Testimony of

Wesley L. Harris
Charles Stark Draper Professor of Aeronautics and
Astronautics and Associate Provost
Massachusetts Institute of Technology
and
Chair, Committee to Assess NASA's Aeronautics Flight
Research Capabilities
Division Committee on Engineering and Physical Sciences
Aeronautics and Space Engineering Board
National Research Council
The National Academies

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Mr. Chairman, Ranking Member Costello, members of the committee, colleagues, I am Wesley Harris, Chair of the National Research Council's Committee to Assess NASA's Aeronautics Flight Research Capabilities. It is a pleasure to come before you today to speak to you about the work of our committee. The National Research Council (NRC) is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. In 2011 NASA asked the NRC to undertake a study of NASA's flight research capabilities. I am here to report on the results of that study.

Our committee consisted of members of industry and academia, former NASA aerospace officials, UAV designers, test pilots, and even an Apollo moonwalker with a strong interest in flight research. We met multiple times throughout 2011, visiting NASA centers involved in flight research and hearing from numerous NASA and industry representatives. We received extensive cooperation from the agency for which the committee is very grateful.

Many people may be aware that unmanned aerial vehicles (UAVs), sometimes referred to as uninhabited aerial systems, are a vital part of America's national security and a highly dynamic part of our aerospace industry, something where the United States remains the world leader. What few people realize, however, is that during the 1990s NASA played a major role in making this happen by supporting the development of multiple advanced UAV designs, thereby spawning the industry that is so active today. This was an industry where the United States was behind, and now it leads. That was NASA's flight research in action, not in the distant past, but relatively recently and in my personal opinion NASA should receive recognition for this achievement.

Currently NASA often calls for "game changing" ideas. Our committee concluded that in order to achieve game changing results in aeronautics, the agency has to conduct useful, efficient aeronautical flight research. However, in the course of the study, we found that NASA is only conducting a low level of flight research and we concluded that they should, and they can, do much more.

Flight research is only one part of a healthy aeronautics research enterprise, but it is a vital part. A common analogy is that aeronautics research is like a three-legged stool. One leg is simulation and modeling, taking advantage of powerful computing technology. Another leg of the stool is wind tunnel testing. The third leg is flight research—flying aircraft to test new theories, test new combinations of technologies, validate existing computer and mathematical models, and demonstrating and validating technologies and concepts so that they can be adopted by commercial and military operators and manufacturers. Remove one leg of the stool and it topples over. A commonly held misconception is that flight research is something that comes at the *end* of a research program; however, in many cases it is necessary in the middle of a program in order to validate aspects of the research. For instance, it is very common in the aeronautics world

to update sophisticated computer simulations based upon data collected by actually flying a vehicle.

Since the middle of the last decade NASA has dramatically reduced its flight research to focus more on ground-based investigations and activities in what NASA describes as its "fundamental" aeronautical research. Today we see the results of that development. If you visit a NASA center involved in flight research, you will see very few programs that involve actual flying. In the committee's opinion, most flight research today can be characterized as limited in scope, such as putting a new structure on or under the wing of an existing airplane such as an F-15, or flying a small-scale UAV. There are almost no unique flight research vehicles currently flying, that is aircraft specifically designed for research such as the famed X-planes. NASA has tremendous personnel and capital resources, however the committee concluded that it is not using those resources to conduct the kind of flight research we would expect would inspire future generations of aeronautical engineers, or that is required to make major advances on the frontiers of knowledge and functionality.

Our committee recommended that NASA should start from two to five focused, integrated, higher risk, higher payoff, and interdisciplinary programs with total budgets of $30 to $50 million (per vehicle/program) over three years. In order to achieve progress for fundamental aeronautics as well as other relevant related military requirements, we recommended that these priority focused projects should be drawn from the high priority research areas identified by the 2006 NRC decadal survey of civil aeronautics.

The committee concluded that additional funding for aeronautics was not a prerequisite for NASA being able to begin to implement this recommendation provided that the agency phases out the majority of its lower-priority aeronautics activities—a move that we believe would facilitate implementing two to three new vehicles. If aeronautics receives additional funding, NASA could implement three to five new vehicles. Naturally, there is a tradeoff between the size of the individual projects and the number the agency could pursue—that is, more, smaller projects versus fewer, larger projects. As stated, the committee estimated that to make significant progress in each of the selected areas, the $30 million to $50 million (total over three years) would be the appropriate scope for such activities. An ambitious UAV project could be built at the lower end of that range, while a more ambitious piloted vehicle could be built at the higher end. For example, Sikorsky's piloted X-2 helicopter, which recently won the Collier's Trophy, cost approximately $50 million.

Our committee specifically mentioned the Collier's Trophy as an aspirational goal for NASA's aeronautics program. The Trophy is awarded for outstanding aeronautics achievement in the previous year. NASA has won the Trophy in the past and is capable of doing so again. Although our report does not recommend this, I personally think that NASA should consider approving new projects on the basis of their ability to compete for such a prestigious prize. The agency should aim high in its ambitions.

The committee also recommended that NASA's aeronautics research projects have a defined "path to flight"—essentially a roadmap that indicates how they intend to conduct actual flight research. The lack of such roadmaps leads to many current projects getting canceled before they can be pursued to the flight phase and their progress is subsequently lost. In addition, by failing to define such a path, many projects never even get started because their advocates determine that they can never get sufficient funding to conduct flight research. Thus, many promising research subjects are never explored.

Our committee notably did not recommend more money for NASA's aeronautics program. However, we do believe that it could benefit from additional funding—if NASA's budget shifted only one percent of its total funding to aeronautics research it would enable substantial new research in several vital areas of prime national interest. But in the current fiscal environment we also believe that the aeronautics program could benefit from reordering its priorities, establishing focused goals, and eliminating lower-priority research programs if flight research is to be a priority activity.

The committee selected three areas of NASA aeronautical research as case studies. We selected these subjects because NASA has already made substantial progress in them—a fact the agency should be commended for—and we believed each of these areas are at the point where transitioning to flight research could produce significantly more progress. The detailed case studies enabled the committee to assess the essential strengths and weaknesses, challenges and opportunities in NASA aeronautical flight activities. These areas were environmentally responsible aviation, supersonics, and hypersonics.

Environmentally responsible aviation essentially involves developing highly fuel efficient aircraft that produce little noise. This is important because of rising fuel prices, and the encroachment of residential areas upon airports, as well as the increasingly strict noise and pollution regulations that are being imposed upon aircraft, particularly in Europe. If the United States is to remain a world leader in commercial aviation, we must be able to sell competitive aircraft to airlines around the world. The committee found that NASA could make substantial research leaps by developing a large scale aircraft that integrated many relevant technologies. Such aircraft might look radically different than those that people fly in today. NASA could develop this technology in concert with other government agencies as well as commercial industry.

In the area of supersonics, NASA is on the cusp of making a substantial leap that could create an entire industry of small supersonic passenger jets, just as NASA helped to create the modern UAV industry in the late 1990s. The agency has already performed considerable research into so-called low-boom technology, or aircraft that do not produce the loud sonic boom that prevents supersonic aircraft from operating over most of the United States. If NASA were to build a research aircraft, it could demonstrate that such vehicles could fly across the United States without producing loud sonic booms and with only a slight increase in fuel burn. This could put the United States at the forefront of such development.

Hypersonics is another area where NASA has developed great expertise over the years. We found that the agency could better focus its efforts on development of a hypersonic vehicle capable of high-speed, relatively long duration flight. Naturally, NASA would support DoD research in this area.

During the course of our study, the committee spoke with various representatives from industry, including people from Boeing, Lockheed Martin's Skunk Works, Aurora Flight Sciences, and other companies. Despite what I believe is a common perception that aeronautics is so mature that NASA's research role should be limited, that is NOT an attitude that we encountered within industry. Quite to the contrary, the industry representatives we talked to believed that NASA can play a vital role in helping to develop technologies that industry is too risk averse to address. They want NASA to be involved, doing what NASA does best, and what they believe industry cannot do.

When answering the question of "why should NASA be involved in aeronautics research, particularly conducting flight research," the committee concluded that industry in these economic times cannot and will not take on the full cost risk of moving technologies from the laboratory to operations. NASA's founding charter tasks the agency to help with this process. NASA's role is to develop requirements for the next research vehicles and then work with industry to build and test those aircraft.

Some of the potential areas that industry said NASA could help with are:

- Collecting high-altitude atmospheric data that could be used in the design of new high-altitude UAVs. This includes characterization of high-altitude turbulence, which is fundamental to understanding the aeroelastic effects on flight vehicles as well as characterizing the radiation environment at high altitudes, which could affect avionics systems. NASA currently has assets such as the U-2 and WB-57 high-altitude aircraft, as well as balloons, capable of gathering this data.
- Conducting research on pilotless commercial aircraft, perhaps starting with unpiloted cargo aircraft.
- Conducting research into electric aircraft propulsion and electric vehicle subsystems.
- A larger-scale experimental aircraft to explore ERA and N+3 technologies. This would be bigger than the X-48C, with a wingspan of perhaps 40 to 50 feet (compared to 21 feet for the X-48B). The cost of such a vehicle, according to an aerospace company with experience producing similar vehicles, could be in the range of $25 million to $60 million.
- Initiating programs to develop low-cost ($30 million to $50 million) innovative flight research vehicles, to demonstrate new technologies such as lift fan and fan-in-wing for a high-speed VTOL, or to gather useful data in the transonic or supersonic flight regimes.
- Conducting research on autonomous systems and the interaction between human operators and autonomous systems.

- Conducting research on hybrid propulsion, especially electric, quiet powered, distributed lift concepts, especially those enabled by hybrid electric systems, and quiet trans- and supersonic small aircraft for both commercial and military applications.

NASA cannot and should not go it alone. Our report contained the following recommendation:

> **Recommendation: NASA aeronautics should aggressively pursue collaboration with DOD, FAA, the U.S. aerospace industry, and international aeronautics research agencies. NASA should adopt management practices to facilitate effective collaboration and treat external organizations as customers and partners. NASA leadership should develop a formal process for regularly soliciting input from the U.S. aerospace industry and universities as well as key government agencies to assure the relevancy of its flight research programs to national needs.**

Although NASA is currently involved in numerous cooperative efforts, our committee heard from other government agency representatives that NASA often participates in cooperative efforts, but does not always bring its own resources to the table. In order to maximize its effectiveness, NASA should provide funding for all its cooperative efforts.

Despite an outstanding history of NASA-led aeronautics flight research successfully transitioning to the U.S. aerospace industry, NASA could be more effective in identifying and communicating these accomplishments to key stakeholders within industry, government and academic institutions. One aspect of communication to stakeholders is the effective dissemination of technical data to relevant aerospace researchers after a flight research program is completed. Prior National Advisory Committee on Aeronautics (NACA—NASA's predecessor) reports, generated more than 50 years ago, are rich resources of information for the aerospace community to this day and are relatively accessible. However, more recent NASA aeronautics flight research programs have generated useful data that is relatively inaccessible to aerospace engineers and scientists. This led our committee to the following recommendation:

> **Recommendation: NASA aeronautics should become the nation's repository of flight research data and flight test results and should make these archival data readily accessible to key stakeholders—the engineers and scientists in industry, academia, and other government agencies. NASA should also require principal investigators in flight research projects to publish their results and provide funding for them to do so.**

NASA's flight research inventory is a mix of vehicles that are currently distributed across NASA centers, including Dryden Flight Research Center, Glenn Research Center, Ames Research Center, and Langley Research Center. NASA may be able to achieve greater efficiencies by designating a single center as the primary flight research center for the agency. We recommended that NASA study this possibility, fully aware that some flight

research aircraft may be best supported at locations around the country. However, the current level of flight activity is so low that consolidation may free up valuable funds.

NASA is a highly capable organization with many excellent people in the area of aeronautics research. The contributions the agency has made and continues to make in aeronautical research are significant and in my personal opinion the importance of the work done by NASA's Aeronautics Research Mission Directorate should be more broadly recognized. However, we were asked to look at the area of flight research and having conducted our study we believe that we as a nation have an opportunity to accomplish much more in this research area of prime national importance if given the opportunity. If we give NASA the tools to take flight, we believe—I believe—they will soar.

Thank you for the opportunity to testify. I would be happy to answer any questions the Subcommittee might have.