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U.S. House of Representatives
Washington DC 20515

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March 8, 2019

SUMMARY OF SUBJECT MATTER

TO: Members, Subcommittee on Aviation
FROM: Staff, Subcommittee on Aviation
RE: Subcommittee Hearing on "Looking Forward: Aviation 2050"

PURPOSE

The Subcommittee on Aviation will meet on Tuesday, March 12, 2019, at 10:00 a.m. in HVC-210 of the Capitol Visitor Center to hold a hearing titled, "Looking Forward: Aviation 2050." The hearing will explore the future of U.S. aviation and the National Airspace System (NAS), including how the NAS is evolving as a result of new aviation and aerospace technologies, as well as how new and future entrants (including unmanned aircraft, passenger air taxis, and supersonic aircraft) will change our airspace. The Subcommittee will hear testimony from the National Aeronautics and Space Administration (NASA), PrecisionHawk, Boom, Uber Elevate, and the Air Line Pilots Association.

FUTURE OF U.S. AVIATION AND AEROSPACE

Civil aviation plays a central role in the United States, supporting more than $1.5 trillion of economic activity and more than 11 million jobs, according to industry groups. This role will only grow with the introduction of new airspace users, such as unmanned aircraft and passenger air taxis, and the development of new aerospace technologies that change the way we operate in the airspace. The Federal Aviation Administration (FAA)—the Federal agency responsible for ensuring the safe and efficient operation of the NAS—along with NASA and industry are continuously exploring ways to make current airspace operations safer and more efficient, as well as to prepare our airspace for the arrival and integration of new users and technology.

The FAA's William J. Hughes Technical Center—a world renowned air transportation system laboratory—conducts extensive research and development to find solutions to air transportation safety challenges. The Technical Center also supports the FAA's Next Generation Air Transportation (NextGen) portfolio—an effort to modernize air traffic control systems to increase the safety and efficiency of the NAS.[1] NASA's Armstrong Flight Research Center has numerous flight test and research projects underway that seek to improve fuel efficiency and reduce emissions, reduce or mitigate aircraft noise, and support systems to safely integrate unmanned aircraft.[2] These Government programs, along with industry efforts, and public-private collaboration will ensure the United States remains the world leader in civil aerospace.

UNMANNED AIRCRAFT SYSTEMS

Unmanned aircraft systems (UAS)—ranging in size from those that can fit in your hand to 40-foot military drones weighing 16,000 pounds—are proliferating in the NAS. In fact, in its most recent aerospace forecast, the FAA estimates that the hobbyist (recreational) UAS fleet will more than double over the next four years—to more than three million units by 2022. For the commercial UAS fleet, the FAA projects an increase from 110,000 units in 2017 to 450,000 units by 2022.[3] The Association for Unmanned Vehicle Systems International (AUVSI) estimates that by 2025, the UAS industry will have created more than 100,000 new jobs in the United States and have a total economic impact of more than $80 billion.[4]

UAS can be small, lightweight, inexpensive, easy to operate, and equipped with various technologies, such as cameras and infrared or thermal sensors, offering a virtually unlimited number of potential applications. UAS can perform work that manned aircraft cannot, such as close inspections of bridges, pipelines, railroad tracks, runways, and other critical infrastructure. UAS can also, among other things, image and survey wide swaths of land to monitor wildlife and combat animal poaching, inventory and classify forests, and deliver products such as medicine or medical supplies to rural and physically isolated areas. Over the past two years, UAS were vital in recovery efforts following hurricane events affecting several U.S. States and territories and in responding to wildfires that blazed across multiple Western States.[5]

UAS Integration

The *FAA Modernization and Reform Act of 2012* (Pub. L. 112-95) required the FAA, in consultation with other Federal agencies and industry, to develop a comprehensive plan to accelerate the safe integration of civil UAS into the NAS[6] and subsequently issue regulations applicable to the operation of small commercial UAS.[7] In June 2016, the FAA issued its final rule on small commercial UAS operations—"Operation and Certification of Small Unmanned Aircraft Systems" (14 C.F.R. part 107)—which significantly expanded and standardized the ability to conduct

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[1] *See William J. Hughes Technical Center*, https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/; FAA, *NextGen by the Numbers*, https://www.faa.gov/nextgen/by_the_numbers/.
[2] NASA, *Overview* (Feb. 16, 2015), https://www.nasa.gov/centers/armstrong/about/overview.html.
[3] *FAA Aerospace Forecast Report Fiscal Years 2018 to 2038: Unmanned Aircraft Systems*, *available at* https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2018-38_FAA_Aerospace_Forecast.pdf.
[4] AUVSI, *The Economic Impact of Unmanned Aircraft Systems Integration in the United States* (Mar. 2013), *available at* http://www.auvsi.org/our-impact/economic-report.
[5] *See, e.g.*, Andy Pasztor, *Drones Play Increasing Role in Harvey Recovery Efforts*, THE WALL ST. J. (Sept. 4, 2017, 6:51 PM), https://www.wsj.com/articles/drones-play-increasing-role-in-harvey-disaster-recovery-efforts-1504474194; Elizabeth McLaughlin, *National Guard Using Reaper Drone to Fight Wildfires*, ABC NEWS (Aug. 15, 2018, 5:17 PM), https://abcnews.go.com/US/national-guard-reaper-drone-fight-wildfires/story?id=57199785.
[6] Pub. L. 112-95, § 332(a).
[7] *Id.* § 332(b).

commercial UAS activities.[8] For commercial UAS operations, part 107 imposed requirements on UAS pilots[9] and aircraft,[10] as well as operational limitations. Most notably, the UAS must remain within the visual line of sight (VLOS) of the remote pilot in command and must not to fly over people not involved in the operation.[11] Operations outside of the defined limitations require an FAA-waiver signifying the FAA finds the proposed operation can be performed safely. Notably, under part 107, no waivers can be issued for commercial UAS operations carrying property for compensation or hire beyond-VLOS.[12] This, in effect, bars the ability of U.S. companies to conduct package delivery via UAS.

The *FAA Extension, Safety, and Security Act of 2016* (Pub. L. 114-190) includes a subtitle on UAS safety. Notable provisions include requiring the expeditious authorization of UAS in support of firefighting operations and fines for those who interfere with such operations, and permitting expanded UAS operations involving critical infrastructure, such as pipelines and facilities that generate electric energy or produce oil or gas. The *FAA Reauthorization Act of 2018* (Pub. L. 115-254) authorizes the FAA to fully regulate hobby and recreational UAS in order to ensure the safety and security of U.S. airspace; advances the safe and efficient integration of UAS into U.S. airspace through the development and testing of new UAS technologies; and directs the FAA to move forward with authorization of certain advanced operations (e.g., package delivery).

Other UAS Integration Efforts

UAS Integration Pilot Program. In October 2017, under the directive of a Presidential Memorandum, the Department of Transportation (DOT) announced a three-year "UAS Integration Pilot Program." Under the program, DOT selected and entered into agreements with ten State, local, or tribal governments, in partnership with private entities, to test and validate advanced UAS operations and technologies.[13] The program, designed to accelerate the testing of UAS operations that are currently restricted (such as beyond-VLOS operations and flights over people) allows lower levels of government to participate in the development of Federal UAS guidelines and regulations.[14]

UTM. The FAA, NASA, other Federal agencies, and industry are working closely on the development of UAS Traffic Management (UTM).[15] Similar to how air traffic systems manage manned aircraft operations today, UTM will include systems necessary to manage UAS traffic in

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[8] FAA, *Operation and Certification of Small Unmanned Aircraft Systems*, https://www.faa.gov/uas/media/RIN_2120-AJ60_Clean_Signed.pdf. *See also* 14 C.F.R. § 107 (2016).

[9] A pilot must be at least 16 years old, obtain a remote pilot airman certificate (or be under the direct supervision of a certificate holder), demonstrate aeronautical knowledge in order to obtain such a certificate, and pass vetting by the Transportation Security Administration.

[10] An aircraft must weigh less than 55 pounds, and any aircraft that weighs more than 0.55 pounds must be registered with the FAA online. The aircraft must undergo a pre-flight check to ensure it is in a safe operating condition.

[11] FAA, *Summary of Small Unmanned Aircraft Rule (Part 107)*, https://www.faa.gov/uas/media/Part_107_Summary.pdf. The UAS must also fly under 400 feet and at or below 100 miles per hour, during the day, yield right of way to manned aircraft, and not from a moving vehicle. *Id.*

[12] FAA, *Beyond the Basics*, https://www.faa.gov/uas/beyond_the_basics/.

[13] DOT, *Press Release – U.S. Transportation Secretary Elaine L. Chao Announces Unmanned Aircraft Systems Integration Pilot Program Selectees* (May 9, 2018), https://www.faa.gov/news/press_releases/news_story.cfm?newsId=22755.

[14] FAA, *UAS Integration Pilot Program*, https://www.faa.gov/uas/programs_partnerships/uas_integration_pilot_program/splash/.

[15] FAA, *Unmanned Aircraft System Traffic Management*, https://www.faa.gov/uas/research_development/traffic_management/.

low-altitude airspace, allowing the FAA to communicate real-time airspace status and constraints to operators,[16] and provide services to prohibit UAS from operating in certain airspace or colliding with other aircraft.[17] UTM will enable complex UAS operations, such as beyond-VLOS operations, and is critical to the full integration of UAS into the NAS.

Government-Industry Collaboration. Government and industry have collaborated extensively on UAS issues. Key partnerships, which have resulted in data and research to help integrate UAS, include:

- The **Drone Advisory Committee,** formed in 2016 to support the safe and efficient introduction of UAS into the NAS;[18]

- **UAS Test Sites**, established under the 2012 law,[19] to develop research findings and operational experiences that will help ensure the safe integration of UAS through regulations and operational procedures;[20]

- The FAA's **UAS Center of Excellence**—the Alliance for System Safety of UAS through Research Excellence (ASSURE)—comprises more than 20 leading aviation research universities that work to provide the FAA with the research needed to safely and efficiently integrate UAS into the NAS;[21] and

- The **Low Altitude Authorization and Notification Capability (LAANC)** (pronounced like "Lance"), launched in October 2017, is a system that can enable efficient (almost instantaneous) authorizations for otherwise-permissible UAS operations in controlled airspace (e.g., near an airport). LAANC supplements a manual process that takes 80 days on average to complete. LAANC is available today at nearly 300 FAA air traffic control facilities across the United States, covering approximately 500 airports.[22]

Challenges to UAS Integration

Safety. The FAA receives more than 100 UAS sighting reports each month.[23] While the Government Accountability Office (GAO) has concluded that the extent to which these reports represent actual incidents of unsafe UAS use is unclear,[24] the volume of the reported sightings reflects the risk of collision between UAS and manned aircraft near airports, critical infrastructure, and over populated areas. For example, in late 2017, a UAS collided with and damaged a U.S. Army

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[16] *Id.*
[17] NASA, *UAS Traffic Management*, https://utm.arc.nasa.gov/index.shtml.
[18] *See* FAA, *Drone Advisory Committee*, https://www.faa.gov/uas/programs_partnerships/drone_advisory_committee/.
[19] Pub. L. 112-95, § 332(c). Current UAS test sites are located in Alaska, Nevada, New Mexico, New York, North Dakota, Texas, and Virginia.
[20] FAA, *Fact Sheet – FAA UAS Test Site Program* (Dec. 30, 2013), https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=15575.
[21] *See* ASSURE, *About Us*, http://www.assureuas.org/about.php.
[22] FAA, *UAS Data Exchange (LAANC)*, https://www.faa.gov/uas/programs_partnerships/data_exchange/.
[23] FAA, *UAS Sightings Report*, https://www.faa.gov/uas/resources/public_records/uas_sightings_report/.
[24] GAO, *Small Unmanned Aircraft Systems, FAA Should Improve Its Management of Safety Risks*, GAO-18-110 (May 2018).

UH-60 Black Hawk helicopter near Staten Island, New York.[25] Another UAS struck a commercial plane with 8 passengers onboard as it approached the Jean Lesage International Airport in Québec City, Canada.[26] More recently, a UAS spotted near London's Gatwick Airport led to the cancellation or diversion of approximately 1,000 flights, affecting nearly 150,000 passengers.[27] UAS technology such as geofencing, collision avoidance, automatic landing, and return-to-home technology can help UAS prevent accidents with other aircraft, infrastructure, and people; however, the standardization, security, and availability of this technology are limited and not currently mandated.[28]

Security. Identification of UAS operators is a key concern of the FAA and law enforcement community. The *FAA Extension, Safety, and Security Act of 2016* required the FAA to convene industry stakeholders to facilitate the development of consensus standards for remotely identifying operators and owners of UAS, which would assist the FAA in the issuance of subsequent regulations or guidance, including those that allow expanded commercial UAS operations over people and beyond-VLOS. On December 20, 2018, the FAA issued a request for information to inform ongoing remote identification rulemaking. To date, the FAA has not issued a proposed rule on remote identification standards for UAS operations.

URBAN AIR MOBILITY (UAM)

Americans lost, on average, 97 hours a year due to traffic congestion in the United States, costing them nearly $87 billion in 2018, according to a recent industry report.[29] This not only impacts drivers, but also has harmful effects on businesses.[30] With recent advances in technology, flying cars, passenger air vehicles or taxis, and personal hovercraft may take to the skies as early as 2020. More than 70 concepts are reportedly in development and testing.[31] These concepts have the potential to reduce traffic congestion on U.S. roads and commute times, especially in cities and urban areas, and lessen the current burden on surface infrastructure.

Take Off and Landing. These aircraft must be small and lightweight, compared to conventional aircraft, so many concepts will rely on batteries and electric engines. While some concepts are designed to drive on the road before transitioning to flight mode with airplane-like wings,[32] others will operate as vertical takeoff and landing (VTOL) aircraft, with multiple rotors like

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[25] David Shepardson, *U.S. Probing Collision Between Civilian Drone, Army Helicopter*, REUTERS (Oct. 5, 2017, 12:30 PM), https://www.reuters.com/article/us-usa-military-drone/u-s-probing-collision-between-civilian-drone-army-helicopter-idUSKBN1CA1Z0.
[26] Travis Andrews, *A Commercial Airplane Collided With a Drone in Canada, a First in North America*, WASH. POST (Oct. 16, 2017), https://www.washingtonpost.com/news/morning-mix/wp/2017/10/16/a-commercial-airplane-collided-with-a-drone-in-canada-a-first-in-north-america/?utm_term=.1337b42f8e49.
[27] Jamie Grierson, *Gatwick Returns to Normality but Drone Threat Remains*, THE GUARDIAN (Jan. 4, 2019, 12:32 PM), https://www.theguardian.com/world/2019/jan/04/gatwick-returns-to-normality-but-drone-threat-remains.
[28] Tim Moynihan, *Things Will Get Messy if We Don't Start Wrangling Drones Now*, WIRED MAG. (Jan. 30, 2016, 7:00 AM), https://www.wired.com/2016/01/things-will-get-messy-if-we-dont-start-wrangling-drones-now.
[29] INRIX, *Congestion Costs Each American 97 Hours, $1,348 A Year* (Feb. 11, 2019), http://inrix.com/press-releases/scorecard-2018-us/.
[30] *See id.*
[31] Samantha Masunaga, *A New Generation of Flying Cars is Taking to the Air. But Without the Cars*, L.A. TIMES (Feb. 22, 2019, 5:00 AM), https://www.latimes.com/business/la-fi-flying-cars-20190222-story.html.
[32] *See, e.g.*, Terrafugia, *The Transition*, https://terrafugia.com/transition/.

a helicopter.[33] VTOL aircraft can lift off from existing city infrastructure (such as modified parking garage rooftops) instead of airports or long runways.[34]

Anticipated Operations. Unlike conventional aircraft, these aircraft are intended to fly at low altitudes and across short to medium distances, often in heavily congested areas.[35] Some UAM concepts include plans to fly more than 100 miles per hour and close to one hour on a single battery charge. Current models can be single-seated, or carry as many as five passengers.[36]

Ownership. While some of these concepts contemplate personal ownership and use, other companies' models rely on ride-sharing (i.e., air taxis) to reduce operational costs and ensure accessibility. These companies anticipate these concepts will be an affordable and a viable option for the traveling public, especially in urban areas.[37] Some companies claim their air taxi concepts will be less expensive than personal car ownership.[38]

UAM Integration and Challenges

Safety and Security. Unlike small UAS, which generally weigh less than 55 pounds, UAM concepts will be heavier, typically with a pilot and one or more passengers on board. A mid-flight event, such as a failed battery or structural failure, could pose significant safety risks to the vehicle's occupants and to people and property on the ground, particularly if the vehicle is used in congested urban areas. UAM concepts, like small UAS, will fly in low-altitude airspace, and will need to be safely integrated with conventional airspace users, especially around airports. Not unlike unauthorized helicopter operations, unauthorized UAM operations, such as those over critical infrastructure or other restricted or sensitive areas, could pose even greater safety and security risks than small UAS. [39]

Air Traffic Management. Like small UAS, these aircraft would generally operate in low-altitude airspace (below 400-500 feet); however, some may fly as high as 2,000 feet above ground level. Such operations would pose challenges to traditional FAA air traffic control methods of managing air traffic and separation, particularly in urban settings and with large volumes of these vehicles and small UAS in the vicinity.[40] Technologies currently in development such as UTM—a system that can provide airspace design, dynamic geofencing, conflict avoidance, and separation and sequencing for small UAS—will assist the FAA in safely separating flying cars from other aircraft.[41]

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[33] *See, e.g.*, Aurora Flight Sciences: A Boeing Company, *PAV – Passenger Air Vehicle*, https://www.aurora.aero/pav-evtol-passenger-air-vehicle/.
[34] *See* Gideon Lichfield, *When Will We Have Flying Cars? Maybe Sooner Than You Think*, MIT TECH. REV. (Feb. 13, 2019), https://www.technologyreview.com/s/612891/when-will-we-have-flying-cars-maybe-sooner-than-you-think/.
[35] CRS, *Flying Cars and Drones Pose Policy Challenges for Managing and Regulating Low-Altitude Airspace* (July 23, 2018), *available at* https://fas.org/sgp/crs/misc/IN10934.pdf.
[36] *See* Jeremy Bogaisky, *Your Flying Car May Be Almost Here*, FORBES (May 31, 2018), https://www.forbes.com/sites/jeremybogaisky/2018/05/24/your-flying-car-is-almost-here/#4c7d6aeb5724.
[37] *See* MIT, *supra* note 34.
[38] *See* Uber Elevate, *Fast-Forwarding to a Future of On-Demand Urban Air Transportation*, 3 (Oct. 2016), *available at* https://www.uber.com/elevate.pdf.
[39] *See id. See also* CRS, *supra* note 35.
[40] *Id.*
[41] *Id.*

Pilot Training and Certification. The FAA is charged with ensuring aviation safety, which includes establishing the requirements for a pilot's license and the standards for the design, production, and maintenance of aircraft. In many cases, the FAA's current regulatory framework does not contemplate UAM concepts and their anticipated business models.[42] The FAA will need to provide this framework to allow the safe integration of these new technologies and operations.

Noise and Emissions. Many UAM concepts would rely on electric propulsion technology to operate, thereby having no direct emissions and emitting little noise relative to conventional airplanes and large trucks. Low noise and emissions will be necessary to their acceptance and utility in heavily populated settings.[43]

Weather. A UAM aircraft, like other aircraft, would be much more sensitive than a traditional ground vehicle to inclement weather. To ensure safe operations, these concepts will require the physical and operational standards necessary to avoid unsafe weather and to fly safely in weather conditions like rain and strong wind that do not preclude safe flight.[44]

State and Local Participation. Federal aviation statutes and regulations preempt State and local laws respecting aviation,[45] which includes the regulation of aviation safety, the use of airways, and aircraft certification. The supremacy of Federal authority has led to a consistent regulatory structure for all airspace users, ensuring safety and efficiency across the NAS.[46] In the UAS context, States and cities have sought to enact laws and regulations that control or restrict UAS operations,[47] potentially in contradiction to Federal law. Defining and delineating Federal, State, and local responsibilities with respect to both UAS and urban air mobility will continue to be a topic of discussion and need to be addressed as these operators are safely integrated into the NAS.

SUPERSONIC AIRCRAFT

Supersonic flight is faster than the speed of sound, which can be upwards of 750 miles per hour.[48] The Concorde aircraft performed the first trans-oceanic commercial supersonic passenger flight in 1976, flying at twice the speed of sound and at a cruising altitude of 65,000 feet. Concorde flights could cut the duration of a subsonic trans-Atlantic flight in half. More than 2.5 million passengers flew at supersonic speeds along a limited number of routes until the Concorde terminated service in 2003; no supersonic passenger aircraft have flown since that time.[49]

Several factors contributed to the Concorde's lack of widespread success. Concorde aircraft were expensive to operate, particularly due to high fuel consumption. These high operating costs meant a roundtrip on the Concorde could cost as much as $15,000 U.S. dollars today.[50] The aircraft

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[42] *See id.*; MIT, *supra* note 34.
[43] Uber Elevate, *supra* note 38, at 6.
[44] *See id.* at 70–73.
[45] *See, e.g.*, City of Burbank v. Lockheed Air Terminal, Inc., 411 U.S. 624, 638–39 (1973) (recognizing the need for a "uniform and exclusive system of federal regulation if the congressional objectives underlying the Federal Aviation Act are to be fulfilled").
[46] *See* CRS, *supra* note 35.
[47] *See id.*
[48] CRS, *Supersonic Passenger Flights*, 1 (Nov. 14, 2018), *available at* https://fas.org/sgp/crs/misc/R45404.pdf.
[49] *Id.* at 1–3.
[50] *Id.*

itself also had limited cargo space, preventing airlines from generating additional revenue by transporting cargo or mail. In addition, unlike traditional subsonic flight, the Concorde's design and speed created a "shock wave," experienced by people on the ground as a "sonic boom" as it passed overhead. This aircraft noise led to many countries banning supersonic flights from their airspace, limiting the number of routes the Concorde could fly.[51]

There has been a revival of interest in supersonic flight since the end of the Concorde in 2003. In addition to the time that can be saved traveling at supersonic speeds, the advancement of technology, materials and composites, aircraft design, and manufacturing can make the aircraft lighter, improve fuel efficiency, and reduce noise impacts. Several domestic and foreign airlines have already purchased options for supersonic aircraft in design and testing, and the first delivery of a supersonic aircraft to an airline may occur as early as 2025.[52]

Supersonic Aircraft Integration and Challenges

There are several challenges to the integration of supersonic aircraft into U.S. airspace, beyond aircraft design and public acceptance. Today, there are no international certification, noise, or emission standards for supersonic aircraft under development.[53] In addition, varying operational standards from country-to-country will prohibit many routes at the start. For instance, FAA regulations prohibit supersonic flight in the continental United States that cause a sonic boom.[54]

Congress sought to address some of these issues in the *FAA Reauthorization Act of 2018*. The law requires the FAA to exercise international leadership in the creation of Federal and international policies and standards regarding the certification and operation of supersonic aircraft. The FAA is required to submit a report to Congress with recommended regulatory changes related to supersonic aircraft and a timeline for executing those changes. The law also requires that, within the next two years, the FAA issue notices of proposed rulemaking to update noise standards for supersonic aircraft and to modernize the application process to operate supersonic aircraft.[55]

OTHER FUTURE AEROSPACE TECHNOLOGIES

Looking ahead to 2050, there are a number of exciting technologies, designs, and operational models that have the potential to vastly change transportation. Advances in aircraft, commercial space vehicle, and engine designs, such as the use of composite airframes and parts, hybrid-electric and all-electric engines, and highly flexible, lightweight wings, as well as new commercial space transportation launch vehicles are under development and promise more efficient and environmentally-friendly operations. Alternative fuels and fuel sources also show great promise to reduce aviation's environmental footprint. Commercial space transportation will continue to grow and will need to be safely integrated into the NAS. What this new mode of transportation will mean for travel and shipping on a global level is still to be determined. Technologies to improve air traffic control and space traffic management will need to keep up with new entrants, technologies, and business models. In the next 30 years, there will doubtless be other examples of American

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[51] *See id.*
[52] *See id.* at 6–7.
[53] *Id.* at 7.
[54] *Id.* at 3, 8.
[55] *See* Pub. L. 115-294, § 181.

innovation and ingenuity that cannot even be conceived of today, but will change and improve the safety, availability, and efficiency of the National and global transportation system.

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