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Report to Congressional Requesters

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NATIONAL AERO-SPACE PLANE

A Need for Program Direction and Funding Decisions

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The Honorable John Conyers, Jr.
Chairman, Legislation and
National Security Subcommittee
Committee on Government Operations
House of Representatives

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

The Honorable Patricia Schroeder
Chairwoman
The Honorable Bob Stump
Ranking Minority Member
Subcommittee on Research and
Technology
Committee on Armed Services
House of Representatives

This report responds to your request that we monitor the status of the National Aero-Space Plane (NASP) Program. We provided an interim assessment in March 1992[1] and a more detailed report in December 1992.[2] This report discusses the status of efforts to resolve the program's cost, schedule, and technical problems and addresses the lack of top-level management direction.

Background

The presidentially directed NASP Program is a joint Department of Defense (DOD)/National Aeronautics and Space Administration (NASA) technology development and demonstration program. The program's goal is to provide the technological basis for future space launch and hypersonic flight vehicles by developing critical or enabling technologies, such as the

[1]National Aero-Space Plane: Key Issues Facing the Program (GAO/T-NSIAD-92-26, Mar. 31, 1992).

[2]National Aero-Space Plane: Restructuring Future Research and Development Efforts (GAO/NSIAD-93-71, Dec. 3, 1992).

scramjet engine. DOD and NASA intended to demonstrate these technologies by building and testing the X-30, a manned experimental flight vehicle that is to be capable of single-stage-to-orbit (SSTO) flight. The concept is to develop a vehicle that can take off horizontally from a runway; reach hypersonic speeds of up to 25 times the speed of sound (Mach 25); and attain low earth orbit, without the use of external booster rockets or propellant tanks.

The program currently consists of three phases. Phase I (1982 to 1985), which preceded the formal initiation of the program, evaluated the feasibility and technical concept for an aerospace plane. Phase II (1985 to 1994) is a technology development and maturation phase. The program is in the final segment of phase II, which is intended to develop the critical technologies and manufacturing processes, build and test specific structural articles, and test a subscale engine to demonstrate the propulsion system's concept. A decision was to be made in September 1993 based on cost and technical maturity on whether to proceed into phase III, which involves designing, building, and testing the X-30. However, funding constraints and technical concerns have caused DOD and NASA to reconsider the timing of this decision and to restructure the current contract and associated technical efforts.

The National Space Council had been responsible for developing overall national policy, direction, and guidance on space activities such as the NASP Program; however, the new administration has designated the Office of Science and Technology Policy to assume these roles. In 1986, the Secretary of Defense and the Administrator of NASA chartered the NASP Steering Group to provide policy, guidance, and broad programmatic direction to the program. Among the Steering Group's tasks were approving both the program's entrance into phase III (subject to the consent of the Secretary of Defense and Administrator of NASA) and substantive changes to the program, resolving programmatic issues, and reviewing proposed changes and making recommendations relative to the program's funding. The Steering Group is currently chaired by the Under Secretary of Defense for Acquisition and the Deputy Administrator of NASA is vice-chair.

The Air Force is the program's executive agency and has established a Joint Program Office at Wright-Patterson Air Force Base, Ohio, to manage the program. The NASP National Contractor Team, consisting of five major

aerospace contractors,[3] is responsible for the majority of the technology development efforts. Since fiscal year 1986, Congress has provided about $1.7 billion to DOD and NASA for phase II.

Results in Brief

We reported in December 1992 that the projected cost for the baseline program had increased from $3.1 billion to $17.0 billion, the time frames for achieving such milestones as first flight were uncertain, and the development of key technologies had encountered difficulties. These cost, schedule, and technical problems will not be resolved by the completion of the currently planned phase II efforts. Consequently, a decision to begin phase III has been effectively deferred.

Neither the Office of Science and Technology Policy, the Steering Group, nor DOD has provided clear direction on what the program's future efforts and objectives should be. The Air Force and NASA have generally accepted a program office proposal to conduct a series of flight test experiments prior to committing to building the X-30; however, DOD has not made a final decision on this proposal. Additionally, DOD and NASA have not achieved consensus on the current and future funding needs for the program. These conditions hinder efforts to properly plan and execute future technical efforts, initiate required contractual action, and project program costs.

Technical Uncertainties Will Not Be Resolved by End of Current Phase II Efforts

In December 1992, we noted that testing had identified a number of problems concerning (1) the design and performance of the engine's[4] low speed and ramjet test articles, (2) the development of a key engine material, and (3) the ability of the vehicle to achieve SSTO flight at its projected takeoff weight goal. The contractor team has made some progress in resolving these problems, but significant challenges remain. Because of the decisions to adjust to recent funding reductions and the inherent limitations of ground test facilities, many of the uncertainties cannot be resolved by the end of current phase II efforts.

[3]Lockheed Corporation (through its recent acquisition of General Dynamics Corporation's Fort Worth Division), Rockwell International Corporation's North American Aircraft Division, and McDonnell Douglas Corporation are the airframe contractors, while United Technology Corporation's Pratt & Whitney Division and Rockwell International Corporation's Rocketdyne Division are the engine contractors.

[4]As currently conceived, the X-30's propulsion system will operate in three modes—low speed (takeoff to Mach 3); ramjet (Mach 3 to Mach 6); scramjet (above Mach 6) and then use rocket propulsion to achieve orbit.

A 42-percent reduction in anticipated fiscal years 1992 and 1993 funding for phase II—caused by lower than projected DOD and NASA budget requests and significant congressional funding reductions—has led to numerous changes in the current phase II effort. Contractor officials cited funding instability as the single most disruptive factor that hindered the execution of phase II and noted the changes necessitated by this instability will reduce the amount of information that will be obtained. For example, the contractor team's efforts to produce a conceptual design that met the program's technical and weight objectives were significantly reduced in November 1992 after completion of the third of four planned design cycles. According to program and contractor officials' projections, the vehicle, if built according to the design at the end of the third cycle, would not have been able to achieve SSTO flight at its takeoff gross weight goal. The program office directed the contractor team to document the work accomplished but not complete the fourth design cycle so that the resources that were to be used on additional vehicle design activities could be reallocated to propulsion technology, selected high-priority material efforts, and those activities supporting the proposed flight test experiments.

Several other efforts will be reduced or eliminated, including those relating to resolving problems with the low speed propulsion system, building and testing articles to demonstrate specific characteristics of the X-30's airframe, and further developing the capability to use slush hydrogen as a fuel and coolant. Consequently, the contractor team reported in February 1993 that 17 of the 38 milestones used to measure progress toward meeting the phase II exit criteria will not be fully satisfied by the end of the current phase II effort.

In addition, inherent limitations in ground test facilities and historical data bases will preclude resolving the uncertainties relative to scramjet performance at high Mach speeds. For example, the primary engine test remaining in the current phase II effort involves the concept demonstration engine, which is approximately 30 percent of the size of the X-30's propulsion system. However, due to the test facility's size and technical limitations, the engine will not be tested past Mach 6.8, which is in the early stages of the scramjet cycle. Consequently, there is some question on whether the data can be extrapolated to higher Mach speeds.

Similar uncertainties exist relative to the effects of boundary layer transition—when smooth air flow becomes turbulent—at high Mach speeds. This transition influences heat transfer to the vehicle's surface, as

well as within the engine. Since protecting these surfaces would generally increase the vehicle's weight, excessive conservatism in transition predictions could lead to an overweight design incapable of achieving SSTO flight. Conversely, excessive optimism could lead to a vehicle unable to survive in the hypersonic flight environment. Predictions on where transition occurs have been developed from tests in which key parameters were known. The ability to use this information in situations where the parameters are not known is questionable. Additionally, available data are based on experiments using conical-shaped test articles and vehicles such as ballistic missiles, and recent information indicates that the data are not applicable for nonconical vehicles such as the X-30. Finally, existing ground test facilities are not capable of accurately reproducing the transition phenomena at high Mach speed.

Additional Flight Test Experiments Proposed to Address Technical and Affordability Concerns

To address technical and affordability concerns, the program office has proposed a series of flight test experiments through the turn of the century. As currently conceived, the flight experiments would be an interim development phase before building a full-scale, SSTO-capable vehicle. This proposal appears to have been generally accepted by the Air Force and NASA, but DOD officials told us they have not made a final decision on the proposal.

Concerns over the program's technical maturity are exemplified by those raised by the Defense Science Board in its 1992 assessment of the program. The Board concluded that fundamental uncertainties will exist at the end of the current phase II efforts in at least four critical areas: propulsion system performance; boundary layer transition; stability and controllability; and structural and subsystem weight. The Board concluded that if SSTO flight were the major requirement in the program, then the technology and design bases required to justify building the X-30 would not be available at the conclusion of the current phase II program.

Similar questions arose over the program's total cost and the annual funding needed for the phase III effort as planned. We reported in December 1992 that projected program costs had increased from $3.1 billion in 1986 to a preliminary estimate of $17 billion in January 1992. Further, program officials recognized that it was unlikely that sufficient funding—estimated to exceed $1 billion annually between fiscal years 1994 and 1996—would be provided to execute the phase III effort as planned. Consequently, a great deal of uncertainty existed as to when such milestones as first flight would be achieved.

In response, the program office proposed in November 1992, and subsequently revised in March 1993, a long-term development strategy that includes conducting three series of experiments through the turn of the century, each involving one or more flights. Program officials project these tests will provide additional technical data in the Mach 12 to Mach 15 speed regime (see table 1).

Table 1: Proposed Flight Test Experiments

Series[a]	Booster rocket	Test article	Time frame	Primary objectives
I	Minuteman II	Wedge-shaped	Mid-1990s	Determine the boundary layer transition location on vehicle's forebody.
II	Minuteman II	Wedge-shaped; incorporates engine flowpath	Mid- to late 1990s	Determine inlet operability and airflow characteristics inside the engine; demonstrate scramjet performance.
III	Titan II	Subscale X-30	Late 1990s	Demonstrate scramjet performance and stability and control.

[a]As of May 1993, the sequence of the Minuteman II flight test experiments has not been finalized. Time frames are approximate.

The program office has proposed conducting a concurrent ground test and design effort that would further evaluate the propulsion system, materials, structures, subsystems, and other technologies. Program officials believe that the proposed flight test experiments, if successfully completed in conjunction with the ground tests and design efforts, would provide the necessary information to begin building an SSTO vehicle with a reasonable degree of risk. These officials told us that they would attempt to accomplish both the flight and ground tests, but acknowledged that the ground tests are secondary to the flight test experiments and may be delayed or reduced by the funding made available. They noted this condition posed a potential risk in that the flight test experiments will not provide, by themselves, adequate information on a variety of technical issues, such as on the low speed and ramjet propulsion systems. Consequently, without a balanced program, the amount and type of data collected over the next several years may not provide sufficient information for later decisions. These officials also noted that an SSTO vehicle such as the X-30 would still need to be built and tested to demonstrate the necessary technologies to produce future operational vehicles.

The proposed efforts are in the advanced planning stage; thus, no detailed information is available on their projected cost or schedule. Program officials expect that a detailed cost estimate, excluding the cost of the third flight test series, will be available by July 1993. Program officials were developing a strategy that could be executed within a $700 million funding level for fiscal years 1994 through 1996, with another $1.2 billion required for fiscal years 1997 through 1999. This funding level did not include the additional funding needed to design, build, and test the X-30. The proposed schedule—as shown in table 1—is likely to be delayed by a year or more since the President's fiscal year 1994 budget request of $123 million was about half the $240 million on which the initial proposal was based. Because an estimated $93 million of the fiscal year 1994 budget request is needed to complete current phase II efforts, only $30 million—not the planned $147 million—will be available to initiate other activities.

Recent congressional testimony by Air Force and NASA officials indicates that the agencies generally support the proposed flight test experiments.[5] In discussing a draft of this report, however, DOD officials told us DOD had not decided if it should proceed with the proposed experiments nor could they tell us when such a decision would be made. DOD and Air Force officials also commented that since the program's future direction has not been determined, the specific tasks for which the remaining $30 million of fiscal year 1994 funding will be used have not been determined.

Lack of Top-Level Direction Hinders Planning Efforts

The lack of top-level direction and unstable funding have hindered efforts to develop an affordable, executable program. As of May 1993, neither the Office of Science and Technology Policy nor DOD had provided clear direction on what the program's future should be, nor had DOD and NASA reached agreement on how much funding should be requested.

Several factors contribute to this lack of consensus. According to program officials, the change in administrations has caused some delays in achieving consensus on the program's direction. These officials noted that the new administration has designated the Office of Science and Technology Policy to assume the role of providing overall policy, direction, and guidance on space activities. However, Office representatives stated they are still defining their role in the development of space-related policy and have not taken an active role in providing

[5]Testimony provided to the House Science, Space, and Technology Committee, Subcommittee on Technology, Environment, and Aviation, May 5, 1993.

specific guidance to the program. Additionally, the Steering Group has not formally met since January 1992, and there is some question as to whether the Steering Group will be reconstituted under the same structure. Also, there are several vacancies on the Steering Group due to delays in designating individuals for several senior DOD and NASA positions. Consequently, many of the oversight functions that were performed by the National Space Council and the Steering Group are being temporarily assumed by DOD and NASA officials who meet quarterly to review the program's technical progress. However, these officials do not have the authority to provide the required direction or ensure that any tentative agreements will be implemented.

Compounding the effects of the lack of top-level direction are concerns over the adequacy of available funding. For example, DOD's fiscal year 1994 request of $43 million is $50 million less than requested by the Air Force, while NASA's funding request of $80 million is $40 million less than the amount identified in its 1992 planning documents. Representatives from the Office of Science and Technology Policy and NASA have expressed concern that the level of DOD funding could be interpreted as a lack of commitment by DOD and lead to further congressional funding reductions. In commenting on a draft of this report, DOD officials acknowledged this concern but told us, in their opinion, if DOD's request—in conjunction with NASA's request—were fully funded, the requested funds would be adequate to complete the current phase II efforts, and at the same time, would allow a more thorough review of future options.

Similarly, the level of future funding for the program is also uncertain, as DOD has no current out year[6] funding profile. A representative from DOD's Office of the Comptroller stated that DOD is conducting a detailed review of its out year funding requirements for all programs, including the NASP Program. This review is to be completed in time to support the President's fiscal year 1995 budget request. As such, the representative noted that no decision has been made on the level of funds that will be requested for the program in the out years. A NASA program official told us that NASA's current out year funding plans budget approximately $535 million through fiscal year 1998 for the NASP Program. This official believed these funds would be sufficient to execute the proposed flight test experiments, assuming that DOD contributed at a 2-to-1 ratio, the maximum allowed under current legislative direction.

[6]In this report, out year refers to those fiscal years following fiscal year 1994.

The lack of top-level direction and unstable funding, for all intents and purposes, effectively deferred the decision on whether or not to build the X-30 and contributed to the uncertainty concerning the program's future. For example, since early 1992, the program office has proposed four different development strategies in an attempt to resolve the discrepancy between the previous development strategy to begin building an X-30 and projected out year funding availability. Current and former program officials told us that they believed they had been given tentative approval to proceed with their various proposals but were subsequently required to develop a new strategy after changes were made in projected funding levels or technical requirements.

Recommendations

Timely direction is needed to allow the NASP Program office sufficient time to initiate the required contractual action—since the current phase II contract is to be completed in March 1994—as well as to properly plan and execute a balanced ground and flight test effort. We, therefore, recommend that the Director, Office of Science and Technology Policy, provide clear overall direction and guidance for the NASP Program. Further, we recommend that the Secretary of Defense and the Administrator of NASA, through the Steering Group, provide specific direction on the program's long-term technical objectives and goals.

Matters for Congressional Consideration

Constrained federal funding makes it essential that Congress and the administration form a consensus on whether the nation will pursue this technology at the present time and whether it is willing to devote sufficient resources to achieve this goal. This consensus needs to be achieved prior to proceeding with the next phase of the program to assure that the effort can be properly planned, managed, and executed.

Congress may, therefore, wish to consider restricting DOD and NASA from obligating any fiscal year 1994 funds appropriated for the NASP Program beyond those necessary to complete the current phase II efforts until the program's future is better defined. In addition, Congress may wish to require the Secretary of Defense and the Administrator of NASA to report on the programmatic and funding implications concurrent with the program's fiscal year 1995 budget request. Such a report should include a certification by the Secretary and the Administrator that their respective agencies have allocated sufficient funds in their out year budgets to execute the next phase of the program.

Scope and Methodology

To assess the need for top-level direction on the program's future efforts, we analyzed the various options proposed by the Joint Program Office since 1991 relative to cost, schedule, technical objectives, and funding requirements. We discussed the implications of this condition with officials from the Office of Science and Technology Policy, DOD, NASA, the Air Force, and the contractor team.

To determine the program's technical status and the implications of restructuring the current contract, we reviewed numerous contractual documents and correspondence, program schedules, cost performance reports, test reports, and other pertinent documentation. We discussed various contractual and technical issues with responsible officials from the Joint Program Office and the contractor team.

We conducted our review between September 1992 and May 1993 in accordance with generally accepted government auditing standards. The majority of our work was conducted at the NASP Joint Program Office. We also interviewed responsible officials within DOD and NASA in Washington, D.C., and conducted televideo conferences with program and contractor officials at the team's National Program Office, Palmdale, California.

As requested, we did not obtain written agency comments. However, we discussed a draft of this report with responsible officials from the Office of Science and Technology Policy, DOD, the Air Force, and NASA. We have incorporated their comments where appropriate and clarified DOD's position on the proposed flight test experiments and funding.

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 10 days from the date of this letter. At that time, we will send copies to the Secretaries of Defense, State, Commerce, the Air Force, and the Navy; the Administrator, National Aeronautics and Space Administration; the Directors, Advanced Projects Research Agency, Ballistic Missile Defense Office, Central Intelligence Agency, Office of Management and Budget, and the Office of Science and Technology Policy in the Executive Office of the President; and interested congressional committees. Copies of this report will also be made available to others on request.

This report was prepared under the direction of Louis J. Rodrigues, Director, Systems Development and Production Issues, who can be reached on (202) 512-4841 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix I.

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