NASA's Aeronautics Technology Program

Statement of

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Committee to Review NASA's Aeronautics Technology Program

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An Assessment of NASA's Aeronautics Technology Program

Mr. Chairman, Mr. Udall, and members of the committee, thank you for the opportunity to testify before you today. My name is John Klineberg. I have recently retired from my position as the president of Space Systems/Loral and served for over 25 years in a variety of management and technical positions with NASA. I appear before you today in my capacity as chair of the National Research Council's committee assessing NASA's aeronautics technology programs. The Research Council 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 late 2002, the National Research Council was asked by NASA and the Office of Management and Budget to examine the technical quality of its aeronautics research and development. The National Research Council formed our committee under the auspices of the Aeronautics and Space Engineering Board to respond to this request. Our committee's report was released in November of 2003.

I am aware that NASA's program has been changing since our report was issued and that it will continue to change. However, the following material summarizes the findings and recommendations of our report as it was issued in November 2003.

OVERVIEW

The National Research Council (NRC) of the National Academies performed this detailed, independent assessment of NASA's Aeronautics Technology Programs by establishing three panels, one for each of the component programs within the Aeronautics Technology Programs. The NRC also established a parent committee, consisting of the chairman and a subset of members from each panel. The committee and panels began their activities in early 2003.

The three subordinate panels conducted an independent peer assessment of the Vehicle Systems Program (VSP), the Airspace Systems Program (ASP), and the Aviation Safety Program (AvSP), the three elements of NASA's Aeronautics Technology Programs. The committee and panels were asked by NASA to address four questions:

1. Is the array of activities about right?
2. Is there a good plan to carry out the program?
3. Is the program doing what it set out to do?
4. Is the entire effort connected to the users?

The committee developed findings and recommendations at three different levels. At the top level, it created a list of 12 key crosscutting recommendations for the overall

Aeronautics Technology Programs on issues that span the entire set of programs. These recommendations are appropriate for guiding Congress, NASA Headquarters, and the White House in prioritizing NASA's aeronautics research and development programs. At the second level of detail, the committee provided program-level recommendations appropriate for program and project managers at the NASA Research Centers. Finally, the committee developed findings and recommendations at the task level that are designed to assist the individual principal investigators in improving the quality of their research. These third-level recommendations are numerous and detailed and are not included in this document.

OVERALL ASSESSSMENT

The committee's simple answer to the four questions posed by NASA is that, in general, the Aeronautics Technology programs are very good but could be greatly improved by following the committee's 12 top-level recommendations. The array of research activities is about right, although a few additions and deletions are recommended in various areas. There are good plans to carry out the programs and they are accomplishing much of what they were established to do, but with some changes in the plans for execution results could improve results significantly. In addition, the programs are reasonably well connected to the users, but here again the committee recommends some improvements. These issues—scope, planning, achievement, and ties to users—are addressed more completely in the specific recommendations themselves:

Top-Level Recommendation 1. The government should continue to support air transportation, which is vital to the U. S. economy and the well-being of its citizens.

A strong national program of aeronautics research and technology contributes to the vitality of the U.S. aeronautics industry, the efficiency of the U.S. air transportation system, and the economic well-being and quality of life of people in the United States. The government has an important role in assuring the best possible air transportation system and the development of related technologies that enable products and services to compete effectively in the global marketplace. This is consistent with the legislative charter for NASA, the National Aeronautics and Space Act of 1958, as amended. The Act specifies that NASA's aeronautics research and technology development should "contribute to a national technology base that will enhance United States preeminence in civil and aeronautical aviation and improve the safety and efficiency of the United States air transportation system."

Top-Level Recommendation 2. NASA should provide world leadership in aeronautics research and development.

To provide leadership, NASA should develop consistent strategic and long-range plans to focus the aeronautics program in areas of national importance. NASA should have

well-formulated, measurable, attainable goals at all program levels. To be meaningful, goals should be based on a sound evaluation of future needs, technological feasibility, and relevant economic and other non-technical factors.

Top-Level Recommendation 3. NASA has many excellent technical personnel and facilities to achieve its aeronautics technology objectives but should improve its processes for program management.

Many NASA facilities are world class national assets. In addition, the committee was impressed with the technical expertise of many program personnel. To maximize these assets, NASA needs to improve its program management and systems integration processes, including integration across programs. In particular, NASA should assure clear lines of responsibility and accountability. The use of matrix and line management reporting structures sometimes obscures lines of accountability, and subproject and task-level plans, funding, goals, metrics, staffing, and responsibility are often difficult to define or cannot be clearly traced back to a plan or vision for the program as a whole. Further, NASA should use independent quality assurance processes for program evaluation, and all projects should be evaluated on a regular basis to determine whether continued investment is warranted.

Top-Level Recommendation 4. NASA should eliminate arbitrary time constraints on program completion and schedule key milestones based on task complexity and technology maturity.

Research priorities, funding, and organizational structure change during the course of any research and development effort. However, NASA should resist constant changes and realignments designed to meet artificial 5-year sunset requirements. Several long-term research efforts have been disguised as a series of 5-year projects with different names so that it is not easy to trace the real progress of the research. In addition, the continuous reorganization and restructuring that occur in response to the 5-year sunset rule create an unstable atmosphere that does not permit NASA researchers to pursue the best path to technology maturation. NASA programs need clear exit criteria at the task level that specify when research is complete or ready for transition to industry or other agencies.

Top-Level Recommendation 5. NASA should reduce the number of tasks in its aeronautics technology portfolio.

NASA is trying to do too much within the available budget and resists eliminating programs in the face of budget reductions. Often, there are too many tasks to achieve research objectives in key areas. This overload may be partly the result of including various research tasks within more focused efforts. The committee is concerned that breadth of activities is coming at the expense of depth.

Top-Level Recommendation 6. NASA should pursue more high-risk, high-payoff technologies.

Many innovative concepts that are critical to meeting aviation needs in the next decades will not be pursued by industry or the Federal Aviation Administration (FAA). NASA should fill this void. The committee applauds the inclusion of high-risk, revolutionary sub-projects in many areas and believes the program portfolio could benefit from additional far-reaching efforts with the potential for high payoff. This type of research is critical to investigating the feasibility of innovative concepts and reducing risk to the point where the concepts are suitable for advanced development and transfer to industry or the FAA.

Top-Level Recommendation 7. NASA should reconstitute a long-term base research program, separate from the other aeronautics technology programs and projects.

The current research is mostly product-driven, with not enough fundamental work. Fundamental research is crucial for the development of future products. NASA needs to provide researchers the opportunity to conduct forward-looking, basic research that is unencumbered by short-term, highly specified goals and milestones. Historically, NASA has been a world leader in its core research areas; however, that base has eroded in recent years as the amount of in-house basic research diminishes. NASA needs to reassess its core competencies and assure their support through a base research program.

Top-Level Recommendation 8. NASA's aeronautics technology infrastructure exceeds its current needs, and the agency should continue to dispose of underutilized assets and facilities.

NASA test facilities create large fixed costs. Some of these facilities are not unique, and long-term fixed costs could be reduced through consolidation and deactivation. This should be an ongoing effort as the needs of the industry change and as validated computational tools reduce or eliminate the need for some experimental facilities.

Top-Level Recommendation 9. NASA should implement full-cost accounting in a way that avoids unintended consequences harmful to the long-term health of the aeronautics program.

NASA is in the process of transitioning from a net accounting system to one that uses full-cost accounting. Under the former scheme, researchers managed only costs directly related to research and development. In full-cost accounting, all project costs are included in the project budget, including institutional infrastructure costs such as: research

operations support; direct procurement; direct civil service workforce, benefits, and travel; service pools; center general and administrative; and corporate general and administrative. The committee is concerned that, if not carefully managed, full-cost accounting could result in (1) the closure of critical infrastructure and special-purpose facilities that will be needed for future program execution and (2) a disincentive to use large-scale facilities and flight tests to fully demonstrate technology readiness. This can easily occur if the responsibility for preserving institutional capabilities is delegated to lower level project managers. These project managers will also tend to avoid full-scale flight tests or wind tunnel tests in order to conserve their project budgets, since under full-cost accounting much of the cost of the testing infrastructure will be billed directly to their projects if they perform such tests. The testing infrastructure will be underutilized and will not generate the resources needed to sustain it. The committee recommends that basic research costs should be carried as a line item and not hidden in larger projects and. that large infrastructure costs, such as wind tunnels and full-scale flight testing, should be attributed to the total program and accounted for accordingly.

Top-Level Recommendation 10. NASA should develop a common understanding with the FAA of their respective roles and relationship.

NASA's airspace research ultimately benefits manly government, industry and private organizations with an interest in aviation, including the Department of Defense (DoD), airlines, manufacturers, system operators (air traffic controllers, managers, flight dispatchers and pilots), and the flying public. Practically speaking, however, the most important customers are the senior managers at the FAA, at other government agencies, and in industry who decide whether they will take applied research products from NASA and continue their development to the point of incorporating them in operational systems. Although much of NASA's airspace research is applicable to systems acquired and operated by DoD, other government agencies, and industry, most of it is intended for application to civil aviation systems acquired, operated and/or certified by the FAA. In this sense, customers also include the many other organizations and officials who influence decisions by the government and industry regarding the advanced development of new systems for civil application.

NASA and the FAA often collaborate at the technical level but there is a real need for more effective management coordination. The need for continued improvement in NASA interactions with its customers is indicated, in part, by the committee's observation that NASA officials seem to perceive interactions with the FAA as more effective than do many FAA managers. NASA officials need to recognize that implementation decisions rest with FAA management (for systems to be implemented by the FAA) and advocacy by NASA, when it runs counter to FAA implementation plans, is not helpful. Problems in this area are exacerbated by (1) the view of many NASA personnel that the success of their research is measured only in terms of the extent to which customers incorporate NASA research in operational systems, and (2) competition that may arise between NASA and other organizations that conduct research on behalf of the FAA or other key customers. As as particular NASA research effort approaches the point where the value

of continued development is contingent on operational implementation, the prospective user may decide that implementation is not feasible., NASA should be willing to close out the project that has no future and use the resources to support other research.

Top-Level Recommendation 11. NASA should seek better feedback from senior management in industry and other government organizations.

NASA's customers include aircraft manufacturers, operators, airlines and the FAA. NASA already involves customers in almost all of its research - for example, in the form of joint efforts with the FAA to take research products into the field for testing. Some projects, such as Small Aircraft Transportation Systems (SATS), also sponsor wide-ranging outreach efforts. Usually, however, customer involvement earlier in the process would be beneficial. Early involvement would (1) ensure that researchers understand and are able to respond to user requirements and concerns as early as possible, and (2) probably increase customer buy-in. Customers need not and should not be given veto authority over NASA research, but researchers should be aware of—and research plans should account for—objections or concerns that customers raise. This is especially important for research intended to provide operationally useful products capable of meeting specific functional requirements, but early consultations with user would also be beneficial in a base research program. NASA should improve its relationships with the FAA and other customers by involving them from the early stages of the research and development process through field implementation. One method for improving interaction would be for NASA to convene a yearly meeting, co-chaired by the FAA and NASA Administrators, with participation by industry executives at the chief operating officer level and senior managers from other federal agencies (e.g., Department of Transportation, Department of Homeland Security, and DoD). Topics should be limited to near-term issues and implementation plans, and such a meeting should not be held unless the NASA and FAA Administrators and industry chief operating officers will commit to personally attending.

Top-Level Recommendation 12. NASA should conduct research in selective areas relevant to rotorcraft.

Rotorcraft are an important constituent of air transportation. Many of the research projects currently under way in the Aeronautics Technology Programs, such as synthetic vision and human factors, would be directly relevant to rotorcraft, with only minimal additional investment. NASA could make a significant impact in under-researched areas of rotorcraft such as decision aids, synthetic vision, pilot workload, and situational awareness. Further, the existing U.S. Army programs in rotorcraft technologies and industry research and development in rotorcraft could be leveraged by NASA to meet civilian needs in the area. The committee believes that research in civil applications of rotorcraft will not be conducted elsewhere in government or industry and that NASA's decision to discontinue rotorcraft research has left critical civilian needs unaddressed.

Therefore, NASA should consider potential applications to rotorcraft in its research programs in general aviation and transport aircraft.

SUMMARY

The first two top-level recommendations reiterate the importance of air transportation and of NASA's role in the research and development process. Top-level recommendations 3-7 suggest ways the content and/or structure of the programs could be improved, and 8 and 9 identify near-term important concerns that should be addressed. The final 3 top-level recommendations address the relationships between NASA and its customers. The committee believes that NASA can improve and strengthen its Aeronautics Technology Programs by following this advice.

SPECIFIC ASSESSMENT OF THE VEHICLE SYSTEMS PROGRAM

The Vehicle Systems Program contains seven projects:

- *Breakthrough Vehicle Technologies*. Develops high-risk, high-payoff technologies to dramatically and substantially improve vehicle efficiency and emissions.
- *Quiet Aircraft Technology*. Discovers, develops, and verifies, in the laboratory, technologies that improve quality of life by reducing society's exposure to aircraft noise.
- *Twenty-First Century Aircraft Technology Project*. Develops and validates, through ground-based experiments, the aerodynamic, structural, and electric power technologies that will reduce by 20 percent the fuel burn and carbon dioxide emissions from future subsonic transport aircraft.
- *Advanced Vehicle Concepts*. Develops advanced vehicle concepts and configurations to reduce travel time, expand commerce, and open new markets.
- *Flight Research.* Tests and validates technologies and tools developed by NASA in a realistic flight environment.
- *Ultra-Efficient Engine Technology*. Identifies, develops, and validates high-payoff turbine engine technologies that would reduce emissions.
- *Propulsion and Power*. Researches revolutionary turbine engine technologies, propulsion concepts, and fundamental propulsion and power technologies that would decrease emissions and increase mobility.

The committee noted that VSP has a clear mission statement with a set of fully linked goals and products, but it believes that NASA needs a better understanding of the core competencies required to meet these goals. The committee also believes that the current investment strategy of VSP appears to be ad hoc, with too many unprioritized projects and tasks and no apparent methodology to determine which areas will provide

the greatest benefit. The committee recommends that NASA identify and prioritize technologies with respect to their potential benefit to aviation.

The committee was concerned that the recent transition to full-cost accounting will have an unintended effect on certain facilities and infrastructure that are national assets and will compromise the research program by reducing the number of full-scale tests for concept validation.

The committee was concerned that NASA does not always get the benefit of industry involvement at the appropriate management level and suggests that NASA re-examine the composition of its advisory groups.

The committee evaluated a total of 172 tasks in the VSP portfolio. The committee determined that more than 80 percent were of good quality or better, with 30 percent (51 tasks) rated as world-class. The committee identified 91 tasks that were good quality, 6 that were marginal, and 24 that were poor and should be redirected.

SPECIFIC ASSESSMENT OF THE AIRSPACE SYSTEMS PROGRAM

The ASP is organized into four projects:

- *Advanced Air Transportation Technologies.* Develops air traffic management tools to improve the capacity of transport aircraft operations at and between major airports.
- *Virtual Airspace Modeling and Simulation.* Develops models and simulations to conduct trade-off analyses of concepts and technologies for future air transportation systems.
- *Small Air Transportation Systems.* Develops and demonstrates technologies to improve public mobility through increased use of local and regional airports.
- *Airspace Operations Systems.* Develops better understanding, models, and tools to enhance the efficient and safe operation of aviation systems by human operators.

The committee was concerned that NASA's ASP research was generally too focused on short-term, incremental payoff work. NASA should plan ASP research based on a top-down understanding of the air transportation system. Research should focus on areas of greatest payoff—that is, areas that relieve choke points and other constraints to a more efficient air transportation system.

The committee noted that many existing airspace research tasks will not be completed before the expiration of the projects under which they are currently funded. NASA is establishing a new project, NASA Exploratory Technologies for the National Airspace System (NAS)—NExTNAS—to continue some ongoing research tasks and start some new tasks. The committee recommends that NASA incorporate many ongoing tasks in the NExTNAS project so they can be completed.

The committee determined that the ASP also should support basic research relevant to long-term objectives and other research with a far-sighted vision. More specifically, the committee observed that the portfolio was primarily directed at improving ground-based air traffic management. The committee recommends that NASA

continue distributed air-ground research for autonomous separation, with increased effort on the airborne side.

The committee developed a series of findings and recommendations regarding the FAA-NASA relationship. First, the committee noted that two different tools, Research Management Plans and Research Transition Plans, were being used to facilitate the transition of technology from NASA to the FAA.[1] The committee believes that there are worthwhile elements in the Research Transition Plans that could be included in Research Management Plans. In addition, NASA and FAA program directors should vigorously adhere to the Research Management Plan process, with reviews and updates at regular intervals. If either agency determines that the research results will not be implemented, the Research Management Plan should be cancelled and NASA should formally reassess the merits of continuing to develop a product that will not improve the operation of the NAS.

The committee also had recommendations about how NASA should measure the success of its research. Currently, it tends to view success in terms of the ability to mature technology and get the FAA to implement it for operational use. Some FAA users, however, believe this view of success leads NASA to focus too much on implementation issues, which NASA may not be qualified to address given its limited operational experience. The committee recommends that NASA and the FAA develop a common definition of what constitutes the successful completion of an applied ASP research task. Success of NASA applied research tasks should not be defined solely in terms of implementation.

SPECIFIC ASSESSMENT OF THE AVIATION SAFETY PROGRAM

The AvSP consists of three projects:

- *Vehicle Safety Technology*. Strengthens aircraft to mitigate vehicle system and component failures, loss of control, loss of situational awareness, and post-crash or in-flight fires.
- *Weather Safety Technology*. Researches and develops technologies to reduce the frequency and severity of weather-related accidents and injuries.
- *System Safety Technology*. Reduces the frequency and severity of aviation accidents and incidents by proactively managing risk in a systemwide approach.

The committee found several examples of work of outstanding quality in AvSP, notably the Aircraft Icing subproject (Weather Safety), the Crew Training task (System Safety), the Structures Health Management subtask (Vehicle Safety), the Mode Confusion subtask (Vehicle Safety), and scale-model development and testing work (Vehicle Safety).

[1]The FAA's Free Flight Phase II Office uses Research Transition Plans, which are similar to the Research Management Plans used by other FAA offices.

The committee was concerned about recent changes it observed in the quality of the human factors research in AvSP, partly because the number of in-house human factors personnel was decreasing and those who remained were primarily managing the work of contractors. In addition, the committee noted that human factors work did not appear to be well-integrated across the program. The committee recommends that AvSP strengthen in-house human factors research with federal employees who have outstanding human factors expertise. In addition, NASA should consider human factors requirements early in the design phase of all aeronautics technology research projects.

The committee believes AvSP health would be improved if 5-year lifetimes were not imposed on every project. Instead, a project should endure for the natural lifetime of the research activity, which would allow basic research efforts to extend beyond 5 years. In addition, the committee found the AvSP research portfolio to be too product-oriented and recommended that it include more basic research.

The committee also found that NASA's existing management structure obscures the lines of responsibility and accountability within the program, to the point that it is difficult to trace project, subproject, and task goals to the vision and goals of the program as a whole. The committee recommends that AvSP develop a hierarchy of goals and improve its management processes to create clearer accountability.

The committee believes that several products under development in AvSP duplicate similar products being developed in industry. The committee recommends that AvSP improve its user connections and benchmark its products against similar work performed elsewhere. NASA should not be working in a specific technical area unless it is leading the field. An outside advisory committee structure of some sort could assist AvSP in determining which technical areas it should address.

Finally, the committee noted a large gap in the program portfolio in the area of rotorcraft. NASA could significantly contribute to improving rotorcraft safety without substantial additional investment, particularly in the areas of decision aids, synthetic vision, pilot training, workload reduction, and situational awareness.

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

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