United States Government Accountability Office

Report to Congressional Committees

November 2022

TRANSFORMING AVIATION

Congress Should Clarify Certain Tax Exemptions for Advanced Air Mobility

Accessible Version

GAO-23-105188

GAO Highlights

Highlights of GAO-23-105188, a report to congressional committees

November 2022

TRANSFORMING AVIATION

Congress Should Clarify Certain Tax Exemptions for Advanced Air Mobility

Why GAO Did This Study

Advanced air mobility manufacturers are currently testing their aircraft, with a few companies planning to begin commercial operations in 2025. The Federal Aviation Administration (FAA) will have to certify and integrate these aircraft into the national airspace system. Most of FAA's budget flows from a trust fund supported by various taxes paid by aviation users. Federal tax law administered by the IRS determines whether taxpayers qualify for exemptions to these taxes.

GAO was asked to review funding and infrastructure issues associated with advanced air mobility. This report examines (1) the anticipated capital costs of advanced air mobility infrastructure, (2) stakeholder considerations for infrastructure funding, and (3) the extent to which taxes that support the aviation trust fund apply to advanced air mobility, among other topics.

GAO reviewed laws, regulations, case law, revenue rulings, and other memorandums associated with aviation taxes. GAO interviewed FAA and IRS officials and 25 stakeholders, including academics, trade associations, and aircraft manufacturers. GAO identified these stakeholders through a literature search and consultations with internal and external subject matter experts.

What GAO Recommends

Congress should consider clarifying how advanced air mobility aircraft are defined for the purpose of tax exemptions.

View GAO-23-105188. For more information, contact Heather Krause at (202) 512-2834 or KrauseH@gao.gov.

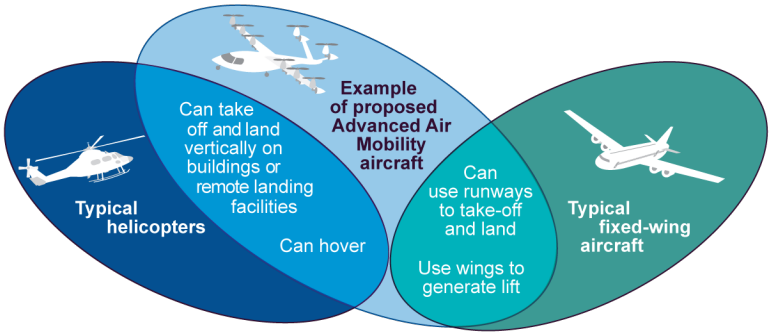
What GAO Found

Advanced air mobility is an emerging form of air transportation that may use aircraft with electrified propulsion systems, increased levels of automation, and vertical take-off and landing capabilities to transport people and cargo. Stakeholders GAO interviewed said that individual infrastructure projects to support such operations (such as take-off and landing sites at airports, hospitals, and parking garages), could cost between $500,000 and more than $10 million apiece. These costs may vary by each project's location, scope of construction, and electrification needs.

Stakeholders expect private funding to play a prominent role in initial infrastructure, though they anticipate public funding may increase over time. Stakeholders noted the balance of public and private funding could affect (1) the speed and ingenuity of infrastructure development; (2) the interoperability of infrastructure; and (3) communities' access to advanced air mobility services.

Taxes applicable to airspace users that fund the aviation system will apply to advanced air mobility operations. However, it is unclear how exemptions for some of these taxes would apply to these operations. For example, eligibility for some tax exemptions depends on the type of aircraft used, such as whether it is a helicopter versus a fixed-wing aircraft. However, "helicopter" and "fixed-wing" are not defined in tax law, and advanced air mobility aircraft can share features with both (see figure).

Shared Features of Proposed Advanced Air Mobility Aircraft and Typical Aircraft



Source: GAO. | GAO-23-105188

While the current aviation financing system has been amended over time, existing tax law does not address how to classify some emerging advanced air mobility aircraft. Internal Revenue Service (IRS) officials said that in the absence of congressional clarification, the agency might face challenges in determining the applicability of tax exemptions for these operations when they begin. Officials said that congressional clarification would provide a framework for the agency to administer the tax law efficiently and effectively. For example, such clarity would facilitate more consistent tax treatment and reduce litigation that the federal government might otherwise face.

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Abbreviations

AAM	advanced air mobility
AATF	Airport and Airway Trust Fund
ACI-NA	Airports Council International – North America
AIP	Airport Improvement Program
ATO	Air Traffic Organization
eVTOL	electric vertical take-off and landing (aircraft)
FAA	Federal Aviation Administration
IRS	Internal Revenue Service
NPIAS	National Plan of Integrated Airport Systems
PBIA	Palm Beach International Airport
PFC	passenger facility charge
RAM	regional air mobility
UAS	uncrewed aircraft systems

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November 30, 2022

The Honorable Peter A. DeFazio
Chair
The Honorable Sam Graves
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Rick Larsen
Chair
The Honorable Garret Graves
Ranking Member
Subcommittee on Aviation
Committee on Transportation and Infrastructure
House of Representatives

Advanced air mobility (AAM) is an emerging concept of air transportation that will use revolutionary aircraft—which may feature electrified propulsion systems, increased levels of automation, and vertical take-off and landing capabilities—to transport people and cargo. According to proponents, AAM could be transformational because it offers the potential to expeditiously move people and goods while reducing combustion fuel emissions, cargo delivery timeframes, vehicle traffic on congested roads, and noise near existing airports, among other potential benefits. Though many obstacles still remain, a few companies intend to begin piloted commercial operations in 2025.[1] Industry leaders anticipate that these aircraft will eventually be capable of autonomous flight. According to a Deloitte analysis (based on its 2021 Advanced Air Mobility Survey), the domestic AAM industry is projected to grow to more than $100 billion annually by 2035.[2] In addition, global investment in AAM is rapidly increasing. According to data compiled by the Lufthansa Innovation Hub,

[1]In May 2022, we reported that many stakeholders predict piloted, commercial AAM flights within the next five years. GAO, *Transforming Aviation: Stakeholders Identified Issues to Address for 'Advanced Air Mobility,'* GAO-22-105020 (Washington, D.C.: May 9, 2022).

[2]Deloitte Insights and Aerospace Industries Association (AIA), *Advanced air mobility: Can the United States afford to lose the race?* 2021.

as of December 2021, publicly disclosed worldwide investment in the AAM sector grew from $180 million in 2019 to $5.8 billion in 2021.[3]

Supporting the AAM industry will inevitably involve federal resources as well. The Federal Aviation Administration (FAA) must certify the safety of these aircraft and oversee their introduction into the national airspace to ensure the safety of all airspace users. Most of FAA's enacted budget historically flows from the Airport and Airway Trust Fund (AATF), though the agency also typically receives support from the General Fund.[4] In addition, airports might conceivably use federal grant funds to retrofit existing infrastructure to support non-exclusive, public use AAM operations.[5] Furthermore, a law passed in October 2022 directs the Department of Transportation to establish an AAM interagency working group to plan and coordinate efforts to bolster the AAM ecosystem in the United States.[6]

You asked us to review issues related to AAM oversight and infrastructure financing. To that end, this report examines four objectives:

1. What are FAA's current and anticipated future expenses to support safe operation of AAM within the national airspace?
2. What is known about the forecasted capital costs of AAM ground-based infrastructure?
3. What are considerations for how AAM ground-based infrastructure might be financed?
4. How will the existing excise tax structure that supports the AATF apply to AAM?

[3]TNMT, Lufthansa Innovation Hub, *The Advanced Air Mobility Investment Dashboard,* accessed August 8, 2022, https://tnmt.com/infographics/advanced-air-mobility-investment-dashboard/.

[4]The AATF receives income from a variety of excise taxes generally paid by users of the national airport and airway system. In fiscal years 2018 through 2022, the AATF provided between 55 and 94 percent of FAA's budget.

[5]Proposed legislation (which passed the House in June 2022) would establish grants to help airport sponsors and a variety of other entities plan for AAM operations. See Advanced Aviation Infrastructure Modernization Act, H.R. 6270, 117th Cong. (2021). Similar legislation was introduced in the Senate. S.4246, 117th Cong. (2022).

[6]Advanced Air Mobility Coordination and Leadership Act, Pub. L. No. 117-203, 136 Stat. 2227-2230 (Oct. 17, 2022).

For all four objectives, we sought the views of 25 stakeholders with AAM expertise. We identified these stakeholders through a literature search of academic journals and industry publications, as well as consultations with internal and external subject matter experts. We used a semi-structured interview tool for our discussions with each of the stakeholders to ensure that we asked the same questions of each interviewee. We obtained their perspectives on FAA's anticipated future expenses related to AAM, the potential capital costs of ground-based AAM infrastructure, the likely financing and funding sources for such infrastructure projects (e.g., federal versus private funding), and considerations for taxation and fees related to AAM operations. Using the information received from these discussions, we conducted a content analysis to identify key themes from these interviews related to each research question.[7]

To describe FAA's current and anticipated future expenses associated with AAM, we reviewed FAA documentation on the resources the agency expended on AAM activities from 2018—when FAA first began tracking such expenses—through May 2022. Furthermore, we interviewed FAA officials about anticipated future expenditures, their efforts to track AAM costs, and their progress toward implementing our 2019 recommendation that the agency better track the costs associated with uncrewed aircraft systems (UAS).[8]

To describe forecasted capital costs of AAM ground-based infrastructure, we interviewed stakeholders and reviewed literature on the forecasted costs of individual projects. In addition, to describe cumulative forecasted costs across multiple cities, we reviewed and summarized projections from a private company—UAM Geomatics Inc.—on the predicted capital costs of ground-based AAM infrastructure for 38 U.S. metropolitan areas

[7]Because the stakeholders we interviewed represented a wide range of organizations with differing areas of expertise, not all stakeholders provided information about each topic. In this report, we refer to a "few" stakeholders if 2-4 of the stakeholders expressed a particular view, "some" stakeholders if between 5-7 expressed a view, "many" stakeholders if between 8-10 expressed a view, and "numerous" if 11 or more stakeholders expressed a particular view. While the views presented in our report provide perspectives from a range of knowledgeable stakeholders, they are not generalizable.

[8]We have previously used the term "unmanned aircraft systems." GAO, *Unmanned Aircraft Systems: FAA Should Improve Drone-Related Cost Information and Consider Options to Recover Costs,* GAO-20-136 (Washington, D.C.: Dec. 17, 2019). FAA regulations also use the term "unmanned."

from years 2023 through 2045.[9] To describe the considerations for financing such projects, we reviewed and summarized UAM Geomatics' predicted revenue-to-investment ratios for these locations, as these projections can provide insight into the likelihood that the private investors will enter the market. We also interviewed stakeholders and reviewed literature on federal grants programs, such as the Airport Improvement Program (AIP). In addition, we reviewed related GAO work, such as leading practices for fee design.

To assess how the existing tax structure might apply to various AAM designs and operations, we analyzed the laws, regulations, case law, revenue rulings, and Internal Revenue Service (IRS) Office of Chief Counsel legal advice memorandums associated with taxes funding the AATF. We also interviewed IRS officials about their process for interpreting excise tax exemptions and their perspectives on how they would interpret situations involving AAM operations. Furthermore, we sought the perspectives of four individuals or entities who had previously published information on AATF taxes. We did not estimate the value of excise tax exemptions if applied to AAM aircraft due to the significant uncertainty associated with key variables, such as passenger ticket price, and the extent to which AAM aircraft would replace existing aircraft used for exempted purposes. For a more detailed summary of our methodology, including the entities that we interviewed, please see appendix I.

We conducted this performance audit from April 2021 to November 2022 in accordance with generally accepted government auditing standards. These standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[9]UAM Geomatics was the only source we identified that could provide cumulative cost estimates across a broad time period. According to officials from UAM Geomatics, 32 of these locations are metropolitan areas that UAM Geomatics selected because they had the highest gross domestic product in the U.S. In 2021, UAM Geomatics added six additional metropolitan areas in Ohio to its analytical portfolio as a result of a partnership with the Ohio Department of Transportation. According to UAM Geomatics, these 38 areas collectively produce approximately half of the U.S. gross domestic product.

Background

AAM Operations and Aircraft

AAM is an emerging aerospace sector characterized by aircraft that are expected to be highly automated and electrified, though until recently the term “AAM” was not precisely defined. In October 2022, Congress passed legislation that defines AAM as a transportation system that transports people and property by air between two points in the United States using aircraft with advanced technologies.[10] Such technologies include electric aircraft or electric vertical take-off and landing aircraft, in both controlled and uncontrolled airspace. FAA envisions AAM as a safe and efficient aviation transportation system that will use highly automated aircraft to operate and transport passengers or cargo at lower altitudes within a variety of locations. NASA views the term AAM to encompass developing and deploying aviation in transformative and innovative manners in order to provide aerial mobility in ways not typically seen today.

Some of the technologies that support certain applications of AAM, such as vertical or short take-off and landing capabilities, have existed for decades. However, more recent developments—such as higher-capacity batteries, lightweight materials, and faster sensors—are expanding the possible uses of existing technology. Initial AAM is expected to involve aircraft known as eVTOLs (an acronym for electric vertical take-off and landing).[11] While these aircraft can take-off and land vertically like a helicopter, they do not rely on combustion engines. Rather, these aircraft will use electric propulsion, which can be powered by on-board, rechargeable batteries. Initial eVTOL flights will have a pilot onboard, but some manufacturers intend for these aircraft to be capable of significant automation, including full autonomy, in future years. Integrating automation would reflect a more mature state of AAM operations.

[10]Advanced Air Mobility Coordination and Leadership Act, Pub. L. No. 117-203, 136 Stat. 2229 (Oct. 17, 2022).

[11]eVTOLs are one type of initial AAM aircraft. AAM aircraft may also feature conventional take-off and landing or short take-off and landing capabilities. In addition, some AAM manufacturers are pursuing hybrid options that include a combustion element. For the remainder of this report we focus primarily on eVTOLs, but in cases where we refer to a broader range of aircraft designs, we use the term “AAM aircraft.”

The planned propulsion systems, weight, and maximum flight distance of eVTOL designs vary among manufacturers. However, according to industry reports, many current designs have an expected maximum flight distance of less than 250 nautical miles and an anticipated weight of less than 7,000 pounds (approximately the weight of a large SUV).[12] Some designs outwardly resemble helicopters in that they have multiple rotors, but no fixed wing. Other eVTOL designs have a fixed wing and various ways to take-off and move forward in flight, such as lift propellers, ducted fan jets, tilt propellers, or rotors combined with a pusher propeller (see fig. 1).[13]

Figure 1: Examples of Advanced Air Mobility Designs

Source: Photos courtesy of Lilium, © 2022 Wisk Aero LLC, and Joby. | GAO-23-105188

Although some of these new designs with characteristics of both airplanes and helicopters meet the definition of powered-lift, FAA has not

[12]For example, see Cowen Equity Research, *When Will The EVTOL Disruption Curve Pay Off?* (June 21, 2021) and Canadian Advanced Air Mobility Consortium and Nexa Advisors, *Advanced Air Mobility Comes to Toronto*, (October 2021).

[13]Fixed-wing aircraft achieve lift via airflow around stationary wings, while helicopters achieve lift through spinning rotors. In both cases, the lift mechanism at take-off is the same as the in-flight lift mechanism. Some eVTOLs defined as powered-lift under FAA regulations share both technologies, with rotors for lift at take-off and a fixed wing to provide lift in flight. A fixed wing can allow such eVTOLs to take-off and land on runways like a traditional fixed-wing aircraft, and benefit from the energy efficiencies of fixed-wing flight. Vertical take-off and landing capabilities, like a helicopter, allow eVTOLs to hover and access remote sites. However, not all eVTOL designs use this blend of technologies.

created a new aircraft category for safety review purposes.[14] To account for novel design features, the agency plans to approve eVTOLs as special class aircraft and will issue appropriate airworthiness criteria to define their certification requirements.[15]

eVTOL Uses and Infrastructure

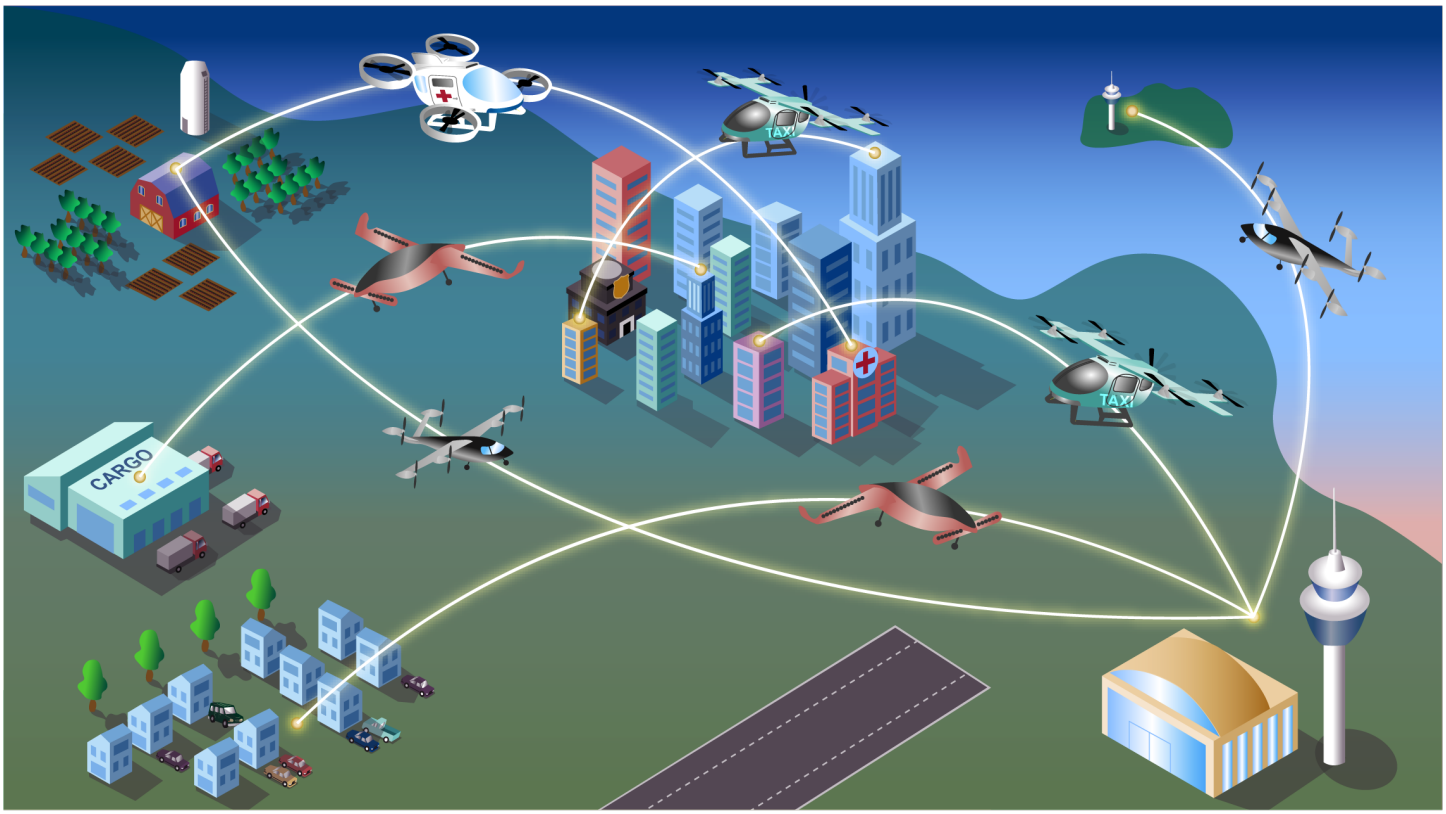
Proponents believe that eVTOLs' combination of features may facilitate new aviation services. Specifically, because manufacturers predict that eVTOLs will be significantly quieter than helicopters, operators may be able to provide air services in environments where a helicopter would be too disruptive.[16] Furthermore, proponents believe that electric aircraft will be less expensive to operate than conventional aircraft—and autonomous aircraft even more so— leading to a diverse range of purposes and increased use (see fig. 2). For example, they could transport cargo between logistics hubs and small airports. In other cases, eVTOLs might serve as an alternative to medical helicopter transport for organ transplants, or provide air taxi services in urban environments.

[14]Powered-lift means a heavier-than-air aircraft capable of vertical take-off, vertical landing, and low speed flight that depends principally on engine-driven lift devices or engine thrust for lift during these flight regimes and on nonrotating airfoil(s) for lift during horizontal flight. 14 CFR 1.1.

[15]For special classes of aircraft, FAA certifies the aircraft using a combination of existing applicable regulations and additional airworthiness criteria that apply only to a particular aircraft design but still provide an equivalent level of safety as FAA's regulations. 14 C.F.R. § 21.17(b).

[16]In 2022, NASA found that Joby's aircraft produced an acoustic profile below 65 decibels—comparable to a conversation—at 330 feet. NASA intends to continue further testing with other eVTOL designs. See: K.A. Pascioni, M.E. Watts, M. Houston, A. Lind, J.H. Stephenson, J. Bain, "Acoustic Flight Test of the Joby Aviation Advanced Air Mobility Prototype Vehicle." We have previously reported helicopter noise can potentially expose members of the public to a variety of negative effects. GAO, *Aircraft Noise: Better Information Sharing Could Improve Responses to Washington, D.C. Area Helicopter Noise Concerns,* GAO-21-200 (Washington, D.C., January 2021).

Figure 2: Examples of Advanced Air Mobility (AAM) Potential Uses



Source: GAO analysis of information from the Federal Aviation Administration and National Aeronautics and Space Administration. | GAO-23-105188

Regardless of the specific use, AAM operations using eVTOLs will require ground and air traffic infrastructure to take-off, land, charge, and load passengers or cargo. For example, AAM proponents have proposed locating eVTOL ground-based infrastructure for take-off and landing—known as “vertiports”—at a variety of locations including airports, cargo logistics hubs, hospitals, and on top of parking garages. Some stakeholders believe that existing ground infrastructure—such as small local airports—may be retrofitted or expanded to help meet this infrastructure need. For example, some proponents envision eVTOLs taking passengers from small, local airports to larger transit hubs. However, other infrastructure will need to be constructed or retrofitted specifically for AAM. For example, some eVTOL uses may require

additional airspace management infrastructure, such as remote towers.[17] In addition, since eVTOL aircraft use electricity as their energy source, airports and vertiports will require a reliable and plentiful supply of electricity that may not be presently available at a given location.[18]

Status of AAM Operations

To date, the AAM industry in the U.S. has been largely focused on designing, building, and pursuing FAA certification to commercially operate its aircraft. eVTOLs are not yet in commercial service either domestically or abroad, though efforts to support operations are underway across the world (see sidebar for further details of international operations). In the U.S., federal, tribal, state, and local government entities are planning how they will integrate AAM operations into the existing aviation environment. For example, in June 2022 Congress formed a bipartisan AAM Caucus, and in August 2022 the White House Office of Science and Technology Policy, in coordination with the National Security Council, hosted a summit to discuss AAM integration with government, tribal, and industry officials. Similarly, several state legislatures have passed laws related to AAM operations or advisory

Selected Examples of Foreign Government Actions

Some examples of steps that other governments have taken to support AAM include:

- Australia's aviation regulator outlined a long-term vision for the integration of air taxis into the country's aviation system in April 2022, envisioning highly automated AAM by the mid-2030s.
- Europe's aviation safety agency issued a proposed comprehensive regulatory framework on June 30, 2022 to address new operational and mobility concepts, including aircraft with vertical take-off and landing capabilities.
- South Korea's government developed a roadmap to commercialize urban applications by 2025.

Stakeholders we interviewed varied in their assessment of how the U.S. trajectory compares to that of other countries. Of those who commented, seven said the U.S. was behind other countries and seven said the U.S was on par with or ahead of certain international developments.

Source: GAO analysis. | GAO-23-105188

[17]Remote towers are a new technological concept that FAA is testing but has not yet approved for use in the national airspace. A remote tower would allow air traffic control services to be provided from a remote location via a network of cameras, sensors, displays, and other supporting equipment. A remote tower could be located either on-airport property or off-airport property in a remote location, as compared to a traditional brick-and-mortar air traffic control tower, which must be located on airport property.

[18]While this report focuses on eVTOLs, electricity isn't the only energy source contemplated under AAM. Each type of AAM aircraft may have a different power supply need. For example, vertiports may also need to supply hydrogen for aircraft with hydrogen fuel cells, or conventional liquid fuel for hybrid aircraft.

committees, while other state entities have developed studies to guide future policy actions.[19]

In May 2022, we reported on industry stakeholders' views regarding the AAM industry's domestic operational trajectory.[20] We reported that many stakeholders believe AAM operations will begin within the next 5 years in a limited number of locations.[21] During the first 5 years of operations, the AAM industry expects to test the viability of various business models. We also reported that after more than 10 years, AAM could become a major part of the U.S. transportation system provided that it can demonstrate clear benefits over existing transportation alternatives. However, a variety of factors will influence the industry's operational trajectory in the long term, including the extent of public acceptance, the speed of regulatory and oversight processes to ensure the operational safety of various new technologies, and the availability of physical infrastructure to land and charge eVTOLs.

FAA's Role in AAM

FAA reviews AAM aircraft design, production, and operations; develops ground-based infrastructure requirements; and ensures regulatory compliance. FAA also operates the air traffic control system, which is responsible for the safe, orderly, and expeditious flow of air traffic. Within FAA, a variety of offices currently support AAM development. According to FAA officials, the following offices provide the majority of support for agency AAM efforts:

- The Unmanned Aircraft Systems Integration Office, within the Office of Aviation Safety, is responsible for developing a unified FAA

[19]For example, see OKLA. STAT. tit. 3, § 374; TEX. TRANSP. CODE ANN. § 21.004 (West 2022); UTAH CODE ANN § 72-14-103 (West 2022); W. VA. CODE, § 5B-2-18a; W. VA. CODE, § 5B-2M-1-§ 5B-2M-6.

[20]GAO-22-105020.

[21]In late April 2022, FAA made an agency-wide determination that eVTOLs will generally be certified as special class powered-lift aircraft. Thus, all certification requirements will be defined per 14 CFR part 21.17(b), go through the public notice and comment process and be issued in the Federal Register. This decision differed from the certification approach that the AAM industry had expected, and the implications of this decision are not yet known. Some industry and trade groups indicated that it would slow the introduction of AAM into the U.S. airspace. In November 2022, FAA published the first proposed airworthiness criteria for a specific AAM design in the Federal Register, which is a step towards certification.

strategy for integrating AAM into U.S. airspace. This office is responsible for coordinating FAA activities (and resolving conflicts) across five AAM areas: aircraft, airspace, operations, infrastructure, and community.

- The Aircraft Certification Service, within the Office of Aviation Safety, provides AAM applicants with early engagement and formal processes to develop a clear path to aircraft certification. The Aircraft Certification Service includes more than 1,400 engineers, scientists, inspectors, test pilots and other experts responsible for oversight of design, production, airworthiness certification, and continued airworthiness programs for all U.S. civil aviation products and foreign import products.
- The Flight Standards Service, within the Office of Aviation Safety, provides guidance and direction for AAM applicants regarding air carrier and air operator certifications. This service engages with AAM applicants regarding pilot training and all other unique operational challenges that AAM aircraft present to the existing regulatory structure.
- The Office of Airports provides support for vertiport design and infrastructure guidance.

According to FAA officials, the Air Traffic Organization (ATO)—which is responsible for the safe, orderly, and expeditious flow of traffic within U.S. airspace—will also play a role in future operations. According to FAA, the ATO will identify airspace requirements, procedures, uses, and rules to enable safe and scalable AAM operations in the national airspace. For example, if future AAM operations take place in FAA-controlled airspace, the ATO will have to determine how they can integrate AAM operations with commercial airline and other types of operations in an efficient and safe manner. If future AAM operations occur in uncontrolled airspace, the ATO will play an integral part in developing the operating rules in these airspace areas.

Airport and Airway Trust Fund (AATF)

In 1970, Congress established the AATF, providing a dedicated source of funding for the U.S. aviation system, independent of the General Fund.[22] Specifically, the AATF provides funds for four major FAA accounts:

- **Operations:** which includes the administration, operation, repair, and maintenance of the national airspace system, aircraft certification, and aviation safety oversight.
- **Facilities & Equipment**: which includes current infrastructure, and technological upgrades to the air traffic control system.
- **Research, Engineering and Development:** which includes research for certain aviation programs, such as projects to ensure a safe, efficient, and environmentally compatible air transportation system.
- **Grants-in-Aid for Airports:** for the FAA's Airport Improvement Program (AIP), which supports the development of a nationwide system of public-use airports to meet the current needs and the projected growth of civil aviation.

The AATF receives income from a variety of excise taxes related to the use of the national airport and airway system, including passenger, cargo, and fuel taxes (as shown in table 1), as well as appropriations from the General Fund that vary from year to year.

Table 1: Airport and Airway Trust Fund Taxes, Calendar Year 2022

Category	Tax	Rate as of January 1, 2022
Passenger Taxes	Passenger percentage tax (on amount paid for domestic passenger transportation and mileage awards)	7.5%
Passenger Taxes	Flight segment tax (domestic, indexed annually to Consumer Price Index)	$4.50
Domestic Cargo Taxes	Tax on the amount paid for transportation of property by air	6.25%
Liquid Fuel Taxes	General aviation gasoline[a]	19.3 cents/gallon
Liquid Fuel Taxes	General aviation fuel[a] (kerosene)	21.8 cents/gallon

[22]The Airport and Airway Revenue Act of 1970, Pub. L. No. 91-258, § 208, 84 Stat. 250. The Operations and Grants-in-Aid for Airports accounts receive appropriations from the General Fund in addition to AATF funds. The AATF also provides funding for essential air service to small communities that would otherwise not have scheduled air services.

Category	Tax	Rate as of January 1, 2022
Liquid Fuel Taxes	Commercial fuel[a] (kerosene)	4.3 cents/gallon
Liquid Fuel Taxes	Fractional ownership surtax on general aviation fuel	14.1 cents/gallon
International Facilities Taxes	Tax on transportation between continental United States and Alaska/Hawaii (indexed annually to Consumer Price Index)	$9.90
International Facilities Taxes	International arrival/departure tax (indexed annually to Consumer Price Index)	$19.70

Source: Federal Aviation Administration and Department of the Treasury data. | GAO-23-105188

[a]Does not include 0.1 cents/gallon for the Leaking Underground Storage (LUST) trust fund.

Airport Infrastructure Financing

Typically, most financing for airport infrastructure comes from non-federal sources, such as passenger facility charges, airport-generated revenue, bonds, or other means (depending on the specific project). More specifically:

- Passenger facility charges are federally authorized fees which were established in 1990 in part to help pay for infrastructure at commercial service airports.[23]
- Airport-generated revenue consists of both "air side" aeronautical revenues derived from the operation and landing of aircraft, passengers, or freight, as well as "land side" non-aeronautical revenues derived from terminal concessions and parking fees.
- Bonds enable airport authorities to borrow money secured by future revenues or the taxing authority of the sponsor to finance infrastructure projects; this money can then be paid back with interest over a longer time period.
- Sponsors of an airport (often a state or municipality) may provide contributions on an individual project basis. Other sources, such as an airline, may also contribute to specific projects.
- Private financing might be used to cover the infrastructure costs of wholly private facilities.

As we previously reported, between fiscal years 2013 to 2017, on average, less than one quarter of funding for ground-based airport infrastructure projects stemmed from federal sources.[24] Federal funding for airport infrastructure is primarily provided through the federal AIP

[23]49 U.S.C. § 40117. Although passenger facility charges (PFCs) are local funds subject to the airport's control, FAA oversees the program and approves applications by airports to collect PFC revenues. PFCs are currently capped at $4.50 per flight segment with a maximum of $18 total. Among other requirements, PFC projects must meet one or more of the requirements of 14 C.F.R. § 158.15 which include: (1) preserve or enhance safety, security, or capacity of the national air transportation system; (2) reduce noise or mitigate noise impacts resulting from an airport; or (3) furnish opportunities for enhanced competition between or among air carriers. In 2020, we reported that most current and future PFC funds are already obligated to service debt on completed and ongoing infrastructure projects. See GAO, *Airport Infrastructure: Information on Funding and Financing for Proposed Projects*, GAO-20-298 (Washington, D.C., Feb. 13, 2020).

[24]GAO-20-298.

program. In fiscal years 2017-2019, FAA typically awarded between $3.2 and $3.5 billion in annual AIP grants to more than 1,600 airports to support their eligible infrastructure project costs.[25] For AIP-funded projects, other than projects using certain funds appropriated in response to the COVID-19 pandemic, the airport must provide a share of matching funds. The federal share generally ranges from 75 to 90 percent depending on the size of the airport or type of project.[26] In recent years, Congress has provided additional funding for AIP or established new programs for infrastructure projects, which allow funding to be used for projects that are ineligible under AIP.[27] However, all of these provisions are temporary, with the latest set to expire in 2027.

FAA Has Spent at Least $2.7 Million on AAM Activities, and Future Expenses Will Depend on FAA's Involvement

According to FAA officials, the agency is able to quantify certain expenses for its AAM-related activities, but current identifiable costs are a fraction of its actual expenses to support AAM. FAA officials also said that the agency is taking steps to support future AAM industry needs. However, it does not have specific estimates for future AAM expenses because it is too early in the industry's development to develop such estimates. Officials told us that the extent of FAA's future activities and related expenses, though currently unknown, will likely continue to be driven by the agency's role in certifying aircraft and operations,

[25]Only public use airports are eligible for AIP grants. Airports must adhere to a variety of stipulations when accepting AIP grant funds, such as nondiscriminatory use and repayment if the airport is privatized within a certain timeframe.

[26]In certain instances, the federal share may be increased. For example, the federal share for airports in economically distressed communities is typically 95%. Additionally, the Coronavirus Aid, Relief, and Economic Security (CARES) Act provided $500 million to pay airports' share of matching funds for some AIP projects in 2020, permitting those projects to be 100 percent federally funded. The American Rescue Plan Act of 2021 provided an additional $608 million to pay the federal share of AIP infrastructure costs in 2021.

[27]In fiscal years 2020 and 2021, AIP grants increased to approximately $13 billion and $10 billion, respectively, as a result of additional financial support due to the COVID-19 pandemic. In addition, from fiscal years 2022 to 2026 the Infrastructure Investment and Jobs Act of 2021 (IIJA) provides public service airports within the national airspace system approximately $15 billion for projects such as runways and airport transit connections, and an additional $5 billion for terminal construction and renovation.

developing infrastructure requirements, and operating the air traffic control system.

FAA Has Spent at Least $2.7 Million on AAM Activities since 2018

From September 2018 through May 2022, FAA documented spending at least $2.7 million on AAM-related activities, but officials told us the agency's actual costs are significantly higher. FAA's documented AAM costs are for activities charged to two work codes. These activities include spending time on certification activities for a specific aircraft, meeting with manufacturers, and developing AAM-related policies. More specifically, in 2018, the agency established a work code to capture staff time spent on issues related to a specific AAM company, primarily technical support for that company's certification efforts. From September 2018 through May 2022, FAA staff charged approximately $1.8 million in time costs to this code.[28] In 2021, the agency created a broader work code to capture additional, more general, AAM activities. From April 2021 through April 2022, FAA staff charged over $982,000 in time costs to this code—nearly all of which were charged by the Office of Aviation Safety.

However, FAA officials estimated that these two work codes only account for a small portion of total hours spent on AAM efforts. According to FAA officials, the agency's current work on AAM is predominantly "concepts and strategic planning," with limited certification and approval activities. FAA officials added that time spent to date on developing AAM-related guidance or certification activities are charged under more general work codes. For example:

- **Guidance and standards.** In September 2022, FAA published interim safety standards for vertiport designs that accommodate vertical take-off and landing aircraft; these standards are contained in FAA's Engineering Brief 105. The brief provides interim guidance to infrastructure owners, operators, and their support staff for the design of vertiports for vertical take-off and landing operations. According to

[28]FAA does not typically track a specific company or aircraft's certification costs. FAA officials said that the agency created a work code for that specific company because it was the first to pursue certification for an AAM aircraft. FAA noted that this special work code is intended to track efforts spent exclusively in support of that single company (e.g., FAA meetings with company officials about a topic germane only to that company). From September 2018 to May 2022, FAA staff charged 18,125 hours to that work code.

FAA officials, time spent developing guidance is charged to a broad policy development work code.

- **Aircraft certification.** FAA does not distinguish between aircraft types when recording staff hours spent on certification. For example, it does not distinguish between time spent certifying an eVTOL versus conventional aircraft, just as it does not distinguish between certifying small, general aviation aircraft from large, commercial aircraft. While the work code for FAA time spent on a specific AAM company provides some insight into certification expenses, agency officials said that significant certification time would not be reflected in charges to that work code. Officials said that because certain certification efforts could conceivably benefit others applying for AAM aircraft certification, that time would be charged to general certification work codes.

FAA officials said that they anticipate creating new codes for more specific aspects of AAM-related work as the agency's role continues to evolve. However, officials said that they want to align their efforts with industry progress, and that it would be premature to determine what AAM cost information, if any, would warrant additional collection and analysis. Officials said that before FAA takes additional steps, the industry needs to provide greater clarity around certain vehicle, operational, and manufacturing capacities. As we have previously reported, investments in collecting better data are not only appropriate as capabilities and regulations evolve, but will be an important resource to guide future decisions by FAA and policy-makers.[29]

[29]In December 2019, we recommended that FAA develop and implement a process to ensure that cost information for UAS—an aviation platform which our prior report noted would include autonomous AAM aircraft—is complete and reliable as capabilities and regulations evolve. We noted that without such cost information, FAA, the administration, and Congress may lack the information needed to effectively prioritize resources in an evolving aviation landscape. As of September 2022, FAA officials said efforts to collect this cost information were ongoing for current, established UAS uses. FAA plans to analyze a survey of UAS owners to better understand UAS usage patterns, which the agency hopes will help to better understand associated costs for FAA. FAA officials noted that certain forms of UAS have been operating in U.S. airspace for years (such as hobby drones), while remotely piloted AAM remains theoretical. See GAO-20-136.

FAA's Future AAM Expenses Will Depend on the Extent of Aircraft Certification, Standards Development, and Airspace Management Activities

According to officials, FAA's future expenses to facilitate safe AAM operations will likely involve certifying new aircraft, developing and implementing AAM-related standards, as well as managing the nation's airspace.[30] AAM operations could place additional demands on the agency's resources over time. The extent of FAA's future expenses will depend upon the quantity and complexity of the aircraft designs submitted for certification, the degree to which standards will need to keep pace with new developments, and the prevalence of AAM operations in U.S. airspace.

Aircraft Certification

FAA officials told us reviewing and approving aircraft design applications will be a key AAM-related expense for the agency, although the extent of the costs will depend upon how the AAM industry develops. The first FAA AAM type certification project was initiated in 2018. Between then and April 2022, FAA has received applications for four additional AAM type certification projects. FAA officials said they anticipate receiving additional applications as the industry continues to grow, though they could not predict an exact number. A few stakeholders we interviewed believe that FAA will need additional personnel in order to review the influx of eVTOL certification requests in a timely manner. A few stakeholders cautioned that future innovation could be stifled without sufficient staffing to process certifications. FAA officials agreed that the agency's AAM-related personnel expenses may have to increase in order to accommodate a need to review and certify more applications.

Guidance and Standards

Another anticipated AAM-related expense for FAA will be continuing to develop AAM-related guidance and standards. These expenses would largely consist of the salaried hours FAA staff would charge to conduct

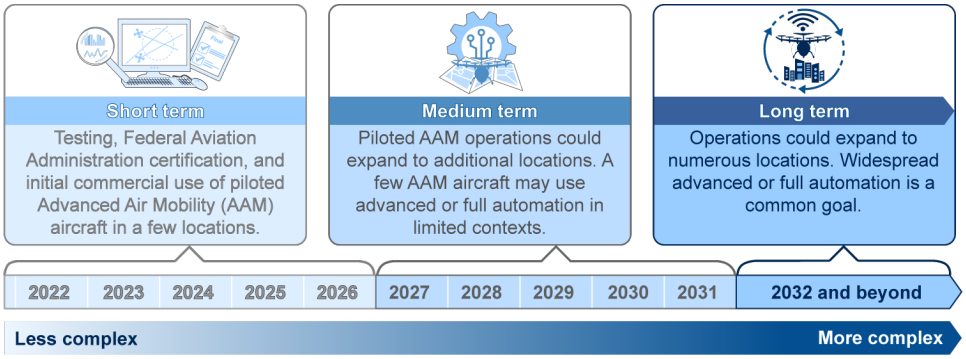
[30]In addition to these expenses, several FAA offices and initiatives included AAM as part of their overall fiscal year 2023 budget request to include the Office of Airports, the Office of Integration and Engagement, UAS Integration, and research and development efforts. Precise numbers of funding requested for AAM were not included, though AAM was mentioned as one of the initiatives that the fiscal year 2023 budget would support.

this work. Officials said that the agency does not have any estimates for these anticipated expenses, although there are specific AAM-related guidance efforts underway. For example, FAA officials said that they plan to continue further developing their vertiport guidance. The agency released the final version of the Vertiport Design Engineering Brief in September 2022 and plans to publish an Advisory Circular on vertiport design, which will provide additional guidance, by early 2025.[31] FAA officials described these efforts as "living documents" that will continually be updated as the industry grows and as the agency gathers more data.

In addition, numerous stakeholders we spoke to believe that FAA will need to develop additional standards that address autonomous flight, such as on-board collision avoidance systems. A few stakeholders also believe that the agency will need to hire additional staff to develop these standards, and that autonomous flight may begin in limited contexts within the next 10 years (see fig. 3). However, numerous stakeholders said that they did not anticipate widespread, autonomous flights to be operating in the national airspace until after 2032. Stakeholders expressed a broad range of perspectives regarding how long it might take for widespread, fully-autonomous flight to take hold in the U.S., and what types of flights would be more likely to achieve consumer approval. Regardless, advanced or fully-autonomous flight is a common goal for AAM companies.

[31]An Advisory Circular is a type of publication developed by FAA to provide guidance for compliance with airworthiness regulations, pilot certification, operational standards, training standards, and any other rules within the 14 C.F.R. Aeronautics and Space Title. In 1991, FAA published an Advisory Circular on vertiport design that provided vertiport design guidance and was based on civil tiltrotors modeled after military tiltrotor technology. However, the intended aircraft were never used commercially, and the Advisory Circular was cancelled on July 28, 2010.

Figure 3: Stakeholder Predictions of Timeframes for Autonomous Advanced Air Mobility (AAM) in the U.S.



Source: GAO analysis of interviews with 25 selected AAM industry stakeholders. | GAO-23-105188

As of September 2022, FAA officials said they have hired three additional program managers who will address AAM infrastructure standards and related issues as part of their duties. In addition, by the end of 2022 the agency plans to hire a program manager to stand up a new division within the Office of Airport Safety and Standards to help accommodate additional AAM-related infrastructure requirements. However, agency officials said that these personnel will also support additional emerging technologies, such as drones and commercial space. Furthermore, FAA officials said that the agency does not yet know if additional hires would be warranted to support AAM, due in part to the uncertainty surrounding what specific technology may be proposed by industry, and when.

Airspace Management and Safety Oversight

FAA's role in the airspace management of AAM aircraft will also influence its future AAM expenses. According to FAA's published *Concept of Operations* as well as some stakeholders we spoke with, FAA's initial costs of managing AAM aircraft within the national airspace will be minimal. This is because AAM operations will likely account for a small percentage of overall air traffic in controlled airspace. Initially, operations may also be limited to specific locations, such as large metropolitan areas that already have the infrastructure to support the industry. This could mean that the air traffic burden would not be evenly distributed across existing airports. Then, as the industry continues to grow, the burden on airspace management may increase as AAM aircraft begin occupying airspace in greater numbers.

Stakeholders expressed a variety of opinions regarding the impact of automation on FAA air traffic management costs. For example, a few

stakeholders said that if the AAM industry is able to successfully integrate automation, FAA's air traffic management personnel expenses may decrease later in the future, as automated air traffic control could require less staff. However, a few other stakeholders noted that increased automation could increase costs for other air traffic management programs, such as remote towers.[32]

FAA officials from the Office of Aviation Safety said that they expect some additional oversight costs to occur with AAM, though it is too early to determine what oversight will be required. According to these officials, the amount of additional oversight that may be required would be proportionate to the size of the AAM fleet, although it is too early to predict the size, oversight, and airspace management needs of the industry. Officials from the Air Traffic Organization said that they discuss possible future demands related to AAM—for example, how much additional air traffic such flights might add to certain urban areas—but the extent of oversight expenses will not be evident until at least 2030. A few stakeholders raised the possibility of FAA allowing other entities, such as AAM operators, to take some responsibility for airspace management. FAA officials we spoke to did not rule out such an arrangement but noted that the agency has no such plans at this time.

Forecasted AAM Infrastructure Capital Costs Are Highly Uncertain

Stakeholders we interviewed cautioned that it is challenging to provide specific, accurate cost forecasts for AAM infrastructure at either the individual project level or in aggregate. At the individual project level, stakeholders said that the capital costs of an AAM vertiport may range from $500,000 to more than $10 million. Stakeholders said that a project's location, electrification needs, and scope (including whether the project is new construction or a renovation) will greatly influence the eventual project cost. At the aggregate level, a forecast of 38 U.S. metropolitan areas indicates that the costs of vertiport construction and renovation in the U.S. could be significant. The forecast predicts costs exceeding a cumulative total of approximately $4.5 billion by 2045 for these

[32]A few stakeholders we spoke to advocated for the use of remote towers to assist with autonomous flight, as they can assist with managing multiple airport operations from an offsite control center.

metropolitan areas, though such forecasts rely on analytical assumptions that are uncertain at this time.

A Variety of Factors Could Influence Individual AAM Projects' Capital Costs

Stakeholders told us that location, electrification needs, and the scope of construction required for vertiports and associated charging stations will be major factors in determining the cost of individual AAM ground-based infrastructure projects. Depending on these factors, stakeholders we interviewed predicted that the capital costs of an individual vertiport could range from $500,000 to more than $10 million.

Location

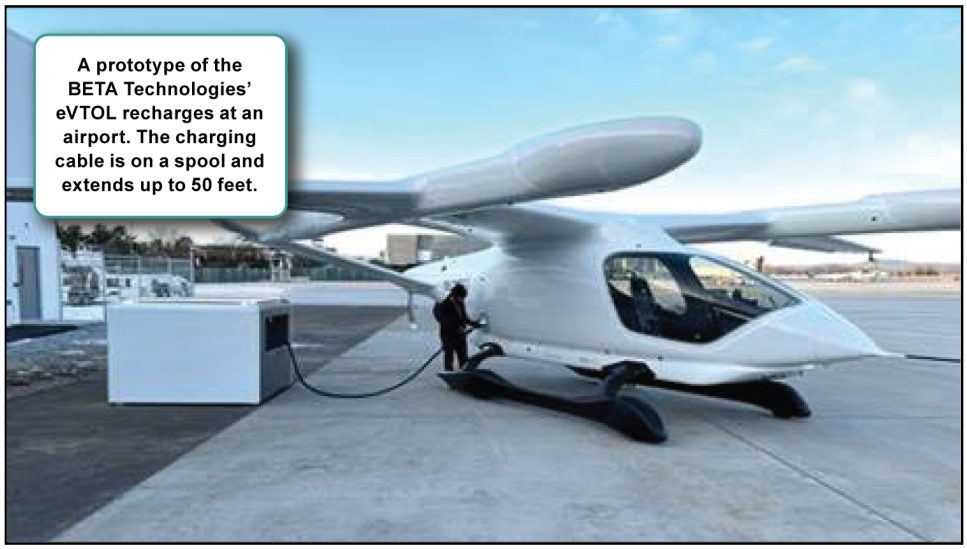
Depending on the location, capital costs for AAM ground-based infrastructure may be higher or lower, for a variety of reasons:

- **Price of real estate.** The capital costs of new vertiport construction will largely be influenced by the local price of real estate, according to a few stakeholders. For example, officials from one AAM start-up stated that building a vertiport in a low-population area will generally cost less than building in a high population area where the cost of real estate is higher.
- **Non-federal requirements.** A few stakeholders said non-federal regulations and local ordinances will influence capital costs. For example, one start-up company explained that Los Angeles has additional permitting and state-specific and local seismology requirements that make it costly to build a vertiport there. Specifically, this stakeholder estimated that their company's vertiports (when equipped with a terminal building, landing area, and charging station) could cost $4 million in Los Angeles, which would be about four times higher than the costs for building a vertiport in Ohio.
- **Building on the "land" or "air" side of an airport.** For passenger use cases, locating a vertiport on the "land" side of an airport (i.e., outside security) may require constructing completely new passenger facilities and other support infrastructure. For example, the Palm Beach International Airport (PBIA) entered into an agreement with a private company to renovate an unused car rental facility on the land side of the airport. PBIA officials said that the company, which will bear 100 percent of the costs, is contractually required to spend at

least $7 million to develop the site. This site will have two take-off and landing spots, a passenger terminal, charging facilities, and parking.

Building AAM infrastructure on the “air” side of an existing airport (i.e., behind security) may require significant renovations to jet bridges and re-configuration of how to handle security, baggage, charging, and other support services. For example, a few stakeholders told us that airports are accustomed to bringing fuel to aircraft. If eVTOLs use fixed charging infrastructure, the aircraft will approach the energy source, not vice versa (see fig. 4).

Figure 4: Example of Electric Vertical Take-off and Landing (eVTOL) Airport Charging Infrastructure



Source: BETA Technologies. | GAO-23-105188

Electrification Needs

Electrification is another area that numerous stakeholders said will be a factor in determining the costs of AAM ground-based infrastructure projects. Because eVTOL aircraft are electrically powered, stakeholders said they will require large quantities of electricity to charge their batteries. Some stakeholders told us that some airports, as well as high-rise rooftops and other potential locations for vertiports, do not currently have the electrical capacity to quickly recharge eVTOL aircraft and would

need to obtain more power from a substation in order to support AAM.[33] Facilities in need of additional power may face steep costs if they are located far from the nearest substation. As shown in table 2 below, new electrical distribution lines can cost over $1 million per mile.

[33]In 2022, the National Renewable Energy Laboratory (NREL) announced plans to assess a selection of U.S. airports to determine solutions for implementing electrical infrastructure at scale.

Table 2: Estimated Costs of Selected Electrical Upgrades to Support Advanced Air Mobility

Numbers in dollars

Description	Estimated cost
Service supply extension; up to 1 megawatts (up to 3 aircraft chargers)	100,000
New conductor/reconductor; up to 5 megawatts (up to 8 aircraft chargers)	264,000 - 1,300,000 per mile
New transformer bank; over 10 megawatts (over 15 aircraft chargers)	3,000,000 to 11,000,000
New substation bank; over 20 megawatts (over 30 aircraft chargers)	40,000,000 to 80,000,000

Source: Black and Veatch, *Powered for Take-Off, NIA-NASA Urban Air Mobility Electric Infrastructure Study* (2018) | GAO-23-105188

Scope of Construction

Lastly, some stakeholders said that one of the other major factors affecting capital costs of individual ground-based infrastructure projects will be the scope of the construction required. For example, the size of the required infrastructure will depend in part on the ultimate dimensions of certified eVTOL aircraft. In addition, projects to integrate AAM into complex, existing systems of mass transportation could be significantly more expensive than smaller, standalone projects. Furthermore, the quantity of eVTOLs that need to be accommodated could significantly impact the eventual cost (see examples of varying infrastructure designs in fig. 5, below). A few stakeholders also said that the cost to retrofit existing infrastructure will depend on how prepared the structure is to accommodate an eVTOL's ability to take-off, land, and recharge.[34]

[34]While FAA's vertiport requirements are still under development, a few stakeholders said that it is likely that some existing heliports will need certain upgrades in order to host AAM aircraft. During an open forum on FAA's proposed vertiport guidance, an industry stakeholder expressed concern that some current heliports, such as those at hospitals, would not fit within the standards described in the FAA's interim vertiport guidance. FAA officials responded that in order for hospital heliports to accommodate eVTOL operations, modifications will need to be made to the facility in accordance with the standards in FAA's Engineering Brief.

Figure 5: Examples of Electric Vertical Take-off and Landing (eVTOL) Infrastructure

Source: Photo courtesy of BETA Technologies. Rendering courtesy of Lilium. | GAO-23-105188

Many stakeholders noted that it is challenging to provide specific, accurate cost estimates without knowing the regulatory requirements for such infrastructure. While FAA has published an engineering brief that describes interim vertiport standards, the agency has yet to publish final requirements. Even without defined requirements, one estimate from Booz Allen Hamilton suggested that retrofitting a parking garage for AAM could cost $30,000 per eVTOL landing spot. Another stakeholder estimated it may cost more than $10 million to retrofit an entire parking structure to accommodate a vertiport.

Aggregated, Long-term AAM Infrastructure Costs May Be Substantial and Vary Significantly by Location

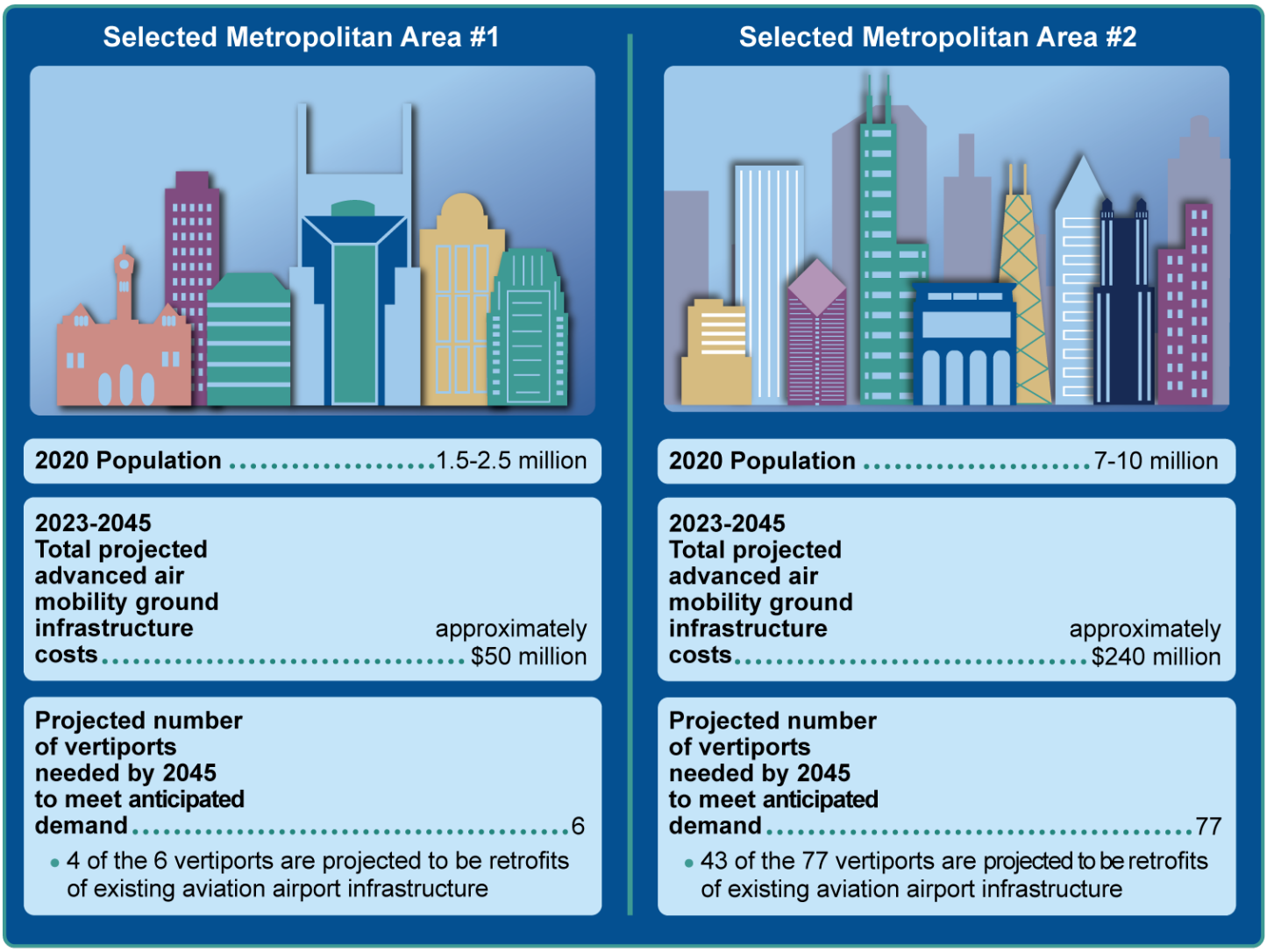
The extent and total capital costs of ground-based infrastructure to support AAM are uncertain at this time, but aggregated, long-term infrastructure costs could be substantial. Ultimately, the costs of this infrastructure will depend on many of the factors already discussed, as well as the extent to which the market evolves in different locations throughout the U.S. Stakeholders told us this evolution is difficult to predict given the nascent stage of the industry. However, while such forecasts for ground-based infrastructure to support AAM are uncertain, they can provide a general sense of scale for building and upgrading such infrastructure.

One study by UAM Geomatics provides such estimations using a proprietary method.[35] In the study, this research group made broad estimations on the cost and deployment of AAM infrastructure in 38 large metropolitan areas throughout the U.S.[36] For these 38 areas, UAM Geomatics projects that the cumulative cost of vertiport construction and renovation could exceed $4.5 billion by 2045, with projected totals varying between locations (see fig. 6).

[35]The AAM forecast conducted by UAM Geomatics predicts demand and extrapolates cost based on the quantity of infrastructure that needs to be built based on demand. Due to the proprietary nature of UAM Geomatics methodology, GAO was not able to fully assess the methodology or replicate the estimates. Further details on assessing the reliability of these estimates are located in appendix I.

[36]UAM Geomatics developed the forecast for each location by analyzing existing passenger demand for flights, population size, and per-capita income, among other factors. In its methodology, UAM Geomatics used existing passenger demand for air travel as a measure to extrapolate potential future demand for AAM flights. They also analyzed the availability of current infrastructure, such as airports and helipads, which could be retrofitted for eVTOL aircraft. While the forecast relies on numerous assumptions and does not include certain costs, such as increasing green electric power generation, it provides a sense of scope for the costs of building and upgrading ground-based infrastructure for AAM and the cost differences that may exist between locations.

Figure 6: Examples of Projected Capital Costs and Vertiport Needs for Two Selected Metropolitan Areas



Source: GAO analysis of UAM Geomatics projections as of January, 2022. | GAO-23-105188

In each year from 2023 through 2045, the aggregate annual projected capital cost of these 38 locations varies from approximately $70 million to $280 million depending on the year. Within each year, there are significant variations in cost between the selected metropolitan areas due to a variety of factors, such as existing infrastructure. For example, the lowest projected cost for the year 2036 was approximately $60,000 in one metropolitan area, while the highest projected cost was approximately $30 million in another metropolitan area.

Stakeholders Identified Various Financing Considerations for AAM Infrastructure

Stakeholders Provided a Range of Considerations for Private and Public Financing Options

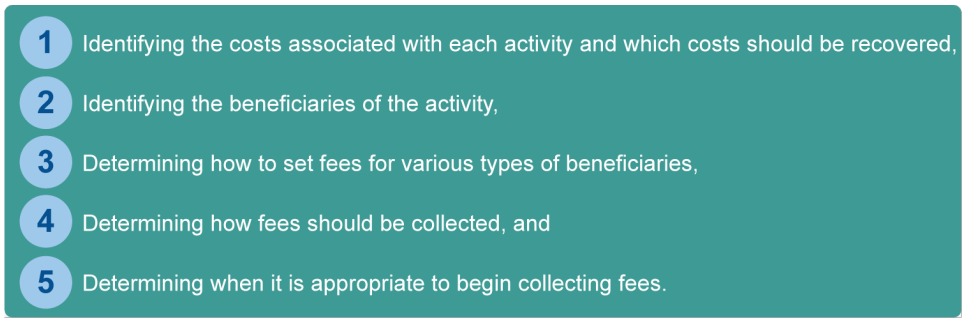
Stakeholders provided views regarding AAM ground-based infrastructure financing and various considerations that may be associated with different funding approaches. Specifically, numerous stakeholders predicted that infrastructure investment would include more public financing over time, especially as the technology becomes publicly accepted. In the near-term, 12 of the 25 stakeholders we interviewed predicted that the private sector alone would finance AAM infrastructure projects over the next 5 years, whereas 11 stakeholders foresaw a mix of different funding types, such as public-private partnerships.

Some stakeholders also said that at present, there are no unique or novel considerations regarding who should fund AAM infrastructure. Considering AAM costs, benefits, and beneficiaries, among other things, can help to inform decisions on how or whether to provide financing for infrastructure investments and recover costs. We have previously reported on considerations for designing user fee mechanisms and other revenue streams to recover federal costs (see fig. 7),[37] as well as

[37]As we have previously reported, there are various ways to design federal user fees to encourage greater efficiency, equity, and revenue adequacy and reduce the administrative burden on the agency and payers of fees. See GAO, *Federal User Fees: A Design Guide,* GAO-08-386SP (Washington, D.C., May 29, 2008). We have also previously reported on key considerations and options for designing user fee mechanisms that could recover FAA's costs. See GAO, *Unmanned Aircraft Systems: FAA Should Improve Drone-Related Cost Information and Consider Options to Recover Costs*, GAO-20-136, (Washington, D.C.: Dec. 17, 2019).

principles and options for Congress to consider in examining and funding infrastructure investments.[38]

Figure 7: Leading Practices for Designing Fees



Source: GAO. | GAO-23-105188

[38]Through prior analyses of existing programs, we identified a number of principles that could guide a reexamination of federal infrastructure programs, including creating well-defined goals, establishing the federal role, and employing the best tools and approaches to emphasize return on investment. See GAO, *Physical Infrastructure: Challenges and Investment Options for the Nation's Infrastructure,* GAO-08-763T (Washington, D.C., May 8, 2008). In 2015, we also identified key elements of regulatory user fees for decision makers to consider as they design, implement, and evaluate these fees. See GAO, *Federal User Fees: Key Considerations for Designing and Implementing Regulatory Fees*, GAO-15-718 (Washington, D.C., Sept. 16, 2015).

Regional Air Mobility

Regional air mobility (RAM) is an application of AAM in which electrified and/or automated aircraft could carry up to 19 passengers, or the equivalent weight in cargo, to adjoining regions and cities. As opposed to the urban air mobility model, in which air taxis fly passengers within a city center utilizing skyscraper roofs as vertiports, RAM would typically utilize existing airport infrastructure to connect nearby regions. Rather than focusing on large airport hubs in metropolitan areas, RAM would leverage thousands of under-utilized public use airports available throughout the U.S., opening up new regional transportation corridors. Since smaller public use airports may be closer to home, this method can shorten the time for passengers between leaving their starting point and reaching their ultimate destination. This model would also provide improved transportation and logistics services to rural and semi-rural locations. Advancements in automation could make this a less expensive and more available mode of travel than traditional airline transportation and air cargo delivery.

Source: NASA. | GAO-23-105188

A few stakeholders shared observations on potential differences between private and public funding approaches related to the following issues:

- **Speed and ingenuity.** One major advantage stakeholders pointed to regarding private investment is the speed and ingenuity it brings to the industry. According to some stakeholders, because private companies compete for profits, they are often able to bring new technologies—such as AAM aircraft and the infrastructure to support it—to the consumer market faster than the public sector. Private companies also bring innovative techniques to cater to consumer demand in a way the public sector cannot.
- **Interoperability.** Stakeholders noted that there will likely be differences in the degree of interoperability among AAM aircraft and infrastructure, including charging mechanisms, depending on whether the infrastructure is privately or publicly funded. Some stakeholders said that a major disadvantage with private financing of AAM infrastructure is the potential for lack of interoperability among systems and designs. With each AAM operator and manufacturer may come different aircraft and vertiport designs, some of which may not operate interchangeably with others. Moreover, stakeholders added

that private companies might choose to limit access of their vertiports to their own aircraft, a tactic that could create barriers to other new entrants as well as inefficiencies for consumers. On the other hand, when financed publicly through federal programs like AIP, entities must be public-use and conform to FAA standards.

- **Equity and accessibility.** Equity and accessibility of AAM infrastructure may differ depending on whether the AAM infrastructure is financed privately or publicly. Stakeholders said privately funded infrastructure will likely be located based mostly on economic considerations. As such, some locations may attract AAM services more readily than others. An analysis by UAM Geomatics forecasted that by 2045, AAM infrastructure will be an attractive private sector investment in most, but not all, of the 38 metropolitan areas they analyzed. The analysis predicted that private investment will become increasingly economically attractive in certain cities by the late 2020s and in others by the 2030s or 2040s. However, five of the 38 metropolitan areas did not meet UAM Geomatics' estimated threshold for attracting private investment by the end of 2045. In areas where there is a public interest in accessing AAM services but private investment is not independently forthcoming, stakeholders said that public financing would be an important bridge to accessibility. Public financing of infrastructure can help achieve more equitable access and promote mass transit, bringing the availability of service to a greater amount of people, including rural areas. For example, a recent NASA report found that rural areas could benefit from AAM based transportation and logistics services through the application of a regional air mobility (RAM) model (see sidebar for explanation of RAM from a 2021 NASA report).

  In the past we have reported that a variety of funding approaches—such as grants, direct loans, loan guarantees, and tax incentives—might be used to support infrastructure for emerging aviation technology.[39] Leading practices in infrastructure investment emphasize the importance of considering ways in which various potential funding approaches might support national interests; avoid overlap or duplication of federal effort; and enhance, not substitute, participation by non-federal stakeholders.[40]

  However, the availability of funds from existing federal grant programs to build AAM ground-based infrastructure may be limited. More

[39]GAO, *Commercial Space Transportation: FAA Should Examine a Range of Options to Support U.S. Launch Infrastructure*, GAO-21-154 (Washington, D.C., Dec. 22, 2020).

[40]GAO-08-763T, GAO 21-154

specifically, stakeholders noted that federal funding options for AAM infrastructure will depend, in part, upon whether vertiports are eligible to receive AIP funds and the competitiveness of those projects among other airport infrastructure plans.

- **Eligibility.** All AIP-funded projects must be located at a National Plan of Integrated Airport Systems (NPIAS) airport. Sponsors of a vertiport could apply to become a NPIAS facility, although individuals we interviewed said this was unlikely to be a common practice.[41] FAA officials said federal AIP funding would not be available to developers seeking to build their vertiports on a site that was located at a non-NPIAS airport, such as private vertiports atop rooftops or parking garages that are not open for public use. FAA officials said that vertiport infrastructure projects located at NPIAS airports would be eligible for AIP grants, provided that airport operators desired to submit them for consideration among their other priorities.[42]
- **Competing needs.** Airports' planned development exceeds funding from federal resources. According to our February 2020 report on airport infrastructure, airports' planned development exceeds historical funding by roughly $8 billion per year. In 2021, a report by Airports Council International – North America (ACI-NA) estimated that the infrastructure needs for American airports from 2021-2025 will be $23.1 billion per year. A few stakeholders we interviewed said that given the other projects that compete for AIP funds—such as safety improvements to existing infrastructure—it is unlikely airports will use AIP funding for AAM infrastructure.[43]

[41]Of the more than 19,000 airports in the United States, roughly 3,300 are NPIAS facilities. Fewer than 10 NPIAS facilities are heliports.

[42]AIP projects must meet certain criteria. Generally, most types of airfield improvements—such as runways, lighting, navigational aids, and land acquisition—are eligible for AIP funding. However, some projects, such as maintenance or repair of buildings, are ineligible for AIP funding. FAA officials said that it is unknown if these restrictions would extend to AAM projects.

[43]The distribution of federal AIP grants is complex. It is based on a combination of formula funds—also referred to as entitlement funds—that are available to national system airports, and discretionary funds that FAA awards for selected eligible projects. Entitlement funds are apportioned by formula to airports and may generally be used for any eligible airport improvement or planning project. Discretionary funds are approved by FAA based on FAA selection criteria and a priority system, which FAA uses to rank projects based on the extent to which they reflect FAA's nationally identified priorities. Under the Infrastructure Investment and Jobs Act of 2021 (IIJA), airport infrastructure funding is also now available through Transportation Infrastructure Finance and Innovation Act (TIFIA) program loans.

Existing Tax Structure Will Apply to AAM but Applicability of Some Exemptions is Unclear

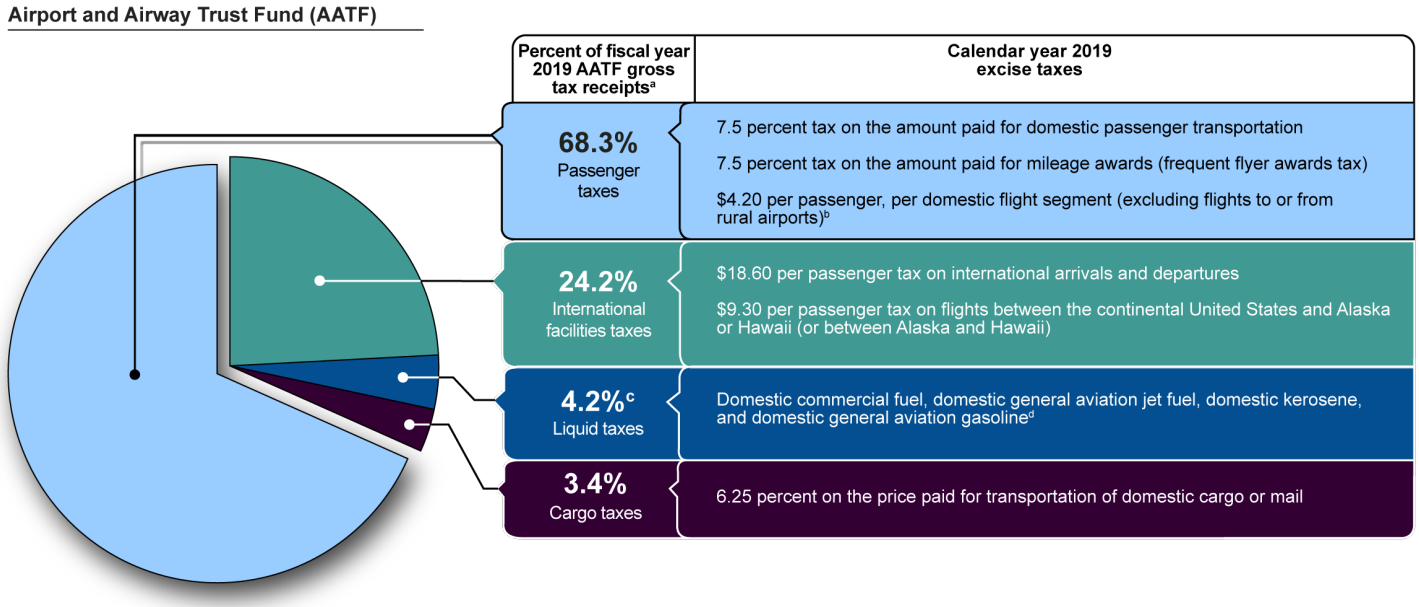
While the taxes that fund the AATF will apply to AAM operations, it is unclear how certain exemptions from domestic passenger and cargo excise taxes would apply to these operations. Current tax exemptions are based in part upon the type of aircraft, and eVTOLs do not clearly align with existing statutory categories of aircraft. Additionally, initial flights are unlikely to pay certain excise taxes—such as liquid fuel or international passenger taxes—because eVTOLs are not expected to operate in a manner that would incur those taxes.

Existing AATF Tax Structure Applies to AAM Operations

All airspace users—including future AAM users—are subject to taxes that fund the AATF, including passenger, cargo, and fuel taxes. AAM users would need to pay these taxes unless (1) they fall into existing exemption categories (e.g., exemptions to the passenger tax for skydiving flights), or (2) the tax does not apply to the specific flight's circumstances (e.g., cargo taxes are not applied to passengers).

Each of these taxes contributes a different amount of revenue to the AATF. In fiscal year 2019—the most recent full fiscal year before Congress approved a temporary suspension of excise taxes on passenger, cargo, and fuel receipts—domestic passenger taxes accounted for more than two-thirds of the AATF's revenue, while domestic cargo taxes provided approximately 3.4 percent of the revenue (see fig. 8).

Figure 8: Airport and Airway Trust Fund (AATF) Taxes and Revenue Sources, 2019



Source: Federal Aviation Administration and Department of the Treasury data. | GAO-23-105188

Accessible Data for Figure 8: Airport and Airway Trust Fund (AATF) Taxes and Revenue Sources, 2019

Percent of fiscal year 2019 AATF gross tax receipts	Calendar year 2019 excise taxes
68.3% Passenger taxes	7.5 percent tax on the amount paid for domestic passenger transportation 7.5 percent tax on the amount paid for mileage awards (frequent flyer awards tax) $4.20 per passenger, per domestic flight segment (excluding flights to or from rural airports)
24.2% International facilities taxes	$18.60 per passenger tax on international arrivals and departures $9.30 per passenger tax on flights between the continental United States and Alaska or Hawaii (or between Alaska and Hawaii)
4.2% Liquid taxes	Domestic commercial fuel, domestic general aviation jet fuel, domestic kerosene, and domestic general aviation gasoline
3.4% Cargo taxes	6.25 percent on the price paid for transportation of domestic cargo or mail

[a]We used gross receipts from 2019 because Congress approved a tax holiday in parts of fiscal years 2020 and 2021 that temporarily suspended the collection of excise taxes on passenger receipts. Pub. L. No. 116-136, § 4007 134 Stat. 281, 477 (2020) (codified at 15 U.S.C. § 9046).

[b]A domestic flight segment consists of one take-off and one landing within the United States or a point in Canada or Mexico within 225 miles of the continental United States.

[c]Taxes collected on kerosene used in aviation are initially deposited in the Highway Trust Fund and then transferred by accounting adjustments to the Airport and Airway Trust Fund. 26 U.S.C. § 9503(c)(5).

[d]This percentage includes fiscal year 2019 gross tax receipts for Liquid Fuel—Fractional Ownership Flight.

The Internal Revenue Code establishes a number of exemptions to passenger and cargo taxes. IRS is responsible for applying these exemptions, and issues regulations and guidance such as revenue rulings. Courts also interpret the Internal Revenue Code and IRS regulations.[44] To apply the exemptions to new situations, IRS officials said the agency relies on the Internal Revenue Code, case law, regulations, previous revenue rulings, and other agency guidance. Regulations issued by FAA do not determine classification of aircraft for tax purposes. When not in conflict with the Internal Revenue Code or published IRS guidance, the content of FAA regulations may inform determinations of tax liability in some cases. However, IRS is not required to follow FAA regulations or guidance.

Aircraft Definitions Make the Applicability of Some Excise Tax Exemptions Unclear

Based on our analysis, it is uncertain whether some eVTOLs would qualify for exemptions from domestic passenger and cargo excise taxes because eVTOLs do not neatly fit into the existing aircraft types that are eligible for the 1) flight purpose and 2) non-established line tax exemptions:

- **Exemptions for certain flight purposes.** Eligibility criteria for flight purpose tax exemptions can depend upon what kind of aircraft is being used. It is unclear how certain flight purpose excise tax exemptions will apply to eVTOLs since these aircraft may share features of both helicopters and fixed-wing aircraft.[45] For example, helicopter flights that are *used for e*mergency medical services are exempt from the passenger tax, the passenger segment tax, and the cargo tax.[46] Fixed-wing planes must be *specifically equipped for* and *exclusively dedicated* on t*hat flight to* acute care emergency medical

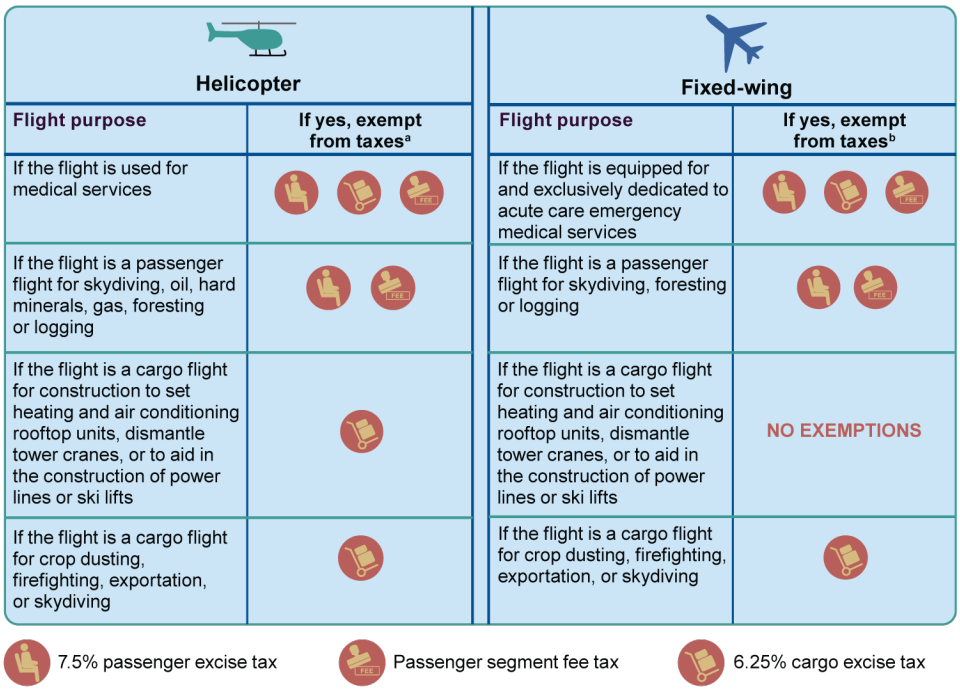
[44]Court decisions generally take precedence over revenue rulings, and IRS relies on court decisions in interpreting the excise tax exemptions.

[45]Federal law also provides exemptions specific to other aircraft types (such as seaplanes). We do not include such types in this discussion.

[46]For calendar year 2022, the domestic passenger tax is set at 7.5 percent, the domestic passenger segment tax is $4.50 per passenger, and the domestic cargo tax is 6.25 percent.

services in order to qualify for those exemptions, which is a higher standard (see fig. 9).

Figure 9: Examples of Differences in Passenger and Cargo Tax Exemptions for Helicopter and Fixed-wing Aircraft



Source: GAO legislative analysis. | GAO-23-105188

[a, b]These are statutory exemptions from taxes in situations where taxes apply. Exemptions do not include situations where the tax is not applicable (e.g., cargo taxes do not apply to flights solely carrying passengers).

The applicability of certain tax exemptions depends on whether a flight uses a “helicopter” or “fixed-wing” aircraft, but existing law—including excise tax statutes—does not define either term. According to IRS officials, the lack of clear statutory definitions for helicopter and fixed-wing aircraft had not previously been concerning. Officials said the agency had been able to identify traditional helicopters and fixed-wing aircraft. However, they said AAM introduces significant uncertainty because it is unclear how an aircraft that uses rotors to achieve lift for take-off and transitions to using a fixed wing to achieve lift during flight—a design proposed by multiple AAM manufacturers—would be classified for the purposes of determining flight purpose excise tax exemptions. Existing tax law does not specify whether an aircraft should be classified in accordance with its lift mechanism at take-off and landing, versus the lift mechanism in the cruise phase of

flight. Furthermore, officials from IRS's Office of Chief Counsel confirmed that there is no statute, case law, or previous revenue ruling that directly addresses this issue.

- **Exemption for small non-jet aircraft on non-established lines.** Another exemption to domestic passenger and cargo excise taxes is for non-jets that weigh 6,000 pounds or less and are flying on a "non-established line."[47] According to the Internal Revenue Code, a jet is defined by what it is not. Specifically, a jet is not a rotorcraft or propeller aircraft.[48] Under IRS regulations, helicopters are considered rotorcraft.[49] However, IRS regulations do not further define helicopter, rotorcraft, jet aircraft, or propeller aircraft. As previously discussed, some eVTOLs may use rotors, pusher propellers, or a combination thereof, while others may use ducted fan jet engines or other technologies. IRS officials said there is little existing case law to guide decisions, and IRS has issued few relevant revenue rulings or other agency guidance.[50]

According to leading practices developed by GAO, tax systems are supposed to be transparent and administrable, but systems that are difficult to interpret and comply with may lack these qualities.[51] The transparency of a tax system refers to taxpayers' ability to understand

[47]A flight is on a non-established line if it meets all three prongs of the following IRS test: (1) travel is between two undefined points, (2) the operator does not retain decision-making control, and (3) the flight does not operate regularly. 26 C.F.R. 49.4281-1(c). According to IRS officials, an air taxi with multiple vertiports to choose from might meet the first prong of the three-part test because the destination is not known until expressed by the passenger, and thus the travel is not between two defined points. However, the same flight might not meet the second prong of the test if the pilot is able to refuse service to the passenger (and thus maintain control over the flight). IRS officials said that they would consider the full range of information about a flight when making a determination on whether the aircraft operates on an established or non-established line.

[48]26 U.S.C. § 4281(d). Furthermore, although IRS does not rely on FAA definitions in its rulings, IRS may consider the definitions in its rulings if the definitions are not in conflict with tax law or the tax law is silent. FAA officials said that they do not have a specific definition of a jet.

[49]26 C.F.R. § 49.4281-1(d)

[50]According to IRS officials, the low weight threshold for this exemption restricts the flights that can qualify, as few aircraft weigh 6,000 pounds or less. As a result, there are few instances when the exemption has been applied or adjudicated. However, eVTOLs can be significantly lighter than traditional aircraft, and at least one manufacturer has publicly announced that their eVTOL's take-off weight would be at or below the 6,000 pound threshold.

[51]GAO-05-1009SP and GAO-13-167SP.

how their liabilities are calculated, the logic behind the tax laws, what their own tax burden and that of others is, and the likelihood of facing penalties for noncompliance. Administrability refers to the costs—ultimately borne by taxpayers—of collecting and processing tax payments as well as to the costs of enforcing the tax laws. GAO's leading practices suggest that when considering the soundness of a tax system, Congress should consider the costs to taxpayers, IRS, and other government agencies. We reported, in some cases, it can be cheaper and simpler to address issues through the tax code rather than piecemeal approaches.

In the case of AAM, IRS officials cautioned that the variety of novel AAM designs in combination with the lack of statutory clarity would introduce significant challenges for IRS and AAM operators related to both transparency and administrability. For example, the lack of clarity regarding how to classify AAM aircraft for the purpose of excise tax exemptions could cause AAM operators to inconsistently or incorrectly interpret their excise tax burden. In addition, IRS officials said the agency would have difficulty administering excise taxes that pay into the AATF for AAM operations because these aircraft may have characteristics of helicopters and fixed-wing aircraft, or use novel propulsion systems that do not clearly fall within existing statutory classifications.

In the absence of congressional clarification, IRS said it would use existing law to interpret how AAM would fit within excise tax exemptions to the best of its ability.[52] However, officials said that IRS might need to expend significant resources to develop its response.[53] Officials said congressional clarification would provide a framework for the agency to administer the tax law efficiently and effectively. For example, such clarity

[52]FAA regulations and determinations do not determine the classification of aircraft for tax purposes. When not in conflict with the Internal Revenue Code or IRS published guidance, their content may inform determinations of tax liability in some cases. However, IRS is not required to follow FAA guidance. FAA has a class of aircraft called 'powered-lift', which covers aircraft that use engine-driven lift devices such as rotors to take-off and land vertically like a helicopter, but that also have wings that they can use for horizontal flight like an airplane. As previously discussed, FAA plans to certify powered-lift aircraft as special class aircraft, not as traditional helicopters or airplanes. Powered-lift is not mentioned in the Internal Revenue Code.

[53]In an example where IRS previously interpreted aviation terms for excise tax exemptions, IRS relied on legislative history to define a jet aircraft as a turbine engine powered aircraft, including turboshaft helicopters. Congress subsequently acted to supersede the IRS's opinion, clarifying that a jet aircraft should not include a rotorcraft or propeller aircraft.

would provide for more consistent tax treatment and reduce litigation that the federal government might otherwise face.

Furthermore, perceptions and uncertainty regarding future tax obligations could potentially affect how the nascent AAM industry develops. Numerous stakeholders we interviewed said that in order to be economically successful in the United States, the AAM industry needs clarity from the government on the applicable regulatory framework, and a few specifically cited concerns that taxes might not be tailored to AAM operations. Such clarity—or lack thereof—could affect private investment decisions or the viability of various business models. IRS officials said that additional congressional clarification on aircraft definitions related to AAM would improve the tax code's transparency and administrability.

Initial AAM Operations Are Unlikely to Incur Certain Excise Taxes

When applying the existing tax law, taxes on liquid fuels may or may not be incurred depending on the technology of the aircraft. Taxes on liquid fuels would not be relevant to AAM aircraft that are fully electric.[54] However, in the case of hybrid aircraft, fuel taxes would generally apply to the kerosene or aviation gas used in the aircraft. As of July 2022, the majority of the AAM type certifications under review by FAA do not use a liquid fuel. As previously mentioned, fuel taxes constitute a small source of tax revenue for the AATF, at approximately 4.2 percent.

International arrival and departure taxes, as well as taxes on flights to and from Alaska and Hawaii, are unlikely to be charged to initial eVTOL operations because of range limitations. Publicly available designs indicate that initial eVTOLs will generally have a range of less than 250 miles. Alaska and Hawaii are more than 600 and 2,000 miles from the continental U.S., respectively. In addition, international arrival and departure taxes do not apply to flights to or from Canada and Mexico when the entirety of the flight is within 225 miles of the continental U.S. border. While international arrival and departure taxes would apply to AAM if such flights were to occur, none of the AAM manufacturers we

[54]The current imposition of excise tax on fuels used in aviation is complex. The tax rate and who pays the tax depends on a number of factors. However, current law would not impose a fuel tax for AAM aircraft that do not use liquid fuel. According to NASA and FAA officials, a variety of AAM energy supply systems would not use liquid aviation fuel, such as battery packs providing electrical power to the engines, or onboard hydrogen fuel cells generating electric current.

spoke to indicated that their aircraft were likely to be used for such flights within the next 5 years.

Conclusions

The aircraft technology that underlies AAM did not exist when Congress originally established the AATF tax structure in 1970, and subsequent amendments do not account for AAM technology. With FAA reviewing AAM aircraft and industry plans for commercial operations on the horizon, it is important to consider how current policies—such as tax exemptions—would interact with this new technology. Certain aspects of the current tax structure will not be transparent or easy to administer. Without congressional clarification, businesses could face unexpected tax audits, and some AAM operations could experience different tax treatment for otherwise similar uses. In addition, the IRS could expend resources to develop a policy response that might not align with what industry anticipated or congressional intent. Furthermore, uncertainty regarding AAM operations' eventual tax obligations could skew how the industry develops, or even hinder investment from the private sector.

Matter for Congressional Consideration

Congress should consider legislation to clarify how AAM aircraft should be defined for the purpose of exemptions related to taxes that fund the Airport and Airway Trust Fund (AATF). This might include clarifying whether AATF excise tax exemptions should be determined in accordance with the take-off versus in-flight lift mechanism, creating new aircraft category types, further defining jet aircraft as it relates to newer technologies, or other approaches. (Matter for Consideration 1).

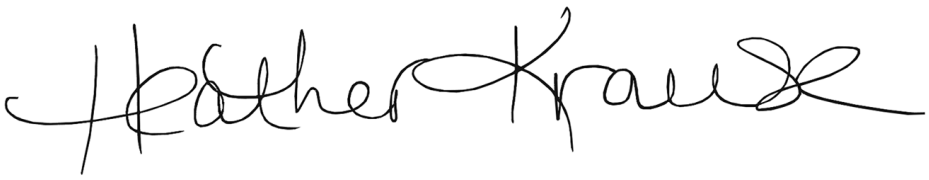
Agency Comments

We provided a draft of this report to FAA, NASA and IRS for review and comment. FAA and IRS provided technical comments. NASA did not have any comments.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees and other interested parties. In addition, the

report will be available at no charge on the GAO website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834, or krauseh@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.



Heather Krause
Director, Physical Infrastructure

Appendix I: Objectives, Scope, and Methodology

To address all four objectives, we interviewed 25 stakeholders with knowledge of advanced air mobility (AAM). We identified these stakeholders through a literature search of academic journals and industry publications, as well as consultations with internal subject matter experts. In addition, we used initial interviews with AAM aircraft manufacturers, operators, professional organizations, and state and local governments to identify additional industry stakeholders. We developed four categories to describe stakeholders and placed the stakeholders we identified into one of those four categories. Table 3 below identifies these categories and the stakeholders included in each.

Table 3: Stakeholder Categories

Stakeholder category	Stakeholder types	Stakeholder Identities
Industry	Airports, companies with AAM infrastructure expertise, aircraft manufacturers, and aircraft operators	• Archer • BETA Technologies • Joby Aviation • Lilium • Los Angeles International Airport • Palm Beach International Airport • Skyports • United Airlines • Wisk Aero
Trade associations and consultants	Consultants with expertise in aviation or electric infrastructure, and professional organizations representing manufacturers, airports, or other areas of aviation	• Airports Council International— North America • Aerospace Industries Association • Airports Consultants Council • Black and Veatch • Community Air Mobility Initiative • General Aviation Manufacturers Association • GRA, Incorporated • National Air Transportation Association • National Business Aviation Association • Vertical Flight Society
Government	State and local government entities that are working with AAM industry to plan for future operations	• City of Los Angeles • Ohio Department of Transportation

Stakeholder category	Stakeholder types	Stakeholder Identities
Academia and research organizations	Researchers with expertise in AAM, aviation, or transportation	• Congressional Research Service • George Mason University • Georgia Tech • Massachusetts Institute of Technology

Source: GAO. | GAO-23-105188

In making our final decisions regarding whom to interview, we considered the need to achieve balance within the categories. We also considered the likelihood that an interviewee would be able to comment on multiple topics. Using a defined question set, we obtained their perspectives on Federal Aviation Administration (FAA) costs related to AAM, the projected costs of ground-based AAM facilities, the likely funding sources for infrastructure projects, and considerations for taxation and fees related to AAM operations. The views of these stakeholders are not generalizable to all entities involved in AAM. However, we believe that the information provides a balanced and informed perspective across stakeholder groups on the topics discussed.

To describe FAA's current expenses to support AAM, we analyzed FAA documentation on the resources the agency expended on AAM activities from September 2018 through May 2022, such as staff time spent meeting with a specific AAM manufacturer. Furthermore, we interviewed FAA officials regarding how expenses associated with staff time are recorded and the extent to which expenses for AAM can be delineated from other expenses. To describe the agency's anticipated future expenses, we reviewed FAA's 2023 budget request and asked FAA officials about expected future expenses.

To describe forecasted AAM infrastructure costs, we analyzed cost projections developed by UAM Geomatics Inc., a private company that created an urban air mobility (UAM) infrastructure cost model for more than 80 locations around the world. We analyzed forecasted costs for 38 U.S. metropolitan areas, which was the full extent of UAM Geomatics' domestic modeling available at the time. Many factors provided data or context for the projections at each location, such as per capita city income, air service affordability, transportation substitutes, congestion, cost of living, and educational levels. We assessed the reasonableness of the inputs used in the demand model to forecast passenger demand (a crucial input to their cost forecasts), and we determined the choice of inputs to be reasonable. However, due to the proprietary nature of the model we were not able to assess the details of the company's methodology.

Modeling is inherently uncertain. This uncertainty is particularly acute for a nascent market such as advanced air mobility, as there is no historical AAM data on which to base assumptions. According to representatives from UAM Geomatics, forecasted passenger demand, along with price-elasticity-demand, are crucial inputs to the company's infrastructure projections. However, projected demand and costs might differ from actual demand and costs due a variety of economic and technological factors that are difficult to predict. For example, the estimates of passenger demand assume that sufficient aircraft are manufactured to satisfy this demand. Furthermore, the model assumes an "inflection point" brought about by the assumption that automated flight will be achieved and then increase over time. This inflection point is very important to the model's predictions, as certain costs are expected to decrease when this technological milestone is reached. According to UAM Geomatics, the inflection point is a key assumption of their model, since the industry's full potential will be achievable only with higher levels of automation. To help mitigate the impact of these uncertainties, as well as to respect the proprietary nature of the projections, we grouped locations together when reporting costs. In addition, we anonymized case studies and provided approximations of the cost estimates, rather than specific amounts.

To describe considerations for financing AAM ground-based infrastructure, we identified leading practices for making capital investment decisions through a review of our prior work. We also reviewed and summarized predicted revenue-to-investment ratios from UAM Geomatics, as these projections can provide insight into the likelihood that the private investors will enter the market.

To assess how the existing tax structure that supports the Airport and Airway Trust Fund (AATF) will apply to AAM, we analyzed laws (e.g. 26 U.S.C. §§ 4261-4283), regulations (e.g. Treas. Reg. Ch. I, Subch. D, Pt. 49, Subpt. D & Subpt. E (26 C.F.R. §§ Part 49, Subparts D & E)), case law (e.g. Papillon Airways, Inc v. United States, 105 Fed. Cl. 154 (2012); Lake Mead Air, Inc. v. United States, 991 F. Supp. 1209 (D.Nev.1997)), revenue rulings (e.g. Rev. Rul. 78-75, 1978-1 C.B. 340; Rev. Rul. 72-617, 1972-2 C.B. 580), and Internal Revenue Service (IRS) Technical Advice Memoranda (e.g. Application of new § 4821 jet aircraft provision to helicopters, Memorandum from the Office of Chief Counsel, Internal Revenue Service (July 25, 2012), https://www.irs.gov/pub/lanoa/pmta_2012-20.pdf). We also interviewed IRS officials from the Office of Chief Counsel and the Small Business/Self-Employed (SB/SE) division regarding the applicability of AATF taxes and how the agency might interpret certain situations. In

addition, we identified four individuals or entities who had previously published information on aviation excise taxes, and for context, sought their views on how the AATF tax structure might be applied to AAM.

Appendix II: GAO Contact and Staff Acknowledgements

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Staff Acknowledgements

In addition to the contact named above, Jean Cook (Assistant Director); Vashun Cole (Assistant Director); Alison Snyder (Analyst-in-Charge); Amy Abramowitz; Paul Aussendorf; Lilia Chaidez; Melanie Diemel; Juliet Logan; Alicia Loucks; Chi Mai; Matty Njie; Patrick Tierney; Michelle Weathers; Alicia Wilson; and Elizabeth Wood made key contributions to this report.

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