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Hearing on NASA's Aeronautics Mission: Enabling the Transformation of Aviation
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Statement of
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Madam Chair, Ranking Member Babin, and members of the subcommittee, thank you for the opportunity to testify today. I am Alan Epstein, the RC Maclaurin Professor Emeritus at MIT, Chair of the Aeronautics and Space Engineering Board of the National Academies of Science, Engineering, and Medicine, and a member of the NASA Advisory Council. I am here to address this nation's aeronautical enterprise and the role that NASA can and should play. I speak today as an individual, not for any organization.

I believe that we are living in the most exciting era in civil aviation in 50 years, essentially since the development of the Boeing 747. As is often the case, the excitement stems both from opportunities and from challenges. Opportunities now include dramatic reductions in aircraft noise, drones of all sizes and shapes, true air-taxi service, and low-boom supersonic travel. Challenges include environmental concerns, especially those associated with climate change; the rise of foreign competition; refreshing our talent pool; and, of course, safety. An additional element of the excitement is that many of the opportunities are being pursued by wholly new entrants rather than the few traditional, large aerospace companies. Many of the new entrants are based outside the U.S., and many have considerable resources from venture capitalists.

What is the proper government role in all of this? Why should the American people and Congress care? Fundamentally, it is because aerospace is very big business, and it is very much an American business. Not including airline operations, aerospace is a more than 800 billion dollars a year worldwide enterprise, with the US responsible for 49% of that total. In 2017 alone, about 180 billion dollars of new aircraft were delivered, of which almost 80% were civil aircraft. Aircraft maintenance, repair, and overhaul add another 130 billion dollars annually. Civil aerospace employs about half a million people in the US. Aerospace products combined are the largest net export of the US (and it should be noted that complete aircraft account for less than half of this total; the majority is components - engines avionics, landing gear and brakes, and so on). All-in-all, civil aerospace is a vital, vibrant segment of our economy.

Other countries recognize the importance of this market and have made concerted attacks on US leadership through government investment. We have lost unquestioned leadership in helicopters, the US military now flies European designs, Airbus has been extraordinarily successful in the airliner business, and China is making large investments to enter and the capture market. To no small degree, NASA Aeronautics holds stewardship of this nation's civil aeronautical future and it is essential to that future that its research is appropriately supported.

Historically, NASA Aeronautics' research activities and influence have spanned the entire range from basic science to large scale demonstrations. It is the principal funder of university aeronautical research and supports the students that are this nation's aeronautical future. NASA researchers partner with universities and industry to stimulate and pursue new ideas and concepts. Many of the widely used aeronautical design codes of today had their origin at or with NASA. Widely used technologies such as winglets originated in NASA research, as did many, many less visible examples inside airplanes and engines. Also, NASA is responsible for much of the nation's sizable aeronautical research and development tools such as wind tunnels and test facilities.

NASA occupies a unique position in the nation's aeronautical enterprise. It is both a funder and an executer of research. It originates or the funds new ideas and has the where-with-all to shepherd concepts to the point that an industrial enterprise can plan product development. How much of this activity is performed or funded by NASA varies widely. I would like to touch on a few areas in which NASA investment have, can, or should have significant impacts.

First, let me point out that shortly after the turn of this century, a decision was made to dramatically cut the NASA Aeronautics budget, by more than half in terms of operational funds. The budgets of the last decade or two has remained steady at that low level, even with Congressional help. So, NASA has been able to do much in civil aeronautics with what really is relatively little resources.

One current example of a NASA activity which advances US aviation and which I believe to be both appropriate and useful is the X-59 airplane research program. This nation has spent decades researching supersonic flight. One new discovery by NASA was a basic theory predicting that an airplane could be shaped in such a way to dramatically reduce its sonic boom as perceived on the ground. The X-59 is designed to validate this theory. The X-59 will then be used to generate data from cooperating communities on their residents' tolerance for these new low-intensity booms. This data will provide a foundation to enable the FAA to reexamine its ban on overland supersonic flight. Currently, there are no international certification standards for supersonic civil aircraft. This lack of standards is impdes significant corporate investment. Data from the X-59 program can aide the FAA's work with the international community to set data-based standards for supersonic civil aircraft.

A second example is personal air vehicles, an area generating much excitement and investment. While referred to as Urban Air Mobility (UAM), I believe this to be a misnomer since many of the benefits from such aircraft will accrue to suburban and rural communities. Air-taxis have been a dream since the late 19th century. The 20th century was littered with enthusiastic but unsuccessful attempts at flying cars and the like. The present excitement is fueled by the confluence of two maturing technologies – great computational power and enhanced navigation that enable autonomy, and electric-hybrid propulsion that facilitates vertical flight without the mechanical complexities and associated costs of traditional helicopters.

Personal air vehicles have the potential to transform parts of our transportation system. For such aircraft to become wide spread, public acceptance will first require very low noise and close to accident-free operation. NASA can certainly help here given its low noise expertise and interest in safe electric propulsion. Second, the most challenging task may be the requirement to integrate these air-vehicles, along with large numbers of drone, into the national air navigation system. Our airways are crowded now, so the enormous expansion predicted will require new technology and new approaches. While the operation of the air traffic control system is the responsibility of the FAA, NASA has, can, and must contribute significantly to the underlying technology for this effort to be successful.

UAM is by no means a US-dominated business. When last I looked, over 300 companies stated they there were working on UAM, and that doesn't include those working only on drones. Most of these 300 are not in the U.S. and many of the test sites are overseas as well. NASA can help the U.S. capture this market both by pursuing pre-competitive technology developments and by providing the aeronautical depth that some startups lack. NASA is also learning how to work with companies that don't have the patience and breadth of large aerospace firms.

Now, I would like to touch on a topic for which I am passionate, airplane noise. Noise has been a challenge from the beginning of aviation. As we all know noise is a major irritant to the communities around airports and therefore it is a significant impediment to the expansion of our air transportation network. People just do not want new or expanded airports near them. Historically, engines were the dominant noise source, so NASA and industry worked hard for many decades to reduce engine noise. They have made impressive progress. Now, the noise from a modern airliner the size of a Boeing 707 impacts about one tenth the area on the ground and thus one tenth the number of people than did the 707's. In fact, modern engines are so quiet that if you turned the engines off on approach to landing, people on the ground would not hear a difference. The engines are now quieter than the airframe.

While NASA still works on noise reduction, I believe that this is an area where much more can and should be done to the great benefit of this nation. Technology investments to date have brought us to the point where we can envision airliners so quiet that they would not be noticed in an urban environment. Such aircraft will likely look much different than the legacy designs of today so an X-plane research program may well be needed. By that, I mean NASA's flying a special purpose research vehicle to provide data on fundamental technologies that can enable quiet flight. Virtually silent airliners would bring enormous relief to communities around the country and stimulate an expansion of U.S. air transportation. With aggressive NASA action, I believe that such ultra-quiet airliners could be ready to enter service by the end of the next decade.

Lastly, I would like to address aviation's most pressing challenge and opportunity, climate change. Climate change and its political ramifications constitute a significant threat to air transportation. Many people and nations are concerned with anthropogenic drivers, especially CO_2. Some have misidentified aviation as major part of the problem and so attack even the idea of flying. For example, The Bishop of London declared vacation flying "a sin" and "flight-shaming" is growing in Scandinavia. In fact, modern aircraft produce less CO_2 per passenger mile than do cars and trains in this country. Never-the-less, the threat is very real indeed. A decade ago, in response to this concern, aviation leaders pledged to reduce aviation's CO_2 by half by the year 2050. Given that air travel is growing by 4 to 5 percent a year, this is no easy challenge.

The aeronautical technology side of the challenge needs NASA leadership. In house and in-partnership with industry and university researchers, NASA has pursued some very advanced airliner designs which promise significant reductions in energy requirements. These designs depart considerably from traditional approaches and so this is another challenge that warrants an X-plane research program.

Given that aviation is growing so fast, CO_2 reduction requires reducing the energy needed for flight or reducing the carbon associated with that energy, or preferably both. More than 98% of aviation's CO_2 comes from larger airliners (70 passengers and above) flying distances more than 500 miles. So, to achieve a significant CO_2 reduction, new technology is needed for large airliners, not general aviation or small regional aircraft. Aviation cannot follow the auto industry. It cannot move to electric airplanes. Sufficient technical work has been done so we now understand that there is no battery technology known or on the horizon that can power large electric airliners.

Furthermore, even if there were a scientific breakthrough that enabled a battery powered airliner, that airliner would produce more net CO_2 than do current jet engine powered airliners. This is simply because current airline engines produce considerably less CO_2 per unit power than does the nation's power grid and are projected to do so for several decades. Hybrid-electric approaches at airliner scale now look to save only a few percent in fuel consumption, even given the assumption of greatly improved batteries and electrical gear. So, they are not a solution. NASA's work on the energy reduction side of the problem should focus on more efficient airplanes and engines.

I think it is clear that the only path forward that has the potential to significantly impact aviation's net CO_2 by 2050 is improved airplanes and engines fueled with a liquid hydrocarbon fuel that does not release fossil CO_2 into the atmosphere. Several of these fuels exist today, have been proven safe, and are in limited commercial service. Known as Sustainable Alternative Jet Fuels (SAJF), they can save 80% or more on CO_2, yet are compatible with existing aircraft and fuel infrastructure, while not adversely affecting food and water supplies. Much more can be done to expand their availability, especially to improve their economics. This research area is now the purview of the Departments of Energy and of Agriculture. NASA can play a role in advancing engine technology to reduce emission including CO_2 and exploiting the properties of these fuels.

To close, civil aeronautics is a major economic and trade strength of the United States. NASA contributions have played an important in the past and a strong NASA Aeronautics is need to maintain our strength. The support and leadership that NASA provides is important at all levels – supporting university research and students, stimulating and new concepts and cultivating new technologies, and performing large scale technology validation experiments and demonstrations.

Thank you.

Dr. Alan H. Epstein is the R.C. Maclaurin Professor of Aeronautics and Astronautics Emeritus and former Director of the Gas Turbine Laboratory at the Massachusetts Institute of Technology (MIT). While at MIT, he consulted widely for aerospace, energy, and high-tech industries. He continues to work as a consultant. In 2018, he retired as Vice President Technology and Environment at Pratt & Whitney where he was responsible for setting the direction for and coordinating technology across Pratt & Whitney. He also provided strategic leadership in reducing the environmental impact of P&W's world-wide products and services.

Dr. Epstein has over 140 publications in the fields of aircraft and gas turbine technology, aviation and the environment, rocket propulsion, and microsystems. He was a co-author of the IPCC report on climate change that won the Nobel peace prize in 2007. He has given over 250 plenary, keynote, and invited lectures around the world on topics including aviation and the environment, aerospace propulsion, power and energy, micro and nano systems, and the role of new technology in military affairs. He has over two dozen patents granted or pending on gas turbine and on microsystems technologies.

Dr. Epstein has served on many panels and committees advising the US government, industry, and academia. He is currently the chair of the NASA Aeronautics and Space Engineering Board and member of the NASA Advisory Council. He has also served as chair of the US Board on Army Science and Technology. He has won many international awards for his work in propulsion including seven best paper awards, the American Institute of Mechanical Engineers (ASME) Gas Turbine Award, the ASME Gas Turbine Scholar Award, the ASME R. Tom Sawyer Award, the American Institute of Aeronautics and Astronautics (AIAA) Dryden Lectureship in Research, the International Gas Turbine Institute Gas Turbine Technology Award, the Canadian Aeronautics and Space Institute Turnbull Lectureship, the Engineer's Council Honorary Engineer of the Year Award, and the General James H. Doolittle Award. Dr. Epstein is a member of the U.S. National Academy of Engineering and past chair of its Aerospace Section. He is an Honorary Fellow of the AIAA, a fellow of the ASME and a fellow of the UK Royal Aeronautical Society. He received B.S., M.S., and PhD degrees from MIT.