

National Aeronautics and
Space Administration

Office of Inspector General
Washington, DC 20546-0001



July 8, 2008

TO: Associate Administrator for Exploration Systems
Associate Administrator for Space Operations

FROM: Assistant Inspector General for Auditing

SUBJECT: Final Memorandum on the Review of NASA's Plan to Build the
A-3 Facility for Rocket Propulsion Testing (Report No. IG-08-021;
Assignment No. S-08-012-00)

The Office of Inspector General (OIG) conducted a review of NASA's plan to build a new rocket propulsion test facility.¹ We initiated this review in response to a complaint forwarded to the NASA OIG from the Government Accountability Office (GAO), alleging that NASA's planned rocket propulsion test facility at the Stennis Space Center would duplicate the capabilities found at the Air Force's Arnold Engineering Development Center (AEDC) in Tennessee.

Specifically, the complainant alleged that

- NASA ignored the National Rocket Propulsion Test Alliance (NRPTA) process when deciding to build a new test facility at Stennis;
- the planned Stennis test facility would duplicate existing capabilities found at AEDC; and
- building the facility would result in a waste of funds.

See Enclosure 1 for details on our scope and methodology.

Executive Summary

The NRPTA, formed by an agreement between NASA and the Department of Defense (DoD), was established to shape the Government's rocket propulsion testing capability to efficiently meet national test needs through intra- and inter-agency cooperation. The NRPTA reviews testing needs and recommends solutions that provide the best overall value to the taxpayer. NASA's Rocket Propulsion Test Management Board (RPTMB) serves as the NASA decision-making body for rocket propulsion testing.

¹ The structure NASA plans to build is technically a single rocket propulsion "test stand." However, the allegation referenced a "facility," as does the preponderance of documentation, including briefs and reports, used for this review. For the purpose of this report, the terms are interchangeable.

We found that NASA's Upper Stage Engine (USE) Element Manager, located at Marshall Space Flight Center in Alabama, reviewed the J-2X rocket propulsion testing options and selected the A-3 test stand to be built at Stennis without the required formal reviews or recommendations of the NRPTA, or NASA's RPTMB. This occurred because NASA did not appropriately engage the NRPTA as required by the NRPTA Memorandum of Agreement (MOA). The NRPTA MOA and the RPTMB Operating Procedures require member reviews and recommendations prior to major test facility investments or modifications. In addition, we found that the processes contained in the the NRPTA MOA and the RPTMB Operating Procedures are not included in either a NASA Policy Directive or NASA Procedural Requirements.

Although the Rocket Propulsion Test (RPT) Program office used the NRPTA to gather information on potential J-2X testing options, NASA did not make a request for NRPTA member reviews and recommendations and subsequently made a unilateral decision to build the A-3 test stand at Stennis. The USE Element Manager stated that he selected the A-3 without, or prior to, receiving any recommendations from the RPTMB or NRPTA because the selection needed to be made in March 2007 to maintain the critical path of the Ares Project. We confirmed that the test facility was on the Ares Project's critical path. However, we found that the schedules projected for the A-3 and upgrading AEDC's J-4 facility, which presented a competing option, were the same, 3½ years. Although the critical path of the Ares Project may explain the timing of the decision, it does not adequately justify the decision to build the A-3 exclusive of cost and technical risk comparisons with other facilities as would have been provided if the appropriate request was made of the NRPTA.

We also found that the test stand NASA intends to build at Stennis would not duplicate existing capabilities found at AEDC. We reviewed the J-2X engine testing requirements and determined that at the time of the decision to build the A-3, in May 2007, a test stand with all of the testing capabilities required for the new J-2X engine, as defined by Constellation Program and Ares Project requirements, was not available at AEDC, Stennis, or any other NASA or DoD facility. In addition, based on current cost estimates, we determined that building the A-3 would not be a waste of funds. However, concerns with the technical risks associated with the A-3 design and operations remain and could result in significant cost increases and schedule delays, which may in the future substantiate an alternative option as ultimately more cost-effective. Using the NRPTA process could have provided a forum for the resolution of these concerns and the development of a risk mitigation strategy, which may have provided added assurance of the successful development and implementation of a facility to meet J-2X engine testing requirements.

By failing to appropriately engage the NRPTA, NASA may have missed an opportunity to promote a more cooperative partnership with DoD in the area of rocket propulsion testing as well as an opportunity to benefit from the technical expertise resident among NRPTA members. In addition, because of NASA's unilateral decision, the Agency assumed technical and cost risks without the benefit of an independent review and the recommendations of NRPTA members.

Our May 19, 2008, draft of this memorandum recommended that the Associate Administrator for Space Operations issue a NASA Policy Directive (and NASA Procedural Requirements, if applicable) detailing the requirement for NASA's rocket propulsion test organizations to request formal reviews and recommendations from the RPTMB and, as applicable, the NRPTA, in accordance with RPTMB and NRPTA guidelines. Additionally, we recommended that the Associate Administrator for Exploration Systems take advantage of the technical expertise available in the rocket propulsion test community and request an independent review and assessment of the technical and cost risks associated with the planned A-3 test stand in order to develop a comprehensive risk mitigation strategy.

Management provided an initial response to the recommendations on June 30, 2008 (see Enclosure 3), and subsequently provided estimated completion dates, which we included in the "Recommendations, Management Response, and Evaluation" section of this memorandum. Management's comments are responsive. In commenting on the draft of this memorandum, NASA management concurred with our recommendations and proposed appropriate corrective actions. The recommendations are resolved and will be closed upon completion and verification of management's corrective actions.

Background

The Stennis Space Center in Mississippi is NASA's primary Center for the testing and flight certification of rocket propulsion systems for the Space Shuttle and future generations of space vehicles. Because of its role in engine testing for four decades, Stennis has evolved into a multi-agency, multidisciplinary center for Federal, State, academic, and private organizations engaged in space, ocean, and environmental programs, as well as national defense. In addition to NASA, there are 30 other agencies located at Stennis.

NASA's RPT Program office—located at Stennis under the Space Operations Mission Directorate (SOMD)—reviews, approves, and provides direction on rocket propulsion testing assignments, capital asset improvements, test facility modernization and refurbishments, integration for multi-site test activities, identification and protection of core capabilities, and the advancement and development of test technologies. NASA's RPT Program office provides the program management structure for accomplishing rocket propulsion testing and is NASA's authority for rocket propulsion assignments and management of the budget for rocket propulsion testing.

NASA's RPTMB consists of member organizations (Marshall, Stennis, Plum Brook Station, and White Sands Test Facility) and associate members (Glenn Research Center and Kennedy Space Center) and serves as the NASA decision-making body for rocket propulsion testing, and the RPTMB reviews, approves, and provides direction on the following:

- All testing assignments.

- All capital investment recommendations for rocket propulsion test facilities and equipment.
- All facility modifications or refurbishments affecting the Agency's rocket propulsion test capability.
- Annual budget requirements (establishment and approval).
- All official documentation pertaining to multi-site test activities.
- All key decisions relating to NASA rocket propulsion testing.

NASA's RPT Program Manager is a member of the NRPTA.² The NRPTA, formed by an agreement between NASA and DoD and jointly chaired by the two organizations, was established to shape the Government's rocket propulsion testing capability to efficiently meet national test needs through intra- and inter-agency cooperation. The NRPTA reviews testing needs and recommends solutions that provide the best overall value to the taxpayer.

The NRPTA's Senior Steering Group (SSG) is an advisory group made up of senior officials from NASA and each DoD member organization.³ The SSG is chartered to provide guidance and direction to the NRPTA. Additionally, the SSG provides a forum for NRPTA members to present recommendations and proposed actions and to obtain resolution of disagreements. Senior NASA and DoD officials signed the initial MOA for the NRPTA on January 9, 1998, and the most recent MOA on January 15, 2003. In addition to the MOA, the NRPTA Operating Procedure provides detailed guidelines for the NRPTA process.

Under the Exploration Systems Mission Directorate (ESMD), the Constellation Program, located at Johnson Space Center in Texas, has overall responsibility for the development of the vehicles (crew exploration vehicle and crew launch vehicle) and related systems that will support NASA's exploration missions to extend a human presence throughout the solar system. The Exploration Launch Office, located at Marshall, is responsible for the design and development of the Ares vehicles (the Ares I crew launch vehicle and the Ares V cargo launch vehicle) that will support the Constellation Program. The Exploration Launch Office's USE Element Manager is responsible for the development of the J-2X rocket engine.

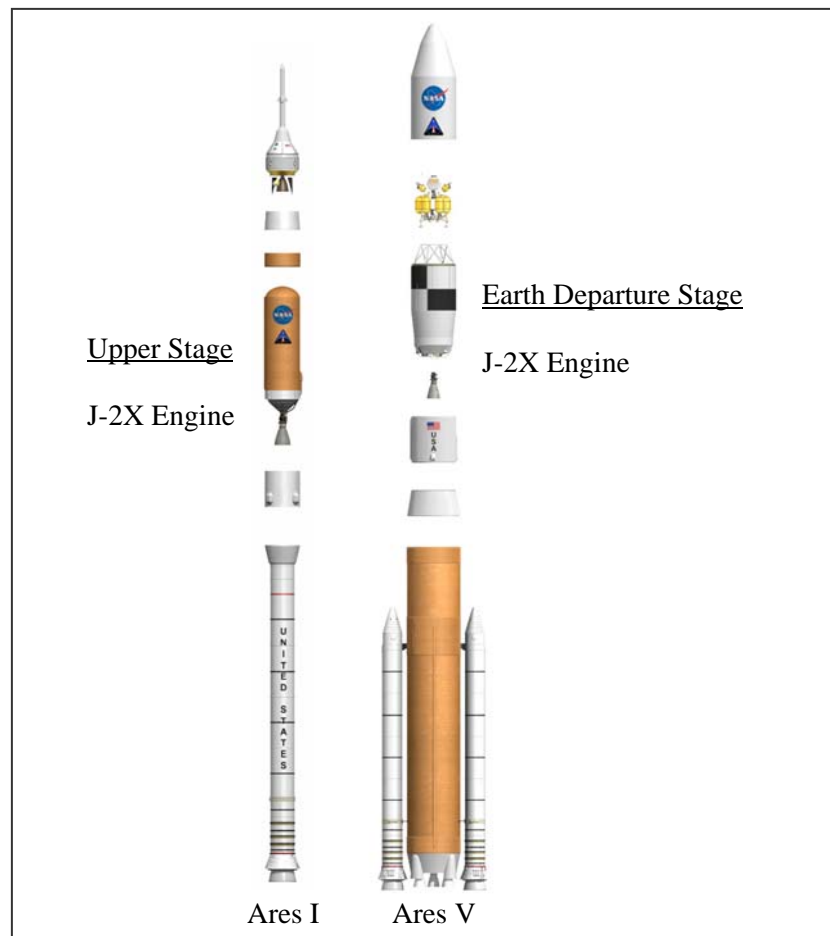
NASA is developing the new J-2X rocket engine to power the upper stage of Ares I and the Earth departure stage of Ares V (as shown in the following figure). Powered by liquid oxygen and liquid hydrogen, the J-2X is an evolved variation of two historic

² The NRPTA consists of nine members: one each from the four DoD rocket test sites (AEDC; Air Force Research Laboratory Propulsion Directorate; Army Redstone Technical Test Center; and Naval Air Warfare Center, Weapons Division, China Lake); one each from the four NASA test sites (Marshall, Stennis, Plum Brook Station, and White Sands Test Facility); and the RPT Program Manager.

³ The SSG consists of one NASA representative and one representative from each of DoD's four member organizations (AEDC; Air Force Research Laboratory Propulsion Directorate; Army Redstone Technical Test Center; and Naval Air Warfare Center, Weapons Division, China Lake).

predecessors: the J-2 upper stage engine that propelled the Apollo-era Saturn IB and Saturn V rockets to the Moon in the late 1960s and 1970s, and the J-2S, a simplified version of the J-2 developed and tested in the early 1970s but never flown. Testing of the turbo machinery, injector hardware, and ignition system components of the J-2X is ongoing. On April 3, 2008, NASA's Associate Administrator for ESMD explained during a congressional hearing before the House Science and Technology Committee's Subcommittee on Space and Aeronautics that early J-2X testing was underway at Stennis's A-1 test stand and that the A-2 test stand at Stennis would be providing early developmental testing.⁴ The first integrated testing of the full J-2X engine system is scheduled for September 2010. During testing, the J-2X will require long duration run times at vacuum pressure to simulate the environmental conditions it will encounter during flight. As of May 2008, there was no test facility equipped with the capabilities necessary to satisfy this testing requirement.

Ares I and Ares V Launch Vehicles



Source: NASA Ares I and Ares V Fact Sheets

⁴ Witness testimony is available at <http://science.edgeboss.net/real/science/scitech08/040308.smi> (accessed April 17, 2008).

In November 2006, the USE Element office defined the J-2X engine testing requirements and established a Study Team to assess facility options for the testing. In December 2006 and January 2007, the Study Team visited AEDC, Glenn Research Center in Ohio, and Stennis to hold concept familiarization meetings for the prospective test stands: the J-4 at AEDC, the B-2 at Glenn's Plum Brook Station, and the planned A-3 at Stennis. Each facility developed supportability concepts and cost estimates for meeting the stated testing requirements for the J-2X engine. In February 2007, the Study Team held multiple briefs with representatives from the J-2X Project Office, AEDC, Glenn, and Stennis to discuss the Team's results and the technical risks associated with developing each facility's test stand for J-2X engine testing.

On March 1, 2007, AEDC notified the RPT Program office and the Exploration Launch Office of a technical issue with its original J-4 design concept for J-2X engine testing that would result in significantly greater cost than originally estimated. This new cost estimate was roughly equivalent to the estimated cost of the A-3. On March 2, 2007, the Exploration Launch Office's USE Element Manager selected the planned A-3 for J-2X testing, commenced construction planning for the test stand, and created a NASA-led "Red Team." The Red Team was tasked with generating a cost estimate of the A-3 proposal, assessing the A-3 schedule, and evaluating technical risks. The USE Element Manager selected AEDC's J-4 as the backup test stand in case the Red Team's evaluation of Stennis's A-3 did not confirm the A-3 Project Office's estimates.

The Red Team review concluded that the costs of building the A-3 were commensurate with the costs of upgrading the J-4, the schedule was attainable, and the technical risks were manageable. Subsequently, the USE Element Manager recommended construction of the A-3 test stand at Stennis in support of J-2X engine testing in a briefing to the following:

- USE Element Control Board
- Exploration Project (Ares Project Manager and Constellation Test and Verification Manager)
- Constellation Program Manager
- Marshall and Stennis Center Directors
- ESMD and SOMD Associate Administrators
- NASA Administrator

On May 1, 2007, the NASA Administrator approved the construction of the A-3 test stand at Stennis, and ground was broken on August 23, 2007.

Allegations

Allegation 1. NASA ignored the NRPTA process when deciding to build a new test facility at Stennis.

We found that NASA did not follow the NRPTA process, or NASA's RPTMB process, in choosing to build the A-3 as the best course of action to meet testing requirements for the J-2X rocket engine. Instead, the Exploration Launch Office reviewed the J-2X rocket propulsion testing options and selected the A-3 test stand without the formal NRPTA review and recommendations required by RPTMB and NRPTA guidelines. This occurred because the USE Element Manager did not appropriately engage the NRPTA, as required by the NRPTA MOA. The USE Element Manager used the NRPTA to gather information instead of requesting the appropriate NRPTA member reviews and recommendations for J-2X testing options. NASA Policy Directives and NASA Procedural Requirements do not require adherence with RPTMB or NRPTA guidelines, which may have contributed to this decision.

NASA Selected A-3 without NRPTA Member Reviews and Recommendations. In December 2006, NASA's RPT Program office submitted an Action Request⁵ to the NRPTA to support a "J-2X Altitude Facility Cost and Capabilities Study." According to the NRPTA Operating Procedure, an Action Item Request is used to initiate a review of facility investments, test assignments, and changes in status or functionality. The December 2006 request simply stated that the "J-2X Engine Project has commissioned a comparative study to be briefed to RPT Program Office and J-2X Engine Project, (by Feb 2007)." The Study Team was led by personnel from Marshall. All submissions from rocket propulsion test sites, including DoD partners, were coordinated through NASA's RPT Program office. In April 2007, the RPT Program office drafted the following NRPTA recommendation:

Support has been provided to J-2X project office in the form of facilitating the collection of data from the requisite NRPTA members: AEDC, SSC [Stennis Space Center], and PBS [Plum Brook Station]. A secure FileShare FTP Site was established for the electronic transport of the large data files. Additionally, meeting facilitation and WebEx support were provided. No additional requirements are anticipated for this support, and no specific recommendations need be made. Suggest the NRPTA close the associated Action Request, and this Recommendation.

Although the RPT Program office solicited NRPTA member input to assist in accumulating facility capability information and preliminary designs, no other Action Item Requests were submitted to the NRPTA. Specifically, no Action Item Request was ever developed or submitted to review facility options for a new test requirement. Therefore, contrary to the terms of the MOA and the NRPTA Operating Procedure,

⁵ NASA's RPTMB Operating Procedures labels this document an "Action Request." The NRPTA Operating Procedure refers to the comparable document as an "Action Item Request."

NRPTA members were never provided the opportunity to review, discuss, or vote on the respective options for addressing the new test requirement.

The USE Element Manager selected the A-3 for J-2X testing without recommendations from NASA's RPTMB or the NRPTA. Reasons cited by the USE Element Manager as the basis for the decision to build the A-3 test stand, instead of using AEDC's existing J-4 test stand, included

- the A-3 had the lowest non-recurring cost solution;
- the A-3 had the shortest schedule to activation;
- the A-3's technical risk was manageable;
- the A-3 would be co-located with three other test stands, allowing for shared resources among the A-3, engine assembly facility, sea-level test facility, and passive-diffuser test facility; and
- the A-3 would provide a multi-purpose testing capability, which would allow for the consolidation of testing into one test stand, resulting in long-term recurring benefits that include having a NASA test stand (the A-3) available for flight engine acceptance testing, anomaly resolution, and testing of future engine upgrades.

The USE Element Manager stated that he selected the A-3 without, or prior to, receiving any recommendations from the RPTMB or NRPTA because the selection needed to be made in March 2007 to maintain the critical path of the Ares Project. He stated that a March 2007 decision was required in order to either refurbish the J-4 or build the A-3 and have initial operational capability by September 2010 for the planned January 2011 testing. We confirmed that the test facility was on the Ares Project's critical path, which may have influenced the USE Element Manager's decision to select a facility at that time. However, we found that the schedules projected for the A-3 and J-4 facility were the same, 3½ years. Although the critical path of the Ares Project may explain the timing of the decision, it does not adequately justify the decision to build the A-3 exclusive of cost and technical risk comparisons with other facilities as would have been provided if the appropriate request had been made of the NRPTA.

Rocket Propulsion Testing Decision Process. There is no NASA Policy Directive or NASA Procedural Requirements that contains any provision to direct the use of RPTMB or NRPTA processes when contemplating rocket propulsion testing or facility modifications. However, RPTMB Operating Procedures and the NRPTA MOA and Operating Procedure contain specific requirements for member organizations to request reviews and recommendations when considering rocket propulsion testing needs and facility modifications. These Operating Procedures are designed to ensure that testing requirements are adequately addressed in the decision-making process.

RPTMB Operating Procedures state that when an RPTMB member organization desires to make a facility modification greater than \$500,000 or a baseline capability deviation, or is contacted about potential testing, an RPTMB Action Request and any related information is to be forwarded to the RPT Program office. The RPT Program office distributes the information to all RPTMB members, who evaluate Action Requests to ensure project requirements are adequately considered and addressed in the decision-making process. When modifications to a facility or unique equipment investments for a test program exceed \$1 million in 1 year or \$5 million total, RPTMB Operating Procedures state that the RPT Program office's distribution is to include all NRPTA sites, and the NRPTA process is to be followed.

The NRPTA MOA between NASA and DoD states that the NRPTA will "review significant facility modifications, upgrades, and new construction and make formal recommendations to guide NASA and DoD rocket test facility investments." The MOA further states that NRPTA member organizations will "[c]onduct test programs within the established test capability database, roadmaps and investment strategies [and] obtain Alliance recommendation if a test program or capacity is contemplated outside these guidelines. . . . The NRPTA, as a group, will integrate, review and approve products from Alliance member inputs and make recommendations to agency management and the SSG, including all dissenting opinions."

The NRPTA Operating Procedure provides detailed guidelines applicable to all rocket propulsion test activities conducted at DoD or NASA locations. The NRPTA Operating Procedure states that an Action Item Request will be submitted by any member organization to its respective NRPTA chair (NASA or DoD) to document planned actions or investments or to initiate a review of issues raised by the NRPTA membership, to include facility investments, test assignments, and changes in status or functionality. All facilities belonging to NRPTA members, as well as commercial facilities, are considered for each new capability, modification, investment, or test assignment. Once NRPTA members have discussed and validated an Action Item Request, the NRPTA members affected by the proposed action develop Decision Packages. Decision Packages are distributed to NRPTA members and, following the NASA/DoD co-chairs' determination that sufficient discussion has occurred, members vote on the respective options. The position with the most votes is forwarded as the NRPTA recommendation. Unresolved issues are forwarded to the SSG for resolution.

NASA Management Did Not Honor Provisions of the NRPTA MOA. GAO's March 1998 report, "Aerospace Testing: Promise of Closer NASA/DoD Cooperation Remains Largely Unfulfilled," cited that "[c]ongressional intent,⁶ as reflected in the statutory

⁶ Section 211(c) of the National Defense Authorization Act for Fiscal Year 1997 (Pub. L. 104-201, Sept. 23, 1996) states: "Not later than 90 days after the date of the enactment of this Act, the Secretary of Defense and the Administrator of the National Aeronautics and Space Administration shall submit to Congress a joint plan for coordinating and eliminating unnecessary duplication in the operations and planned improvements of rocket engine and rocket engine component test facilities managed by the Department of the Air Force and the National Aeronautics and Space Administration. The plan shall provide, to the extent practical, for the development of commonly funded and commonly operated facilities."

requirement for joint planning of rocket propulsion test facilities, is not being fully met by NASA and DOD.” The report stated that inter-agency competition was one reason for the largely unfulfilled promise of closer NASA/DoD cooperation and the development of a national perspective on aerospace test facilities.

The NRPTA MOA, which was first signed in January 1998, states that the NRPTA will review significant facility modifications, upgrades, and new construction and make formal recommendations to guide NASA and DoD rocket test facility investments. NASA management did not facilitate the required inter-agency discussions or cooperation, but instead chose to have NASA’s RPT Program office review the J-2X testing options and the USE Element Manager brief those options to the Administrator.

The DoD co-chair of the NRPTA stated that NASA’s actions were not in keeping with the provisions of the NRPTA MOA and expressed concern regarding future cooperation between DoD and NASA. AEDC personnel also emphasized that DoD members of the NRPTA were not given the opportunity to view or comment on the USE Element Manager’s May 1, 2007, briefing to the NASA Administrator and were excluded from any final discussion of the J-2X test facility decision. Additionally, AEDC personnel stated that the briefing presentation contained some erroneous information, including statements that AEDC’s schedule to deliver an operational facility was 3 months longer than the A-3 schedule and that AEDC could not provide NASA guarantees as to the long-term availability of the J-4 facility.

AEDC personnel stated that the J-4 facility option was at a disadvantage because NASA had not used the NRPTA process and only NASA presented information on the J-2X options to Constellation Program managers and the Administrator. Had NASA vetted the decision through the NRPTA process, the NRPTA could have addressed AEDC’s concerns before NASA made the decision to build the A-3.

We found that NASA did not provide DoD members of the NRPTA the opportunity to view, substantiate, or comment on the content of the decision briefing presented to the NASA Administrator or on the studies used in support of the briefing’s content. As a result, NASA not only missed an opportunity to fulfill congressional requirements of fostering a more cooperative partnership with DoD in the area of rocket propulsion testing, but may have forfeited potential benefits gained from the technical expertise resident among NRPTA members to recognize and mitigate technical risks of the A-3’s design.

Allegation 2. Building a new rocket propulsion test facility at Stennis would duplicate existing capabilities found at AEDC in Tennessee.

We found that the test stand NASA intends to build at Stennis would not duplicate existing capabilities found at AEDC. We reviewed the J-2X engine testing requirements and determined that at the time of the decision to build the A-3, in May 2007, a test stand with the long duration run time at vacuum pressure testing capability required for the new J-2X engine, as defined by Constellation Program and Ares Project requirements, was not

available at AEDC, Stennis, or any other NASA or DoD facility. AEDC personnel confirmed in January 2008 that the J-4 test stand did not have the capability to meet the requirements. They provided us a copy of an AEDC presentation made to NASA's RPT Program office on January 19, 2007. The presentation, "J-4 Test Facility Reactivation and Modification Study for NASA's Ares I J-2X Engine Simulated Altitude Test Program," addressed AEDC's feasibility assessment of reactivating and improving the J-4 for simulated altitude testing of the J-2X and a possible reconfiguration concept. The AEDC presentation showed that the J-4 test stand would require significant refurbishment and modification to satisfy all of the J-2X test requirements. AEDC personnel estimated that refurbishment and modification costs would be around \$135 million. Additionally, commission, testing, and activation costs amounted to \$31 million, resulting in a total cost of approximately \$166 million to bring the J-4 test stand up to full operational capability for J-2X testing.

Existing NASA facilities also did not possess a test stand able to meet the technical requirements for J-2X engine testing. On January 5, 2007, the RPTMB issued a directive that confirmed neither the A-1 nor A-2 at Stennis was suitable for J-2X engine testing. Additionally, the NASA Engineering and Safety Center (NESC)⁷ performed a feasibility assessment for conducting J-2X engine testing at Plum Brook Station's B-2. NESC issued a report on its assessment on March 15, 2007, "Feasibility of Conducting J-2X Engine Testing at the Glenn Research Center (GRC) Plum Brook Station (PBS) B-2 Facility," in which NESC stated that, among other technological challenges, "concepts significantly different from the current configuration are necessary for the diffuser, spray chamber subsystems, and cooling water."

NASA's RPT Program office also contracted an independent firm, Aerospace Corporation, to conduct a study to provide "an assessment of whether the capabilities of the existing liquid rocket propulsion testing infrastructure are consistent with the emerging testing requirements envisioned over the next ten years." The study considered current and emerging user needs and the associated programs of NASA, DoD, and commercial providers. In June 2007, Aerospace Corporation provided a report of its results and conclusions, "Rocket Propulsion Test Capability Alignment Study." Aerospace Corporation found that "[t]he primary shortcoming identified in this study was in the area of satisfying particular requirements for long duration altitude/cold soak testing for the NASA Ares I second stage engine system [J-2X] and stage. These would require either significant upgrades to existing facilities or the development of a new facility." Aerospace Corporation stated that in order to meet the J-2X testing requirement of long duration run times at vacuum pressure, the J-4 facility would need to increase its liquid hydrogen storage capacity and procure a new propellant storage system and water chiller, as well as new steam supply, control, and ejectors. Aerospace Corporation concluded that these upgrades and refurbishments would cost approximately \$134 million.

⁷ NESC is an independently funded program with a dedicated team of technical experts. NESC provides objective engineering and safety assessments of NASA's high-risk projects to ensure safety and mission success.

Allegation 3. Building the new A-3 test facility at Stennis would result in a waste of funds.

Our analyses of the various test facility cost estimates indicate that building the A-3 would not be a waste of funds. However, unresolved issues related to the technological risks of the proposed A-3 design and additional costs that have recently been identified could result in significant cost increases and schedule delays, which could in the future prove that an alternative option would have been more cost-effective.

We confirmed that existing facilities could not meet the requirements for testing the J-2X; therefore, a significant expenditure of funds was necessary to either modify an existing test stand or build a new one. We found that the most recent A-3 cost estimates, from Stennis's A-3 Project Office (February 2008), Aerospace Corporation (June 2007), and the NASA Red Team (March 2007), ranged from \$163 million to \$185 million. These cost estimates were less than the NESC cost estimate (March 2007) of \$173 million to \$198 million to modify the B-2 at Plum Brook Station and within approximately 10 percent of AEDC's cost estimates (January 2007) of \$152 million to \$166 million for the activation and modification of the J-4 (see Enclosure 2). On April 9, 2008, because of indications of increasing costs, the A-3 Project Manager directed a standdown of some A-3 design work until cost reviews and mitigation plans were developed. An April 30, 2008, Jacobs Technology, Inc. presentation showed a significant increase in the cost of labor and materials. Additionally, questions concerning the technological feasibility of the planned A-3 design have been raised, which could impact the final cost and scheduled availability of the test stand.

AEDC and NASA RPTMB personnel had expressed to the RPT Program office concerns with the technical risks associated with the A-3 design and operations. Of primary concern is the technical design risk posed by the development of the chemical steam generator (CSG) system. CSGs, using isopropyl alcohol, liquid oxygen, and water, are used to achieve the simulated altitude environment. CSGs are designed to run for the duration of the engine test, generating approximately 4,620 pounds per second of steam in order to reduce the pressure in the test cell and downstream of the engine. AEDC personnel expressed concern that NASA minimized technical risk by rating the A-3's use of 27 CSGs as a medium risk. Their opinion was that the risk should be rated medium to high since the design is fashioned after the CSG system at NASA's White Sands Test Facility, which uses only three CSGs. White Sands personnel expressed concern that the planned techniques for bringing the A-3's CSGs online and for shutting them down are unproven and considered very significant technical risks. NASA RPTMB members also expressed concerns about the plan to use CSG techniques that had not been attempted before and might not be possible.

There are additional technological risks associated with the planned A-3 test stand design. RPTMB members were concerned that converting the A-3 to a sea-level test facility may not be practical from a cost and scheduling standpoint. AEDC personnel also questioned NASA's use of the A-3 for future sea-level and altitude testing, stating

that they did not believe the A-3's design would permit such reconfiguration without significant modification and additional operating costs.

In addition, the June 2007 Aerospace Corporation study included additional concerns with the A-3, citing two specific technical risks: (1) the ability to manage a smooth shutdown that will not damage the J-2X engine nozzle and (2) adequate cooling of the diffuser wall may require some modification to the design. However, these concerns were not considered during the decision-making process because the report on Aerospace Corporation's study was issued over a month after the NASA Administrator had approved the construction of the A-3.

The USE Element Office did not provide feedback regarding the identified risks and, as a result, questions persist as to how NASA plans to mitigate those risks, which could impact the final cost and development schedule of the facility. Using the RPTMB and NRPTA processes could have provided a forum for members to communicate their opinions and resolve their concerns.

Recommendations, Management's Response, and Evaluation of Management's Response

Recommendation 1. We recommended that the Associate Administrator for Space Operations issue a NASA Policy Directive (and NASA Procedural Requirements, if applicable) detailing the requirement for NASA's rocket propulsion test organizations to request formal reviews and recommendations from the RPTMB and, as appropriate, the NRPTA, in accordance with RPTMB and NRPTA guidelines.

Management's Response. The Associate Administrator for Space Operations concurred, but noted that the RPT Program Commitment Agreement and NRPTA MOA are in revision. Both documents are scheduled for completion in December 2008. Concurrently, SOMD intends to draft a NASA Policy Directive. SOMD estimates the NASA Policy Directive will be approved and in place by August 30, 2009.

Evaluation of Management's Response. Management's planned action is responsive. The recommendation is resolved and will be closed upon completion and verification of management's corrective action.

Recommendation 2. We recommended that the Associate Administrator for Exploration Systems take advantage of the technical expertise available in the rocket propulsion test community and request an independent review and assessment of the technical and cost risks associated with the planned A-3 test stand in order to develop a comprehensive risk mitigation strategy.

Management's Response. The Associate Administrator for Exploration Systems accepted the recommendation and intends to take advantage of the technical expertise available in the rocket propulsion test community and form independent cost estimates for the planned A-3 test stand. Results of the assessment will be used to ensure technical, cost, and schedule threats are identified and are incorporated into the existing threat and risk management systems. ESMD will request that an independent cost assessment of technical and cost risks associated with the planned A-3 test stand be completed by November 30, 2008.

Evaluation of Management's Response. Management's planned action is responsive. The recommendation is resolved and will be closed upon completion and verification of management's corrective action.

We appreciate the courtesies extended during our review. If you have any questions, or need additional information, please contact Mr. Raymond Tolomeo, Science and Aeronautics Research Director, at 202-358-7227.

signed

Evelyn R. Klemstine

3 Enclosures

cc:

Chief Engineer

Assistant Administrator for External Relations

Director, Johnson Space Center

Director, Marshall Space Flight Center

Director, John C. Stennis Space Center

Scope and Methodology

We performed this review from January through May 2008 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform our work to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on the objectives. We believe that the evidence obtained during this review provides a reasonable basis for our findings and conclusions based on our objectives.

For this review, we interviewed

- Marshall and Stennis employees who prepared A-3 cost estimates and performed analyses of the J-2X engine test facility options and the Environmental Assessment;
- past and current members of the RPTMB and NRPTA;
- AEDC personnel; and
- Aerospace Corporation employees involved in the development of the “Rocket Propulsion Test Capability Alignment Study.”

In addition to interviewing RPTMB and NRPTA members, we reviewed SSG documentation to determine whether the SSG evaluated, discussed, and approved the development of the new test site. The documentation included the minutes for the June 2007 NRPTA SSG Meeting. We also reviewed the minutes to determine whether NASA or AEDC personnel expressed opinions related to the A-3 decision.

We interviewed AEDC personnel to determine NASA’s prior use of AEDC facilities, the status of the J-4 test stand, and AEDC’s opinion of the A-3 decision. We also reviewed AEDC’s October 2007 draft report, “J-4 Test Facility Reactivation Study for NASA’s J-2X Engine” to determine AEDC’s assessment of NASA’s decision to select the A-3 for J-2X testing.

We reviewed documentation of AEDC’s J-4 cost estimates provided to NASA in various reports. We also obtained and reviewed data that Aerospace Corporation provided to NASA, including the June 21, 2007, “Rocket Propulsion Test Capability Alignment Study.” We compared the various cost estimates, to include the Red Team and A-3 Project Office estimates; verified adherence to Office of Management and Budget (OMB) criteria to establish reasonableness; and determined the specific data applicable for comparative cost analysis.

We did not evaluate the technological feasibility of individual test stand designs or proposed modifications.

Additional documentation and applicable regulations, policies, and instructions relating to the allegations that we reviewed included

- RPTMB Operating Procedures;
- the NRPTA MOA and Operating Procedure;
- Stennis Policy Directive 1107.1, Rev. D, “John C. Stennis Space Center, SSC Organization, Mission and Responsibilities-TA00/Rocket Propulsion Test Program Office – Appendix J,” September 2006;
- Stennis Work Instruction SOI-8080-0045-LC, “NASA Rocket Propulsion Test Management Board (RPTMB) Operating Procedures,” June 2006;
- Rocket Propulsion Test Program Commitment Agreement, May 2005;
- the chronology of events from the November 30, 2006, altitude facility study kick-off through the Agency’s decision to approve the A-3 on May 1, 2007;
- NASA’s “J-2X Altitude-Simulation Test Facility Recommendation, May 1, 2007,” which documents NASA’s process and justification for selecting the A-3 as the best course of action; and
- information from NASA personnel regarding the RPTMB and NRPTA processes and how NASA determined that the A-3 facility was the best course of action.

Computer-Processed Data

We relied on computer-processed data for this review. We obtained A-3 cost estimates from the A-3 Project Manager at Stennis. We performed limited testing to validate the reliability and integrity of estimated costs by comparing project element costs presented in a February 2008 A-3 Work Breakdown Structure with cost amounts in awarded contracts and vendor quotes. We found no discrepancies and, based on our limited testing, we placed reliance on the adequacy of the data and considered it sufficient for the purposes of our review.

Prior Coverage

During the last 5 years, the Government Accountability Office (GAO) and the NASA OIG have issued three reports of particular relevance to the subject of this memorandum. In addition, GAO testimony in 2008 and a GAO report issued in 1998 are relevant. Unrestricted GAO publications can be accessed over the Internet at <http://www.gao.gov>, and unrestricted NASA reports are available at <http://oig.nasa.gov/audits/reports/FY08/>.

Government Accountability Office

“NASA: Ares I and Orion Project Risks and Key Indicators to Measure Progress”
(GAO-08-186T, April 3, 2008)

“Agency Has Taken Steps Toward Making Sound Investment Decisions for Ares I but
Still Faces Challenging Knowledge Gaps” (GAO-08-51, October 31, 2007)

“Aerospace Testing: Promise of Closer NASA/DoD Cooperation Remains Largely
Unfulfilled” (GAO/NSIAD-98-52, March 11, 1998)

National Aeronautics and Space Administration

“Final Memorandum on the Audit of NASA’s Management of the Test Operations
Contract” (Report No. IG-08-019, May 9, 2008)

“Final Memorandum on the Audit of Requirements for Testing Facilities at Plum Brook
Station” (Report No. IG-07-033, September 28, 2007)

Summary of Cost Estimates

A-3 Project Office Cost Estimate. The A-3 Project Office formulated the A-3 cost estimate with the assistance of Jacobs Technology, Inc. In January 2007, the A-3 Project Office initially estimated the cost to build the A-3 test stand at \$119 million. In March 2007, the Project Office revised this estimate to \$163 million, which included validation testing, activation, upgrades, and contingency funds. In April 2007, the A-3 Project Office further revised its cost estimate to \$175 million, to include more contingency funds.

We verified that the requirements of OMB Circular No. A-11, Section 33, “Estimates Related to Specific Types of Programs and Expenditures,” July 2, 2007, and OMB Circular No. A-94, “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs,” October 29, 1992, were adhered to when completing the cost estimate. In addition, the A-3 Project Office adhered to the provisions of the NASA Cost Estimating Handbook by employing the “engineering build-up methodology,” sometimes referred to as “grassroots” or “bottom-up” estimating. The A-3 Project Office presented the cost estimate in a detailed Work Breakdown Structure; estimated costs were based on vendor quotes and historical engineering test facility data; and appropriate funding was added to cover project uncertainties and assurance that facilities provided a safe and healthful workplace for employees.

On April 9, 2008, the A-3 Project Manager directed a standdown of some A-3 design work until cost reviews and mitigation plans were developed because of indications of increasing costs. An April 30, 2008, Jacobs Technology, Inc. presentation showed a significant increase in the cost of labor and materials. Specifically, the presentation showed increases of \$16 million due to refinement of initial assumptions, \$8.4 million due to changes in A-3 design requirements, \$15 million due to the increased cost of steel and pressure vessels, and \$15 million due to increased labor costs. We did not verify the additional cost estimates.

Aerospace Corporation A-3 Cost Estimate. Aerospace Corporation stated that its initial estimate for the development of the A-3 test stand was approximately \$390 million. However, Aerospace Corporation met with Stennis personnel and found that the proposed design for the A-3 test stand was significantly different from the design that Aerospace Corporation considered for its initial estimate. For example, Stennis had more infrastructure and existing utilities in close proximity to the planned site than Aerospace Corporation had assumed. Based on the additional information, required upgrades, and added conservatism, Aerospace Corporation revised its A-3 cost estimate to \$173 million in April 2007. Aerospace Corporation based this cost estimate on estimates provided by Stennis, background data from two similar Air Force projects, and standard industry estimating tools. Aerospace Corporation also recommended a review of the facility options for J-2X testing, both fiscally and technically, to get the most effective strategy to support the Constellation Program and other future U.S. space propulsion requirements.

NASA Red Team A-3 Cost Estimate and Evaluation. In March 2007, NASA formed a Red Team, consisting of Kennedy Space Center and Marshall personnel and a consultant from GPS Solutions, to review the A-3 Project Office's \$163 million cost estimate. Marshall's Exploration Launch Office directed the Red Team to ensure that the A-3 Project Office's estimate was sufficient for a complete and operational facility. The Red Team was also tasked with evaluating environmental plans; approval and acquisition strategy; and technical risk mitigation plans to ensure a realistic schedule. On April 12, 2007, the Red Team presented its results to the RPT Program office and the Constellation Program Office. The Red Team's estimate of \$185 million for the A-3 test stand included more upgrades and contingency funds than the March 2007 A-3 Project Office cost estimate of \$163 million. The Red Team also concluded that the A-3 schedule was achievable and the technical risk was manageable.

AEDC J-4 Estimate. AEDC's J-4 facility has been in an inactive status since December 2001. The initial cost estimate for upgrading and activating the J-4 facility was \$112 million, as documented in AEDC's January 19, 2007, study, "J-4 Test Facility Reactivation and Modification Study for NASA's Ares I J-2X Engine Simulated Altitude Test Program." However, on March 1, 2007, AEDC informed the RPT Program office and the Exploration Launch Office of a technical issue with AEDC's original J-4 concept, related to the exhaust plant performance, which would increase the estimated cost to \$152 million. In AEDC's "J-4 Test Facility Re-Study for NASA's Ares I J-2X Engine Simulated Altitude Test Program" presentation of April 2007, AEDC provided NASA a revised estimate of \$163 million. In June 2007, AEDC provided comments in response to NASA's May 2007 decision briefing to the NASA Administrator. The comments included a final AEDC estimate of \$166 million to activate and modify the J-4 to meet the test requirements of the J-2X.

Plum Brook Station B-2 Estimate. In January 2007, Plum Brook Station provided a cost estimate of \$131 million to upgrade and modify the B-2 to meet J-2X testing requirements. Additionally, the Exploration Launch Office requested that NESC perform a feasibility assessment of conducting J-2X engine testing at the B-2. NESC issued a report on its assessment on March 15, 2007, in which NESC concluded: "The concepts defined for the increase facility capability for J-2X are costly extensions of the current capability. The cost estimates for rehabilitation and increased capability were in the \$173-198M range."

Management's Comments

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001



June 30, 2008

Reply to Attn of:

SOMD/ESMD

TO: Assistant Inspector General for Auditing

FROM: Associate Administrator, Space Operations Mission Directorate
Associate Administrator, Exploration Systems Mission Directorate

SUBJECT: Responses to report "Review of NASA's Plan to Build the A-3 Facility for Rocket Propulsion Testing," (Assignment No. S-08-012-00)

The Office of Inspector General (OIG) issued a report entitled, "Review of NASA's Plan to Build the A-3 Facility for Rocket Propulsion Testing," (S-08-012-00). Responses to the Inspector General's recommendations are provided below. Recommendation 1 is addressed to the Associate Administrator, Space Operations Mission Directorate (SOMD), and Recommendation 2 is addressed to the Associate Administrator, Exploration Systems Mission Directorate (ESMD).

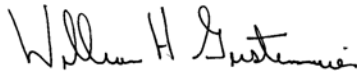
OIG Recommendation 1: "We recommend that the Associate Administrator for Space Operations issue a NASA Policy Directive (and NASA Procedural Requirements, if applicable) detailing the requirement for NASA's rocket propulsion test organizations to request formal reviews and recommendations from the RPTMB and, as appropriate, the NRPTA, in accordance with RPTMB and NRPTA guideline."

Response to Recommendation 1: SOMD concurs with the recommendation to create a NASA Policy Directive (NPD) and NASA Procedural Requirements (NPR), if applicable, detailing the requirements for the Rocket Propulsion Test (RPT) Program Commitment Agreement (PCA) and the Memorandum of Agreement (MOA) of the National Rocket Test Propulsion Test Alliance (NRPTA). Currently, the PCA for the RPT and the MOA for the NRPTA are in revision. Both documents are scheduled for completion in December 2008. The associated NPD/NPR will be drafted in conjunction with these revisions and will begin the concurrence cycle once both original documents are approved.

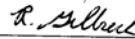
OIG Recommendation 2: "We recommend that the Associate Administrator for Exploration Systems take advantage of the technical expertise available in the rocket propulsion test community and request an independent review and assessment of the technical and cost risks associated with the planned A-3 test stand in order to develop a comprehensive risk mitigation strategy."

Response to Recommendation 2: ESMD accepts the recommendation to take advantage of the technical expertise available in the RPT community and from independent cost estimators for the planned A-3 test stand. Results of the assessment will be used to ensure appropriate technical, cost and schedule threats are identified and are incorporated into the existing threats and risk management systems.

If you have any questions regarding this response, please call the audit liaison representatives; SOMD/Gail Gabourel, (202) 358-1462, ESMD/Elsie Weigel, (202) 358-2345, and Sue Curley (202) 358-1721.



William H. Gerstenmaier



Richard J. Gilbrech

cc:

OCE/Mr. Ryschkewitsch

OER/Mr. O'Brien

SOMD/Mr. Wrobel

Mr. Kelly

Ms. Gabourel

ESMD/Mr. Timms

Ms. Curley

Ms. Weigel

ICMS/Mr. Roberts

Ms. Miller

JSC/Mr. Coates

MSFC/Mr. King

SSC/Mr. Cabana