Urban Air Mobility

Opportunities for the Weather Community

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FIG. 1. Artist's rendering of urban air mobility. (SOURCE: NASA)

The vision of avoiding gridlock on the ground by speedily traveling across metropolitan areas through the air is not just a fantasy from *The Jetsons* (www.youtube.com/watch?v=tTq6Tofmo7E). This idea, called urban air mobility (UAM), has galvanized the aviation industry (Fig. 1). Uber published “Elevate” (Uber 2016), a vision for on-demand aerial ride sharing, and NASA has been investing in UAM-enabling technologies for the past decade and recently issued the *Urban Air Mobility Grand Challenge* (www.nasa.gov/uamgc). UAM is happening: the industry is moving fast.

Helicopters, long a form of UAM, have been restricted by noise constraints, limited takeoff and landing sites, and cost. The latest advances in

batteries, electric propulsion, and rotor designs promise aircraft that are decisively quieter than helicopters, however. As a result, manufacturers are investing heavily in developing electrically propelled, vertical takeoff and landing aerial vehicles (eVTOLs) that will likely carry up to six people and eventually may operate autonomously. Multiple eVTOL flight demonstrations have already occurred in the United Emirates (*Volocopter*, www.volocopter.com/de/), South Korea (*eHANG*, www.ehang.com/ehang184/index), New Zealand (*Kitty Hawk*, <https://kittyhawk.aero>), the United States (*Vahana*, <https://vahana.aero>; *Aurora*, www.aurora.aero) and several other places. In addition, Airbus is testing its on-demand helicopter booking platform (*Voom*, www.voom.flights/en) in Sao Paulo, Brazil, and Mexico City, Mexico, toward future use with on-demand UAM services.

Substantial research is underway to examine all aspects of UAM, including business viability, infrastructure requirements, safety and convenience, scalability, traffic management, and public acceptance. The anticipated benefits are obvious: increased mobility, faster commutes and deliveries, and decreased surface congestion and pollution (emissions and noise). Moreover, ultimately eVTOLs may be cleaner,

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safer, quieter, cheaper, more reliable, and faster than traditional rotorcraft.

The sensitivity of aviation to weather hazards (Haupt et al. 2019, Stith et al. 2019) rapidly increases with decreasing size of an aircraft: that is, a *DJI Phantom 4* drone will struggle with winds that a *Cessna 152* pilot would consider benign. For eVTOLs, take-off, landing, and the transition from vertical to horizontal flight will be demanding in the complicated wind and turbulence of a cityscape. Meteorological observing networks and prediction will have to be upgraded to support UAM, especially considering the needs of eVTOLs to reliably operate in all weather conditions.

Unfortunately, our current observing infrastructure (Stith et al. 2019) undersamples the airspace in and above cities. Ongoing efforts to improve monitoring of urban heat waves, air quality, street flooding, radiation, disease outbreaks, or toxic releases will also benefit UAM. Equipping eVTOLs with

meteorological sensors could provide unprecedented weather data in real time based on the thousands of flights envisioned across a metropolitan area. Given that disclosure of hazardous weather conditions is a requirement for aviation (e.g., notification through pilot or automated reports), all aerial vehicles should collect and share meteorological (and maybe other) measurements, with benefits not just to aviation but to society as a whole.

In addition to expanded observing capabilities, remarkable scientific and technical advances are underway to propel modeling capabilities from meso- to microscales and, eventually, building-resolving scales (Chen et al. 2012, Best and Grimmond 2015, Muñoz-Esparza et al. 2018, Blocken 2018). Finescale urban modeling capabilities require substantial computational resources, with potentially millions or tens of millions of grid points covering a limited spatial domain. Opportunities exist to improve the atmospheric process representation, increase the

FIG. 2. Translation of wind and turbulence into remaining battery charge along flight path.

efficiency of computer code, and/or utilize emerging computational resources such as graphical processing units (GPUs) to decrease computational time for finescale urban predictions.

To support eVTOL flight operations in urban environments, it is necessary to provide timely and actionable weather guidance (Fig. 2). This may require a reduction of model complexity (and thus computational time) to the minimum needed to capture a given weather situation. In addition, “actionable” means that the weather information has been translated into location- and time-specific operational impacts or constraints and associated uncertainty. Small-scale processes are less predictable and, thus may encourage probabilistic approaches. Guidance quality has to be assessed on the value added to the decision-making process.

To realize the UAM promise, the weather enterprise and the aviation industry need to engage in an ongoing dialogue about information needs and requirements for a wide range of aerial vehicles—and then act to minimize avoidable weather-related risks. The Automated Vehicles and Meteorology Summit (www.ametsoc.org/index.cfm/ams/meetings-events/ams-meetings/automated-vehicles-meteorology-summit/) hosted by the AMS in October 2018 fostered such a dialogue, but much more is needed. Broad representation of public, private, and academic stakeholders is needed. Moreover, the weather enterprise needs champions in the aviation industry to embrace and promote weather as an integral component in the design, certification, and operation of aerial vehicles like eVTOLs or unmanned aerial systems (UAS).

The steps toward fully-autonomous UAM require comprehension of how weather affects sensors and automation algorithms. Testbeds are needed to examine aerial vehicle performance degradation and failure in a safe environment and under varying weather conditions. Similarly, progress toward simultaneous operation of multiple vehicles and eventually full-scale air traffic requires multiple steps. Learning from these controlled steps, best practices, standards, and requirements can be developed for both the aviation industry and weather enterprise. This also builds trust in the safety and efficiency of UAM as well as in operation-specific microweather guidance. The weather enterprise needs to develop and adapt benchmarks for creating and validating finescale weather guidance for urban aviation.

New modes of aerial transportation are emerging. It is time for interdisciplinary research and development partnering the aviation industry and the weather community in operational UAM scenarios. The aviation and weather communities will also need to work together to identify funding for development and evaluation of the necessary methodologies.

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FOR FURTHER READING

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