# Concerning the NASEM's Report on Flying Cars, *Advancing Aerial Mobility: A National Blueprint (2020)*

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## 1. Background of This Report

In 2018, the National Aeronautics and Space Administration (NASA) asked the National Academies of Sciences, Engineering, and Medicine (NASEM) to conduct research on flying cars, which are expected to have future technological advancements, to evaluate its potential benefits and challenges. While the term, "Urban Air Mobility" (UAM) was used in the original work instructions, "Advanced Aerial Mobility" is used in this research to broadly cover areas outside of urban spaces, and to study transportation, excluding those carrying people and goods. (That is to say, UAM is a part of Advanced Aerial Mobility.)
Upon the request from NASA, the NASEM established a committee consisting of experts from universities, research institutes, and aircraft manufacturers, who conducted three reviews during the space of spring to fall in 2019. The official version of the research report, which includes a summary of the reviews, was published in 2020 after it had completed a strict and independent peer review. [1)]
The next paragraph will cover the contents of this published report.

## 2. The Contents of the Published Report

The published report consists of five chapters. In the 1st chapter, an outline detailing the concept of Advanced Aerial Mobility and an introduction of how its development is connected to U.S. aviation history are given. In the second chapter, future notions for Advanced Aerial Mobility, including essential characteristics that it should embody, are expressed. In the 3rd chapter, descriptions on how to create an environment where early operators are able to cooperate with government agencies to form markets is disclosed. Chapter 4 goes into details about the importance of having comprehensive research on the following: key technological developments that are essential for the security and safety of Advanced Aerial Mobility, a safety analysis tool for managing unexpected situations, cyber security, and auto-pilot of aircraft. Furthermore, Chapters 2, 3, and 4 reveal some challenges that exist for achieving future goals. They also describe the impacts of companies' efforts towards Advanced Aerial Mobility, and views on how NASA could support these efforts. In the fifth and final chapter, an examination is given on how to achieve future visions of Advanced Aerial Mobility by supporting and developing its expansion into airspace, cooperating with public and private sectors, and overcoming systematic challenges.
The next sections will primarily explain the recommendations offered to NASA and other affiliated organizations listed in Chapters 2 to 5.

### 2.1 Chapter 2: The Future of the Country with Advanced Aerial Mobility

According to estimates by the United States Department of Transportation, in 2050 over 65% of the world population will live in urban areas, and ground infrastructure for traditional means of transportation will suffer a loss of $1.2 trillion in GDP in 2025. Furthermore, in the long term, there will be secondary impacts to land utilization and urban planning from Advanced Aerial Mobility. Therefore, planning for a future where the country has Advanced Aerial Mobility, and implementing actins for its achievement, will have national benefits.

However, no organization of the U.S. government has a clear mandate to promote development, adoption, and commercialization of such new technology. Furthermore, as Advanced Aerial Mobility is complicated and is related to many fields, no public or private organization has all the necessary capabilities. Thus, it is advised that NASA and the Federal Aviation Agency (FAA) cooperate in managing responsibilities of the various stakeholders involved in making a master plan for Advanced Aerial Mobility.

Along with challenges of verifying the safety of aircraft and integrating them into airspace, social acceptance of Advanced Aerial Mobility, especially regarding noise and its psychologic factors, is considered the biggest issue, and could be a setback for its introduction if unresolved.

Consideration for initial uses of Advanced Aerial Mobility have included operations in rural areas where infrequent usage will allow for a low noise footprint, and also highly public operations, such as for search and rescue and disaster responses. These uses are expected to be beneficial experiments for building public acceptance along with studying low-noise operations.

Therefore, it is advised that NASA promote cooperation among the FAA, the United States Department of Defense, the National Institutes of Health, academic societies, local communities, industry associations, operators, and non-profit organizations to prioritize research on the noise quantity of Advanced Aerial Mobility and how to minimize any social disservices that may occur due to its operations, as well as to instruct the completion of said research within two years.

In addition, in order to evaluate the social impacts of Advanced Aerial Mobility and its infrastructure, such as on health, human services, and privacy, it is advised that NASA promote that the aforementioned organizations conduct cooperative scenario-based research, and once concluded, for NASA to press for the maximization of social benefits.

### 2.2 Chapter 3: Market Formation

It is expected that no aircraft of any kind will be restricted in future aviation systems, and that properly linked aircraft data sharing networks will enable shared airspace. With this data sharing network, Advanced Aerial Mobility operators will be able to pursue safety and the greatest efficiency without the cost of attaching multiple sensors on every aircraft. It is unrealistic that a complex system having many interested parties can be created without any coordination between them, and so coordination will be important for interoperability.

For this reason, it is advised that NASA and the FAA expand the concept of operations management of unmanned aircraft systems and conduct research to enable Advanced Aerial Mobility to fly in all airspaces.

Additionally, transportation of commercial goods are expected to be the first applications of cargo operations using automation technology in rural areas. Thus, it is recommended that NASA partner with cargo transportation companies and related development companies that will be the first adopters of this technology within the next year. Furthermore, these companies should work to achieve automation by developing technology for drone transportation of small to large sized goods within 3 years.

In addition, it will be required to define milestones of increasingly complex capabilities and the system components that support these efforts. These requirements embody the more sophisticated operations in an aviation system with increasing capabilities and frequency of operations, and form a goalpost for the development of standards, systems based on those standards, and for new operational rules. Therefore, NASA is advised to prioritize research related to the development of architecture, requirements, and related technology to accomplish Advanced Aerial Mobility integration in future aviation system.

NASA runs a National Campaign program to increase the frequency of operations and improve safety through integrated demonstrations of Advanced Aerial Mobility flight concepts and scenario candidates. The purpose of this program is to accelerate certification, formulate flight procedure guidance, evaluate communications, navigation and surveillance, verify airspace flight management, and understand noise characteristics. NASA's priorities in this program are leading research for Advanced Aerial Mobility, its systems, and operational concepts to become realized. Good examples and lessons learned will be beneficial to all the parties involved.

Therefore, NASA is recommended to work with industry associations to continuously strengthen the National Campaign program, and to extend those beneficial outcomes to all parties as an example of best practices, tools, resources and training programs.

## 2.3 Chapter 4: Safety, Security, and Management of Contingency Situations

Traditional testing and simulations on their own are not appropriate for ensuring the safety of automation systems, which are complicated and software-intensive. Thus, it is advised that NASA work with the FAA to support research on new and stronger safety analysis tools, which are currently widely used, and that can be applied to software-intensive advanced systems.

Current approaches to cybersecurity focus on information security, and so aren't appropriate for Advanced Aerial Mobility, which include operations that are directly linked to safety of aircraft through automated systems. For this reason, it is advised that NASA conduct research and develop cybersecurity for Advanced Aerial Mobility. Furthermore, in order to support applicants for certification, it is recommended that NASA coordinate with FAA certification experts to formulate guidelines and technology to examine complicated software and hardware, including a nondeterministic functionality.

Due to projections of increased aircraft operation numbers and decreased pilot training, automation for managing contingencies is an integral part of Advanced Aerial Mobility. It is dependent on various real-time data for detection, avoidance, traffic adjustments, and weather information updates, and automation technology must be resilient in order for operations to continue safely, even if one or more data links of the systems gets lost or becomes unstable.

Therefore, it is advised that NASA conduct research, development, and testing of automation technology for the management of emergency situations to support the safety of Advanced Aerial Mobility.

## 2.4 Chapter 5: Introducing Advanced Aerial Mobility

Flight tests for unmanned aircraft need to be performed under special conditions, and in many cases, have testing sites specifically designed for these purposes. In some cases, flight tests are required to be performed in airspaces that are isolated from the outside world. These tests demand locations that allow companies to carry out a wide range of verifications and developments, grant airspace access, modify ground equipment to suit flight test scenarios, and facilitate easy work conditions in test areas.

Therefore, in order to establish flight test capabilities that support smooth developments of aircraft, operations, communications, monitoring technology, traffic management, noise-reduction, and ground infrastructure, it is advised that NASA cooperate with the FAA on allocating equipment resources and providing flexibility on airspace and rules.

Furthermore, building new heliports and vertiports, which allow for aircraft to take off and land vertically, have high costs and are complicated. On the other hand, although new kinds of aircraft might not require a runway, current infrastructure and partitioning of existing airports and heliports are valuable. Infrastructures required for UAM include vertiports, maintenance areas, and power feeding /oil feeding infrastructure. In order to formulate a design standard for vertiports, the FAA is officially requesting industry associations to provide information. In UAM systems, many vertiports would exist in big city areas, and would require for UAM infrastructure to be dispersed.

Therefore, it is recommended that public-private partnerships are established to promote the introduction of Advanced Aerial Mobility within virtual environments so that performance capabilities may be determined and system and infrastructure can be designated in the near future. Regarding partnerships, NASA is advised to work with the FAA directly, and coordinate with them and other public organizations, industry associations, and standard-setting bodies along the divisions of shared responsibilities.

Data exchange for Advanced Aerial Mobility is diverse in in its contents, size, and real time update requirements. In order to detect, avoid, and secure separation, not only is it required for the communication intentions and air traffic control directives to be shared, but also the common geospatial framework for updating the aircrafts' state. However, no public organization currently owns an authority to formulate and manage data standards for this data exchange.

Therefore, it is recommended to prioritize research on communication protocols, data forms, and data exchange standards to support a real-time geospatial information system for Advanced Aerial Mobility through a working group composed of NASA, industry associations, academic societies, and standard-setting bodies.

## 3. Conclusion

As mentioned in the beginning, the published research report was requested by NASA, and thus, the recommendations are intended for them. However, as most of the guidance is unfeasible for NASA to accomplish by themselves, they will need to work together with the FAA and industrial associations.

In particular, along with safety, social acceptance of Advanced Aerial Mobility is listed as the greatest challenge, especially pertaining to noise and its psychological effects.

To encourage social acceptance, starting operations which produce a low noise impact and high publicity, and determining an implementation plan that maximizes social benefits are required.

On the other hand, a plan that maximizes social benefits may not necessarily correlate with the high needs of operations. Therefore, the most important notion for whether or not Advanced Aerial Mobility succeeds or fails is dependent on if public organizations and private companies are able to discuss and find a mutually-beneficial plan for its introduction.

## Reference

1) National Academies of Sciences, Engineering, and Medicine, Advancing Aerial Mobility: A National Blueprint

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