National Aeronautics and Space Administration

Office of Inspector General
Washington, DC 20546-0001

January 30, 2014

TO: Jaiwon Shin
Associate Administrator for the Aeronautics Research Mission Directorate

FROM: Paul K. Martin
Inspector General

SUBJECT: The Aeronautics Research Mission Directorate's Management Strategy for Conducting Aeronautics Research (Report No. IG-14-012)

Since its formation in 1958, a primary mission for NASA – represented by the "first A" in its name – is aeronautics. However, over the past decade the proportion of NASA funds dedicated to aeronautics research has declined from approximately 6 percent in fiscal year (FY) 2005 to 3 percent today, dwarfed by the Agency's focus on space exploration and operations (44 percent) and scientific investments (22 percent).

During the past decade, the National Research Council (NRC) has played a key advisory role in defining NASA's aeronautics research mission. In 2006, the NRC issued a Decadal Survey identifying 51 high-priority civil aeronautics research challenges NASA should pursue.[1] The NRC grouped these challenges into five areas that it believed advances would have significant, long-term impact on civil aeronautics in the United States.[2]

In a 2012 follow-up report, the NRC found that NASA had made limited progress in achieving the 51 research challenges and concluded that it had proposed too many challenges given NASA's resources.[3] The NRC also noted that NASA's Aeronautics Research Mission Directorate (ARMD) appeared to be avoiding investments in flight research because of the perceived high cost of flight-testing. Therefore, the NRC recommended that NASA abandon lower research priorities and focus on fewer, high pay-off programs; perform more flight-testing; and solicit input from external customers to ensure the relevancy of its research and development (R&D) programs.

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[1] NRC, "Decadal Survey of Civil Aeronautics: Foundation for the Future," 2006.

[2] The five areas are: (1) aerodynamics and aeroacoustics; (2) propulsion and power; (3) materials and structures; (4) dynamics, navigation, control, and avionics; and (5) intelligent and autonomous systems, operations and decision-making, human integrated systems, and networking and communications.

[3] NRC, "Recapturing NASA's Aeronautics Flight Research Capabilities," 2012.

In 2009, the Office of the Inspector General (OIG) reviewed NASA's efforts to support ARMD's Joint Planning and Development Office.[4] During that review, we observed that high, inflexible funding goals could increase the risk of programs and projects using NASA Research Announcements (NRAs) in situations where another procurement instrument such as a contract would be more appropriate. In contrast to more formal Requests for Proposal that contain a defined statement of work developed by NASA, NRAs allow researchers to propose projects they believe meet NASA's broad aeronautics research objectives.

With the 2012 NRC study and work from our 2009 review as a backdrop, the OIG initiated an audit to examine NASA's plans for advancing civil aeronautics research and technology. Specifically, we reviewed NASA's management strategies in five key areas of aeronautics R&D: (1) strategic research planning, (2) monitoring and evaluation of research progress, (3) technology transfer and collaboration, (4) fundamental versus advanced research, and (5) procurement.

To conduct our review, we interviewed senior Directorate management officials, reviewed program and project plans, and surveyed external customers. We focused primarily on projects in ARMD's Fundamental Aeronautics Program because it has the largest budget of ARMD's five programs and tends to focus on long-term, cutting-edge research.[5]

Having identified no significant concerns at the conclusion of the initial phase of our review, we are issuing this memorandum and discontinuing the audit. Management reviewed a draft of this memorandum and had no comments. (See the Enclosure for details of our scope and methodology.)

Background

NASA's Role in Aeronautics R&D. Federal guidance sets forth broad policy objectives for government investment in aeronautics R&D. For example, Executive Order 13419 states it is the policy of the United States to support through funding and activities of the Federal Government R&D that is not more appropriately performed by the private sector.[6] The Order calls for development of a National Aeronautics Research and Development Policy to help guide U.S. aeronautics R&D programs through 2020 and a series of follow-on plans to implement the Policy.

[4] NASA OIG, "NASA Could Improve Analyses and Coordination in Support of the Joint Planning and Development Office to Develop the Next Generation Air Transportation System" (IG-09-019, July 30, 2009).

[5] ARMD's other four programs are Aeronautics Test, Airspace Systems, Aviation Safety, and Integrated Systems Research Programs.

[6] Executive Order 13419, "National Aeronautics Research and Development," December 20, 2006.

In December 2007, the National Science and Technology Council issued a "National Plan for Aeronautics R&D and Related Infrastructure" that established national aeronautics R&D challenges and prioritized goals and objectives.[7] In 2010, the National Science and Technology Council updated this document with the "National Aeronautics Research and Development Plan" (National Plan).[8] The National Plan lays out high-priority national aeronautics research and development challenges, goals, and supporting objectives to guide the conduct of U.S. aeronautics activities through 2020 and provides a strategic framework to help focus and coordinate high-level aeronautics research and development efforts among Federal research programs. The Plan represents a consensus of the departments and agencies that staff the Aeronautics Science and Technology Subcommittee of the National Science and Technology Council and was formulated with input from the broader research community. The Plan does not assign specific responsibilities to NASA or any other Federal agency.

In 2011, the National Science and Technology Council assessed the progress made on the National Plan's goals and objectives and found that the combined aeronautics R&D efforts by Federal agencies were adequate to advance them.[9] The Council found 72 percent of Federal Government R&D activities sufficient to achieve Plan objectives and only 1 percent subject to serious risk of significant delay or in danger of not being completed.[10]

NASA Strategic Plan. NASA's 2011 Strategic Plan describes two goals for ARMD.[11] First, ARMD will work to improve current and future air transportation by developing innovative solutions and advanced technologies through a balanced research portfolio. This includes basic research on promising aeronautics concepts and technologies as well as applied research demonstrating capabilities in a relevant flight or ground environment. Second, ARMD must provide and maintain program and institutional capabilities, such as wind tunnels, necessary to conduct NASA's aeronautics and space activities.

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[7] The National Science and Technology Council is a cabinet-level council chaired by the President and composed of, among others, the Vice President, the Director of the Office of Science and Technology Policy, and agency heads with significant science and technology.

[8] In January 2011, the White House published the "National Aeronautics Research, Development, Test and Evaluation (RDT&E) Infrastructure Plan" identifying the infrastructure needed to support the National Plan's goals and objectives.

[9] In December 2011, the White House published the "2011 Progress Assessment of the 2010 National Aeronautics Research and Development Plan." This assessment fulfills the requirement established in Executive Order 13419 that called for periodic assessments of the progress of the executive departments and agencies towards achieving the R&D goals and objectives in the approved plan.

[10] The 2011 Progress Assessment determined that 72 percent of the activities were sufficient to achieve the objectives; 27 percent were assessed as sufficient to achieve the objectives with some risk; and 1 percent of the activities (a far-term objective) were considered subject to serious risk due to programmatic, technical, or other constraints that will significantly delay or prevent completion.

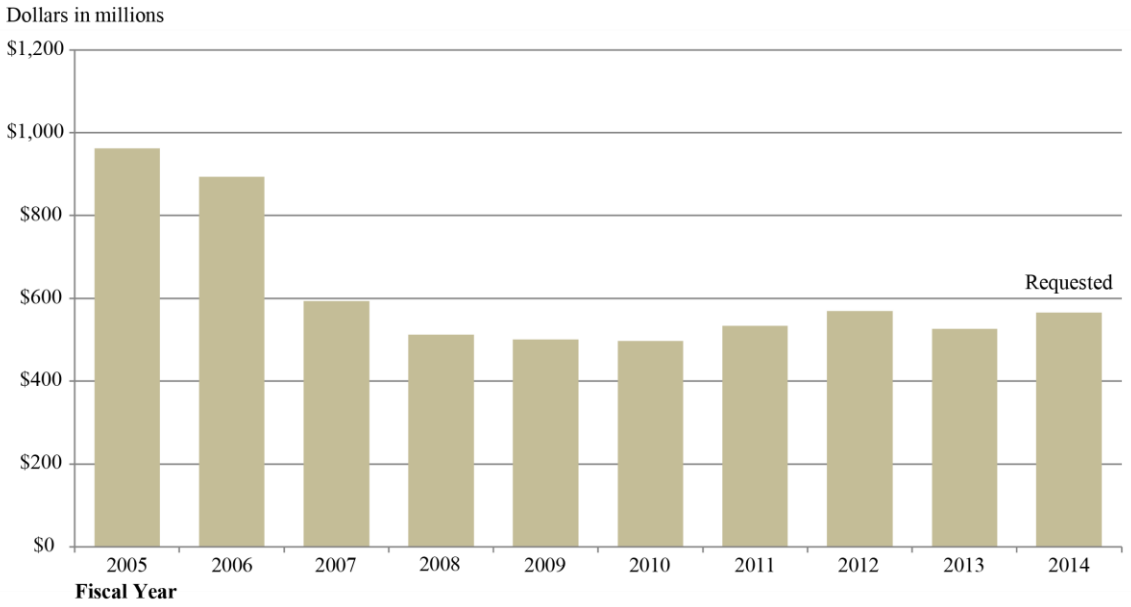
[11] Available at http://www.nasa.gov/pdf/516579main_NASA2011StrategicPlan.pdf (accessed on January 10, 2014).

ARMD Programs. ARMD organizes NASA's aeronautics R&D activities into four research programs. A fifth ARMD program is responsible for maintaining Agency ground and test flight facilities used by NASA researchers, industry, and academia.

- The *Fundamental Aeronautics Program* (Program) addresses national challenges in air transportation by advancing technologies that seek to improve the performance and environmental impact of future air vehicles. The mission of the Program is to conduct fundamental research that will generate innovative concepts, tools, technologies, and scientific knowledge for a wide range of air vehicles, including helicopters, commercial airliners, and high-speed vehicles that can travel faster than the speed of sound. The Program is charged with advancing promising concepts and technologies to a point where they are sufficiently mature to be demonstrated and proven. As noted previously, for this audit we focused primarily on projects in this Program.
- The *Airspace Systems Program* focuses on research to achieve the goals of the Federal Government's Next Generation Air Transportation System (NextGen). NextGen is focused on accommodating projected growth in air traffic while enhancing safety; providing airspace system users more efficiency in the use of airports, airspace, and aircraft; and maintaining pace with an evolving scientific and technical environment. NASA's Airspace Systems Program is integral to attaining these goals in partnership with the Departments of Transportation, Defense, Commerce, and Homeland Security.
- The *Aviation Safety Program* seeks to develop cutting-edge technologies to improve the safety of current and future aircraft as the nation transitions to the NextGen environment. The Aviation Safety Program strives to develop technologies that will increase capabilities to predict and prevent safety issues.
- The *Integrated Systems Research Program* focuses on maturing and integrating NextGen technologies into major vehicle and operational systems and subsystems. Integrated systems research generally covers system and components at higher technology readiness levels, which includes flight-testing and prototype development.
- The *Aeronautics Test Program* establishes the strategic direction for NASA's aeronautics ground and flight-test research capabilities. The Aeronautics Test Program's portfolio includes 13 ground test facilities – 2 at the Ames Research Center, 5 at the Glenn Research Center, and 6 at Langley Research Center – and flight operations and test infrastructure, including simulation laboratories, test ranges, and aircraft, at Dryden Flight Research Center.

ARMD Budgets. Over the past decade, ARMD funding has declined significantly. In FY 2005, NASA's aeronautics budget was nearly $1 billion, but by FY 2013, that amount decreased to about $530 million. As a percentage of the total NASA budget, aeronautics research has decreased from approximately 6 percent in 2005 to an estimated 3 percent in 2014. Figure 1 illustrates the decline in ARMD's budget since 2005.

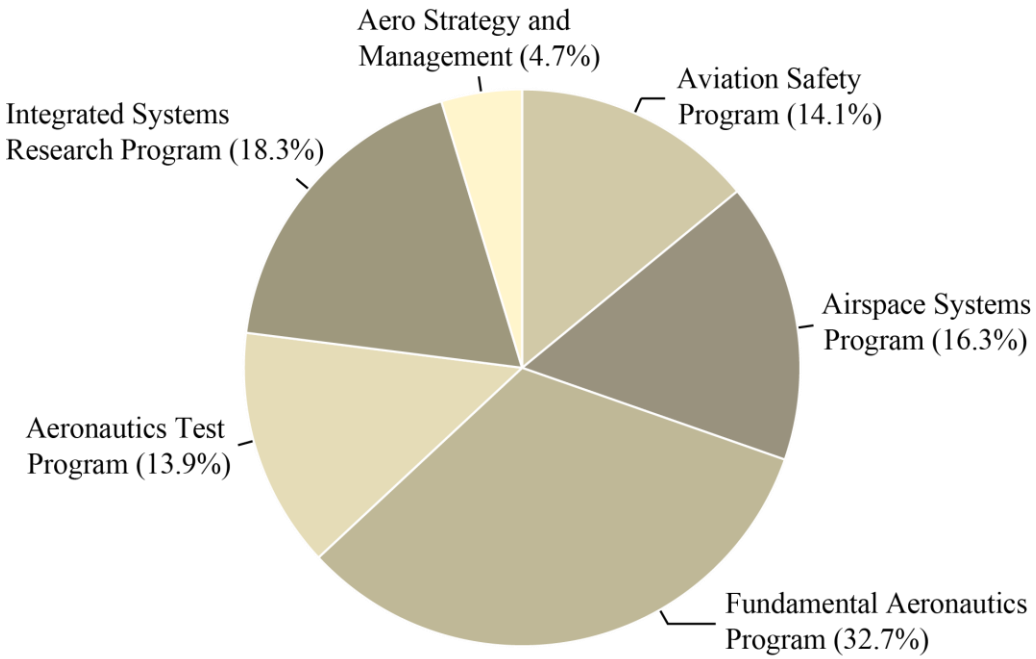
Figure 1. ARMD Annual Funding



Source: OIG analysis of NASA budget requests and data provided by ARMD.

In FY 2012, ARMD allocated its $569 million budget to its programs as shown in Figure 2.

Figure 2. Allocation of ARMD's FY 2012 Budget



Source: OIG analysis of the President's FY 2014 Budget Request.

ARMD Research Management Strategy. In light of its declining budget and other priorities, in 2006 the Associate Administrator for ARMD established a new research strategy focusing on long-term, cutting-edge research. As part of the new strategy, the Associate Administrator committed to spending at least $50 million annually on NRAs and to doubling NRA funding by FY 2013. With this commitment, NRA funding was projected to account for more than 21 percent of ARMD's total budget. This shift in strategy caused ARMD to reduce emphasis on maturing technologies in favor of spending money on fundamental research and to eliminate or reduce NASA-owned research capabilities associated with advancing and validating R&D projects. For example, in 2006 ARMD ended a Langley-based program known as the Simulation-to-Flight Program that used a Boeing 757 to help develop and flight test new technologies. Similarly, between 2006 and 2008 ARMD directed less funding to wake turbulence research and a simulation facility known as Future Flight Central. The wake turbulence research examined the dangers of turbulent air that trails behind aircraft and helped the Federal Aviation Administration establish safe separation distances between aircraft during takeoff and landing. Future Flight Central is an air traffic control simulation facility located at Ames designed to help solve overcrowding problems at the nation's airports.

Results

We found that over the past few years, ARMD's leadership has refined the research strategy announced in 2006 to include more flight testing and technology advancement. We believe that with these refinements, ARMD is supporting advancement of the nation's civil aeronautics research and technology objectives consistent with the National Plan.

Strategic Research Planning. ARMD's Associate Administrator; the Director of Strategy, Architecture, and Analysis; and several program directors told us that ARMD considers the National Plan the defining policy document for NASA's aeronautics research. We found that ARMD follows the goals and objectives established by the National Plan, and that the National Science and Technology Council periodically assesses progress of the executive departments and agencies towards achieving the Plan goals.

Similarly, our review of project plans for the Fundamental Aeronautics Program found that NASA's ongoing research in this area aligned with requirements established in the National Plan. For example, ARMD's Fixed Wing Project includes a milestone to "reduce fuselage structural weight by 15 percent… while not affecting certification and passenger comfort." This objective aligns with National Plan goals related to mobility, energy and environmental, and national security.

Furthermore, responses to our survey of external customers confirmed that ARMD solicits input from industry, academia, and other Federal agencies regarding research needs and found that it uses this information to develop its research plans.

Monitoring and Evaluation of Research Progress. We reviewed ARMD's strategy for measuring progress toward achieving its research and technology goals. We also interviewed senior Directorate management officials and project managers in the Fundamental Aeronautics Program and reviewed planning documents.

We found that in early 2013, ARMD refined its performance evaluation process to emphasize "management by technical challenge." Technical challenges are specific research areas in which Agency managers expect NASA efforts to have an impact. According to senior Directorate officials, program and project managers monitor their programs' progress toward meeting these challenges. Specifically, programs pursue long-term technical challenges (those anticipated to take more than 10 years to accomplish); set 5-year milestones; and annually evaluate progress toward those milestones, making adjustments based on actual progress.

For example, the Fundamental Aeronautics Program is pursuing the long-term technical challenges of reducing airframe weight by 15 percent without impacting safety or passenger comfort and reducing nitrogen oxide emissions to 80 percent below the standards adopted in 2008. Managers in each of the four projects in the Program annually evaluate progress toward meeting the 5-year milestones related to these long-term technical challenges and adjust plans and milestones based on these annual assessments.

Technology Transfer and Collaboration. ARMD transfers research products to external customers and collaborates with external parties to better define advanced airframe and propulsion concepts. We reviewed these activities to examine NRC concerns regarding the usefulness of ARMD research products to external customers.

To assess the technology transfer and collaboration process, we surveyed 17 external customers of the Fundamental Aeronautics Program and received 8 responses. All eight of the respondents reported that the technical transfer process is working to further their aeronautics research and technology development. In addition, all eight indicated that NASA's Fundamental Aeronautics Program is providing useful research products and expect that the Program will meet their needs in the future.

Additionally, the Associate Administrator for ARMD said Directorate staff work closely with industry, academia, and other Federal agencies to develop tools and technologies to improve the efficiency, safety, and adaptability of air transportation. For example, NASA collaborated with the Federal Aviation Administration to complete a field evaluation of the Precision Departure Release Capability, which uses takeoff time estimates from a surface automation system to improve departure scheduling in a constrained airspace. Similarly, NASA and the Department of Defense collaborated on multiple research and development efforts, including vertical lift aircraft and integrated hypersonic research. Several years ago, NASA established an Executive Research Council with the U.S. Air Force, which meets at least twice a year to ensure close coordination of research. Furthermore, in 2012 ARMD established the Integrated Systems Research Program to advance promising research from projects using a system-level approach that examines how individual research activities contribute and interact in a system-wide context. One of the Integrated Systems Research Program's main goals is to accelerate the transition of aeronautics R&D results to industry and government.

Fundamental versus Advanced Research. We reviewed ARMD's Fundamental Aeronautics Program to address NRC concerns that ARMD appeared to be avoiding investments in flight research in favor of a focus on fundamental research.

We found that the Program balances fundamental research and advanced research, including flight-testing. We surveyed Program customers and found that six of eight survey respondents reported they had received technologies from ARMD that had matured beyond fundamental research levels. ARMD's approach in this area is a notable shift from its previous strategy that focused on fundamental research and reduced the amount of advanced research conducted. As part of our review, we also identified areas where ARMD was collaborating with partners and conducting flight-testing. For example, in 2011 NASA, Bell Helicopter, and the U.S. Army performed flight-testing to measure the noise levels of a Bell Helicopter 430 aircraft.

Procurement. In light of our previous audit observation that a predetermined funding level increased the risk that projects would use an NRA when another procurement instrument would be more appropriate, we examined the procurement instruments used by ARMD to acquire research and technology to support its programs.

As originally conceived in 2006, ARMD's strategy predicted that NRA funding would grow to $100 million annually by FY 2013. However, ARMD has lowered its annual NRA funding goals and, according to officials, final FY 2013 NRA obligations are expected to be about half of the 2006 estimate. Because of ARMD's lower overall NRA funding levels, we believe that program and project managers are less likely to award an NRA when another procurement instrument, such as a Request for Proposal, would be a better match for the research NASA seeks to acquire.

ARMD has also given project managers flexibility regarding their annual NRA funding goals. For example, according to the May 2013 "Fundamental Aeronautics Program Plan," if a project's acquisition planning process concludes that a Request for Proposal may be more appropriate than an NRA, and if the Proposal can be shown to meet the intent of a widely-competed external research investment, then the Proposal may count toward the project's NRA funding goal. This flexibility helps lessen the risk that NRAs may be used inappropriately.

In our judgment, these adjustments help lessen the risk of projects using an NRA when another procurement instrument would be more appropriate.

Conclusion

Although NASA's aeronautics budget has decreased by almost half since 2005, NASA remains an important contributor to civil aeronautics. In light of its declining budget and multiple priorities, ARMD restructured its research portfolio in 2006 to focus on long-term, cutting-edge research. In the intervening years, Directorate senior managers have added advanced research projects to ARMD's portfolio. Based on our analysis of the Fundamental Aeronautics Program and discussions with senior officials, we concluded that ARMD's current portfolio is balanced and that it is investing in flight research commensurate with its mission to further the nation's aeronautics research goals.

Enclosure

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Scope and Methodology

We performed this audit from June 2013 through January 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our conclusions based on our audit objective. We believe that the evidence obtained provides a reasonable basis for our conclusions.

To conduct our review, we discussed ARMD's management strategy with senior Headquarters officials including the Associate Administrator for Aeronautics Research; Deputy Associate Administrator; Director for Strategy, Architecture, and Analysis; and research program directors.

We performed a detailed review of the four projects in the Fundamental Aeronautics Program. We focused on the Fundamental Aeronautics Program because it is the largest of ARMD's four research programs and we assessed it as a high-risk program due to its focus on long-term cutting-edge research activities. To review each project, we:

- interviewed project managers;
- reviewed project plans, annual implementation plans, and associated milestones;
- assessed human capital and facilities resource planning;
- compared each project's technical challenges to goals specified in the 2010 National Plan; and
- surveyed external customers.

We surveyed external customers within the American Institute of Aeronautics and Astronautics community to assess their satisfaction with research products from the Fundamental Aeronautics Program. We obtained a list 17 external customers from Directorate senior officials to create our survey sample. In addition, to identify additional external customers we requested and received points-of-contact from the NRC. We also assessed whether external customers had meaningful input into the Program's research planning. The survey methodology consisted of obtaining written responses to a 15-question survey instrument. We received responses from 8 of 17 survey recipients.

Use of Computer-Processed Data. We did not rely on computer-processed data in meeting the audit objective.

Review of Internal Controls

We assessed the control environment associated with ARMD's research and procurement management strategies. Our review did not identify reportable control weaknesses.

Prior Coverage

During the last 5 years, the NASA OIG and the NRC have issued four reports of particular relevance to the subject of this report. Unrestricted reports are available at http://oig.nasa.gov/audits/reports and http://www.nationalacademies.org/nrc/index.html, respectively.

NASA Office of Inspector General

"NASA Could Improve Analyses and Coordination in Support of the Joint Planning and Development Office to Develop the Next Generation Air Transportation System" (IG-09-019, July 30, 2009)

"NASA's Use of Research Announcement Awards for Aeronautics Research" (IG-12-011, April 30, 2012)

National Research Council

"Decadal Survey of Civil Aeronautics: Foundation for the Future" (ISBN: 0-309-65895-0, 2006)

"Recapturing NASA's Aeronautics Flight Research Capabilities" (ISBN 978-0-309-25538-7, 2012)