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Statement of

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before the

Subcommittee on Space and Aeronautics Committee on Science, Space, and Technology
U.S. House of Representatives

Chair Horn, Ranking Member Babin, and Members of the subcommittee, I am pleased to have this opportunity to discuss the FY 2020 budget request for NASA's Aeronautics Research Mission Directorate (ARMD). I would like to thank you for your continued support of NASA and the groundbreaking work we are doing in ARMD. We are at a pivitol point within the agency as we focus on important programs and projects like Artemis agency-wide, and commercial supersonic flight, electric propulsion and Unmanned Aerial Systems integration among others within ARMD.

I mentioned Artemis. Artemis is the name of NASA's lunar exploration program that will send the first woman and the next man to the South Pole of the Moon by 2024 and develop a sustainable human presence on the Moon by 2028. Artemis takes its name from the twin sister of Apollo and goddess of the Moon in Greek mythology. Our hope is that this program, and the full complement of NASA missions will serve to inspire the Artemis generation to continue to explore, discover, and achieve.

NASA is working to build a sustainable, open architecture that returns humanity to our nearest neighbor. We are building for the long term, utilizing the Moon as a proving ground for humanity's first crewed mission to Mars. We are intending to design an open, durable, reusable architecture that will support exploration for decades to come. Sustainability requires reusable systems and partnerships from across the commercial sector and around the world. Robotic scientific missions delivered by commercial landers will be the first Artemis elements to land on the Moon. NASA is completing development of both the Orion spacecraft that will carry humans to lunar orbit, and the Space Launch System (SLS) rocket that will launch Orion.

We have capitalized on commercial, industry, international and university partners to advance aeronautics research to support design, technology and safety. We will continue to apply these partnerships in the Artemis program to incentivize the best in these areas for exploration.

Aviation moves the world, and an efficient and safe air transportation system is fundamental to the future of the U.S. economy. NASA's cutting-edge aeronautics research is delivering new concepts and technologies that will change the face of aviation as we know it, boosting U.S. technological and economic leadership in this global industry and creating high quality American jobs. Growing consumer demand, combined with development of innovative technologies and disruptive thinking are leading to transformation of the aviation sector in ways we could hardly imagine just a few years ago.

Aviation generates $1.6 trillion in total U.S. economic activity a year, and contributes about 5 percent of the U.S. Gross Domestic Product.[1] Aviation in the U.S. supports 10.6 million direct and indirect jobs,[2] and generates the largest positive trade balance of any manufacturing sector, over $84.8 billion per year.[3]

Tomorrow's aviation system will change the world. People and packages will move more quickly, and in new ways. Tomorrow's aviation system will still be safe and efficient, but now much more widely accessible to all citizens. Aviation enables new ways of living, working and connecting with others. Exciting new technology and changing consumer demand will change our relationship with aviation. Today's explosion of new business models for ground transportation (such as ride sharing and package delivery) is taking to the air, enabling an entirely new aviation mobility market and opportunity space for tomorrow.

These trends are real. Innovation and growing global economies will double global passenger air travel in the next twenty years as new products are introduced. Air travel will expand as economies grow and develop.[4] Boeing predicts demand of 42,730 new aircraft in the next twenty years and a market worth over of $6 trillion.[5] According to Airbus, there will be another $3 trillion in aftermarket services needed in that time period.[6] High speed flight – faster than the speed of sound – will open up new routes and new opportunities for air travel around the world.

This growth in aviation means jobs. Boeing has projected that aviation will need 790,000 new pilots by 2037 to meet growing demand, with 96,000 pilots needed to support the business aviation sector.[7] There will be similar growth in jobs for manufacturing, technicians, and aviation services, as well as new jobs created as a result of new economic opportunities..

Global competition is fierce in this sector as companies and countries seek to capture a larger share of this growing market and high wage jobs. U.S. and European companies traditionally

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[1] The Economic Impact of Civil Aviation on the U.S. Economy," Federal Aviation Administration, November 2016, Page 20, PDF

[2] The Economic Impact of Civil Aviation on the U.S. Economy," Federal Aviation Administration, November 2016, Page 20, PDF

[3] The Economic Impact of Civil Aviation on the U.S. Economy," Federal Aviation Administration, November 2016, Page 20, PDF

[4] 2036 Forecast Reveals Air Passengers Will Nearly Double to 7.8 Billion," International Air Transport Association, October 24, 2017, Web Page

[5] https://www.boeing.com/commercial/market/commercial-market-outlook/

[6] https://www.airbus.com/newsroom/press-releases/en/2016/07/airbus-forecasts-3-trillion-commercial-aviation-aftermarket-services-over-the-next-20-years.html

[7] https://www.boeing.com/commercial/market/pilot-technician-outlook/2018-pilot-outlook/

have divided the global market for large civil aircraft and equipment. Now China is investing heavily in aerospace, starting up a new company to build large commercial aircraft to lure some of the large civil aircraft market share. Russia and Japan are seeking to break into the regional jet market, and companies from all around the world are seeking market share for smaller unmanned systems and vehicles.

NASA Aeronautics is uniquely positioned to be the catalyst for this exciting future, and to ensure that the U.S. maintains a strong leadership role. We have been a global leader in creating and realizing amazing advances in aviation for generations, developing new technologies and new concepts for how the aviation system can be better, faster, and more efficient. NASA Aeronautics research has been incorporated into nearly every aircraft flying today. The United States has the safe, global air transportation system we have today in part because of NASA research.

NASA's research today in areas such as composite materials, new airplane concepts, air traffic management, and safe routine integration of unmanned aerial systems (UAS) into the National Air Space is forging the path to the future of aviation.

NASA works with U.S. aviation community and government partners to create opportunities for American businesses, raising the level of performance for all participants. NASA has a vision for what is possible, based on deep insight into the goals and needs of the aviation community and U.S. industry engagement early in the technology development cycle. We invest in aeronautics research to address the most critical challenges, always with an eye toward the practical application of the results. We bring the most promising technologies to flight to demonstrate them in a realistic environment, in collaboration with our U.S. industry partners whenever appropriate. Partners leverage NASA's investments through joint efforts that complement the agency's internal capabilities, provide access to a wide range of technologies beyond the traditional aeronautics portfolio, and facilitate technology transfer to more mature states of development and eventual implementation.

One critical government partner to NASA is the Federal Aviation Administration. We work closely with FAA leaders and technical experts to ensure our research meets their long term needs, and the results of our research can be transitioned and inform their investment decisions. Our successful model for collaboration is embodied in Research Transition Teams (RTTs), which are designed to develop technology for NextGen advancements in critical areas and effectively transition advanced capabilities to the FAA for certification and implementation. RTTs serve as the bridge between NASA's long term technology R&D, and FAA's near term R&D to support implementation and certification of new technologies and systems. Under RTTs, NASA and FAA develop joint research plans and fund their respective portions of the planned research according to the nature of the research, stage of research, and their relative capabilities. Data from our research results are used to develop standards and regulations through rulemaking committees and domestic and international standards bodies.

To achieve our future vision for aviation, NASA is investing in discovery of new concepts and technologies in a few key areas.

Routine supersonic passenger travel will enable passengers to make current long journeys into day trips. However, current rules prohibit supersonic flight over land, a reaction to the public's objection to noisy supersonic Concorde flights in the 1970s. Over the past decade, NASA fundamental research and experimentation has demonstrated the possibility of supersonic flight with greatly reduced sonic boom noise, but the rules prohibiting over-land supersonic flights remain. In order for this sector to take off, regulators need proof that the public will accept these quieter supersonic flights. NASA now is building a quiet supersonic experimental aircraft – X-59 QueSST – to provide this proof, with a commitment for first flight by FY 2022.

Once built, NASA researchers will measure public acceptance of the technology by flying the X-59 over a handful of U.S. cities. This data will be delivered to the Federal Aviation Administration and the International Civil Aviation Organization to support the development of new rules allowing commercial supersonic flight over land. This capability will position the U.S. aviation industry to supply global customers with future supersonic aircraft products.

Subsonic aircraft will still carry the majority of passengers in the foreseeable future, but those aircraft most likely would be different from today. Large leaps in aircraft efficiency coupled with reductions in noise and harmful emissions are critical to the environmental sustainability of aviation. Through technical advances by NASA and industry in the coming years, it is likely that future aircraft may look different, may be made from different materials, may be powered differently, and may even be designed and manufactured differently.

NASA is collaborating with U.S. industry to investigate innovative technology for subsonic aircraft such as advanced configurations and wing design, transformative structures, propulsion-airframe integration, and small core turbine engines.

NASA also is leading research into new components, technologies and powertrain architectures for electric or hybrid electric systems that can bring about revolutionary improvements in small and large transport aircraft. NASA's research on developing an all-electric, general aviation size experimental airplane – the X-57 Maxwell – already is delivering to the community important lessons about designing, building and operating an all-electric system. Ground tests this year and flight tests next year will provide valuable insights into the challenges and opportunities of electric aircraft and serve as the building blocks for industry to create future safe and certifiable aircraft designs.

NASA recently completed single-aisle transport aircraft concept studies with industry to develop hybrid gas-electric propulsion concepts and assess the potential benefits for larger vehicles such as regional transports and airplanes as large as a Boeing 737.

Building on these activities, NASA has begun a multi-year effort to solve the technical challenges of a 1-Megawatt (MW) power electric propulsion system – enough energy to power 165 homes. NASA will refine concepts and technologies and validate new electric systems through ground and flight tests. A shift to hybrid-electric or all electric propulsion from modern turbofan engines could yield a significant fuel savings, with a dramatic impact on airline operating costs. Realizing a practical 1-MW electric propulsion system has never been accomplished and is an area of notable international competition. To support this work, NASA has commissioned a world-leading NASA Electric Aircraft Test Facility (NEAT) capable of conducting full scale ground test of high-power electric propulsion systems.

Future aerospace design and manufacturing processes will be more efficient, reducing the time and cost required to build aircraft. Future computational design and certification capabilities of advanced materials required for emerging aeronautical vehicle applications are identified in NASA's "Vision 2040: A Roadmap for Integrated, Multiscale Modeling and Simulation" report and the CFD 2030 report. Next year, NASA will complete the Advanced Composites Project, a six-year focused effort with industry to significantly reduce the time needed to develop and certify new composite structures for aerospace applications.

Autonomy and increased automation bring new opportunities to do the things we already do even better, but also hold the potential to open new markets and create new benefits that are not yet possible. In 2020, NASA will complete demonstrations of technologies to integrate operations of larger Unmanned Aircraft Systems (UAS) in the existing National Air Space (NAS) as well as manage smaller UAS vehicles safely at lower altitudes.

NASA recently completed the most complex demonstration yet of the UAS Traffic Management System or UTM in Reno, Nevada. These demonstrations are proving that the UTM concept can safely and efficiently manage flights of small UAS in dense urban environments, and represent an important step toward commercial adoption of the UTM concept.

Those efforts are providing the foundation for another major transformation of the aviation sector being led by NASA – creation of an urban air mobility or UAM system that is safe, economical and environmentally friendly to move people and packages in population centers, forever changing how citizens around the world benefit from aviation. UAM vehicles can range from small delivery drones to passenger-carrying air vehicles that have electrically-powered Vertical Take Off and Landing (eVTOL) capability.

NASA will begin a new Advanced Air Mobility project in FY 2020 to enable the emergence of UAM. NASA is preparing a series of "Grand Challenges" that will provide a means to assess the maturity of key systems for Urban Air Mobility. Through these Grand Challenges, NASA will serve as a catalyst for companies to rapidly develop and demonstrate their capabilities, while setting the course for research and investment needed to realize the full potential of UAM. Research to reduce noise and improve efficiency and safety of vertical lift vehicles also is supporting development of this fledgling industry. The initial aerospace community response to NASA's leadership in UAM has been strongly supportive.

NASA research is enabling a transformed airspace system that supports efficient operations of all vehicles across these different market segments, and gives citizens the confidence that every flight is safe and secure. NASA will complete a series of Airspace Technology Demonstrations (ATDs) with the FAA, airlines and airport operators to demonstrate new capabilities for managing efficient airline operations.

The most recent trials at Charlotte airport for ATD2 are demonstrating an Integrated Arrival and Departure and Surface (IADS) management capability, which enables precision gate push back, allowing commercial airplanes to execute a non-stop taxi for take-off and continuous climb to an available overhead stream slot. These integrated capabilities have already yielded benefits for demonstration participants, equal to 2.1 million pounds of fuel saved and an emissions reduction equivalent to over 77,000 urban trees in just the first 19 months of the demonstration. This work has all been coordinated through the NASA-FAA ATD Research Transition Team, such that the ATD-2 demonstration directly influenced requirements and reduced risk for FAA's $1 billion Terminal Flight Data Manager (TFDM) Program which will deploy IADS capabilities to 27 airports beginning in 2021.

A final high-fidelity demonstration of integrated system capabilities will support delivery of the research and development results to the FAA to advance NextGen capabilities and improvements to meet the FAA's air traffic needs. NASA then will turn its attention to new research to address the safety and efficiency challenges of a more complex airspace supporting a broad range of new users.

Beginning in FY 2019, NASA increased its support of unique specialized facilities and experts who conduct fundamental research to address key challenges in hypersonic flight by $5 million, a twenty percent increase above FY 2018. NASA coordinates closely with partners in the Department of Defense (DOD) to leverage DOD investment in ground and flight activities to develop and validate advanced physics-based computational models as building blocks towards a long-term vision for hypersonic flight. At the same time, the DOD benefits from NASA hypersonics expertise, analyses, testing capabilities and computational models.

The global aviation system of 2040 is emerging today – new companies and new systems built on advanced technologies pioneered by NASA and strengthened by steady U.S. investment. NASA Aeronautics strengthens the foundation of U.S. global leadership in both traditional and emerging markets to realize the 2040 aviation system. To do this, NASA Aeronautics will:

- Develop and demonstrate key enabling technologies in close partnership with the U.S. aviation industry to transform the subsonic airliners market, with particular focus on electric or hybrid electric systems that can bring about revolutionary improvements in small and large transport aircraft.
- Develop and demonstrate key enabling technologies in full partnership with the Urban Air Mobility community to ensure U.S. leadership in opening a scalable, safe, efficient, and environmentally acceptable market. This new capability will reduce ground-based traffic congestion, improve local air quality, and transform urban areas.
- Deliver scientifically acquired data of sonic boom community response to the international and U.S. standard and rule making organizations (e.g., ICAO, FAA) to usher in renewed supersonic flight for the flying public.
- Complete a series of air traffic management technology demonstrations with the FAA, airlines, and airports that validate new capabilities that improve the National Airspace System (NAS) efficiency. Also, NASA will complete demonstrations of technologies to integrate larger UAS into the NAS as well as manage smaller UAS at lower altitudes.

Thank you for the opportunity to testify before you today. I welcome any questions you may have.

Biography

Image Credit: NASA/Maria Werries

Dr. Jaiwon Shin

Associate Administrator
NASA Aeronautics Research Mission Directorate (ARMD)

Dr. Jaiwon Shin is the associate administrator for the Aeronautics Research Mission Directorate (ARMD), a position which he has held since 2008. Shin manages the agency's aeronautics research portfolio and guides its strategic direction, including research in advanced air vehicle concepts, airspace operations and safety, integrated aviation systems, and the nurturing and development of transformative concepts for aviation.

Shin co-chairs the National Science & Technology Council's Aeronautics Science & Technology Subcommittee whose charter is to facilitate coordination and collaboration among the federal departments and agencies that fund aeronautics-related research. The subcommittee wrote the nation's first presidential policy for aeronautics research and development (R&D). The policy was established by Executive Order 13419 in December 2006 and will guide U.S. aeronautics R&D programs through 2020.

He is a past chair of the International Forum for Aviation Research, the world's only aviation research establishment network, with 26 member countries that seeks to connect research organizations and enable information exchange on aviation challenges of common interest.

Between May 2004 and January 2008, Shin served as deputy associate administrator for the ARMD, where he was instrumental in restructuring NASA's aeronautics program to focus on fundamental research and better align with the nation's Next Generation Air Transportation System (NextGen).

Prior to coming to work at NASA Headquarters, Shin served as chief of the Aeronautics Projects Office at NASA's Glenn Research Center. In this position he managed all of the center's aeronautics projects. Prior to this, he was Glenn's deputy director of aeronautics, where he provided executive leadership for the planning and implementation of Glenn's aeronautics program, and interfaced with NASA Headquarters, other NASA centers, and external customers to explore and develop technologies in aeropropulsion, aviation safety and security, and airspace systems.

Between 1998 and 2002, Shin served as chief of the Aviation Safety Program Office, as well as the deputy program manager for NASA's Aviation Safety Program, and Airspace Systems Program. He assisted both program directors in planning and research management.

Biography

Dr. Jaiwon Shin (continued)

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NASA Aeronautics Research Mission Directorate (ARMD)

His NASA honors include the 2008 Presidential Rank Award for Meritorious Senior Executive, NASA's Outstanding Leadership Medal, NASA's Exceptional Service Medal, a NASA Group Achievement Award, Lewis Superior Accomplishment Award, three Lewis Group Achievement Awards, and an Air Force Team Award.

In 2019, Shin was honored as a Fellow by the AIAA, a distinction that is conferred upon individuals in recognition of their notable and valuable contributions to the arts, sciences, or technology of aeronautics and astronautics. He is a recipient of the 2017 AIAA Laureate Award for Innovation, and an Office of Personnel Management 2016 Meritorious Presidential Rank Award. He is a graduate of the Senior Executive Fellowship Program at the Kennedy School of Government at Harvard University, has extensive experience in high-speed research and aircraft icing, and has authored or co-authored more than 20 technical and journal papers.

Shin received his doctorate in mechanical engineering from the Virginia Polytechnic Institute and State University, Blacksburg, Virginia. His bachelor's degree is from Yonsei University in Korea and his master's degree is in mechanical engineering from the California State University, Long Beach.