NATIONAL AERONAUTICS SCIENCE & TECHNOLOGY PRIORITIES

Product of the

AERONAUTICS INTERAGENCY WORKING GROUP

of the

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

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About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, the environment, and the technological recovery and use of resources, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of Federal research and development (R&D) in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal government. More information is available at https://www.whitehouse.gov/ostp.

About the National Science and Technology Council

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is to ensure science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at https://www.whitehouse.gov/ostp/nstc.

About Aeronautics Interagency Working Group

The Aeronautics Interagency Working Group coordinates science and technology policy, strategy, and Federal R&D pertaining to prioritizing and developing the U.S. Government's strategy for aeronautics technologies under the auspices of OSTP. This effort aims to ensure that U.S. leadership in all topics pertaining to aeronautics, including aviation and space, for scientific research and technological applications is maintained and expanded.

About this Document

This document outlines United States Government strategic priorities to expand U.S. leadership, enable U.S. government-wide collaboration, and support public-private partnerships to ensure continued success in aeronautics. It updates the "2006 National Aeronautics R&D Policy", which coordinated and provided planning guidance for the conduct of U.S. aeronautics R&D through 2020.

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Executive Summary

Since the development of aircraft and the advent of heavier-than-air flight, the United States has been a world leader in aeronautics research and technologies. The U.S. Government has a vision for continued global leadership in aeronautics. This document describes that vision, as manifested by the U.S. Government's top aeronautics strategic priorities, and as shaped by the U.S. Government's guiding principles. As such, this document updates and replaces the "2006 National Aeronautics Research and Development Policy".

The U.S. Government's top aeronautics strategic priorities are: (1) achieving sustainable aviation; (2) transforming the national airspace system; and (3) promoting connectivity and speed.

The U.S. Government is committed to achieving sustainable aviation to reduce and eventually eliminate the greenhouse gas emissions from aviation by implementing the U.S. 2021 Aviation Climate Action Plan and the Climate Adaptation Plans for each Federal department and agency. Maintaining the nation's edge in aeronautics requires increased use of data, software, automation, and artificial intelligence to integrate drones, Advanced Air Mobility aircraft, and other emerging technologies into the National Airspace System. The U.S. Government will also transition its legacy systems, and modernize and adapt regulatory and operational structures. It will continue to invest in maintaining, enhancing, and advancing national security through superior aircraft and technologies, from subsonic through hypersonic technologies, that emphasize speed. The U.S. Government will also promote connectivity through supporting the development of Advanced Air Mobility to enable more connections to less utilized airports and underserved communities, and a competitive airline industry that results in lower costs for air travel.

Across all priorities, the U.S. Government's efforts will be guided by these principles, which reflect enduring American values: (1) Safety, (2) Environment, (3) Economic Competitiveness, (4) Innovation, (5) Security, (6) Workforce, and (7) Equity.

The choices and investments made today will determine our competitive position long into the future. By highlighting these priorities and principles, it is the United States' intent to empower aeronautics stakeholders across the U.S. Government and private sector to work collaboratively toward achieving these goals. The United States will remain globally competitive in aeronautics innovations through ground-breaking research and development (R&D), the implementation of efficient, timely regulations, and close cooperation with domestic and international partners. By achieving the three top aeronautics strategic priorities, the U.S. Government will ensure that the United States remains the global leader in aeronautics in the 21st century and beyond.

Introduction

U.S. leadership in the aeronautics enterprise has long underpinned economic prosperity and national security. The aeronautics enterprise comprises civil and military aircraft and aviation systems, the air transportation management system, aviation infrastructure, and the people involved in the research, design, development, manufacture, operation and use of these aircraft and aviation systems. The aeronautics enterprise is an integral part of the U.S. economy, annually generating 4.9 percent of U.S. gross domestic product—$1.9 trillion in total economic activity in 2019—and more than 10 million jobs.[1] The aeronautics sector is also a major exporter, the second largest manufacturing export sector in the United States, generating $148 billion in exports in 2019.[2] From next-generation fuels, to advances in aircraft design, to improvements in the aviation infrastructure, the aeronautics enterprise is poised for disruption and transformation. As such, continued investment in state-of-the-art aeronautics research and development (R&D) is critical to ensure the continued vitality of this important sector.

One of the major challenges facing the global aviation industry is to reduce the climate impacts of aviation. Consistent with the 2021 Aviation Climate Action Plan[3] and national security policies, the U.S. Government will prioritize efforts to reduce and ultimately achieve net-zero emissions from United States aviation by 2050. These efforts include improved efficiency in flight operations, innovations in engine and aircraft technology, and the use of emerging energy sources such as Sustainable Aviation Fuels (SAFs), electricity, and hydrogen. In light of the International Civil Aviation Organization (ICAO) goals for net-zero carbon emissions, the U.S. Government will prioritize decarbonization to maintain its global economic competitiveness, national security, and benefits to humanity.

The U.S. National Airspace System (NAS) is the most complex, most efficient, and safest airspace system in the world. It accommodates approximately 2.3 million passengers and 66,000 tons of cargo on 25,000 flights daily. These numbers are projected to increase, as emerging aviation technologies such as drones, air taxis, balloons, and the increasingly frequent launch and re-entry of spacecraft, place increased strain on the NAS. Accordingly, it is imperative that the NAS safely transform into the Federal Aviation Administration's (FAA) Next Generation Air Transportation System (NextGen). Transforming into NextGen is necessary to create an optimal operating environment for integrating new aircraft and traffic management systems, while completing upgrades to legacy systems, and enhancing connectivity and speed.

[1] Federal Aviation Administration. "The Economic Impact U.S. Civil Aviation: 2020". https://www.faa.gov/sites/faa.gov/files/2022-08/2022-APL-038%202022_economic%20impact_report.pdf. Released August 2022

[2] International Trade Administration. "Leading Economic Indicators Aerospace Industry". Accessed February 21, 2023. https://www.trade.gov/leading-economic-indicators-aerospace-industry

[3] Federal Aviation Administration. "United States 2021 Aviation Climate Action Plan". https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf. Released November 2021

New aeronautics technologies are providing users of the NAS better connectivity options, with greater speed. Drones offer the ability to perform complex operations faster and more efficiently. Large electric aircraft can move people or cargo around urban environments with greater speed. Quiet supersonic and hypersonic aircraft have the potential to traverse huge distances in a fraction of current times. Autonomous systems can improve operational and energy efficiencies, while promoting sustainability. These advances in connectivity and speed are expected to significantly benefit both economic competitiveness and national security. To that end, the U.S. Government will prioritize maintaining an agile regulatory framework that rewards innovation and technological advances, while promoting safety and sustainability.

The United States will maintain its global leadership in the aeronautics enterprise by supporting R&D to: (1) achieve sustainable aviation, (2) transform the national airspace system, and (3) promote connectivity and speed. The United States will pursue these priorities as guided by seven principles: (1) Safety, (2) Environment, (3) Economic Competitiveness, (4) Innovation, (5) Security, (6) Workforce, and (7) Equity.

Strategic Priorities

The U.S. Government will maintain U.S. leadership in aeronautics by fostering a vibrant, secure, dynamic R&D aeronautics community and workforce that includes government, private industry, and academia. To this end, the U.S. government will pursue three priorities:

I. Achieving Sustainable Aviation

Consistent with the U.S. 2021 Aviation Climate Action Plan, the U.S. Government will achieve its goal of net-zero emissions of greenhouse gases (GHGs) for civil aviation by 2050. It will employ simultaneous lines-of-effort to achieve a future in which GHG emissions will fall to net-zero using cost-effective, efficient approaches. These approaches include: (1) new aircraft and engine technologies to greatly improve environmental performance; (2) operational improvements to substantially reduce energy use and environmental impacts; (3) widespread domestic production and adoption of Sustainable Aviation Fuels (SAF); and (4) exploration and implementation of new and advanced fuels.

The development and introduction of new aircraft and engines is critical to increasing energy efficiency and reducing pollutants as demand for air transportation continues to grow. The U.S. Government will coordinate with aviation stakeholders to support the adoption of these new technologies by airlines. This new generation of efficient low-emissions aircraft will directly support the sustainability of aviation, while increasing the competitiveness of U.S. aviation products globally.

As demand for aviation services grows, new operational technologies and practices are required to avoid congestion and inefficient operations. Opportunities remain for continued investment in infrastructure and air traffic management tools, and improvements in all phases of flight (surface,

takeoff, cruise, and landing operations) to reduce the consumption of fuel and yield efficiencies in regional and nationwide operations.

The U.S. Government will accelerate the development, testing, and certification of SAF, with a focus on "drop-in" jet fuels, which are fuels created from renewable resources that mimic the chemistry of petroleum jet fuel and can be used in today's aircraft and engines. Consistent with the SAF Grand Challenge Roadmap [4], the United States will increase the production of SAF to at least 3 billion gallons per year by 2030, a necessary first step toward the SAF industry providing 35 billion gallons of SAF by 2050. The widespread development of SAF will ensure that key sectors, including aviation, play significant roles in the transition to a net-zero carbon future, ensuring environmental justice, job retention, and economic growth across the United States. Efforts to incentivize the use of SAF are already underway through the Inflation Reduction Act (IRA) (Pub. L 117-169)[5].

The U.S. Government will also phase out 100 low lead aviation gasoline (100LL avgas) known to cause harmful lead emissions. Significant strides have been made in developing, testing, and certifying lead-free replacement fuels. The U.S. Government is committed to continuing to chart a path to lead-free fuel for piston aircraft through the Eliminate Aviation Gasoline Lead Emissions (EAGLE) Initiative.

Finally, the U.S. Government will improve the scientific understanding of the climate impacts of non-CO_2 aircraft emissions, such as aviation-induced cloudiness. It also will continue to lead development of technologies and science-based decision support tools to help mitigate emissions of conventional pollutants and these non-CO_2 climate impacts.

II. Transforming the National Airspace System

The U.S. Government will prioritize the efforts of the FAA's NextGen Program to modernize the NAS. Emerging technologies, increasingly frequent commercial space launches, and high-altitude operations combined with increases in projected demand for traditional passenger travel and cargo shipments require a continued modernization of the air transportation system. The NAS of the near future will seamlessly manage complexity, become scalable, and dynamically adapt to a diverse set of users. Bolstered by the power of technology, this new paradigm will accommodate traditional aviation activities and the new entrants into the NAS. The safe integration of these aircraft at all levels of airspace challenges current monitoring systems; communications, navigation and surveillance infrastructure; and the regulatory environment. R&D will help mature these advanced technologies, supporting infrastructure, and the regulatory framework for the certification of new aircraft and technologies.

[4] Department of Energy, Office of Energy Efficiency and Renewable Energy. "Sustainable Aviation Fuel Grand Challenge Roadmap: Flight Plan for Sustainable Aviation Fuel". September 2022. https://www.energy.gov/sites/default/files/2022-09/beto-saf-gc-roadmap-report-sept-2022.pdf

[5] Congress, "Inflation Reduction Act". Text - H.R.5376 - 117th Congress (2021-2022): Inflation Reduction Act of 2022 | Congress.gov | Library of Congress

As part of this transformation, the U.S. Government will prioritize the comprehensive integration of new aeronautics technologies, with the potential to transform aviation, in both urban and rural communities, creating new industries and jobs. These technologies include small drones and Advanced Air Mobility (AAM) vehicles, such as electric vertical takeoff and landing (eVTOL) aircraft, electric short takeoff and landing (eSTOL) aircraft, and other highly automated electric passenger or cargo carrying aircraft. The future NAS will incorporate strategies for the safe, efficient integration of civil and national security operations, ranging from slow, low altitude operations with observers to those conducted beyond the pilot's Beyond Visual Line-Of-Sight (BVLOS) at a variety of altitudes and speeds.

The U.S. Government will support updates to the regulatory framework for the certification of new aircraft and technologies, thereby fostering the safe, secure growth of the drone and AAM industries. The U.S. Government will continue to expand drone certification and integration to accommodate the multiple personal and business uses of drones in the NAS as well as support research and training at the many colleges and universities that offer drone programs. The U.S. Government will also promote the safety of pilots, passengers, and the general public by updating infrastructure, training, and certification processes to operationalize AAM services. The U.S. Government will support the development of scalable AAM solutions to permit the growth of applications such as cargo and package delivery and emergency services. It will maintain research facilities and upgrade as needed to keep pace with emerging technologies, including Vertical Lift Research Centers of Excellence, and test facilities such as flight simulation and wind tunnels.

The future of flight is highly automated. Integrating autonomous processes and vehicles into the airspace of the future requires that autonomous vehicles have healthy self-monitoring systems and high-fidelity awareness of their surroundings, especially adjacent traffic. Certification of new vehicle architectures will need to ensure the reliability of the software and sensor suites to effect mature, safe, and stable flight.

In October 2022, the Advanced Air Mobility Coordination and Leadership Act was signed into law (Pub. L 117-203)[6] to coordinate efforts to integrate new aviation technologies into the NAS. Consistent with the law, the Department of Transportation (DOT) will work with relevant Federal departments and agencies to create a national strategy to implement the law, while ensuring continued U.S. leadership in these technologies.

III. Promoting Connectivity and Speed

Air travel quickly moves people and cargo around the nation and the world, and connects people with each other at unprecedented speeds. It plays a critical, unique role in the nation's transportation

[6] Congress, "Advanced Air Mobility Coordination and Leadership Act". https://www.congress.gov/bill/117th-congress/senate-bill/516/text

system. The U.S. Government will continue exploring new technologies that will enhance global connectivity at greater speed.

As the U.S. Government prioritizes the integration of new aerospace technologies into the NAS, these technologies have the potential to provide improved connectivity and speed to communities across the country. AAM vehicles operating as would-be air taxis have the potential to provide people with a new and exciting way to move around their communities. Drones flying at BVLOS can be used to transport high-value goods such as medical supplies point-to-point with unprecedented speed and efficiency. The U.S. Government will create pathways to ensure these technologies can be safely, equitably, and sustainably incorporated into the NAS, thereby promoting connectivity and speed.

To remain a global leader in aeronautics, the U.S. Government will advance connectivity and speed, while maintaining the unprecedented safety of air travel, and ensuring the environmental sustainability of the aviation sector. Beyond improvements to operations for traditional subsonic aircraft, increasing airspeed provides another approach to enhancing connectivity. Supersonic flight is defined as speeds faster than the speed of sound (Mach 1). Supersonic flight has seen emerging commercial interest for cargo and passenger transportation. Hypersonic flight is defined by flight in the earth's atmosphere at speeds greater than Mach 5 for extended periods of time. It also draws upon and drives development of technologies in both air and space domains. Hypersonic flight systems will shorten national security crisis response times, while providing unique capabilities to the aeronautics enterprise. The U.S. Government will develop these technologies and systems via national collaborations across the Federal government, industry, academia, National Laboratories and Federally Funded Research and Development Centers, and University Affiliated Research Centers, as well as collaboration with allies and international partners.

For supersonic flight, the U.S. Government will enable the generation of key data to support the development of enroute certification standards based on acceptable noise levels. It will take a systematic approach involving aircraft development, acoustic validation, and community response testing. R&D will be required to solve the other challenges of sustainable supersonic transportation, including reducing landing and take-off noise and high-altitude emissions, and significantly increased airframe and engine efficiency.

Hypersonic flight systems could, in the future, support national needs for time-critical transportation of cargo, people, and payloads. R&D related to hypersonic applications, ranging from aerodynamics to high-speed propulsion, advanced materials, and resilient guidance, navigation, and control, is critical for U.S. national security. The U.S. Government will continue to empower private-sector innovation to realize a vision for aircraft-enabled, reusable space vehicles through hypersonic flight.

Guiding Principles

To maintain its leadership in the aeronautics enterprise, U.S. Government efforts will be guided by seven principles, which reflect American values.

1. Promoting Safety

The U.S. Government will continue to prioritize safety while fostering innovation to capture the benefits of technological progress. Automated systems need to be safe without impeding software updates or machine learning capabilities. U.S. Government and industry stakeholders need to continuously update systems to meet the needs of the aeronautics community, while continuing to manage safety risks. The United States will promote the continued safety of air transportation as new technologies are integrated into the NAS. In partnership with the aeronautics enterprise, the U.S. Government will maintain public confidence in the safety of the NAS and will continue to invest in systems that facilitate air traffic control and support collision avoidance. Federal departments and agencies will continue to promote the commercial availability of alternate sources of positioning, navigation, and timing to a create a more resilient aviation enterprise.

2. Protecting the Environment

Aviation noise impacts communities near airports, and emissions of conventional pollutants substantially degrade local air quality. Emissions from aviation must be dramatically reduced to achieve net-zero GHG emissions by 2050, from U.S. commitments to decarbonize shared skies with other nations to local communities, where the impact of aviation becomes a community concern. The U.S. Government will promote game-changing research and technological innovations, while advocating for timely state, local, and international policies, to reduce emissions and achieve quiet, clean, energy-efficient air transportation. To achieve these goals, the U.S. Government will work with aviation stakeholders to implement the actions on the aeronautics enterprise stipulated in the U.S. 2021 Aviation Climate Action Plan.

3. Advancing Global Economic Competitiveness

The ability to compete is critical to preserving the role of the United States as the world's leading economy. The U.S. Government will support efforts to create and sustain high-skill, high-paying jobs. The U.S. Government will continue to support entrepreneurs that experiment, innovate, and pursue new ideas in a market that allows all types of businesses to flourish, resulting in improved choice, better service, and lower costs for consumers. The U.S. Government will create systems that foster and enable private sector innovation and international collaboration. Examples include promoting standards and regulatory approaches that support aviation industry's efforts in new technology and innovations, and supporting high-risk design and development approaches for rapid transformation of the technology to increase the Technology Readiness Level (TRL).

One avenue for academic, private sector, and government cooperation is ensuring infrastructure and testbeds are available to the community, consistent with airspace safety and national security considerations. The U.S. Government will provide a safe, timely, responsive regulatory environment, consistent with national security and foreign policy considerations, that supports the infusion and agility needed for new technologies. The U.S. Government will work with ICAO and other international organizations to develop cost-effective, cooperative international standards and regulatory approaches, while promoting safety and sustainability.

4. Accelerating Innovation

The U.S. Government will prioritize R&D investments that expand the boundaries of flight by maturing new technologies and designs through agile development and digital engineering to reduce development times and costs. It will prioritize accessible, domestic, long-term and applied R&D, and the design, testing and evaluation (RDT&E) and manufacturing of emerging aeronautics technologies. It will also draw on expertise at academic institutions to provide independent scientific advice to inform U.S. Government R&D programs and planning processes, and advance a strong U.S. academic community dedicated to aeronautics.

The U.S. Government will coordinate the efforts required to sustain and advance the nation's RDT&E infrastructure, including computational and experimental facilities. It will work with the aeronautics enterprise on training, evaluation, and standards development to better enable new aviation technologies and the regulatory framework required for safe and secure operations. The U.S. Government will continue to promote high-risk, high-reward near- and long-term innovative technologies and solutions that are beyond the scope and time horizon of commercial entities. This includes R&D on advanced energy storage technologies, hydrogen, electricity, alternative fuels, and other technologies needed to reduce GHG emissions. Priority technologies include autonomy, artificial intelligence and machine learning, secure hardware and software systems, high-strength materials, lightweight battery and charging technologies, advanced propulsion systems, new design tools to enable agile development, and new fuels that will result in lower carbon emissions and more efficient operations. The U.S. Government will continue to promote the importance of the regulatory enterprise working closely with the aeronautics enterprise to enable the rapid transition of technologies to new commercial products.

5. Strengthening National Security

The aeronautics enterprise is vital to strengthening the U.S. national security and homeland defense. It is a critical aspect of America's national security strategy, providing needed capabilities to defend U.S. interests. New aeronautics technologies, such as supersonics and hypersonics, are being developed for national security purposes, and are becoming important components of U.S. defense.

All elements of aircraft and the air transportation system must be secure to protect people and goods within the aeronautics enterprise. The U.S. Government will prioritize a secure, agile aviation

technology system that supports air transportation. Modern information technology systems with clear cybersecurity standards and supply chain risk management best practices are critical to aviation operations and integral to building trust in the aeronautics enterprise. To this end, the U.S. Government will prioritize secure-by-design hardware and software systems to build trust and resilience.

6. Developing the Workforce

The U.S. Government will develop the aeronautics workforce by investing in people. To enable a robust, technologically-advanced aeronautics R&D environment, the United States will continue to cultivate human talent and creativity by fostering a vibrant, innovative academic community dedicated to aeronautical technical disciplines. It will promote access to aeronautics activities, technology, and infrastructure for academic use through partnerships with academic institutions. The U.S. Government will continue to engage communities to build relationships for supporting STEM opportunities linked to aeronautics research priorities, and create timely, engaging activities for youth to discover and experience real-life applications of STEM skills. The U.S. Government will identify and provide opportunities to expand the applicant pool for jobs in the aeronautics enterprise, while attracting youth through fellowships, internships, apprenticeships, and other work-based learning experiences.

The growing sector presents an opportunity to educate and employ people from underserved communities and from backgrounds currently underrepresented in science, technology, engineering and mathematics (STEM). A focus on developing a skilled, interdisciplinary technical workforce drawing on trade schools, community colleges, tribal schools, as well as traditional four-year college degrees and universities, will increase diversity in and contribute to the evolution of the aeronautics enterprise.

7. Prioritizing Equitable Access to Air Transportation

Air transportation must remain broadly affordable and accessible. AAM has the potential to transform commercial aviation, connecting underutilized airports in rural communities to other locations. Like high-quality roads, connectivity enables rural and underserved communities to access more opportunities.

Future air transportation should serve all communities wherever they may live. In July 2022, the U.S. Government announced a new set of disability policy priorities, which underscore the importance of inclusion, dignity, and non-discrimination. To this end, the U.S. Government will prioritize airport improvement projects, domestically and internationally, designed to increase mobility, expand access, and improve connectivity for people with disabilities and reduced mobility.

Role of the U.S. Government

The U.S. Government views its roles as a long-term regulator and enabler of a thriving global aeronautics enterprise. True leadership in aeronautics research and aviation sustainability will be attained through cohesive, flexible functions across the interagency, eliminating redundancies and

misaligned timelines. The U.S. Government programs will aid the private sector in transforming the aeronautics enterprise. These programs will foster increasingly rapid development of technologies to higher TRLs through coordinated partnerships among Federal departments and agencies. For instance, National Aeronautics and Space Administration (NASA)-sponsored research for air traffic management is being developed in close collaboration with the FAA and the aviation community.

The U.S. Government will disseminate research results, consistent with national security, domestic, and foreign policy guidelines, to support the development and commercial adoption of the resulting technologies. It will provide the data needed to inform new standards and regulations for the adoption of new technologies in aircraft architectures. Department- and agency-specific U.S. Government roles include:

Department of Commerce (DOC)

DOC recognizes aeronautics as a critical sector in the U.S. economy and works across its bureaus to promote investment, innovation, safety, and standards across the industry. In pursuit of weather and climate forecasting advancements, the National Oceanic and Atmospheric Administration (NOAA) equips its aircraft with cutting-edge technology focused on environmental research and weather forecasting. Improvements in weather forecasting are critical to the guiding principles of promoting safety, protecting the environment, and strengthening national security. NOAA supports innovative research and development on uncrewed systems for collecting data to support its mission of science, service, and stewardship. New technologies and concepts in uncrewed systems that are developed by NOAA or through NOAA programs in partnership with others are often transitioned into use within NOAA or U.S. industries to maintain NOAA's and the U.S. position as global leaders in environmental observations. Additionally, NOAA provides weather observations, forecasts, and weather decision support to the Federal Aviation Administration as part of the mission to maintain the safety and efficiency of flight in the operation of the National Airspace System. As climate change impacts and mitigation measures are considered more broadly by the aviation industry, NOAA services can support optimum long-haul routing - to increase efficiency and lower carbon emissions - and airport density altitudes, which will impact long-term airport capacities.

The National Institute of Standards and Technology (NIST) supports the aeronautics supply chain through direct interactions with the suppliers. The Hollings Manufacturing Extension Partnership (MEP) National Network of 51 Centers (one in each state and in Puerto Rico) engages annually with hundreds of projects and individual manufacturing clients in the aeronautics industry. A majority of these clients are small manufacturers (those with fewer than 100 employees). The work done by NIST MEP and its Centers has resulted in the creation or retention of thousands of aeronautics jobs and billions of dollars in new and retained sales, new investments, and in cost savings. MEP is aligned with National Aeronautics Science & Technology Priorities with emphasis in smart manufacturing by helping small and medium-sized manufacturers, including transportation firms, to integrate physical and digital processes within factories and across other supply chain functions to optimize current and future

supply and demand requirements. In addition, NIST laboratories conduct R&D at the cutting edge of technologies integral to the aeronautics sector. NIST also provides calibration services that ensure that makers and users of precision aeronautics instruments achieve the highest possible levels of measurement quality and productivity.

The International Trade Administration (ITA) supports the international competitiveness of U.S. manufacturers in all sectors by promoting trade and investment, ensuring resilient supply chains to support economic and national security, advocating for U.S. businesses in international markets to promote exports and ensuring fair trade through the rigorous enforcement of our trade laws and agreements. ITA is closely engaged with industry partners working on emerging technologies, in such areas as advanced air mobility, sustainable aviation technology, and high-speed flight to ensure that U.S. companies have the tools to grow and succeed in foreign markets. ITA will continue to advance U.S. competitiveness in the aeronautics sector through exports and assisting emerging aeronautics technology companies to become export-ready.

Department of Defense (DoD)

DoD will enable the United States to continue leading the world in aeronautics innovation for national security purposes. Informed by the National Security Strategy[7] and National Defense Strategy[8], DoD will strengthen and maintain its technological advantage through research, science, technology, engineering, innovation, and deployment of advanced capabilities. DoD will invest, develop, and apply technology (modeling and simulation and design tools), test infrastructure, and workforce development to support key national security challenges.

DoD technology areas supporting aeronautics innovation include advanced materials, renewable energy and storage, hypersonics, and digital transformation. Hypersonics will dramatically shorten U.S. response timelines and increase survivability in times of crisis or conflict. Digital transformation will revolutionize and accelerate optimized decision making by coupling aircraft design with mission utility analyses. The DoD will work with universities to develop new curriculum and applied programs to ensure a future generation of specialists with digital skill sets.

Artificial Intelligence and machine learning, autonomy, aerothermodynamics, quantum sensing and other resilient position, navigation, and timing technologies are imperative for operational effectiveness. Advancements in renewable energy generation and storage, including electronic engines, more efficient batteries, and alternative fuels, are also critical. The electrification of future DoD

[7] White House. "National Security Strategy". https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf. Released October 2022

[8] Department of Defense. "National Defense Strategy". https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF. Released October 2022

aircraft platforms will include electric propulsion systems that will achieve the national objective of net-zero emissions by 2050.

Department of Energy (DOE)

DOE invests in energy and environmental challenges including R&D in renewable fuels for aviation, hypersonics, new materials and new manufacturing processes applicable to many aspects of the aeronautics industry. For example, the DOE will continue its role as a lead agency in the Sustainable Aviation Fuels Grand Challenge through funding R&D that will enable delivery and conversion of sufficient volumes of biomass and waste feedstocks to biofuel intermediates that can meet industry-relevant cost and performance requirements, with a focus on SAF capable of >70% reduction in GHG emissions relative to petroleum. In addition, DOE supports scale-up of high-volume, cost-effective biofuel production pathways for SAF capable of >70% GHG reduction by enabling the construction and operation of demonstration-scale integrated biorefineries, while continuously advancing innovation to reach net-zero emissions. The goal is to produce enough net-zero aviation fuels to meet the demand of the aviation industry by 2050.

DOE conducts R&D to develop materials and processes to reduce the cost and improve the performance of batteries for stationary storage and ground vehicle applications. Advances could be used potential of use in small aircraft for intracity passenger travel and cargo delivery. Research, testing, and prototyping of new innovative on-aircraft energy storage technologies will be conducted across the full range of aircraft sizes. DOE's investment in hydrogen production and silicon-carbide nanofiber composites can support the future of small hydrogen-powered aircraft and continued investment in lowering the cost of advanced materials, such as aluminum-cerium alloys can lower the weight and increase the strength of structural components for aerial vehicles.

DOE stewards a suite of national scientific user facilities that provide researchers with the most advanced tools of modern science – from the most powerful light sources for characterizing new materials and devices to the most advanced supercomputers operating at exascale. These facilities will be leveraged to advance innovative aeronautics concepts through advanced materials development and artificial intelligence and machine learning aided co-design.

Department of Transportation (DOT)

As the primary regulators of the aviation industry, the DOT and the FAA foster innovation while maintaining aviation safety through the establishment of enabling policy and regulations. The certification of aircraft, pilots, air service companies, and the provision of air traffic management are all key responsibilities of the FAA, while the DOT has authority for economic licensing of air carriers, and policies that promote competition and aviation consumer protection.

The over 2.3 million passengers on 50,000 flights that move daily through the NAS could increase by 50 percent by 2027. The United States is focused on completing the FAA NextGen. NextGen is already improving safety, capacity, and efficiency on runways and in our skies while reducing the consumption of aviation fuel, GHG emissions, and noise. The FAA collaborates with stakeholders on this long-term strategic plan by improving (1) air traffic control system reliability and predictability, (2) efficiency and thus environmental sustainability, and (3) air traffic control system capacity, all undergirded by the axiomatic commitment to maintaining safety. The NAS continues to build on past successes in deploying Performance Based Navigation, especially for departures and arrivals; shifting strategic air-to-ground communication from radio voice to data communications; and deploying a second-to-none surveillance infrastructure. Strengthening bilateral agreements with partner nations and supporting sustainability goals for net-zero GHG emissions by 2050 will position the FAA to lead aviation and will ensure the United States' global technological competitiveness.

Grant programs such as DOT's Strengthening Mobility and Revolutionizing Transportation grants, FAA's aviation workforce grants, and Fueling Aviation's Sustainable Transition grants offer opportunities for communities and industry to focus on advanced smart community technologies, the development of the aviation workforce and the advancement of SAFs. Public-private partnerships like the Continuous Lower Energy, Emissions and Noise Program work to accelerate the development of aircraft technologies that reduce fuel consumption, and emissions and noise in the next generation of aircraft. The DOT and the FAA will continue to engage directly with industry and communities to optimize the efficiency of aviation operations while mitigating aviation noise and emissions.

National Aeronautics and Space Administration (NASA)

NASA leads high-risk, high-reward research and development of innovative technologies and solutions to address the most difficult technical aviation challenges, contributing to U.S. leadership in the global aeronautics industry. NASA partners with academia, entrepreneurs, industry and other federal departments and agencies to fuel innovations that grow the economy and high-paying jobs, while improving life on Earth.

Cost-sharing partnerships with U.S. industry and collaboration with other federal agencies through the Sustainable Flight National Partnership (SFNP) will develop and demonstrate in the late 2020s the technologies required for game-changing, ultra-efficient aircraft that will be needed to meet aggressive climate and efficiency goals. Through the SFNP, NASA will partner with aviation stakeholders to demonstrate a suite of aircraft technologies by 2030 that collectively could lead to a 30 percent reduction in fuel burn, while reducing noise and emissions of conventional pollutants. Employing these advanced technologies, new narrow-body aircraft, with a step change in environmental performance could enter the fleet in the 2030s; new wide-body aircraft could enter in the 2040s. NASA also leads exploratory research of aircraft and propulsion systems such as those designed to take advantage of novel, non-drop-in energy sources such as cryogenic fuels, or to incorporate hybrid- or fully-electric

propulsion technologies. NASA assesses the feasibility and climate impacts of sustainable aviation fuels and other non-traditional fuels, and the associated technologies to enable their safe adoption.

NASA systematically works to understand and overcome barriers to increasing connectivity and speed of aviation. NASA will assess community acceptability of quiet supersonic technology through flight demonstrations using the X-59 quiet supersonic aircraft, and will seek solutions to other challenges associated with landing and take-off noise, upper atmospheric emissions, and aircraft efficiency. NASA will advance the understanding and development of critical fundamental technologies necessary for hypersonic flight, and provide world-class U.S. experimental computational, ground, and flight R&D capabilities and expertise relied on by the Nation.

NASA explores cutting edge airspace and safety management tools and demonstrates them in collaboration with industry, the DoD, and the FAA for transition and operational integration. For instance, NASA and FAA are developing a long-term vision for a transformed NAS with safe, scalable, high-tempo airspace access for all users, and pioneering operational automation to safely and automatically optimize flight routes for minimum environmental impact. NASA research in AAM vehicles and operational concepts will establish the foundation for private sector innovation that will transform the way people and goods move through our National Airspace System.

NASA leverages Small Business Innovation Research and Small Business Technology Transfer programs to drive aeronautics innovation across these priorities, engaging small businesses, research institutions, and entrepreneurs in vehicle and airspace management exploratory research. Both programs foster commercial application of research results and encourage participation of socially and economically disadvantaged persons and women-owned small businesses. NASA serves as a catalyst for novel innovations through public challenges and prize competitions. NASA partners with universities to explore advances that can transform aviation and build the next generation workforce.

National Science Foundation (NSF)

NSF invests in research across the breadth of core sciences, including fundamental and translational research and education in all fields of science, engineering, technology, and mathematics and the development of the workforce to help advance aeronautics. Some of these topics include Autonomy and Artificial Intelligence and Machine Learning; advanced materials and structures; future manufacturing; embedded sensors and algorithms; innovations in battery and energy storage technologies; innovations that make hydrogen a viable fuel; fundamental advances in SAFs; increased understanding of thermal aerodynamics and noise through experiments; lifecycle environmental assessment; understanding of equity impacts on underserved communities; tool development; and the development of new measurement techniques. Through the Directorate for Technology, Innovation and Partnerships, NSF also offers programs for translation to practice, moving core science and engineering research to the market place, and capitalizing on the ability of startups and small business

to bridge current gaps and quickly develop new entrepreneurial approaches to solving the challenges of sustainability, speed and scale in the aeronautics industry.

NSF will continue to focus on a skilled, interdisciplinary technical workforce through engagements with secondary school settings, community colleges, and other institutions of higher education including Minority-Serving Institutions, Historically Black Colleges and Universities, Tribal Colleges, and Universities, and Alaska Native and Native Hawaiian-Serving Institutions to broaden participation in aeronautics. In addition, NSF does and will continue to provide fellowships, scholarships, traineeships, and grants to reach the "Missing Millions" to generate opportunities for bright prospective students to achieve their dreams in the STEM workforce, of which aeronautics is one part of STEM.

National Transportation Safety Board (NTSB)

The NTSB's top strategic priority is to be prepared to investigate accidents involving emerging transportation technologies and systems. Innovations in transportation, such as uncrewed aircraft systems, advanced air mobility, supersonic aircraft, and clean energy propulsion will continually challenge the NTSB to grow and expand investigation processes and tools. The agency has established a multimodal emerging technologies team to ensure NTSB investigator professional development and develop best practices for investigating such technologies. The team continues to collaborate with government and industry stakeholders to advocate for emerging transportation technologies to record the necessary data to fully understand the circumstances after any future mishap the agency would investigate.

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