within and around a metropolitan environment. The industry vision involves leveraging new vehicle designs and system technologies, developing new airspace management constructs and operational procedures, and embracing the sharing and services economy to enable a new transportation service network.

The use cases envisioned for UAM include operations expected to enable improvements in efficiency and safety as compared with ground transportation. For example, one use case might involve taking an air taxi to commute from a suburban location to a downtown building. Other examples include airlifting passengers from harmful situations during a natural disaster and providing tourists new sightseeing opportunities by air.

A scan of the industry has revealed a wide variety of current and potential players in the UAM landscape. Participants include a range of aircraft manufacturers, from established aerospace companies such as Bell Helicopters, Boeing, and Airbus, to well-captalized companies not traditionally in the aviation business such as Uber and Larry Page's[3] KittyHawk, to startups such as Joby and Terrafugia. Governments and municipalities, as well as UAM service providers and integrators, are also interested and becoming involved. After initial examination, we have observed some commonalities in the envisioned aircraft designs and the operating concepts.

Aircraft manufacturers and service providers generally expect the following characteristics for UAM aircraft:

- Vertical takeoff/landing (VTOL) to enable runway-independent operations
- Very high degrees of automation, up to and including full automation (self-piloted)
- Distributed electric propulsion with multiple redundant propellers or fans (not rotorwings)
- Equipped with parachute systems

[1] Many in the UAM industry are using the term "self-piloted", to refer to an aircraft that does not have an on-board pilot, with the aircraft essentially piloting itself via automation. Most proponents envision a human will likely be remotely supervising potentially large numbers of simultaneous operations.

[2] This report will focus on the emergence of passenger-carrying operations.

[3] Co-founder Google

- Production versions that are likely to be mass-produced

Likewise, potential operators expect UAM passenger operations to include the following characteristics:

- On-demand operations
- 1000s of operations per city each day
- Cruise altitudes generally between 500 and 5,000 feet above ground level
- Range generally < 100 km
- Payload generally 1-5 passengers
- Speeds generally between 100 and 150 knots

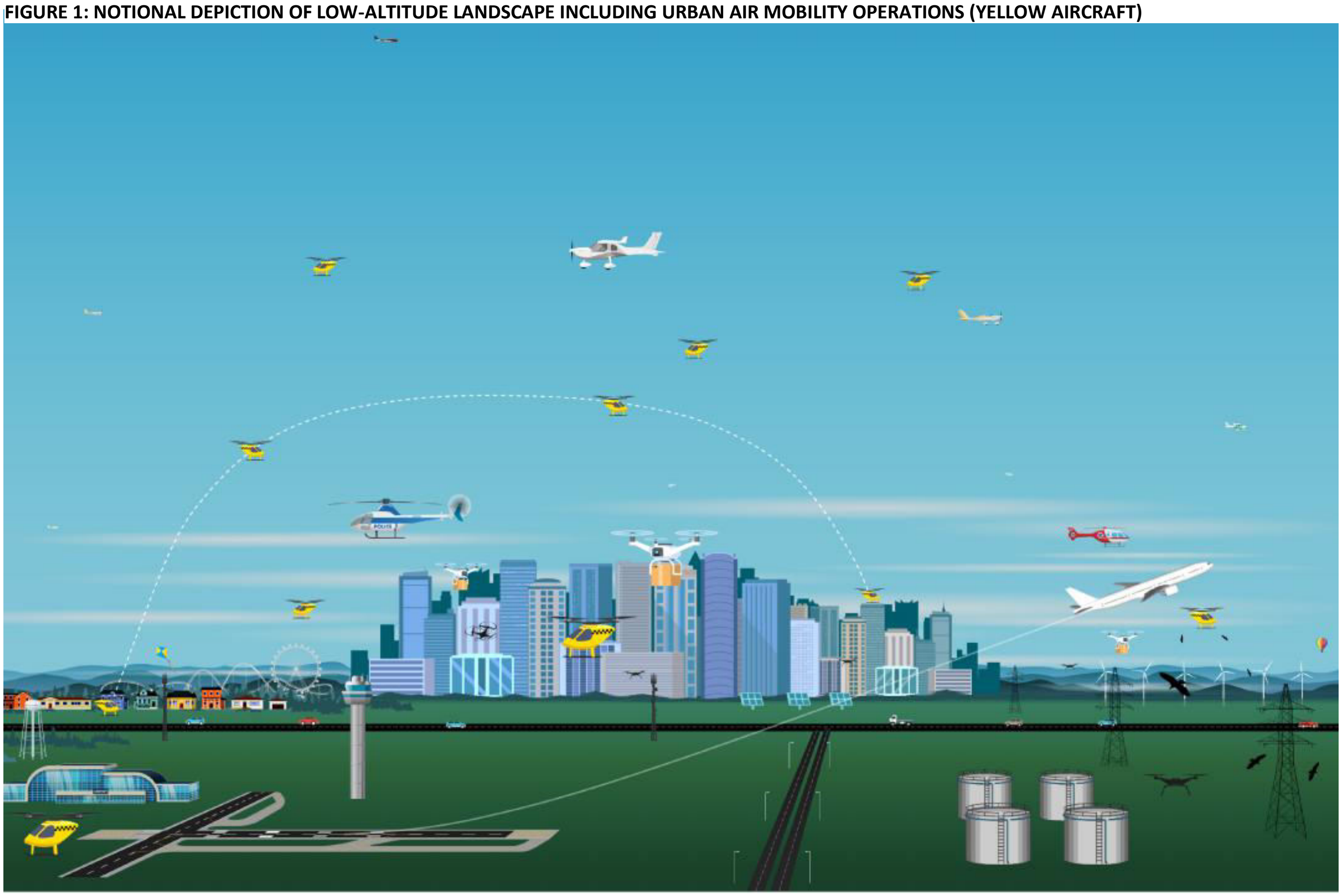
Judging by the scale of the investments, number of proponents, progress to date, and the current state of technology development in the UAM industry, we believe it is not a matter of if UAM will happen but a matter of how quickly regulatory environments and operational policies can adapt to permit full-scale operations.

WHAT IS ENABLING THIS NEW INDUSTRY?

The concept of urban-centered air transportation is far from novel and has been attempted as early as the 1950s with the advent of commercial helicopters. Helicopter services began with mail transport before moving to passenger transport. By the 1970s, several helicopter-based air taxi operators were in business, including an extensive, unscheduled, and on-demand helicopter service in Boston [2]. These services, however, disappeared in the United States due to high-profile accidents, operational expense, and negative public response to noise and pollution.

Like helicopters, "flying car" concepts shared a common vision of mass use in urban and suburban environments. These concepts have not yet been proven successful due to technical, infrastructure, regulatory, cost, and pilot certification requirements challenges.

FIGURE 1: NOTIONAL DEPICTION OF LOW-ALTITUDE LANDSCAPE INCLUDING URBAN AIR MOBILITY OPERATIONS (YELLOW AIRCRAFT)



The lessons of these early attempts, coupled with the convergence of modern technologies and societal changes, has shifted the vision from piloted helicopters and flying cars to one of on-demand, short-range, pilotless air travel as a service [3] [4] [5]**.**

Specific enablers of this new vision include:

- Significant increases in the technological maturity of stable, maneuverable, VTOL, and highly automated flight, all largely driven by the UAS industry
- Small, lightweight, high-power, low-cost computing capabilities
- Mass-produced lightweight composite structures enable large-scale, low-cost vehicle construction through 3-D printing technologies and robotic assembly and inspection
- Advances in machine learning technologies to enable robust detect-and-avoid and other operational control capabilities
- Significant improvements in electrical energy storage capacity, enabling distributed electric propulsion via multiple redundant rotors for lower cost and lower noise flight
- Mobile device / cloud networks to efficiently and automatically manage fleets and customer interactions for on-demand service (e.g., Lyft and Uber business models)
- Greater societal acceptance of a sharing economy
- Greater societal acceptance of automation and complex technology.

Elements of the Business Case for UAM

Numerous large corporations have placed considerable resources towards developing UAM aircraft and UAM operational concepts. While this report does not detail specific UAM business cases, a key aspect they share for enabling profitable and sustainable UAM service is leveraging economies of scale. Manufacturers are aiming to mass-produce their vehicles to lower the per-unit fixed costs, as well as automate their aircraft flight operations to reduce pilot and support personnel costs. They also expect to take advantage of economies of scale from large numbers of daily operations. For example, Uber publically released calculations suggesting that the cost of their envisioned UAM service would be comparable on a per-mile basis to current automobile-based ridesharing services [3].

The Boeing Company recently published a report suggesting that self-piloted electric VTOL configurations could reduce total operating costs per seat mile by 26% compared to piston-engine helicopters used today. These savings come from a combination of a) a reduction in fuel and maintenance costs associated with electric propulsion, b) no costs for onboard piloting or equipment to support an onboard pilot, and c) cost reductions enabled from advanced manufacturing processes [6].

While traditional consumers of on-demand air transportion (such as helicopter services) have been for wealthy individuals or business consumers, the new vision is to make short-range air transportation more widely affordable to the general public.

Consumer Demand

Increased ground traffic gridlock is resulting in longer commutes and significant economic costs. One report estimates that the annual hours wasted due to traffic congestion are predicted to increase by 6% between 2013 and 2030 [7]. The total economy-wide annual costs across the United Kingdom, France, Germany, and the United States are estimated to rise from around $200 billion in 2013 to $293 billion in 2030 [7]. Consequently, many proponents of UAM expect these increasing congestion costs to spur significant consumer demand for better transportation services, which they believe can be satisfied by providing urban air mobility services. Many point to the success of Airbus' subsidiary, Voom, which operates an app-based on-demand helicopter service in São Paulo, Brazil. They claim "the world's first truly on-demand helicopter booking platform. With Voom, you can book a journey on a helicopter affordably — up to 80% less than traditional helicopter services — in just a few clicks" [8]. As such, many players in UAM are moving quickly towards initial operations [9].

WHO ARE SOME MAJOR PARTICIPANTS IN UAM?

Aircraft manufacturers, air service providers, and research organizations are currently leading efforts to enable UAM, many of which we identify below.

AIRCRAFT MANUFACTURERS

Aircraft manufacturers are at various stages of vehicle development, from early stage Computer-aided drawings (CAD) (e.g., Delorean Aerospace) to production-level prototypes (e.g., Volocopter). Table 1 shows a list of manufacturers that are known or expected to have flown a full- or partial-scale prototype (left column), and a list of vehicle manufacturers that have developed a CAD concept and have plans to develop a vehicle (right column) [10], [11], [12], [13]. This list continues to expand as more manufacturers see an opportunity. A continually updated list can be found at [14].

TABLE 1. IN-PROGRESS LIST OF MANUFACTURERS AND CONCEPTS

Manufacturers who have Developed an Aircraft Prototype	Manufacturers who have Designed an Aircraft Concept/CAD
• AIRSPACEX • Airbus A3 • CityAirbus (Airbus Helicopters) • Aurora Flight Sciences (A Boeing Company) • Bartini • Carter Aviation • Lilium Aviation • Passenger Drone • Vimana • Volocopter • Joby Aviation • Workhorse • Terrafugia • Kitty Hawk / Zee Aero	• AviaNovations • Delorean Aerospace • hopFlyt • Hoversurf • Japan Aerospace Exploration Agency • Jetpack Aviation • XTI Aircraft • VerdeGo Aero • Embraer • Pipistrel

SERVICE PROVIDERS

Uber has played a lead role in popularizing the future of UAM both by releasing a white paper [3] outlining their vision of UAM, "Uber Elevate," and by bringing together industry and government stakeholders at a UAM annual summit. Uber sees themselves as playing the role of service connector, connecting passengers with UAM operators much like their ride connection service on the ground. Through data collection from their ground services, Uber believes there would be a strong demand for air services [3].

As mentioned above, Voom operates an on-demand helicopter booking platform which connects passengers with helicopter operators for faster air travel around São Paulo, Brazil. This is similar to the service that Uber envisions providing for UAM in which they do not own or operate the air vehicles, but rather connect passengers with air taxi operators. The lessons learned from Voom's operation will likely provide valuable insight to UAM since the service model is similar [8].

Additionally, in March 2018, Kitty Hawk announced the launch of Zephyr Airworks, which will begin the regulatory approval process required for launching its autonomous passenger-drone system in New Zealand using their Cora aircraft [15] [16].

RESEARCH COMMUNITY

Many in the research community have also shown increased interest in studying UAM. For example, NASA has awarded contracts to Booz Allen Hamilton and Crown Consulting to perform UAM market studies that identify the political, economic, social, environmental, and legal challenges to enabling UAM. NASA plans to use these market studies to inform its UAM research agenda and expand upon the research for UAS Integration into the NAS and for UAS Traffic Management (UTM) [17]. There are elements of research into the technologies associated with UAM in several of NASA's aeronautics research programs [18].

The American Helicopter Society (AHS) International has been leading a series of workshops and working groups with NASA, AIAA, and SAE International on the topic of Transformative Vertical Flight (TVF). The goal of this effort is to explore new forms of air transportation systems that leverage vertical flight, such as UAM, and build a community consensus-based roadmap that can inform stakeholder decisions, guide investment strategies, and identify the hurdles towards achieving these new aviation systems [19], [18].

MIT International Center for Air Transportation (ICAT) released a report presenting a systems-level analysis of on-demand mobility for aviation [2]. Through a literature review, case study, and CONOPS analysis, the research identifies operational constraints to UAM as well as legal and regulatory considerations based on the unique aspects of low-altitude operations.

While still in the conceptual stage, the Blockchain.aero Consortium plans to develop a blockchain platform that enables a transparent information sharing community for Urban Air Mobility. Virtual tokens would be used for service transactions, and all interactions between all stakeholders in the system are stored on the blockchain platform. This combination of two emerging technological systems (blockchain and UAM) brings significant regulatory challenges; however, it bears watching as there are numerous benefits to service providers operating on a decentralized blockchain platform [20].

What are the challenges to enabling UAM operations?

UAM relies on integrating innovative technologies and new operating procedures into a fast-changing low-altitude air transportation system. One of the visionary themes that UAM industry participants share is the notion of taking an incremental approach. Industry is also placing an emphasis on ensuring initial system designs are adaptable to enable a smooth transition to higher-risk operations.

Initial flight demonstrations and operations will focus on addressing lower risk challenges with a steady evolution towards addressing higher-risk challenges associated with the end-state vision of high-density autonomous operations.

Primary Challenges

Many aspects of the National Airspace System will be impacted by the entrance of Urban Air Mobility operations. The subsequent table describes some of the key challenge areas that will need to be addressed to enable operations (left column). Many of these areas are being addressed to some extent with the emergence of UAS operations. The table includes some discussion on how UAS research has reduced the gap towards enabling UAM, and some of the differences that still need to be addressed (right column).

Urban Air Mobility Challenges	Relation to sUAS Challenges
Airworthiness of eVTOL Definition, classification, and certification of distributed electric propulsion (DEP) Vertical Takeoff/Landing (VTOL) systems that transition to fixed-wing flight. These new aircraft systems exhibit new and unique flight profiles and propulsion methods (e.g., DEP) that do not fit within existing classification schemes.	The UAS industry has developed many of the underlying technologies that enable battery-powered multi-rotor propulsion. UAM aircraft will need to expand on these technologies, as they will be much larger in terms of size and weight, requiring higher energy density in batteries and possibly different rotor configurations on the aircraft structure. Many aircraft are designed for hybrid lift, in which multiple propellers generate lift during takeoff and landing, and a fixed-wing configuration generates lift during cruise. The transition between these lift modes will be a challenge. Demonstration of a higher reliability for DEP will also be necessary because of passenger use. Lessons learned from recent efforts in general aviation on fixed-wing electric flight may inform UAM.
Mechanism for Certifying Autonomous Flight Definition, classification, and certification of highly automated software systems. Many functions typically handled by an onboard pilot will now be delegated to software (e.g., flight control, communication, navigation, and separation). The roles and responsibilities of these software systems as aviators (self-piloted) need to be defined. Mechanisms for ensuring that they will function as intended, or more importantly not function in an unintended fashion will need to evolve. Current mechanism for certifying software systems will not scale to the complexity and criticality of the software envisioned.	While most UAS aviation functions are handled through remote human piloting, some applications (e.g., cargo delivery) have been evaluating fully automated flight (no human in the loop, highly automated networks of operations). Certification of pilotless software is not compatible with traditional DO-178C techniques. Some cargo delivery aircraft manufacturers are working towards an alternative process to DO-178C that may set a new standard for which UAM manufacturers can follow. Other certification challenges include more frequent software updates (daily/weekly) and processes for evaluating the safety of non-deterministic systems. The automotive industry is addressing many of the same issues related to fully automated operations.
Required Air Traffic Services Given large numbers of self-piloted flights, it is expected that air navigation services will also need high levels of automation to manage operations. The extent of UAM interaction with the current Air Traffic Control system will also need to be well understood and made clear, though it is expected to be limited. Other air traffic services, such as micro weather support services in urban settings, may be provided by other service providers.	The FAA has announced that it will not provide ATC services to any UAS always operating below 400 ft anywhere, even beyond Part 107 & 101. The set of necessary UAS services is expected to be provided through the UTM construct by private service providers. It is yet to be defined to what extent ATC would provide services to UAM aircraft operating above 400 ft. It will likely be a mixture of defining new communication requirements with existing ATC systems and expanding UTM-like services to higher altitudes for UAM applications. These expanded services may require a higher burden of responsibility than for sUAS since they will be responsible for the safety of passengers onboard.

Urban Air Mobility Challenges	Relation to sUAS Challenges
Detect and Avoid Envisioning operations with neither a pilot onboard, nor a remote pilot, software systems may be responsible for detecting and avoiding both cooperative and non-cooperative traffic (including legacy manned traffic, other UAMs, small UAS) as well as obstacles, terrain, and potential obstructions in the landing area. Procedures and standards will be needed to clarify separation responsibility and define performance requirements. These systems will have to be certified as safe and compatible with other airspace users.	Detect-and-avoid standards for sUAS and larger UAS operations are being defined (RTCA SC-228, ASTM F38, JARUS) based on available technologies (radar, lidar, camera, ADS-B, 5G). These standards and technologies may require better performance and reliability for UAM operations due to the criticality of protecting passengers onboard. Separation, well-clear, and collision avoidance standards need to be defined for all types of interactions and environments (e.g. UAM to sUAS, UAM to manned aircraft, UAM to UAM).
Operating Rules Regulatory requirements will ultimately define the boundaries of UAM vehicle certification, flight operations, and operator qualifications. Some provisions may currently be applicable to UAM, and in some cases new rules and thus rulemaking may be necessary. International harmonization of regulations may be important as countries consider similar operating concepts, and UAM manufactures, operators, and service providers seek consistency in a potential worldwide market. When considering operations without a pilot, UAM operations will have difficulty complying with current visual flight rules (VFR), and the expected density of operations and low-altitude nature of the operations will not support existing instrument flight rules (IFR) (e.g. there will be too many aircraft to meet current separation requirements). Therefore, new or modified rules, procedures, and airspace definitions will be required.	UAS operations have stimulated some rethinking of Part 91 and Part 135 relative to the use of UAS and operations beyond the remote pilot's visual line of sight. Ongoing considerations for UAS will help to formulate regulations around pilotless aircraft and existing passenger protection rules as defined in Part 135 will be applicable. However, other aspects, such as safety briefings and fuel reserves, will need to be considered specifically in the context of self-piloted passenger-carrying flight. Some sUAS applications would be most operationally effective using VFR-like structures in IMC (e.g. is not limited to altitude minimums, communication requirements, weather minimums). The UTM system is developing a concept that would rely on new regulatory constructs for these types of VFR-like operations. However, the extent to which these efforts are impacting rulemaking efforts is unclear. UAM operations will need to be part of the discussion when considering new flight rules for highly automated aircraft.
Information and Communication Networks UAM operations will rely on many critical information and communication services provided from ground systems, such as command and/or control links, ground-based detect and avoid services, and air navigation services. Criticality levels and associated performance requirements need to be defined.	UAS has allocated radio frequencies and defined standards (MOPS and TSO) for terrestrial line-of-sight radios. These standards are for radios operating in the aviation protected spectrum and having high reliabilty, making their use possible for safety critical functions. Additional studies in use of 4G/5G technologies may address the multitude of service-related communications. Vehicle-to-vehicle technologies, as developed in the automotoive industry, may also provide useful aircraft-to-aircraft communication links. Many of these technologies may be adapted for use by UAM operations; however, the safety case will need to be assessed to consider the addition of passengers onboard.

Urban Air Mobility Challenges	Relation to sUAS Challenges
Operational Oversight The industry vision includes a wide variety of possible use cases that may exhibit different levels of automation and different levels of risk to the passengers and people/property on the ground. These various flavors of operation will need to be defined and classified for different levels of certification based on different acceptable levels of safety. Today's 14 CFR Part 135 rule for Commuter and On-demand Operations will not likely be sufficient. This effort will include identifying the roles and tasks for approval management and oversight of operations. Additionally, operating procedures during emergency situations and for vertiport surfaces will need to be established.	Highly automated, networked UAS operations would serve as a good model for how the FAA may oversee UAM operations, maintenance, and continued maintenance programs (e.g., record keeping, personnel training). UAM brings additional aspects, such as swappable components (e.g., swapping battery between flights, training and oversight of passenger entry to aircraft). Due to the large number of passenger operations, the extent and rigor of oversight may be similar to Part 121 operations. Additionally, there will need to be some oversight of service providers that provide information pertaining to the safety of the operation.
Infrastructure for Ground Operations While some operations may take place from existing helipad locations, additional takeoff/landing area infrastructure will likely be necessary to support the expected density of operations. These areas will need to be developed. Definition of management and oversight roles for vertiport and maintenance facility infrastructure (e.g., public vs private, Local vs Regional vs National level) is needed. Some operations may employ novel navigation aids (e.g., LTE, vision-based referencing systems) which will need to be developed and certified for use.	Some UAS applications such as cargo delivery will likely develop takeoff/landing hubs for operations. However, many of these areas may not be large enough to accommodate larger UAM aircraft. Additionally, the safety protocols for passenger loading zones may be more stringent than for cargo loading zones, such as pre-positioning of safety features (markings, fire management) and passenger loading and de-planing procedures. Some unique precision landing technologies have been developed for military UAV applications (e.g., laser-guided UAV landings) which may be applicable for UAM operations.
FAA Role UAM involves new and evolving technologies/operational needs that are difficult to accommodate through traditional processes. The role that FAA plays in providing approval guidance and mechanisms, oversight and enforcement, and safety critical services (e.g., Air Traffic Control) may need to evolve.	UAS operations are helping develop a mindset for oversight and approval of highly automated flight using networks of novel technologies, which will be useful when considering UAM operations. The FAA's approval and oversight role will likely remain unchanged, which will require an evolution of the knowledge base to reflect an understanding of highly automated and networked operations.
Security With the heavy reliance on software and information/communication networks for enabling safe operations, cybersecurity standards will be important. These include methods for identification/authentication of aircraft and information. Physical security needs at vertiports will also need to be considered.	Work towards identification and tracking of UAS will be applicable and possibly reusable for UAM operations. Ongoing UAS studies to understand the importance and requirements for cybersecurity will also apply; however, any work done for UAM may need to consider a higher level of integrity.

Urban Air Mobility Challenges	Relation to sUAS Challenges
Public Acceptance While UAM is expected to provide numerous societal benefits, the general public will need to weigh in on many aspects of operations. For example, zoning requirements will be needed based on noise and visual annoyance. The level of benefits received by the public from these operations may inform the extent to which services are paid for by public or private funds. Identifying the amount of local management and control over local operations is also needed.	As the public gains more interaction with highly automated systems such as UAS and self-driving cars, the lessons learned from trust in autonomy will be applicable to UAM. Many of the negative perceptions, such as noise and extent of public benefit, are not comparable to UAS operations and will not be known until an initial UAM service is offered. Perceptions of similar applications, such as UAS cargo delivery, may provide insight into the challenges of providing a positive UAM service for the public.
Environmental Implications A new transportation system has the potential to bring numerous environmental impacts, especially noise. There will be noise from aviation operations in areas that are not accustomed to such disturbances. What kind of restrictions, if any, will be required on aircraft designs, operational hours, and locations of these new vertiports? There may also be impacts to flying wildlife that will require study.	Environmental policies applicable to sUAS will likely not be applicable to UAM operations due to the difference in aircraft size and noise profile. UAS cargo delivery operators have studied noise issues and are attempting to show noise levels are similar to ambient city noise. While UAM operations are expected to be quieter than helicopter operations, there will still likely be significant efforts to identify applicable routing and noise standards in high-traffic areas.
Personnel Qualifications and training for new personnel roles will need to be addressed. Personnel managing flight operations may have different needs for operational engagement depending on the level of automation in the system. Pilots, if they exist at all, will almost certainly have a limited aviator role in which flight profiles are highly constrained. While not directly involved in the operation, passengers may need guidance on recommended or discouraged actions, particularly during off-nominal situations. Ground personnel servicing UAM and passengers may have unique training and qualification requirements.	Applications that are similar to UAM (e.g., UAS cargo delivery) will require training of personnel managing large networks of highly automated flight operations. Identifying applicable training and human factors considerations will be applicable to UAM operations. Additionally, some of the management of loading/dispatching of cargo delivery would relate; however, there are differences when dealing with loading passengers that would need to be addressed.

WHEN WILL WE SEE UAM OPERATIONS?

While manufacturers are working on flight testing their aircraft, only a few specific operating plans have been released. Most activity in the coming years will likely focus on demonstrating systems in a limited environment.

Uber has taken some concrete steps towards enabling initial UAM operations. The company has partnered with a variety of stakeholders, such as aircraft and battery manufacturers, real estate companies, cities, and charging station manufacturers to establish a network that will enable future customers to easily access urban air transportation. Uber's goal is to have an initial demonstration of a flight within this network in Dallas, Los Angeles, and Dubai by 2020. They would like to transition to full-scale operations by 2023 [21].

The Emirate of Dubai also has plans to operate an air taxi service in the near future. Dubai's Road and Transit Authority (RTA) recently conducted a passenger-less demonstration flight using the Volocopter 2X [22]. The RTA plans to collaborate with the UAE General Civil Aviation Authority and the Dubai Civil Aviation Authority to develop the appropriate policies and standards needed for an air taxi service. JDA Aviation Company, a US-based aviation solutions company, has been tasked to oversee preparations for this service as trials and demonstrations are rolled out over the coming years [23].

The Government of New Zeland has partnered with Zephyr Airworks to develop a path towards certification of Kitty Hawk's Cora aircraft. Kitty Hawk chose to work with the Civil Aviation Authority in New Zealand as a launch pad because the country has a dynamic economy and "the respect of the worldwide regulatory community." This partnership effort hopes to be operating within three years [15] [16].

The White House memo that organized the UAS Integration Pilot Program includes policy language for promoting safe development of a UAS application involving human transportation. Therefore, it is possible that some applicants to the UAS IPP will propose an urban air taxi application that aligns with the vision of UAM.

WHY DOES THIS MATTER?

Given the large amount of time and investment industry proponents are spending to develop UAM systems, it is likely that requests to operate revenue services are only a few years down the road. At least one proponent has already partnered with an aviation authority outside the United States to pave the path towards a certified revenue service. The speed and magnitude of technological changes that are enabling UAM will require fundamentally different processes for certification, rulemaking, and oversight by the FAA. Development of these new processes to address the gaps in enabling UAM will likely take many years. Some of the efforts towards enabling UAS operations will be applicable and shortcut addressing UAM gaps; however, other areas may require new programs and a new knowledge base.

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