

**REPORT TO CONGRESS**

**NASA Response to the  
National Aeronautics R&D Policy**

**February 2007**

# TABLE OF CONTENTS

<b>FOREWORD .....</b>	<b>3</b>
<b>EXECUTIVE SUMMARY.....</b>	<b>4</b>
<b>I. OVERVIEW.....</b>	<b>5</b>
<b>II. PRINCIPLES.....</b>	<b>5</b>
<b>III. POLICY GOAL AND OBJECTIVES.....</b>	<b>6</b>
<b>IV. GENERAL GUIDELINES.....</b>	<b>7</b>
<b>V. STABLE AND LONG-TERM FOUNDATIONAL RESEARCH GUIDELINES... </b>	<b>9</b>
<b>VI. ADVANCED AIRCRAFT SYSTEMS DEVELOPMENT GUIDELINES.....</b>	<b>10</b>
<b>VII. AIR TRANSPORTATION MANAGEMENT SYSTEMS GUIDELINES.....</b>	<b>12</b>
<b>VIII. NATIONAL RESEARCH, DEVELOPMENT, TEST AND EVALUATION</b>	
<b>INFRASTRUCTURE GUIDELINES.....</b>	<b>13</b>
<b>IX. IMPLEMENTATION GUIDELINES.....</b>	<b>14</b>
<b>X. CONCLUSION.....</b>	<b>16</b>
<b>APPENDIX A: AERONAUTICS INTERAGENCY ORGANIZATIONS.....</b>	<b>17</b>

## FOREWORD

On December 20, 2006, President George W. Bush issued Executive Order 13419, entitled "National Aeronautics Research and Development." Section 1 of the Order established a National Aeronautics Research and Development Policy:

*Section 1. National Aeronautics Research and Development Policy. Continued progress in aeronautics, the science of flight, is essential to America's economic success and the protection of America's security interests at home and around the globe. Accordingly, it shall be the policy of the United States to facilitate progress in aeronautics research and development (R&D) through appropriate funding and activities of the Federal Government, in cooperation with State, territorial, tribal, local, and foreign governments, international organizations, academic and research institutions, private organizations, and other entities, as appropriate. The Federal Government shall only undertake roles in supporting aeronautics R&D that are not more appropriately performed by the private sector. The National Aeronautics Research and Development Policy prepared by the National Science and Technology Council should, to the extent consistent with this order and its implementation, guide the aeronautics R&D programs of the United States through 2020.*

The President's Order and the National Science and Technology Council document to which it refers establish an aeronautics R & D policy for the Nation through 2020 and fulfill the request for such a policy in Section 101(c) of the National Aeronautics and Space Administration Authorization Act of 2005 (Public Law 109-155)(42 U.S.C. 16611(c)) and Section 628 of the Science, State, Justice, Commerce, and Related Agencies Appropriations Act, 2006 (Public Law 109-108).

The overarching goal of the Policy is to advance U.S. technological leadership in aeronautics by fostering a vibrant and dynamic aeronautics R&D community that includes government, industry, and academia. This goal is supported in the Policy by principles and objectives that will drive Federal aeronautics R&D activities, and guidelines that delineate agency roles and responsibilities in the following areas: (1) stable and long-term foundational research; (2) advanced aircraft systems development; (3) air transportation management systems; and (4) national research, development, test and evaluation (RDT&E) infrastructure. The Policy also contains implementation guidelines that include tasks such as the development of a National aeronautics R&D plan, an aligned RDT&E infrastructure plan, and a biennial implementation review procedure.

This report to Congress is in response to the requirement in Section 101 of the National Aeronautics and Space Administration (NASA) Authorization Act of 2005 (P.L. 109-155) to provide a report on how NASA will carry out the new National Aeronautics R&D Policy.

## EXECUTIVE SUMMARY

During FY 2006, NASA's Aeronautics Research Mission Directorate (ARMD) conducted a significant restructuring of its aeronautics program to focus on long-term, cutting edge research in traditional aeronautics disciplines as well as in emerging fields with direct applications to aeronautics. Although the restructuring started before the completion of the National Aeronautics R&D Policy, the new aeronautics program aligns very well with the principles, goal, and objectives of the Policy.

The essence of the Policy is captured in its overarching goal, which is to “*advance U.S. technological leadership in aeronautics by fostering a vibrant and dynamic aeronautics R&D community that includes government, industry, and academia*”. This report illustrates how ARMD will contribute to the realization of this National goal by:

- (1) Focusing on high-quality, cutting-edge research that benefits the constituents of the entire aeronautics community. This research includes foundational research across a breadth of core aeronautics competencies that supports aeronautics and space exploration activities; research in key areas related to the development of advanced aircraft technologies and systems, including those related to aircraft safety, environmental compatibility, and fuel efficiency; and research that supports the Next Generation Air Transportation System (NGATS) in partnership with the Joint Planning and Development Office (JPDO);
- (2) Disseminating the results of all of its research to the widest practical and appropriate extent (consistent with national security and foreign policy);
- (3) Pursuing a coordinated approach to managing the Nation's research, development, test, and evaluation (RDT&E) infrastructure;
- (4) Fostering intellectual partnerships with industry and academia by means of cooperative Space Act Agreements and fully and openly competed research awards that emphasize true collaborations among all partners; and
- (5) Establishing strong partnerships with other Government agencies and organizations, especially the Federal Aviation Administration (FAA), Department of Defense (DOD), and the JPDO.

This report also shows that the responsibilities for NASA outlined in each section of the Policy are well covered by ARMD's four programs: the Fundamental Aeronautics Program, the Aviation Safety Program, the Airspace Systems Program, and the Aeronautics Test Program.

As NASA executes its new Aeronautics program, it will continue to work with the NSTC Aeronautics Science and Technology Subcommittee to develop a National aeronautics R&D plan and accompanying RDT&E infrastructure plan during the coming year.

## **I. OVERVIEW**

In the fall of 2005, NASA's Aeronautics Research Mission Directorate (ARMD) initiated a restructuring of its aeronautics program to ensure that it had a strategic plan in place that enables the pursuit of long-term, cutting-edge research for the benefit of the broad aeronautics community. The three principles guiding this restructuring were: 1) NASA will dedicate itself to the mastery and intellectual stewardship of the core competencies of aeronautics in all flight regimes; 2) NASA will focus its research in areas appropriate to its unique capabilities; and 3) NASA will directly address the fundamental research needs of the NGATS while working closely with its agency partners in the Joint Planning and Development Office (JPDO).

Using the above principles, ARMD established four programs: the Fundamental Aeronautics Program, the Aviation Safety Program, the Airspace Systems Program, and the Aeronautics Test Program (ATP). The Fundamental Aeronautics Program conducts cutting-edge research that produces innovative concepts, tools, and technologies that enable the design of vehicles that fly through any atmosphere at any speed. The Aviation Safety Program focuses on developing the cutting-edge tools, methods, and technologies to improve the intrinsic safety attributes of current and future aircraft that will operate in the NGATS. The Airspace Systems Program directly addresses the Air Traffic Management (ATM) research needs of the NGATS initiative as defined by the JPDO. The Aeronautics Test Program ensures the strategic availability and accessibility of a critical suite of aeronautics test facilities that are deemed necessary to meet aeronautics, agency, and national needs.

Both the restructuring of NASA's aeronautics research program and the development of the National Aeronautics R&D Policy took into consideration many of the same reports and studies that have been conducted over the past several years. These reports included the "Final Report of the Commission on the Future of the U.S. Aerospace Industry" by the Aerospace Commission, 2002, "Securing the Future of U.S. Air Transportation: A System in Peril" by the National Research Council (NRC), 2003, and "Wind Tunnel and Propulsion Test Facilities: An Assessment of NASA's Capabilities to Serve National Needs", RAND Corporation, 2003. The use of this supporting information by both parties helped contribute to the alignment of NASA's restructured aeronautics program with the new Aeronautics R&D Policy. In addition, while the recent NRC "Decadal Survey of Civil Aeronautics" (2006) was published after the restructuring of NASA's aeronautics program had begun, NASA's new aeronautics program is very well aligned with the recommendations of that study.

The following sections provide details of NASA's implementation of the new Aeronautics R&D Policy through its programs in ARMD. NASA-specific responsibilities under each section of the Policy guidelines will be addressed to show how NASA's aeronautics programs are fulfilling those guidelines.

## **II. PRINCIPLES**

Many of the guiding principles for the Nation's aeronautics enterprise that are outlined in the Policy are applicable to ARMD's programs. The primary examples are:

- The Fundamental Aeronautics Program directly addresses the first principle of "mobility through the air" by conducting research that can enable the development of advanced aircraft systems that fly with higher performance, lower fuel consumption, and minimum environmental impact (noise and emissions) at a range of speeds and from a wide variety of airports. The Airspace Systems Program directly addresses this principle by conducting air traffic management research that will develop concepts, capabilities, and technologies required to meet the Nation's anticipated growth in airspace operations, both in the air and on the ground.

- Both the Fundamental Aeronautics Program and the Aviation Safety Program address the second principle of “national security and homeland defense” by conducting “dual-use” research in a number of areas including advanced aircraft design, integrated propulsion concepts, multi-functional materials development, and advanced aviation safety technologies.
- The core mission of the Aviation Safety Program directly addresses the third principle that states that aviation safety is paramount.
- All of ARMD’s programs directly address the fifth principle of developing a “world-class aeronautics workforce” by focusing on cutting-edge research, and by fostering intellectual partnerships with industry and academia by means of cooperative Space Act Agreements and fully and openly competed research awards that emphasize true collaborations among partners. In addition, ARMD currently funds graduate student scholarships and intends to expand its scholarship efforts to include scholarships for undergraduates. Both the undergraduate and graduate scholarships will include summer internship opportunities at NASA research centers.
- The Fundamental Aeronautics Program simultaneously addresses the sixth and seventh principles by conducting research to improve aircraft performance, increase fuel efficiency, lower emissions (including particulate matter) and reduce noise. In addition, the Airspace Systems Program also addresses these two principles by conducting research to improve efficiency and reduce environmental impact through better utilization of the airspace.

### III. POLICY GOAL AND OBJECTIVES

The overarching goal and objectives of the Policy are well supported by the four ARMD programs. The overarching Policy goal to “*advance U.S. technological leadership in aeronautics by fostering a vibrant and dynamic aeronautics R&D community that includes government, industry, and academia*” is supported by ARMD’s dedication to the pursuit of cutting-edge research for the benefit of the constituents of the entire aeronautics community. Across all of our programs we are working to establish a collaborative environment among NASA researchers, other Government agencies, academia, and industry to enable revolutionary capabilities that none can achieve alone but from which all can benefit.

Many of the Policy’s objectives are supported by at least one of the four ARMD programs, and in most cases, more than one. The Policy objectives directly supported by ARMD’s programs are:

- *Provide long-term stability and focus in innovative research that leads to ground-breaking ideas, concepts, approaches, technologies, and capabilities in order to provide a robust foundation for the advancement of U.S. technological leadership in aeronautics.*
  - ⇒ This objective is supported directly by the Fundamental Aeronautics Program, the Aviation Safety Program, and the Airspace Systems Program, and indirectly by the Aeronautics Test Program.
- *Pursue and develop promising advanced aircraft concepts and technologies to enable new opportunities to provide unsurpassed military capability.*
  - ⇒ This objective is supported by the Fundamental Aeronautics Program and the Aviation Safety Program, and indirectly by the Aeronautics Test Program.
- *Pursue and develop advanced concepts and technologies that enable increased air traffic capacity and new aircraft concepts in the national airspace.*
  - ⇒ This objective is directly supported by the Airspace Systems Program, the Fundamental Aeronautics Program, the Aviation Safety Program, and indirectly, by the Aeronautics Test Program.

- *Pursue a coordinated approach to managing U.S. Government aeronautics research, development, test, and evaluation infrastructure identified as critical national assets required to maintain and advance world-class U.S. experimental and computational R&D capabilities.*  
⇒ This objective is supported by the Aeronautics Test Program.
- *Cultivate an R&D environment that enables a globally competitive U.S. aeronautics enterprise, and encourages industry investment and academic participation.*  
⇒ This objective is supported by all four programs.
- *Enhance coordination and communication among executive departments and agencies to maximize the effectiveness of government R&D resources.*  
⇒ This objective is supported by all four programs.
- *Strengthen mechanisms to engage partners in industry and academia concerning government R&D priorities, programs, and planning processes.*  
⇒ This objective is supported by all four programs.

Specifics on how these objectives are being supported by ARMD’s programs are detailed in the following sections that cover the Policy guidelines.

#### **IV. GENERAL GUIDELINES**

The Policy defines four general guidelines that apply to all executive departments and agencies. The guidelines deal with the role of the government in aeronautics R&D, the aeronautics workforce, and academic and commercial cooperation. Many of the points made in these guidelines can be directly linked to ARMD’s overall strategic direction.

Under the Policy guidelines, the Federal Government should only undertake roles in supporting aeronautics R&D that are not more appropriately performed by the private sector. Specifically, investment of the federal government in aeronautics R&D should be limited to three areas: (1) those efforts that support national defense and homeland security, (2) long-term research that provides the foundation for future technology development, or (3) advanced civil aeronautics research that meets specific criteria. All research conducted by ARMD falls directly in line with at least one of these areas. Below we provide several examples that illustrate this point:

- ARMD’s overall strategic plan to pursue long-term, cutting-edge research across all of its programs will provide the foundation for future technology development. As part of this general guideline, the Policy also calls for the widest practical and appropriate dissemination of research results, a principle that ARMD has emphasized and that is consistent with NASA’s Space Act of 1958 (as amended).
- Research conducted by the Fundamental Aeronautics Program to reduce aircraft noise and emissions and improve fuel efficiency meets the *public interest research* criteria of advanced civil aeronautics research. Furthermore, all of the projects under the Aviation Safety Program conduct research “that directly benefits the public by improving safety”.
- The Airspace Systems Program, the Aviation Safety Program, and the Fundamental Aeronautics Program all conduct research in support of Government Internal R&D; specifically, the research conducted will support the design and development of the Next Generation Air Transportation System (NGATS).

- Both the Fundamental Aeronautics Program and the Aviation Safety Program conduct research that will lead to “dual use” capabilities applicable to national defense and homeland security in a number of different fields, including the design of revolutionary aircraft concepts, new material and structural approaches, modern integrated propulsion concepts, and innovative aviation safety technologies.

NASA is addressing the Policy guidance regarding both the aeronautics workforce and academic cooperation in many ways, most notably by means of the NASA Research Announcement (NRA) process. This full and open competitive approach allows ARMD to foster collaborative research partnerships with the “best and brightest” in the academic and private sector communities across the country. The NRA process encourages researchers (e.g., faculty, students, members of industry) to spend periods of time (e.g., summers) at NASA centers. This will enhance the exchange of ideas and expand the learning experience for everyone involved. In addition, ARMD ensures access of NASA RDT&E facilities for academic use by means of an ATP-specific NRA solicitation in which substantial involvement of students (e.g., on-site internships at NASA facilities) is a required element of a successful proposal.

As part of its program planning, ARMD has included multiple inputs from industry, which addresses the Policy guidance for commercial cooperation. During the initial restructuring of its programs, ARMD issued a Request for Information (RFI) to industry to solicit input and interest for cooperative partnerships in pre-competitive research that would allow NASA to leverage industrial system-level expertise while facilitating the rapid transfer of knowledge and technology from NASA to industry. Many of the responses (more than 230 overall) have resulted in working collaborations that are currently being defined and finalized through the Space Act Agreement process. During the past year, ARMD programs also held numerous industry working group meetings, and senior management traveled to about 20 different companies across the country to get input from senior engineers and managers. Going forward, each program will continue to hold regular industry working group meetings. Industry partners will be invited to technical interchange meetings where results from research will be presented and discussed. The goal across all programs is to establish a collaborative research environment in which ideas and knowledge are exchanged across all communities (government, academia, and industry).

In addition, the Aviation Safety Program will continue to participate in the Commercial Aviation Safety Team (CAST), a collaboration of government and industry organizations from the commercial transport aviation community that identifies, implements, and tracks new interventions intended to improve aviation safety. NASA has been an active member since the beginning of the CAST and has used findings and recommendations of the CAST to formulate its research portfolio. Currently, the CAST has proposed a vision for industry and government to share operational data in order to detect and correct systemic anomalies within the air transportation system before they manifest themselves into an incident or accident event. NASA, in collaboration with the FAA and the CAST, is working to realize this vision by focusing on the development of advanced algorithms and technologies in data-mining that enable the integration, processing, and analysis of large amounts of disparate data. In addition, building on the success of the CAST, the rotorcraft community has recently formed the International Helicopter Safety Team (IHST) with a goal to reduce the helicopter accident rate by 80%. NASA is involved in the IHST and will use its findings as appropriate to formulate and prioritize research activities relevant to rotorcraft safety.

Furthermore, as called for in this section of the Policy, all of NASA’s ATP facilities are accessible for private use, and one of the Aeronautics Test Program missions is to provide consistent cost and usage policies in those facilities.

Finally, ARMD will continue to host informal meetings with the aeronautics community on a regular basis (roughly every other month) in order to maintain open lines of communication and to generate discussion in areas of broad interest. These meetings provide participants from industry, academia, industry associations, and non-profit associations with a forum to share their experiences and express their individual points of view on the particular topic of discussion. As an example of the impact of such discussions, our most recent meeting focused on aeronautical test facilities, and the dialogue resulted in industry participants deciding to work together to establish the U.S. Industry Test Facilities Working Group under the sponsorship of the American Institute of Aeronautics and Astronautics (AIAA) and its Ground Test Technical Committee (GTTC).

## **V. STABLE AND LONG-TERM FOUNDATIONAL RESEARCH GUIDELINES**

*NASA should maintain a broad foundational research effort aimed at preserving the intellectual stewardship and mastery of aeronautics core competencies so that the nation's world-class aeronautics expertise is retained. These core competencies also include key aeronautical capabilities that support NASA's human and robotic space activities.*

While the Fundamental Aeronautics Program is structured along specific flight regimes (subsonic fixed-wing, subsonic rotary-wing, supersonics, and hypersonics), each project funds relevant research across a wide range of critical aeronautics core competencies. Among others, these include fluid mechanics, combustion, aerodynamics, aerothermodynamics, materials and structures, aeroelasticity, acoustics, guidance navigation and control, physics-based computational methods, and measurement and experimental techniques. Mastery of such competencies will be crucial to our Nation's ability to overcome the significant environmental, performance, and fuel efficiency challenges facing our future air vehicles. For example, significant (and realizable) reductions in aircraft noise levels require both a fundamental understanding of the physical phenomena that create the noise (unsteady flows, turbulence, shock waves, shear layers, vortical wakes, and their interaction) and the ability to credibly assess the impact of noise reduction technologies on the overall system performance. Similarly, in order to tackle revolutionary low emissions concepts (where emissions include NO<sub>x</sub>, CO<sub>2</sub>, water vapor, volatiles, unburned hydrocarbons, particulate matter, and soot), it is essential to understand the physical mechanisms that govern combustion (reaction sets, chemical kinetics, pollutant and soot formation, turbulence interaction) and to develop predictive methodologies that can be used with confidence to guide our efforts. Ultimately, solutions to these challenges must be approached in a systemic manner to ensure that advances in one area (e.g., noise signature) do not result in unacceptable penalties in another area (e.g., fuel efficiency). Hence, the Fundamental Aeronautics Program will pursue an integrated approach to its foundational research across the core competencies of aeronautics to ensure the ability to address the system-level challenges facing our future air vehicles.

In addition, much of the foundational research conducted by the Fundamental Aeronautics program is ultimately applicable to the design of spacecraft as well as aircraft. For example, the atmosphere of Mars presents a daunting challenge for safely landing large payloads. It is thick enough to cause severe heating challenges but thin enough to make deceleration extremely difficult. Currently, our Mars landing capabilities are limited to about 1 metric ton. Foundational research in several core aeronautics competencies such as aerodynamics, aerothermodynamics, computational fluid dynamics, guidance navigation and control, and materials and structures, across all flight regimes from subsonic through hypersonic, will play an important role in advancing NASA's ability to land significantly larger payloads on Mars.

The Aviation Safety Program also conducts research in several critical core aeronautics competencies, including materials and structures, sensors, data mining, flight mechanics, human factors, verification and validation of complex systems, flight dynamics and control, icing physics, and intelligent and adaptive

systems. Mastery of these competencies will be critical to our ability to develop innovative concepts, tools, methods, and technologies that will improve the intrinsic safety attributes of current and future aircraft operating in the National Airspace System (NAS). In addition, just as in the Fundamental Aeronautics Program, much of the foundational research conducted in the Aviation Safety program will ultimately have applicability to spacecraft as well as aircraft. For example, research in core areas such as sensors and data mining in the Integrated Vehicle Health Management project may lead to self-healing systems that are applicable not only to aircraft but to spacecraft as well. Foundational research in materials that leads to advances in our understanding of the aging and durability properties of composites and superalloys will have dual aeronautics and space applications. Foundational research in adaptive controls as part of the Integrated Resilient Aircraft Control project will likely find applications in future space missions where vehicles will be required to operate in and adapt to unknown flight environments. Finally, foundational research in human factors, sensors, and human-automation interface modeling will lead to enhancements in crew-vehicle interface technologies that may have applicability to space vehicles as well.

The Airspace Systems Program conducts foundational research in several critical core aeronautics competencies, including statistical decision theory, data mining, trajectory and wake modeling, applied mathematics for optimization with multiple uncertain variables, and human model development. Such research will be critical to enable the development of revolutionary concepts, capabilities and technologies that will enable significant increases in the capacity, efficiency, and flexibility of our NAS.

Finally the Aeronautics Test Program supports all of these research efforts by ensuring the availability and accessibility of the critical testing assets required to conduct the research.

## **VI. ADVANCED AIRCRAFT SYSTEMS DEVELOPMENT GUIDELINES**

*NASA should conduct research in key areas related to the development of advanced aircraft technologies and systems that support DOD, FAA, the JPDO, and other executive departments and agencies. NASA may also conduct such research to benefit the broad aeronautics community in its pursuit of advanced aircraft technologies and systems, in accordance with the guidelines presented in Section IV.*

All four projects within the Fundamental Aeronautics Program directly address this guidance. Specifically, the key system-level objectives that drive the research investment portfolio in the Subsonic Fixed-Wing, Subsonic Rotary-Wing, and Supersonic projects are strongly driven by the projections established by the JPDO for expected growth in capacity. This includes the focus on aircraft technology and concepts to eliminate the potential “exponential growth” in delays that could result at the Nation’s major airports. For example, the Subsonic Fixed-Wing project has an objective to double the lift coefficient of future transport aircraft. This will enable shorter take-off and landing field lengths and quicker climb-out and descent maneuvers to improve capacity, reduce noise and open many existing airports to air service. The project is also exploring unconventional concepts such as a hybrid wing-body that promise to be much quieter and efficient than conventional tube-and-wing concepts. Rotorcraft have the potential to provide point-to-point travel, thereby making routine air travel more accessible to everyone, but only if key limitations can be overcome. The Subsonic Rotary-Wing project aims to address these limitations by focusing research on technologies that can increase the range, speed, payload capacity, fuel efficiency, and environmental acceptance (especially noise) of rotorcraft. The Supersonic project has the long-term objective of enabling supersonic flight over land by providing the fundamental understanding to enable a dramatic reduction in the disturbance from a “sonic-boom” and facilitate more efficient, environmentally benign propulsion. Because strong, sustained growth will never be possible without consideration of the environment and energy consumption, the three projects will continually adjust research goals for reduced noise, emissions and energy consumption to enable “growth without impact” consistent with future JPDO projections. We note that in all of these cases, the same technologies

have dual-use applications to the DOD (e.g., Vertical/Short Take-Off and Landing (VSTOL), advanced blended wing body transport).

The research conducted in the Hypersonic research project in the Fundamental Aeronautics Program is directly relevant to advanced hypersonic vehicle development being pursued by the DOD. Research pursued in the project will enable sustained hypersonic flight through the atmosphere and can help the DOD achieve its goal of reaching targets from the air with global reach, quick reaction, persistence, and significant payload. The Hypersonic project works closely with the Air Force and the Defense Advanced Research Projects Agency (DARPA) to ensure that the research being conducted is not duplicative of research being funded by the DOD, but rather enhances the knowledge base in hypersonics in a manner that is useful and relevant to DOD needs.

The Aviation Safety Program worked closely with the FAA and the JPDO in developing its research plans with a focus on developing cutting-edge technologies to improve the intrinsic safety attributes of current and future aircraft that will operate in the global NGATS. Furthermore, many of the technologies will have dual-use applications for DOD needs. As such, all four projects within the Aviation Safety Program directly support this Policy guidance. Specifically, the Integrated Vehicle Health Management (IVHM) project will conduct research to advance the state of highly integrated and complex flight-critical health management technologies and systems. These technologies will enable nearly continuous on-board situational awareness of the vehicle health state for use by the flight crew, ground crew, and maintenance depot. Improved safety and reliability will be achieved by onboard systems capable of performing self-diagnostics and self-correcting of anomalies that could otherwise go unattended until a critical failure occurs.

The Integrated Intelligent Flight Deck (IIFD) project will pursue flight deck related technologies that ensure crew workload and situation awareness are both safely optimized and adapted to the future operational environment as envisioned by the NGATS. A key component of this research will be investigating methods to automatically monitor, measure, and assess the state of crew awareness. Project results should enable system designers to eliminate the safety risk of unintended consequences when introducing new and advanced systems into an operational environment.

The Integrated Resilient Aircraft Control (IRAC) project will conduct research to provide onboard control resilience to ensure safe flight in the presence of adverse flight conditions. Specifically, the effort will focus on advancing the state-of-the-art of adaptive controls as a design option to provide enhanced stability and maneuverability margins for safe landing. The technology focus will initially address adverse flight conditions such as loss of control caused by environmental factors, and/or onboard actuator and sensor faults or failures, and will expand toward more complicated damage conditions.

The Aircraft Aging and Durability (AAD) project will develop advanced diagnostic and prognostic capabilities for detection and mitigation/management of aging-related hazards. The research and technologies to be pursued will decrease the susceptibility of current and next generation aircraft and onboard systems to pre-mature deterioration, thus greatly improving vehicle safety and mission success. The intent is to take a proactive approach to identifying aging-related hazards before they become critical, and to develop technology and processes to incorporate durability and aging mitigation into the design of future aircraft.

The Aeronautics Test Program supports all of the above Fundamental Aeronautics efforts, as well as the icing-related advanced technology research in the IVHM and IRAC projects in the Aviation Safety Program, by ensuring the availability and accessibility of the critical testing assets required to conduct the research.

Finally, although addressed largely below, the Airspace Systems Program is also engaged in advanced aircraft systems research and development with primary support to the FAA and the JPDO. As the

program develops concepts and provides research data to define and assess the allocation of ground and air automation concepts and technologies necessary for NGATS, key research will be conducted to address the future needs and benefits of employing flight deck-based traffic management solutions.

## **VII. AIR TRANSPORTATION MANAGEMENT SYSTEMS GUIDELINES**

*The JPDO, through its partner departments and agencies and in collaboration with the private sector, should be responsible for planning, coordination, and oversight of both research and implementation for the NGATS to meet the nation's civil, military, and homeland security needs. The JPDO should encourage research, collaborative technology demonstrations, and other mechanisms that foster innovative uses of technology or policy approaches in support of NGATS.*

As described in Section VI above, both the Fundamental Aeronautics Program and the Aviation Safety Program conduct research that directly supports the goals and objectives of the NGATS. Here, we describe how our Airspace Systems Program addresses this guidance.

The Airspace Systems Program was restructured during FY2006 to directly address the air traffic management research needs of the NGATS in collaboration with member agencies of the JPDO. The restructured Program is comprised of two new projects: NGATS ATM-Airspace and NGATS ATM-Airportal. The two projects have been planned to make major contributions to air traffic needs of the future by the development of en route/transitional/terminal capabilities and surface capabilities. Both projects are, much like the airspace system itself, highly integrated, and pay close attention to information management at critical transition interfaces in the national airspace system. A major goal of the Airspace Systems Program is to explore and develop concepts and integrated solutions to define and assess the allocation of centralized and decentralized automation concepts and technologies necessary for NGATS.

The NGATS ATM-Airspace project will conduct relevant research to assist the JPDO in the detailed definition and development of the NGATS National Plan. The Project will explore and develop concepts and provide research data to define and assess the allocation of ground and air automation concepts and technologies necessary for NGATS. Specific technical goals include:

- Increasing capacity through dynamic allocation of airspace structure and controller resources;
- Effectively allocating demand through departure time management, route modification, adaptive speed control, etc., in the presence of uncertainty;
- Reducing the capacity-limiting impact of human controlled separation assurance by developing methods to improve sequential processing and merging of aircraft in transition and cruise airspace;
- Developing accurate trajectory predictions that are interoperable with aircraft flight management systems and account for prediction uncertainty growth and propagation;
- Quantifying the performance-enhancing effects of emerging airborne technologies; and
- Developing an approach and computer-modeling tools that can evaluate the systematic impact of the research for the NGATS.

The NGATS ATM-Airportal project will enable capacity improvements in the terminal and airport domains of the NAS. The Airportal Project is responding to the need to achieve the maximum possible productivity in the combined use of gates, taxiways, runways, terminal airspace, and other airportal resources necessary to enable key capabilities of the NGATS. Research activities across the project

contribute to technologies, operational procedures, and systems needed to expand NAS capacity to meet future demand with fewer delays and increased throughput. Specific technical goals include:

- Developing trajectory-based automation technologies to increase the safety and efficiency of surface operations and minimize runway incursions in all weather conditions.
- Enabling reductions in arrival and departure separation standards while balancing arrival, departure, and surface capacity resources at a single airport.
- Enabling the use of dynamic NGATS resources by addressing the following challenges in the airportal environment: (1) creation of seamless “ramp to TRACON” (Terminal Radar Approach CONtrol) traffic flow by integration of dynamic operator roles, decision aids, sensor information, airportal and terminal area constraints, real-time weather information, and regional/metroplex operations; and (2) identification and understanding of new roles, responsibilities and authority required between humans and automation.

The Airspace Systems Program has engaged industry, academia, and other government agencies throughout its restructuring. The program included the JPDO at the earliest stages as it reviewed its preliminary roadmaps, and JPDO members played a key role in reviewing the detailed project proposals. Industry input was solicited through the ARMD RFI process of early CY2006 for recommendations of areas of collaboration in system-level capabilities and integrated systems development. Going forward, the Program will continue to engage the community using a variety of mechanisms including technical interchange meetings, cooperative Space Act Agreements with industry, and the NRA process to ensure full and open competition for the best and most promising research ideas from academia and industry.

Finally, it should be noted that in addition to conducting research that directly addresses NGATS challenges, NASA provides workforce, analysis tools, and funding directly to the JDPO in order to assist with the JPDO’s responsibility of planning, coordinating and overseeing the research and implementation for the NGATS, consistent with the above Policy guidance.

#### **VIII. NATIONAL RESEARCH, DEVELOPMENT, TEST AND EVALUATION (RDT&E) INFRASTRUCTURE GUIDELINES**

*NASA, DOD, FAA, and other executive departments and agencies as appropriate, should, in accordance with applicable laws and regulations, develop cost and usage policies that facilitate interagency cooperation and utilization in the management of their respective RDT&E assets, as well as appropriate access by non-Federal users.*

*NASA, DOD, FAA, and other executive departments and agencies as appropriate, should assess current and future needs for constructing, maintaining, modifying, or terminating RDT&E assets and should develop and implement measures to improve coordination of those needs both among executive departments and agencies and across the broader community of users.*

The primary mission of the Aeronautics Test Program (ATP) – to ensure the strategic availability of a minimum, critical suite of NASA aeronautical test facilities that are necessary to meet the long-term needs and requirements of the Nation – is clearly aligned with this Policy guidance. More specifically, the program ensures that funding levels allow for continuous operations at ATP facilities and for the appropriate levels of maintenance and investments in test technologies and test techniques. This program also establishes stable user pricing at the facilities for other government agencies, industry and academia. The program will review the status of its assets annually to insure intelligent investment in, and divestment of, facilities in order to achieve the program’s mission.

NASA and the DOD have had a long-standing relationship with respect to testing and experiments through formal mechanisms such as the National Aeronautics Testing Alliance (NATA), that covered wind tunnels and air-breathing propulsion facilities, and through informal mechanisms such as cost and usage policies that benefit both NASA and the DOD. NASA and the DOD have recently signed a new agreement entitled the National Partnership for Aeronautical Testing (NPAT) that replaces NATA with a broadened scope that includes all aeronautical test facilities owned or operated by NASA and DOD. NPAT will be used by NASA and DOD to facilitate the establishment of an integrated national strategy for the management of their respective aeronautics test facilities. It is also intended that NPAT will provide a means for NASA and the DOD to engage with the aeronautics community, including the private sector, to discuss their RDT&E infrastructure needs.

Industry users have proposed the development of a “US Industry Test Facilities Working Group” which would serve as a kind of focus-group under the auspices of the AIAA Ground Test Technical Committee (GTTC). This group would be a forum for industry to discuss and develop RDT&E infrastructure requirements (regarding both usage and capabilities). The group was recently approved by the AIAA GTTC, and will be formed and developed in the coming months. Details regarding its interactions with the Government are still to be defined.

## **IX. IMPLEMENTATION GUIDELINES**

*NASA, DOD, FAA, JPDO, and other executive departments and agencies as appropriate, should develop a national aeronautics R&D plan comprising national research priorities and objectives, roadmaps to achieve the identified objectives, and timelines. The plan should include foundational research as described in Section V of this policy as well as applied research and technology development for advanced aircraft systems and air transportation management systems. This plan should be coordinated through and published by the NSTC within one year of the signature of this policy and updated every two years thereafter. The NSTC, working with the Office of Management and Budget, should review Federal investment in aeronautics R&D to ensure that it meets the needs outlined in the plan.*

*NASA, DOD, FAA, and other executive departments and agencies as appropriate, should develop an infrastructure plan, aligned with the aeronautics R&D plan, for managing critical Federal RDT&E assets. The infrastructure plan should identify which assets are considered critical from a national perspective and define an approach for constructing, maintaining, modifying, or terminating these assets based on the needs of the broad user community. This infrastructure plan should be coordinated through and published by the NSTC within one year of the signature of this policy and updated every two years thereafter.*

As a member of the NSTC Aeronautics Science and Technology Subcommittee, NASA will be working alongside representatives from DOD, Department of Commerce (DOC), Department of Energy (DOE), Department of Homeland Security (DHS), Department of State (DOS), Department of Transportation (DOT), FAA, JPDO, National Science Foundation (NSF), U.S. International Trade Commission (USITC), Council of Economic Advisors (CEA), Domestic Policy Council (DPC), National Security Council (NSC), Office of Management and Budget (OMB), Office of Science and Technology Policy (OSTP), Office of the Vice President (OVP) and Office of the U.S. Trade Representative (USTR) to develop a National Aeronautics R&D Plan and a National Aeronautics RDT&E Infrastructure Plan as called for by the Policy. Each of the member organizations that funds aeronautics-related research will provide details regarding existing program plans as well as any relevant studies that have informed those plans to the subcommittee for its use. The subcommittee will also leverage, to the extent possible, existing advisory groups and outreach mechanisms from each organization. NASA, DOD, and the FAA, for example, participate in numerous interagency organizations that address particular subjects of long-standing interest. Appendix A contains a list of some of these organizations in which NASA is a major

participant. In addition to using these existing outreach mechanisms, the subcommittee intends to engage experts in the aeronautics community to solicit their views and opinions.

The subcommittee will also leverage resources (e.g., plans, data, outreach activities) from those member organizations that have oversight over RDT&E infrastructure. The newly formed NPAT, described in Section VIII above, is one obvious resource to the subcommittee in formulating the National RDT&E infrastructure plan.

Both the R&D plan and the RDT&E infrastructure plan will be completed and delivered to the NSTC by the end of December 2007. The subcommittee will update these plans every other year.

*Executive departments and agencies conducting aeronautics R&D should engage industry, academia, and other non-Federal stakeholders in support of government planning and performance of aeronautics R&D, and should report to the NSTC within one year of the signature of this policy and every two years thereafter on the results of these interactions.*

*Executive departments and agencies should develop and implement, as appropriate, measures for improving dissemination of R&D results and lowering the barriers that would prevent technology transition from R&D to applications, reporting within two years of the signature of this policy and every two years thereafter any specific actions to the NSTC.*

A primary goal across all of the programs in ARMD is to establish strong partnerships involving NASA, other Government agencies, academia, and industry in order to enable significant advancement in our nation's aeronautical expertise. Every element of our portfolio targets innovative, pre-competitive research that will enhance the technical sophistication of the U.S. R&D/industrial base involved in aeronautical work.

Because these partnerships are so important, NASA has put many mechanisms in place to engage academia and industry, including industry working groups and technical interchange meetings at the program and project level, Space Act Agreements for cooperative partnerships with industry, and the NRA process that provides for full and open competition for the best and most promising research ideas. Cooperative partnerships with industry consortia can result in a significant leverage of resources for all partners and can provide opportunities to test the value of component-technology advances in full system-level contexts.

All research results, whether generated by NASA internally, or by its partners through the NRA, will be openly disseminated through archival publications and conference proceedings as well as NASA publications (consistent with national security and foreign policy guidelines). Such conditions are stipulated in the NRA itself; specifically, the following clause is included in the evaluation criteria:

*Tangible products at the end of the effort are desirable. Annual oral presentations made as part of an open Technical Exchange Meeting for purposes of technology transfer and knowledge dissemination will be expected. Documentation of approach and results in the form of final written technical reports is required. A clear statement of what intellectual property is expected to be publicly available at the conclusion of the work is required. It is our intent to share all knowledge developed under this solicitation, thus, any restrictions to that objective will cause a lower score in this area. Collaboration with NASA researchers (including joint use of facilities, sharing of materials, development of computer code modules compatible with NASA's software, and synergistic research goals) is desirable, with the objective of enhancing knowledge transfer and the long-term value of the proposed work.*

A similar philosophy is being applied in the establishment of Space Act Agreements with industry partners. Specifically, ARMD programs consider the following principles as they assess potential NASA/industry collaborations:

- Collaborations are pursued only when there is significant benefit to NASA and its constituencies (the aerospace community, aerospace industry, academia, and ultimately, the taxpayer).
- Once the collaboration is setup, the results must be appropriately disseminated and validated through a peer-review process.

Finally, NASA recognizes the importance of close coordination not just with industry and academia, but with its partners in other Government agencies as well. As explained earlier in this section, Appendix A provides a list of some interagency organizations (e.g., planning groups, working groups) in which NASA is an active participant. In addition, in May 2006, NASA and the FAA signed a Memorandum of Understanding (MOU) to coordinate their planning efforts in pursuit of complementary goals in aviation and future space transportation. These goals include aviation safety, airspace system efficiency, and environmental compatibility. In August 2006, NASA signed an MOU with the Air Force (AF) to establish partnerships in aeronautical research in areas of mutual interest. As part of the execution of that MOU, the AF and NASA established an Executive Research Committee to oversee joint research efforts. In January 2007, NASA and the DOD signed the NPAT agreement described in Section VIII above. Finally, NASA anticipates signing an MOU with the Army this year that will facilitate the coordination of research efforts between the two organizations in areas pertaining to rotorcraft aeronautics, including rotorcraft dynamics and control, rotorcraft vehicle structures, rotorcraft propulsion, avionics, rotorcraft aeromechanics, and safety and airspace management.

## **X. CONCLUSION**

NASA believes that the content and direction of its reshaped Aeronautics programs are consistent with the National Aeronautics R&D Policy and will contribute to the advancement of Aeronautics for the Nation. NASA will continue to work closely with its partners on the NSTC Aeronautics Science and Technology Subcommittee in its formulation of the National Aeronautics R&D plan and RDT&E infrastructure plan during the coming year.

## **Appendix A: Aeronautics Interagency Organizations**

Joint Planning and Development Office (JPDO) - The JPDO is developing the national Plan for the Next Generation Air Transportation System (NGATS). During FY07, the JPDO will develop an Enterprise Architecture and an Integrated Work Plan that will provide the information needed for FY09 program planning by each member agency. [Principal Members: FAA, NASA, DOT, DOD, DOC, DHS, OSTP]

Commercial Aviation Safety Team (CAST) - Joint objectives to improve aviation safety of commercial aircraft by reducing the fatal accident rate. [Principal Members: NASA, FAA, Industry]

International Helicopter Safety Team (IHST) - Similar to CAST, but focus is on rotorcraft. [Principal Members: NASA, FAA, Industry]

Joint Council on Aging Aircraft (JCAA) - The Joint Aeronautical Commanders' Group (JACG) has focused its resources on the aging aircraft problem. It chartered the Joint Council on Aging Aircraft (JCAA) as the lead board for working a national aging aircraft strategy including identifying and initiating joint R&D efforts. [Principal Members: NASA, USAF, USN, FAA, Defense Logistics Agency (DLA), Army]

Versatile Affordable Advanced Turbine Engine (VAATE) Technology Program -Coordinates turbine engine science and technology (S&T) across DOD and other government agencies (NASA, DOE). Reviews national turbine engine technology roadmaps and progress towards achieving roadmap goals. Interfaces with industry to link government and industry activities in turbine engine S&T. Communicates benefit and need for turbine engine technology S&T to government agencies and industry. [Principal Members: NASA, ODUSD(S&T), USAF, USN, USA, DOE, Industry]

Vertical Take-off and Landing (VTOL) Science and Technology (S&T) Partnership Council - Provides a forum for planning, allocating resources, and executing the Joint Services VTOL S&T Program. Facilitates strategic direction to the Fixed- and Rotary-Wing S&T community. The Council will establish strategic direction and provide the necessary oversight of the S&T process. [Principal Members: NASA, ODUSD(S&T), USAF, USN, USA]

Hypersonics Joint Technology Office (formerly the High-Speed / Hypersonics Steering Committee) - Provides a forum for planning, allocating resources, and executing the Joint Services High-Speed and Hypersonic S&T Program. [Principal Members: ODUSD(S&T), USAF, USN, USA, NASA]

Aircraft Icing Research Alliance (AIRA) - Objective of AIRA is to coordinate collaborative aircraft icing research activities that improve the safety of aircraft operations in icing conditions. Current partners are: NASA, FAA, NOAA, Environment Canada, Transport Canada, Canadian National Research Council, and the UK Defense Science and Technology Laboratory. Every three years this alliance prioritizes research topics and creates collaborative tasks. Current tasks include the development of icing cloud instrumentation by NASA, the FAA, the NRC, and the Meteorological Services of Canada (MSC); high ice water content research by NASA, the FAA, and the MSC; and icing environment remote systems development by NASA, NOAA, the FAA, Transport Canada, and the MSC. [Principal Members: NASA, FAA, NOAA]

Fixed-Wing Executive Council - Coordinates national strategy in this technical area among major Government and industry partners. Participants from USAF, NASA, Army, Navy, and OSD meet with Northrop Grumman, Lockheed Martin, and Boeing three times a year to share opportunities to collaborate, discuss future national direction, and develop strategies to meet warfighter needs. Promote the program at appropriate levels of government and industry. Provide strong leadership to continuously

inspire the team, instill discipline, articulate the team's position at executive levels, and ensure a strong focus on the goals. [Principal Members: NASA, ODUSD(S&T), USAF, USN, USA, Industry]

National Partnership for Aeronautical Testing (NPAT) Council - Council will implement the NPAT agreement between NASA and the DoD. The purpose of the NPAT agreement is to expand cooperation between the two parties and to facilitate the parties' establishment of an integrated national strategy for the management of their respective aeronautical test facilities. [Principal Members: NASA and DoD]

NASA/AF Executive Research Committee - Responsible for the executive direction and oversight of AF and NASA joint aeronautics research and development efforts. Responsibilities include: (1) Fostering an effective AF/NASA partnership in research, development, and applications; (2) Ensuring that AF and NASA planning and resources to achieve the objectives are coordinated, when appropriate; (3) Monitoring progress toward the goals and proposing adjustments in the organizations' roadmaps, plans, and resources, as necessary; and (4) Proposing changes to goals and plans based on changing stakeholder and customer requirements. [Members: NASA and USAF]