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Report to Congressional Requesters

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# NASA AERONAUTICS

# Impact of Technology Transfer Activities Is Uncertain

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The Honorable John Conyers
Chairman, Committee on Government Operations
House of Representatives

The Honorable Tim Valentine
Chairman, Subcommittee on Technology, Environment, and Aviation
Committee on Science, Space, and Technology
House of Representatives

The Honorable Tom Lewis
Ranking Minority Member, Subcommittee on Technology, Environment, and Aviation
Committee on Science, Space, and Technology
House of Representatives

In response to your requests, we have reviewed the National Aeronautics and Space Administration's (NASA) efforts to transfer agency-developed technology to the U.S. civil aeronautics industry.[1] Specifically, we sought to (1) identify NASA's technology transfer activities and (2) assess their impact on the industry's international competitiveness.

## Results in Brief

NASA uses a wide array of technology transfer activities to support the civil aeronautics industry. Although NASA and industry officials believe that all of these activities contribute to the industry's well-being, research contracts and cooperative agreements with industry were generally cited as providing the greatest benefits.

We have testified previously that research into subsonic areas,[2] including commercial jet transports, helicopters, and general aviation, can contribute most to the industry's near-term competitiveness.[3] In fiscal year 1992, NASA had 115 research contracts and cooperative agreements, valued at $45 million, for work in subsonic areas. This funding represented

[1]Senator Barbara M. Boxer, formerly Chair of the Subcommittee on Government Activities and Transportation, House Committee on Government Operations, was an original requester for this report.

[2]"Subsonic" is a range of speed below the speed of sound in air (761.5 mph at sea level). Faster ranges of speed are referred to as "supersonic" and "hypersonic."

[3]NASA Aeronautics: Efforts to Preserve U.S. Leadership in the Aeronautics Industry Are Limited (GAO/T-NSIAD-92-14, Mar. 18, 1992).

8 percent of the agency's $555 million research and development budget. In addition, NASA spent about $98 million on university and in-house subsonic research.

NASA does not have an adequate system to comprehensively monitor and measure the ultimate applications of the technologies it develops. Without this information, the agency is not in a position to focus its resources on research and development activities that can contribute most to preserving the international competitiveness of the U.S. civil aeronautics industry, and cannot determine the impact of its technology transfer activities on the industry's competitiveness.

At the conclusion of our review, the NASA Administrator issued a directive giving technology transfer an increased emphasis within NASA.[4] The directive, among other things, endorses the need for NASA's field centers to be responsible for and be measured on their technology transfer performance and provides an initial approach to systematically gather information on both the process and effectiveness of technology transfer. While the new directive is a step in the right direction, we have several concerns. For example, the directive does not ensure the necessary transfer data will be gathered in a uniform format by the field centers, and it does not include plans for analyzing resource allocation among various transfer activities.

## Background

NASA is the focal point for the federal government's support of aeronautics technology. The National Aeronautics and Space Act of 1958 charges NASA with preserving the role of the United States as a leader in aeronautical science and technology. Furthermore, it stipulates that NASA is to provide for "the widest practicable and appropriate dissemination of information" resulting from its activities.

Accomplishing these missions is vital because the civil aeronautics industry is (1) a major contributor to commerce, transportation, and national security and (2) considered a "technology driver" that leads to spin-offs of advanced technology products useful in other sectors of the U.S. economy. In 1991, the aeronautics industry provided a $29 billion positive contribution to the U.S. trade balance and employed almost 700,000 workers. The industry ranges from large airframe and engine

[4]The directive supports the findings and recommendations of a technology transfer team that was chartered in May 1991 to investigate how NASA transfers technology to other government agencies, the aerospace industry, the national economy, and society.

manufacturers to numerous producers of smaller avionics and supporting products.

In recent congressional testimony, NASA recognized it has a responsibility to help U.S. industry remain competitive.[5]

"Staying ahead in the highly competitive business world of the 1990s will require technical prowess. Only the most efficient firms that are responsive to the needs of a technologically-advanced society will be able to compete effectively in the global marketplace. It is therefore important that industry have quick and easy access to a wide array of commercially-applicable technologies developed for NASA's aeronautics and space programs."

In fiscal year 1992, NASA allocated $981 million, or about 7 percent, of its $14.3 billion budget to its aeronautics program activities. These activities are designed to provide research and facility support to its customers: the civil aeronautics industry, the Department of Defense and its aerospace contractors, the Federal Aviation Administration, and other federal government agencies. About 57 percent of the aeronautics budget was allocated to fundamental research (research that generates new and innovative ideas) and systems technology assistance (work that helps to validate and demonstrate new technologies).[6] NASA allocated 39 percent of the budget for research- and program management-related expenses. These expenses include funding for NASA's professional staff, who assist in the development and transfer of agency technologies to the aeronautics industry. The remaining 4 percent of this budget was allocated for the construction, repair, and maintenance of facilities, such as wind tunnels, at its three aeronautics field centers—Ames, Langley, and Lewis.

## NASA Uses a Wide Array of Technology Transfer Activities

NASA defines "technology transfer" broadly to encompass all activities associated with the management of its aeronautics program, ranging from the development of a program to the execution of specific elements or projects within that program. More specifically, NASA identified eight primary activities used to transfer the results of its fundamental research and systems technology work to the aeronautics industry. Table 1 lists the eight activities and the extent each was used in fiscal year 1992.

[5]NASA statement for the Subcommittee on Oversight and Investigations, Committee on Energy and Commerce, House of Representatives (July 25, 1991).

[6]In general, fundamental research deals with technologies that are not likely to be used on products within 10 years. In contrast, results from NASA's systems technology work could be available for use in the near-term—within 10 years.

**Table 1: NASA Aeronautics Technology Transfer Activities** (Fiscal Year 1992)

| Technology transfer activity | Description | Extent used |
|---|---|---|
| Visiting companies | Visits by individual NASA employees to the aeronautics industry. Visits can last from 1 day to several days. | 4,709[a] |
| Holding workshops and symposia | Workshops and symposia sponsored or cosponsored by NASA involving government, industry, and university personnel. | 29 |
| Exchanging personnel | Formal and informal exchanges of research personnel between NASA and the aeronautics industry. | 7 |
| Conducting advisory committee meetings | Meetings of the NASA Aeronautics Advisory Committee and Aeronautics Research and Technology Subcommittees for the purpose of reviewing and evaluating NASA's research programs and plans. | 3 |
| Publishing technical articles | Technical conference publications, technical memorandums, or other published documents, such as research articles or contract results. | 2,106[a] |
| Releasing computer software | NASA-developed software released to the aeronautics industry. | 422[a,b] |
| Awarding contracts | Research and development contracts awarded to aeronautics companies. | 125 |
| Collaborating under cooperative agreements | Joint research with industry, often involving the use of NASA facilities and equipment, on projects deemed beneficial to both parties. Agreements can be either written or verbal. | 140[c] |

[a]NASA estimate.

[b]Includes data from two of the agency's three field centers.

[c]Includes 125 written agreements and 15 verbal agreements.

## Key Activities for Enhancing the Industry's Near-Term Competitiveness

According to aeronautics industry and NASA officials, NASA's technology transfer activities contribute positively to the industry's competitiveness. While there is no consensus, senior officials in industry and at NASA headquarters stressed that contracts and cooperative agreements can make the greatest contribution to the industry's near-term competitiveness. The impact of contracts and cooperative agreements

stems from the industry's direct involvement in the research, which enables technology to be transferred as it is being developed. In addition, these activities are oriented primarily toward transferring information on more mature technologies, whereas other activities are generally used to transfer information on technologies in the early stages of their development. One airframe manufacturer described how access to NASA's advanced computer codes and wind tunnels, under a cooperative agreement, enabled it to make several design changes to its newest commercial aircraft to improve its speed and aerodynamic performance. The changes made included modifying the overall shape of winglets on the end of both wings and changing the location of fixtures (pylons) that attach the engines to the main aircraft body.

## NASA's Use of Contracts and Cooperative Agreements

NASA had 265 research contracts and cooperative agreements in fiscal year 1992 with a total value of $105 million. Table 2 shows that 115 of the research contracts and cooperative agreements were for work in subsonic areas. These were valued at $45 million, or 43 percent of the total. The $45 million represented approximately 8 percent of NASA's $555 million aeronautics research and development budget. According to NASA officials, however, the research areas listed in table 2 are not mutually exclusive. Some funding of supersonic and hypersonic research, for example, also supports subsonic research.

**Table 2: NASA Research Contracts and Cooperative Agreements With the Aeronautics Industry** (Fiscal Year 1992)

Dollars in thousands

| Research area | Number | Dollar value[a] | Percentage of total dollars |
|---|---|---|---|
| Research contracts | | | |
| Subsonic aircraft | 66 | $31,300 | 41 |
| Super/hypersonic aircraft | 50 | 30,127 | 40 |
| Military/advanced aircraft | 17 | 10,018 | 13 |
| Other research[b] | 27 | 4,656 | 6 |
| **Total** | **125[c]** | **$76,101** | **100** |
| Cooperative agreements | | | |
| Subsonic aircraft | 49 | $14,149 | 49 |
| Super/hypersonic aircraft | 11 | 2,264 | 8 |
| Military/advanced aircraft | 35 | 6,371 | 22 |
| Other research[b] | 45 | 6,152 | 21 |
| **Total** | **140** | **$28,936** | **100** |

[a]Dollar amounts for contracts include contracts valued at $25,000 or more. Amounts represent cumulative obligations against the contracts as of September 30, 1992. Dollar amounts for cooperative agreements represent NASA estimates of resources used in performing work that supports the agreements. No dollar values were provided for some agreements either because no estimate was available or because no dollars were committed under the agreement.

[b]Includes basic scientific investigations and activities in research areas that are thought to have application in several vehicle classes.

[c]Figures do not add because some contracts are used to perform research in more than one area.

In our March 1992 testimony, we stated that subsonic research is most beneficial to the civil aeronautics industry's near-term competitiveness because subsonic transport aircraft will continue to dominate the global commercial market beyond the year 2000. We also noted that NASA's spending on subsonic research was limited. In fiscal year 1992, funding for subsonic research totaled $143.4 million, or 26 percent of the $555 million aeronautics research and development budget.[7] This subsonic funding includes the $45 million spent on research contracts and cooperative agreements with industry, as well as funding for university and in-house research.

We further testified that NASA requested a significant increase in funding for its fiscal year 1983 subsonic research budget, but the Office of Management and Budget cut much of this request, stating that funding for

[7]Funding for subsonic transport aircraft in fiscal year 1992 was $116.7 million, or 21 percent of the total aeronautics research and development budget.

technology development and demonstration projects with relatively near-term commercial applications potential would represent an "inappropriate federal subsidy." Subsequent requests by NASA's aeronautics directorate to increase funding for subsonic research have also had difficulty surviving the budget review process at NASA and the Office of Management and Budget.

## NASA Lacks an Adequate Technology Tracking System

Sound management practice requires that federal agencies monitor and evaluate the performance and results of their programs to ensure their efficiency and effectiveness and to make any needed improvements. This means that agencies should define their program objectives in terms of specific measures of performance and ensure that data on those measures are obtainable at a reasonable cost.

NASA, however, lacks a comprehensive system to monitor and evaluate the ultimate application of the technologies it transfers to the aeronautics industry. Without such a system, the agency does not generate the data necessary to objectively determine the results of its technology transfer activities. NASA, therefore, lacks assurance that its aeronautics program is effective in helping the U.S. civil aeronautics industry remain competitive.

Part of the problem is that the agency has not precisely defined what constitutes technology transfer. Although it has identified eight primary transfer activities, NASA's current broad definition of technology transfer provides no criteria against which the agency can measure the success of these activities with its customers in a meaningful way. Therefore, the agency cannot systematically measure (1) where and when its technology is used by industry or (2) how the value of this technology adds to the civil aeronautics industry's competitive position.

In lieu of a formal tracking system, NASA generally has relied on other feedback from the aeronautics industry to monitor the effectiveness of its technology development and transfer activities. This information is provided, among other means, through advisory committees or visits to companies. NASA uses some of this information to provide anecdotal examples of program success in annual reports to the President. However, NASA does not routinely consolidate transfer data in a central location and in a consistent format for the purposes of analysis and program management.

When we requested certain information on the technology transfer activities for the aeronautics program, NASA officials had difficulty assembling it. For example, the agency had difficulty identifying the number and dollar value of its research contracts with industry, and the data it initially provided had to be substantially refined to arrive at the totals presented in table 2. For instance, the data included procurement and service contracts as well as research contracts. Also, the three aeronautics field centers had no reports or summary records that identified the scope of some of the other transfer activities.

Recognizing the need for more information regarding customers' satisfaction with its aeronautics program activities, NASA contracted for a survey of its major customers in 1991. The survey results provided some insight into the aeronautics industry's overall perception of NASA's technology transfer performance and identified some industry concerns about its aeronautics program. Industry respondents (1) questioned whether the program received sufficient priority and attention within NASA; (2) advocated more funding for the program, especially for systems technology work; and (3) suggested that more contracted research would help technology transfer. However, the survey did not attempt to capture data that would measure the impact of NASA's technology transfer activities on the industry's competitiveness. In addition, the survey was a one-time effort and thus is not useful to track information over time.

NASA officials acknowledged that the aeronautics program lacks an adequate technology transfer tracking system, but they said that developing such a system could be difficult. For example, they noted that the long-term focus of aeronautics-related technology development efforts means some technologies cannot be commercialized for more than a decade. Furthermore, they indicated that NASA-developed technologies "lose" their NASA identity after companies begin to modify the technology for their own use because the companies either do not want to acknowledge NASA as the originator of their products or they have forgotten the origin of the technology as their personnel turn over.

## Agency Actions and Our Assessment

Notwithstanding these concerns, the NASA Administrator has recently directed certain changes in emphasis to NASA's technology transfer activities. His December 21, 1992, directive followed from a NASA study that found that NASA had not (1) developed a clear policy on technology transfer, (2) established an adequate definition of technology transfer, (3) sufficiently documented technology transfer processes, and

(4) systematically measured the effectiveness of technology transfer. The study further noted that NASA employees, contractors, and university grantees did not consider technology transfer to be an important part of their job.

To remedy these problems, the directive recommends that NASA's field centers (1) use a recommended approach for measuring the effectiveness of technology transfer or develop their own approach, (2) make technology transfer a part of their mission statements, and (3) provide training on technology transfer for all of their employees. To track and measure the effectiveness of technology transfers to the aeronautics industry, the directive suggests that the centers monitor (1) the number of NASA citations in the relevant literature, (2) the number and type of "acknowledged uses"[8] of NASA research, and (3) the amount of revenue derived from patent licenses. The directive also recommends that the centers assess the technology transfer-related contributions of their employees and use this assessment in rating and promoting employees.

While it is too early to assess the success of the Administrator's directive, we have several concerns. First, we believe that permitting each field center to develop its own approach for measuring the effectiveness of technology transfer activities could complicate NASA's ability to analyze transfer data on an agencywide basis. Second, the policy establishes no timetables for implementing the recommended improvements. Third, the policy does not address the establishment of a comprehensive agencywide system to monitor resource expenditures associated with such major technology transfer activities as personnel exchanges, research contracts, and cooperative agreements. We believe such a system is necessary for assessing the relative importance of various technology transfer activities. Finally, relying on information provided by industry to identify the acknowledged uses of NASA-developed technology is not sufficient to accurately assess the effectiveness of transfer activities. We believe that without independent verification of the information provided by industry, NASA will not be in a position to tell whether industry has fully disclosed all uses of NASA-developed technologies.

## Recommendations

We recommend that the NASA Administrator (1) establish minimal standards for measuring aeronautical technology transfer to be followed by all field centers, (2) provide milestones for implementing the

[8]"Acknowledged uses" means (1) letters written or some other documentation developed by industry that shows that NASA's technology was used to develop a product, (2) personnel exchanges, and (3) companies that use spin-off technology.

recommendations endorsed by his directive, (3) systematically track aeronautics resource expenditures for major technology transfer activities, and (4) direct the field centers to identify industry applications (products, services, and systems) that have resulted from NASA-developed technologies.

## Scope and Methodology

To accomplish our objectives, we interviewed officials at NASA headquarters in Washington, D.C., and at the Ames, Langley, and Lewis aeronautics field centers in San Jose, California; Hampton, Virginia; and Cleveland, Ohio, respectively. We also interviewed officials from several U.S. aeronautics manufacturing companies and industry associations. Company interviews were with senior design and engineering personnel representing three major industry segments—transport, general aviation, and helicopters.

We obtained information from NASA on the extent to which each of the eight technology transfer activities was used in fiscal year 1992. To obtain information on contracts, we used data from NASA's Automated Resources System for aeronautics research and development contracts that were active during fiscal year 1992. From the total group of 1,262 contracts, NASA identified those that were for industry research. We further classified these contracts by their use—subsonic, super/hypersonic, military/advanced, or other research area—using data codes provided by NASA. To determine contract dollar values, we used a part of NASA's Automated Resources System that provides financial obligations data.

We reviewed the results of a customer service assessment, dated March 1992, produced by The Gallup Organization, Inc., under contract to the Atlantic Research Corporation Professional Services.

We also obtained a recently completed NASA study on technology transfer performance by its field centers. We evaluated the study's findings and recommendations, all of which were endorsed by the Administrator's directive.

We performed our work from April 1992 through January 1993 in accordance with generally accepted government auditing standards. As requested, we did not obtain agency comments on this report. However, we discussed the issues in this report with NASA headquarters and field center officials and incorporated their comments where appropriate.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies to the NASA Administrator and other appropriate congressional committees. Copies will also be made available to other interested parties on request.

This report was prepared under the direction of Mark E. Gebicke, Director, Military Operations and Capabilities, who may be reached on (202) 512-5140 if you or your staff have any questions concerning this report. Other major contributors to this report are listed in appendix I.

Frank C. Conahan
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